جامعة عين شـــــمس

جامعة شتوتجارت

التخفيف من تأثير جزيرة الحرارة الحضرية في تيران

صندوق أدوات التدخل للأحياء السكنية

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

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٠٨/ أغسطس/ ٢٠٢٠

Ain Shams University
Egypt

University of Stuttgart
Germany

Mitigating Urban Heat Island Effect in Tirana

An intervention toolbox for residential neighborhoods

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

by

Malvina Prolla

Supervised by

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Professor of Integrated Planning and Design
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Abstract

Mitigating the Urban Heat Island Effect in Tirana.

Malvina Prolla

The urban heat island effect is not a new phenomenon, but it is still not very familiar in Albania. Even though the cities are suffering from this problem, nor the government and either the citizens are doing much. However, only to recognize the thermal discomfort is not enough to improve the situation. The problem should be seen on a wider scale. Therefore, this research aims to propose solutions to reduce the heat effect in residential neighborhoods, after understanding the scale of the problem. To explore the causes of UHI, I did site analysis, observations, and open-end interviews with experts and residents. The mixed-use research method helps to better understand the problem. It analyzes further, the problem in different neighborhoods, were the UHI differentiates because of the characteristics of the site. The selected study areas represent three different typologies, high rise, middle raise, and detached buildings, mainly single houses. The problem is embodied in different ways in those areas as the urban morphology is different.

Taking the discussion from the neighborhood scale and understanding the wider context, to city and country level, I argue how suggestions that come from open-end interviews should be applied to solve the problem. The suggested strategies and tools consideration the climate, and bring the perceptions of experts and residents adding values to this work.

Keywords: urban heat island effect, neighborhood, mitigation, strategies, tools, Tirana.

Acronyms

UHI – Urban Heat Island Effect

GHG – Greenhouse gasses

LUCF – land use changes and forests

HCFCs – hydrochlorofluorocarbons

GLP – General local Plan

GDCS – The General Directorate of Civil Status

INSTAT – Institute of Statistics

FAR – Floor Area Ratio

COV – Ground Floor Coverage

HEI – Height Index

IA – Islam Alla

MG – Magnet

L – Liqeni

Table of Contents

4. Methodology

5. Findings - Case studies

6. Discussions- Comparing the scale of urban Heat Island effect at neighborhoods of Tirana

7. Recommendations - Reflections

8. Conclusions - Towards a cooler city

List of Figures and Tables

Introduction

This chapter will give an overveiw of the contex of this research. It will describe the general informations related with the topic.

1.1. General introduction of the research

The urban heat island effect is the phenomenon of temperature rise in the urban areas. It is associated with the cities as their surfaces have a low albedo, high impermeability, and favorable thermal properties to store the energy and release the heat. Therefore, the temperatures are higher in the urban areas than in rural areas or peripheries (Camilo Pérez Arrau and Marco A. Peña, 2019). It is a man-made phenomenon. Due to the change of environment from natural to urban the temperatures increase more in dense urban areas. According to The World Bank, 55, 27% of the population lived in urban areas in 2018.

The main causes of Urban Heat Island are related with: gradual loss of urban forest cover, low albedo, and impermeability of materials, city size and morphology, thermal properties of materials, anthropogenic heat and Green House Gas emissions.

During the last century our planet was hit more by climate change effects, and extreme natural events such as an increase of temperatures, changes in precipitations, droughts and heatwaves, stronger and intense hurricanes, and rise of sea levels. The global warming indicates to worsen the the urban heat island effect. Also, the UHI impacts in the climate change.

The average temperatures in the northern hemisphere in the 20th century were recorded as the highest in at least the past 1300 years (IPCC, cited in Horverter 2012). During the last century, temperatures increased by 2 degrees Fahrenheit. July 2019 was the hottest month recorded in Europe since 1981 according to Copernicus services. During July 2019, the highest temperature recorded in Albania was 39.5 °C. Historically, Tirana is one of the cities with the highest temperature recorded in the country. Albania belongs to the subtropical climate zone and has a Mediterranean climate with hot and dry summers and mild and abundant precipitation winters. Subtropical climate zones are the most affected climate zones from the UHI effect.

Since 1990, the population of Tirana has been increased continuously by expanding the city and transforming the land for natural/agricultural to buildup environment. On 1 January 2019, the National Institute of Statistics (INSTAT) reported that 31% of the population of Albania lives in Tirana and 88.3% of the population of the region of Tirana lives in urban areas. The buildup areas continue increasing for the last 30 years to accommodate the people who moved from rural areas to big cities, after changing the system from communism to democracy. Due to better services and job opportunities, the capital became the main host city.

To prevent the urban heat island effect and to mitigate its effect in dense urban areas, mitigation strategies should be implemented. However, the research gives

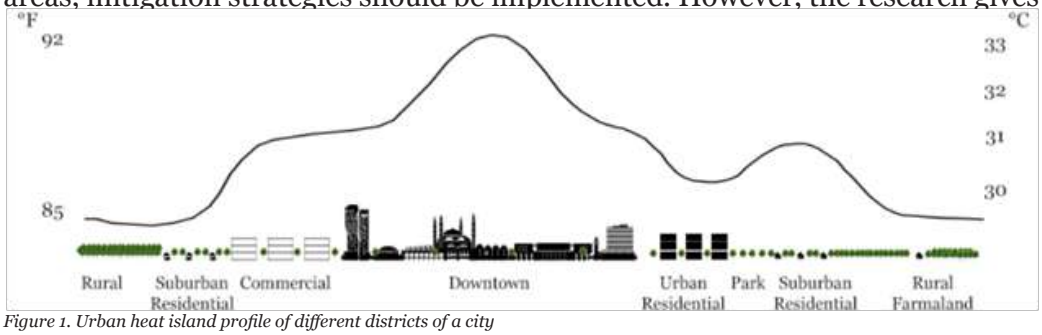


Figure 1. Urban heat island profile of different districts of a city
Source: the author, adopted from Lawrence Berkeley National Laboratory, 2000.

an overview of the methodology to mitigate UHI in residential areas of Tirana, Albania. Therefore it will discuss the research question, strategy, data collection method, and research method and strategy. Furthermore, it will have a quick look at the causes of this problem in Tirana.

1.2. The urban heat island effect

The urban heat island effect causes many problems related to environment and human health. It increases the impact into environment, brings health problems, and affects the quality of life.

1.2.1. Environmental challenges

As 31,8% (INSTAT, 2020) of the population of Albania, lives in the region of Tirana (Qark), the environment has been impacted. Also, the land has been transformed from agricultural to urban land due to the expansion of the city through the years. This has reduced the green areas in the city. Also, the air pollution is one the major problems in Tirana, classified as one the most polluted city in Albania. Based on measurement done in city center and along the boulevard "Dësh-

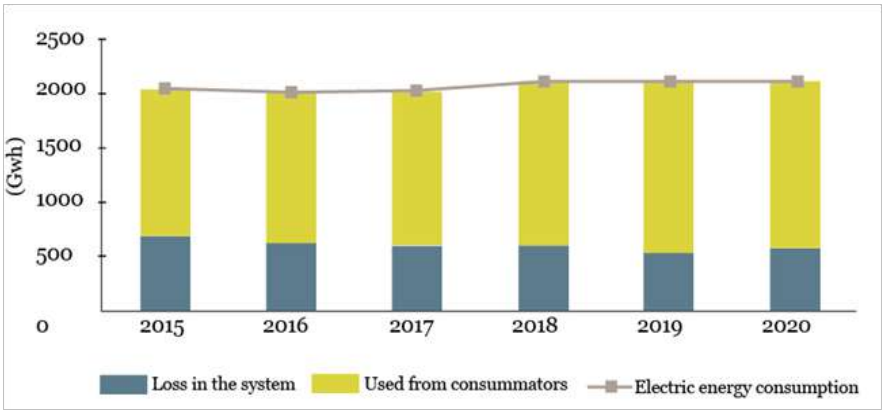


Figure 2. Electric energy consummations by consummators and loss in the system
Source: INSTAT, 2020.

morët e Kombit" of Tirana under the project "Green Lungs For Our Cities", the max value of NO2 is 0.252 mg/m3, while the EU standard is 0.04 mg/m3. On the other hand, the max values of PM10 are 101 mg/m3, while the EU standard is 40 mg/m3. The air pollution impacts the increase of the UHI and affects directly people's health.

Based on data provided by (INSTAT, 2020) in the last five years the energy consumption has increased as showed below.

Only in the first three months of 2020, the energy consumption decreased with 1,5% compared with the three first months of 2019. The reason for the decrease

in energy consummation was because the non-family consummators spend 3,2% less energy than one year before. While, the families consumed 1, 8% more energy than in 2019. This was also related with lockdown due to COVID-19.

The climate data show an increase in temperatures in the last thirty years, because of climate change in general, UHI in the urban areas, and other factors as

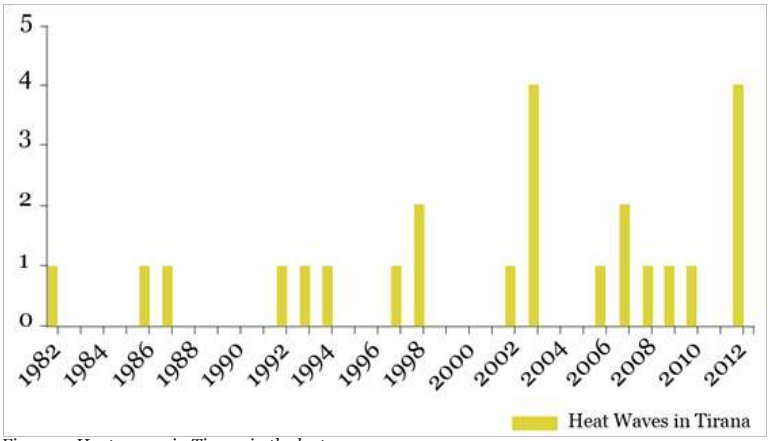


Figure 3. Heat waves in Tirana in the last 30 years
Source: Tanja Porja, "Heat Waves Affecting Weather and Climate over Albania" 20 12

well. Due to those factors the environment has been challenged in many ways.

1.2.2. Challenges for health and wellbeing

From 1982 to 2012, 61 heat waves occurred in Albania, and Tirana is one of the most affected cities due to its climate condition and the dense urban area. The heat waves in Tirana have increased and in the last 30 years they have occurred more often. Such events have impact people's health and wellbeing, by increasing the diseases related with cardiovascular and respiratory deaths.

According to (Ministry of Health, 2011) the climate change has already impacted the climate conditions in Albania. It has brought mild winters, which have favored the growth of tropical plants. Therefore, mosquitoes have appeared even at altitudes above 400 – 500m. The change in temperatures has made Albania vulnerable to disease outbreaks such as Chikungunya, dengue, malaria. Also, climate change has impacted the problems of air pollution, which is related to the increase in temperatures and causes other diseases. Tirana, in particular, has major problems related to air pollution.

The three kinds of health impact caused by the increase of temperatures are those caused by extreme events, as consequences of various processes of environmental change and ecological disruption in response to climate change, and diverse health consequences. The most vulnerable areas, geographically speaking, are the western regions, affected by coastal erosion and flooding, urban and industrial areas, and populations living near the rivers. Regarding those characteristics, Tirana is a vulnerable area and the health of the population will be affected due to the change of climate conditions.

During summer, especially in August, many people who live in Tirana prefer to go to other cities rather than staying here, where temperatures above 33°C. In general, the quality of indoor and outdoor spaces in Tirana is low, from the thermal point of view. The outdoor areas lack green spaces, shading elements and the majority of surfaces are impermeable. This impacts the worsen of the UHI effect and the wellbeing of people.

1.3. Aim, Objectives and hypothesis

As explained in the previous chapters, in Albania and specifically in Tirana the temperature has increased the last thirty years, so the climate condition have changed. This has impacted the people's life in different aspects. Also, the rapid urbanization has transformed Tirana and has impacted its environmental conditions.

Therefore the aim of this research is to build a toolbox, including community, experts and institutions, to reduce the urban heat island effect by following different mitigation strategies. In this regard it gives its contribution to the discourse of UHI mitigation, following EU Legislation and regulation for Climate Change.

To achieve the aim those objectives are set:

- Assessing the UHI effect in neighborhoods with characteristics (urban morphology, building typology, density etc.) in the study city.
- Identifying the causes of the UHI in selected case studies.
- Find suitable mitigation strategies of UHI for those residential neighborhoods.
- Recommend mitigation tools to reduce the UHI effect in selected case stud-

ies.

From the aims above the hypothesis are developed as per forwarding:

- The UHI is now a problem in Tirana.
- Causes of UHI differ by depending on neighborhood characteristics.
- Different mitigation strategies can reduce the heat effect by considering the characteristics of the context.
- Tools can help to achieve the aim each strategy has to mitigate UHI.

1.4. Research questions

The main research question this research explores is: How to mitigate the urban heat effect island effect in different neighborhoods of Tirana?

This leads to other sub-questions that this research looks into. Those sub-questions are:

- What is the scale of the urban heat island effect in different neighborhoods of Tirana?
- What are the main causes and effects of the UHI in the selected case studies?
- What strategies can help to mitigate the UHI? and
- What tools can mitigate UHI in different neighborhoods?

Literature review

This chapter builds on the main concepts used to better understand the phenomena and to analyze it further in the context of the selected case study.

2.1. What is Urban Heat Island effect

The phenomenon of UHI is discuses very early by L. Howard since 1810. He analyzed the temperature data in London and found out that temperatures during July were 0.6 °C higher than in its surroundings while during November the temperatures were 1,2°C higher in London than in its surroundings. It was further analyzed by authors such as Chandler, Landsberg, and Lee, with a focus on measuring the temperatures during summer in urban and suburbs/rural areas during day and night to understand the changes in air temperatures. In 1973, T. R. Oke gave a great contribution to defining and analyzing the phenomenon as we understand it today. As T. R. Oke emphasizes the urban heat island is a result of the modification of the natural environment by people's activities, its aim was to find if there was a relation between city size (as measured by population) and UHI, while till that moment it was related only to the city growth. Furthermore, UHI is a phenomenon that has been studied and research more as it is today's problem in dense urban areas. Also, climate change has worsened the UHI effect especially in big cities and particularly in tropical and sub-tropical climate zones.

In almost all the studies carried out about the UHI, there are two main focuses of analysis of UHI. Meteorological data comparison in urban and rural areas during summer and winter, during day and night, o understand differences in air temperatures in urban and rural areas and analysis of urban morphology to

measures the transformation of the natural environment to build up. The transformation of the environment and the human activities cause GHG, loss of urban forest cover, impermeable surfaces, and an increase of the anthropogenic heat. The UHI has been discussed recently in academia, as an integrated problem with climate change. Nowadays, more than 50% of the world population lives in the cities, and in the short future, this number is expected to increase. The increase in temperatures will worsen the UHI and affect people's health if no measures are taken.

2.2. Climate change and Urban Heat Island Effect

Climate change has impacted the climate conditions overall on the globe. It has led to higher temperatures and more frequent extreme events such as heatwaves. Those factors impact directly the heat effect in urban areas where temperatures are usually higher than in the suburbs or rural areas. As seen in figure 3, over the last 20 years, the extreme summer heat has become more frequent across the country, and particularly in Tirana. Based on this trend, rising temperatures, more heat waves, and the heat island effect will be increasingly harmful to people's health and the air and water quality in Tirana in the short future.

Table 1. Scenarios of increase of temperature;

Season	Change 2025	Change 2050	Change 2100
Annual	0.8 -1.1	1.7 - 2.3	2.9 - 5.3
Winter	0.7 - 0.9	1.5 - 1.9	2.4 - 4.5
Spring	0.7 - 0.10	1.4 - 1.8	2.3 - 4.2
Summer	1.2 -1.5	2.4 - 3.1	4.0 - 7.3
Autumn	0.8 -1.1	1.7 - 2.2	2.9 - 5.2

Source: Ministry of Environment 2002

According to the Ministry of Environment, the future scenarios for temperatures will increase by the end of this century. In the next thirty, years the temperatures are expected to increase annually up to 2.3 ^{o}C.

The increase in temperatures is a result of climate change-induced by GHG. On the other hand, the UHI reduces evapotranspiration, increase solar radiation absorption, and anthropogenic waste heat (Oke, 1982). The expected expansion of urban land to accommodate the population in the upcoming years will affect the increase of temperatures, worsen the UHI, and impact climate change.

2.3. The different scales of heat effect

The heat effect has different scales. (Camilo Pérez Arrau and Marco A. Peña, 2019) made a clarification in five categories: Heat island; Urban heat Island effect; Surface urban heat island; Micro urban heat island effect; urban heat sinks.

This thesis will research two types of heat effects, which are correlated with each other, the urban heat island effect, and the micro-urban heat island effect, which is a reason for the impact on a neighborhood scale and city-scale too.

“The Heat island is the presence of any warmer area than its surrounding landscape, and they are present in either urban or rural areas. Usually don’t represent a risk for the environment or humans, as the change in temperatures is not at a risk of human health. Thus, not much is known or talked about them.”

“Urban heat island effect is the phenomenon of temperature rise in the urban areas. It is associated with the cities as their surfaces have a low albedo, high impermeability, and favorable thermal properties to store the energy and release the heat. Therefore, the temperatures increase in the urban areas in comparison to rural areas or peripheries.”

“Surface urban heat island is the remotely sensed urban heat island effect. It is observed by using thermal infrared data to recapture the land surface temperatures. There is a close relationship between near-surface air temperature and land surface temperature. So the surface of UHI is a reliable indicator of the atmospheric UHI.”

“The micro urban heat island effect or the urban hotspots, which are poorly vegetated, such as parking lot, non-reflective roofs, and asphalt roads. They are affected by microclimate factors, so remotely sensed data are more suitable than atmospheric data for identifying heat spots.”

“Urban heat sinks are manifested if a city is colder than its countryside. This phenomenon is rare, and is observed in cities with temperate, tropical, semi-arid, and arid climates, and mainly during mornings.”(Camilo Pérez Arrau and Marco A. Peña, 2019)

2.4. Causes of urban heat island effect and its impacts

The main causes of urban heat island effect are related with the greenhouse gas emissions, gradual loss of urban forest cover, the impermeability and low albedo of materials, the thermal properties of materials, urban morphology, and the size of cities as well as anthropogenic heat" (Mélissa Giguère, 2009). The effects of urban heat islands are on human comfort, air pollution, energy management, urban planning policy, and climate changes (Bonafoni and Keeratikasikorn, 2018). This effect on human comfort might bring together other effects.

Also, the local climate, influenced by meteorological parameters such as temperature, humidity, and wind, promote the emergence and intensification of urban heat islands. Therefore, the context is very important to consider while analyzing the UHI phenomenon.

As the causes of UHI effect are related with the climate change the mitigation of climate change will improve the UHI problem. But, as the goals of energy and climate strategies are set at the (inter-)national level, it is the regional and local level that needs to translate these goals into action. Due to the lack of such information, relatively few integrated urban approaches have been implemented at the neighborhood scale so that little monitoring on the impacts of implementing such approaches exists (Philipp et al., 2014).

2.4.1. Anthropogenic heat

Anthropogenic heat, is the heat relived by human activities. It is related with rising temperatures of buildings, heat released from factories and industries, heat released from vehicles and extensive use of air conditioners and other electronic items. To reduce the heat released from human activities in outdoor areas action should be taken.

2.4.2. Urban morphology

The heat accumulation can be affected by urban morphology. A dense area without ventilation increases the air temperatures, and worsen the UHI effect. There is a correlation between morphology and urban heat environment. Urban morphology can create canyons where heat, and atmospheric pollutants remains

trapped (Mélissa Giguère, 2009). While, if the urban morphology considers the climate conditions and uses the wind direction to fresh the area, the heat effect reduces.

The cities have become bigger and their natural land is transformed to urban land to accommodate the needs for housing. Therefore the urban morphology does not follow the urban design restrictions in all cases. According to Philipp et al., 2014, continued urbanization and densification will increase the effect of urban heat islands and stormwater runoff in cities. Meanwhile, the on-going urbanization will affect the scale and intensity of this phenomenon be of the UHI (Li et al., 2016).

2.5. How to mitigate the urban heat island effect

This sub-chapter will look into possible ways to reduce the heat effect in neighborhood and city scale, by following different strategies.

2.5.1. Infrastructure strategy

Philipp et al., 2014, argues that different approaches can be considered to reduce building overheats, such as analyzing UHI and climate change aggravations like overheat are available. The materials used on buildings and other infrastructure are usually materials that absorb a lot of solar radiation. The low albedo and high impermeability of building materials indicate directly the increase of UHI effect in the cities.

Increasing the albedo of houses by 0.2 (moderate-dark to medium light color), the cooling-energy use can be reduced by about 30-40%. In Shanghai, showed that increasing albedo to 0.4, indicates to improve of outdoor thermal comfort by 5 – 7 ^{0}C (Wang et al., 2016). Akbari in (Wang et al., 2016) suggested that every increase of temperatures by 0.6 7 ^{0}C, increases with 1.5 – 2 % the demand for cooling energy. The increase demand for cooling energy increases the heat released from building impacting directly the heat effect.

2.5.2. Green strategy

While talking about the heat the first measure that comes into our minds is green.

Maybe the lack of green spaces in the dense cities has become people more aware of its importance.

According to ZSK 2014, different green options such as: vegetation according to on the microclimate, which reduces the overheating effect in neighborhoods; shading by trees, and green facades, that reduce the required heat energy input of the building; and other similar techniques to integrate vegetation into buildings, have the potential to reduce heat by thermal mass and evaporation. (Philipp et al., 2014).

Furthermore, green infrastructure can provide services that help to reduce these effects, so-called regulating. Ecosystem services (TEEB - The Economics of Ecosystems and Biodiversity, 2011).

By increasing the vegetation cover by 30%, the cooling-energy use in Toronto could be reduced by 10% in urban houses and 20% in the houses located in the suburbs (Wang et al., 2016).

2.6. Study model and process aligning with literature

This sub-section aims to bring examples of cities with similar climate conditions as Tirana that is already suffering the urban heat island effect. Hence, it will learn from their experience of mitigation of UHI.

2.6.1. Case of Bologna

In Bologna, Italy, Green roofs were used as a strategy to mitigate the urban heat island effect. Bologna has a Mediterranean climate and is located in a sub-tropical climate zone, the same as Tirana. According to Mirzaei, cited in ((Cipolla et al.), urban planners use thermal models to evaluate the impact of vegetation in the design phase, but they are limited to monitoring those activities to calibrate models under Mediterranean climate conditions. Simulations through ENVI-met, for this case, were done in a typical Mediterranean hot climate day without precipitations, 24 of October, during the whole day. The average temperature was between 13.2 ^{0}C and 27.3^{0}C and Simulations were done for the current situation, and if Green Roofs were installed. Comparing the results of both scenarios, the cooling effect was the difference between both scenarios. Results

indicate that the presence of GRs reduces the pedestrian-level air temperature up to 3.7 °C at 15:00, and in effect, all the area is much hotter in the "As Is" scenario as indicated by yellow and red color representation. The "Green roof" scenario shows that GRs have a positive effect on reducing the air temperature above the building and so the UHI effect. (Cipolla et al.). "Green Roof" strategy reduced the air temperature from 0.5 and 3 ºC during night and day, by improving human comfort.

2.6.2. Case of Avola

Another Mediterranean city that adapted mitigation strategies of UHI is a small city in Sicily, called Avola. This study investigates the UHI of an old neighborhood near downtown. In this case, it was agreed upon that the most relevant strategies to use are urban green, cool roofs, and cool pavements. The vegetation has the benefit of creating shadows. Cool roofs use highly reflective materials which help to reflect the solar radiation. Last, cool pavements increase pavement surface reflectance, increase the emission, and reduce the heat capacity, etc... Simulations results showed that scenarios of 'green roof' and 'cool roof' have the same effect. The temperatures decrease by approximately 1.5 ºC. The best performance to reduce the UHI is using cool pavements, which reduces the air temperatures 2.0 ºC. Such results point out that urban roads, which are usually paved by dark and impermeable materials, significantly contribute to the heat island effect by warming up in the sun and releasing the stored energy to their surroundings during the evening and overnight. (Evola et al., 2017)

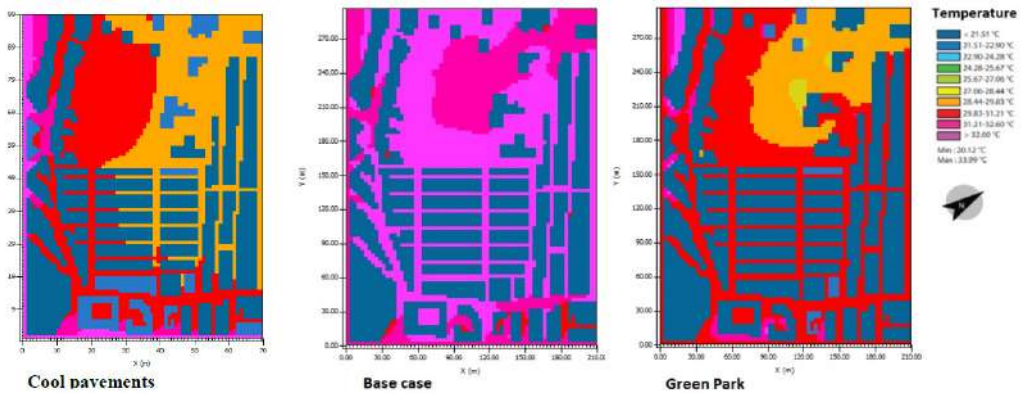


Figure 4. Thermal maps and section at Y=150 m for the various scenario at 13:00
Source: (Evola et al., 2017)

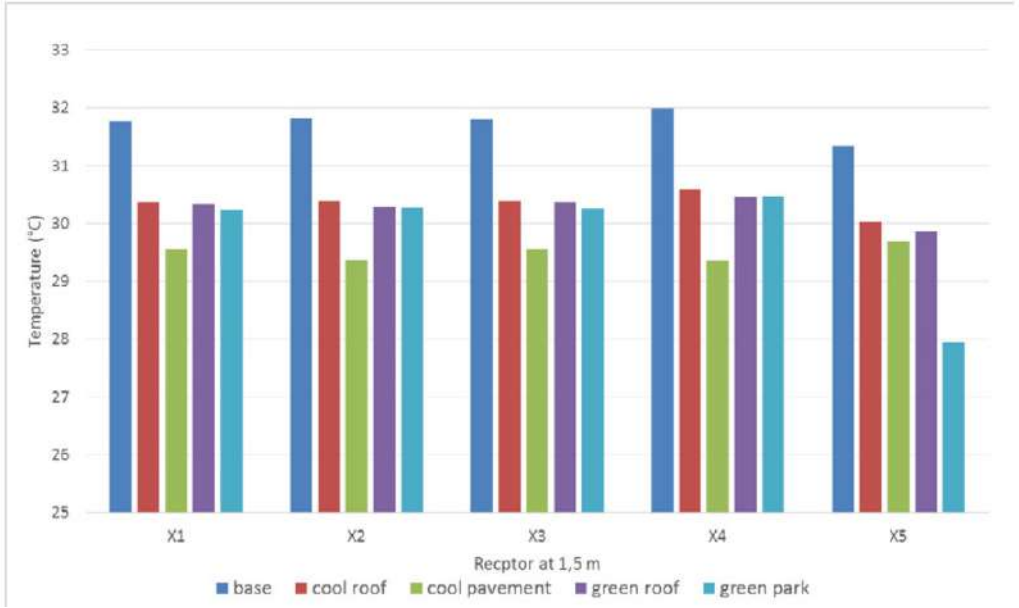


Figure 5. Temperatures in receptors at 1.5 m for the various scenarios at 13:00 o'clock
Source: (Evola et al., 2017)

The urban heat island effect in Tirana

This chapter will look describe the context of Tirana to better understand the causes of the urban heat island.

3.1. The climate profile of Tirana

Referring to the Köppen-Geiger-Pohl system the city of Tirana is classified as a Csa, which means Mediterranean climate. Winters are mild with abundant precipitation, and summers are dry and hot. January is the coldest month of the year with a maximum monthly average temperature above 10 °C and August is the warmest month with a maximum monthly average temperature above 30 °C. Precipitations are higher during winter. During January the monthly average of precipitation reaches till 30mm and during summer in August the monthly aver-

Figure 6. Maximum average of Temperature and precipitation [January] data for Tirana. Source: MeteoALB, 2019; adapted by the author

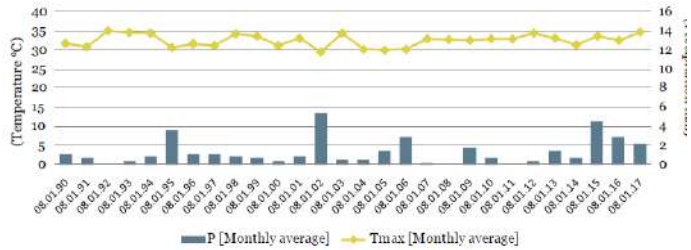


Figure 7. Maximum average of Temperature and precipitation [August] data for Tirana. Source: MeteoALB, 2019; adapted by the author

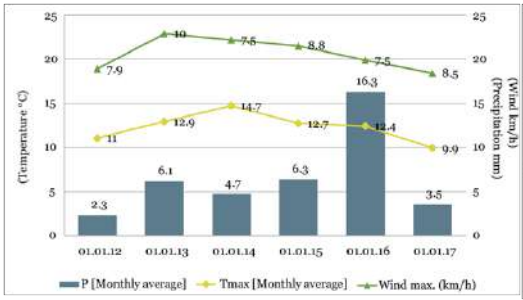


Figure 8. Temperature, precipitation and wind for the last 5 years [August];
Source: MeteoALB, 2019; adapted by the author

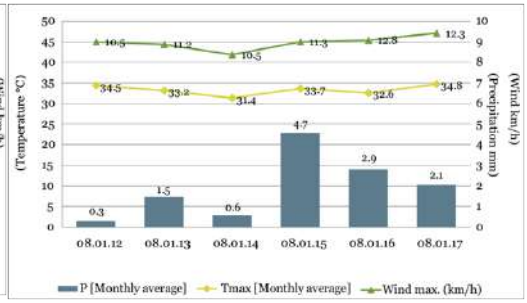


Figure 9. Temperature, precipitation and wind for the last 5 years [January];
Source: MeteoALB, 2019; adapted by the author

age is less than 3mm.

The city of Tirana is located in the Plain of Tirana with an altitude of 113m above the sea level. It reaches its maximum in the direction of East-North-East with a speed of more than 12 km/h (3.3 m/s). The speed is not very strong but if used smartly in urban areas it will help to reduce heat stress. While analyzing the selected cases studies the ventilation is a very important variable as a mitigation

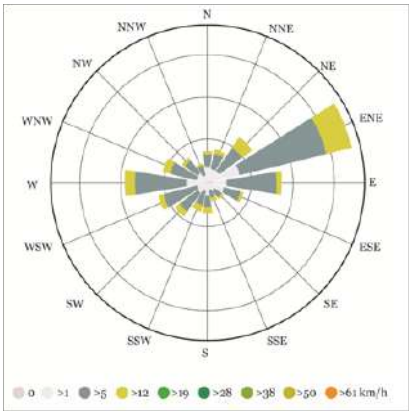


Figure 10. The wind direction in Tirana;
Source: meteoblue.com

strategy. Therefore, to assure the thermal comfort of indoor and outdoor areas needs to use natural ventilation in urban areas. As Tirana is characterized by

3.1.1. Solar radiation

Mediterranean climate, it receives a lot of sunny days, therefore a lot of light and energy too. In Albania the average number of days with sun varies from 240 – 260 days/year. While in the west south-western part of the country, where

Tirana is also located, this number reaches a maximum number of days 280 – 300 days/year. The solar radiation reaches its maximum in August as the hottest month and its minimum in January as the coldest month in Tirana. According

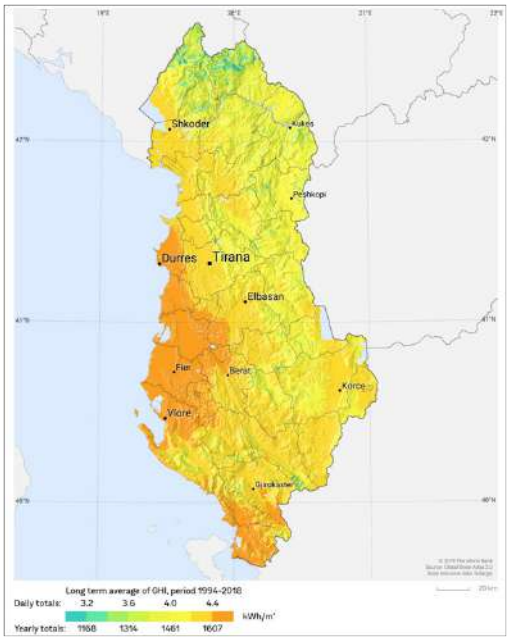


Figure 11. Horizontal Irradiation;
Source: The World Bank 2019, Global Solar Atlas 2.0, Solar resource data: Solargis.

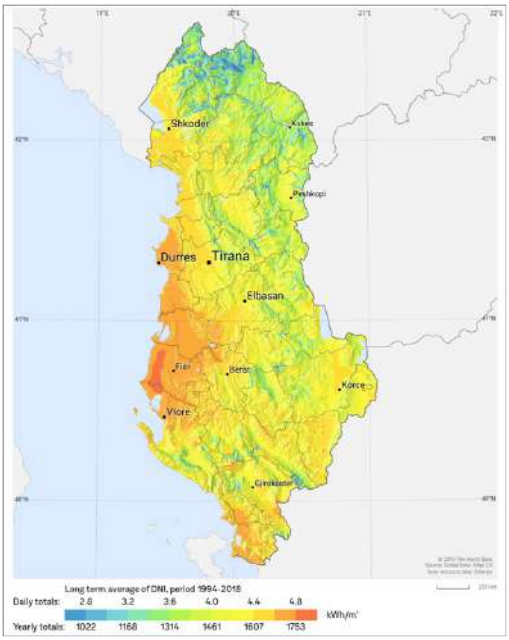


Figure 12. Direct normal irradiation;
Source: The World Bank 2019, Global Solar Atlas 2.0, Solar resource data: Solargis.

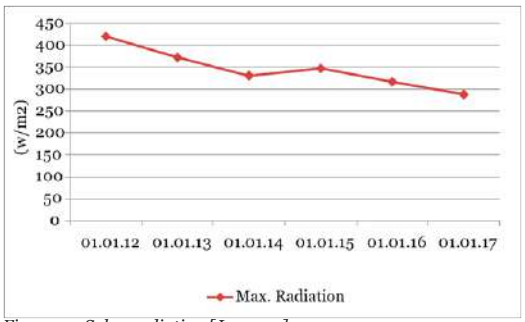


Figure 13. Solar radiation [January];
Source: MeteoALB, 2019, adapted by the author.

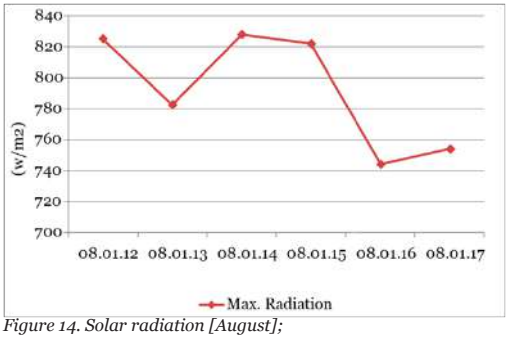


Figure 14. Solar radiation [August];
Source: MeteoALB, 2019, adapted by the author.

to the Institute of Hydro – Meteorology cited in (National Agency of Natural Resources, 2019), solar radiation in Tirana is 1.75 kwh/m2 in a day in January and 6.7 kwh/m2 in a day in August. In the last 5 years the solar radiation has been reduced, while it is varies in August from 820 to 760 w/m2.

3.1.2. Greenhouse Gass in Albania

The main contributors of GHG expressed in CO2 emissions in Albania are the

sector of energy and transport (44.85%), industrial processes (15.83%), agriculture (15.83%), land-use changes and forestry (19.35%), industry (12.61%), and waste (7.37%). In the sector of energy and transport 33. 25% of CO2 emitted by transport. LUCF is becoming the major source of sinks removes as the deforestation is not control (IPCC third). Categorizing the sectors in urban (energy and transport, industry, and waste) and rural (agriculture, LUCF contributors is obvious that the urban areas are the major contributor to CO2 emission.

One of the main of strategic objective 2015 – 2020, is to reduce the GHG with 8%, and reduce of HCFCs with 40% (Ministry of Tourism and Environment, 2018).

3.2. Main causes of UHI in Tirana and its impacts

The main causes or urban heat island effect in Tirana are related with: greenhouse gas emissions, city size and morphology, loss of urban cover forest, low albedo and impermeability of materials, thermal properties of materials, and anthropogenic heat.

3.2.1. City size and urban morphology

The urban heat island effect is already a problem in Tirana. The first, and very important is the transformation of the environment from natural/agricultural to urban. The land use changing transformed in thirty years. In such a time, Tirana has faced rapid urbanization and nowadays is the most populated city. After 1990, when people were free to migrate. Therefore, they moved from rural areas or small towns moved to the capital for better opportunities and a better quality of life. So, the city became denser and lost its natural environment and agricultural land.

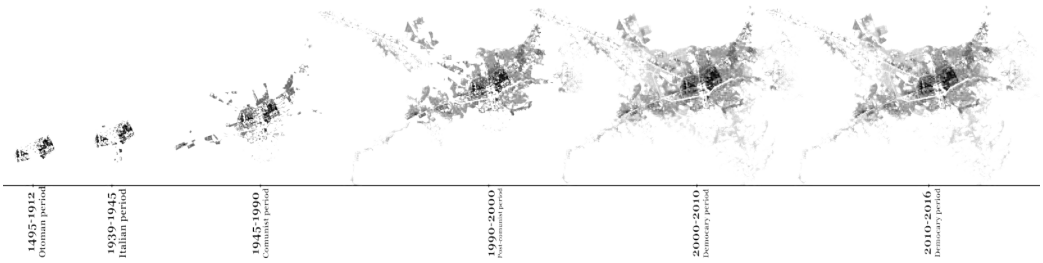


Figure 15. Build era and rapid urbanizations in Tirana;
Source: GLP, adapted by the author.

The first people who came built their houses in the periphery in agriculture lands. They built with light materials such as wood, and later, they have replaced their constructions with concrete and/or bricks houses.

The phenomenon of “usurpation” of agricultural lands developed not only in the periphery but in near the city center in “free” lands. The old villas and houses started to be replaced with multi-story buildings after ’90, and they still do. The government was to a week to control sprawl, urban development, and to prevent people to build in agricultural lands. Nowadays, Tirana is the densest city in Albania.

Referring to GLP the territory is organized in 5 systems. of which the urban system has a surface of 99.03 km2 (10%), infrastructure system 12. 81 km2 (1%), water 24.28 km2 (2%), agriculture 54.46 km2 (5%), and natural system 920.4km2 (82%). As the numbers can show the agricultural system is half of the urban system.

Simultaneously, the existing urban areas started to density, and high rise buildings became more present in the city. The morphology changes from the center to the neighborhoods depending on their location.

The city center’s land use is historical, institutional, and commercial. Neighborhoods located near the city center are denser, and buildings are twelve floors high, and sometimes up to fifteen. Buildings typology changes farther you go from the center. The areas farther from the city center are multi-story up to seven or eight floors, and the distances between buildings are more extensive. While in the periphery building typology is single houses up to four floors, but the one or two-floor buildings are more typical. Also, the uses are more unified in the peripheries. Whereas residential, commercial, or industrials but not mixed in one building.

Depending on urban morphology and building typology the thermal discomfort changes in different neighborhoods. To analyze further the scale of UHI in different areas of the city this research will look into three case studies. The case studies selection relies on their urban morphology, typology, and distance from the city center.

3.2.2. Gradual loss of urban forest cover

In the case of Tirana, the urban morphology has affected the Loss of urban forest cover as the rapid urbanization transformed the natural, and agricultural land to urban. This problem led to informality and sprawl. Therefore, the green index in the city decreased. Unfortunately, data about forest cover loss in the urban areas in the city of Tirana are not published. Therefore, it is difficult to argue on quantitative data. However, based on Google Earth maps of different periods this research assesses urban forest loss. As shown below the green spaces reduce through the years, from 2002 to 2019 and the natural environments have transformed into a buildup environment. As green is one of the elements that help the city to "breath", by reducing the air pollution and air temperatures, loss of green is one of the reasons why UHI has to worsen in recent years in Tirana.

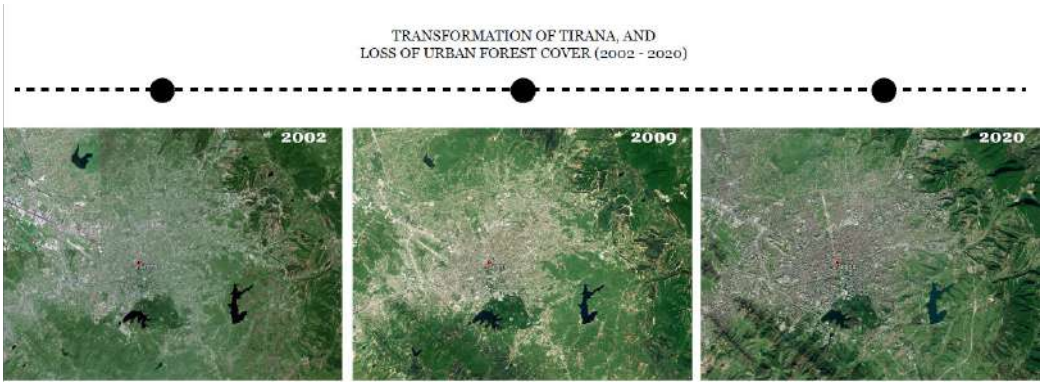


Figure 16. Loss of urban forest cover in the city of Tirana;
Source: Google Earth Pro, adapted by the author (accessed for the last time in May 2020).

3.2.3. Low albedo and impermeability of materials

The materials used in the buildup environment differ from different era's. The old traditional houses in the city center were built with adobe, which replaced with white/red bricks or prefabricated concrete, three to five floors, apartment buildings. Streets were usually unpaved.

During the communist era, the main building materials were bricks and prefabricated concrete. The streets started to pave with asphalt, but very few of them.

From 1900 to 2000, concrete was used extensively to build. After 2000 the reinforced concrete and ventilated facades were introduced to the market. While the

Figure 17. Materials used in a neighborhood of Tirana; Source: the author, Image: Google Earth, January 2020

Table 2 Albedo of materials

Material	Albedo
Highly reflective roof	0.60 – 0.70
White paint	0.50 – 0.90
Grass	0.25 – 0.30
Brick and stone	0.20 – 0.40
Trees	0.15 – 0.18
Red or brown tile	0.10 – 0.13
Concrete	0.10 – 0.35
Corrugated roof	0.10 – 0.16
Tar and gravel	0.08 – 0.20
Asphalt	0.05 – 0.20

Source: US, EPA, 1992

no. of streets paved with asphalt increased, and in exceptional cases, the materials might be soil or gravel yet. Sidewalks in Tirana are usually paved with concrete tales in gray (dark or light) or a very light red color. Also, the green along the streets, which are a shading element during summer, are planted in the main streets, and less in secondary or tertiary. The greenery has 40-70 cm and it is dedicated to trees or grass.

Materials used for buildings, streets, and sidewalks in Tirana have a low albedo, varying from 0.10 – 0.13, and high impermeability. Therefore, they absorb a lot of suns and contribute to an increase in temperatures.

Also, the decrease of green spaces in the urban areas plays a big role in worsened the UHI.

As it's showed in Figure 18, the majority of materials used in a dense neighborhood in Tirana have low albedo's. Thus, the urban heat island effect felt more in such areas. To reduce the heat effect in the future new materials with high albedo are recommended to be used.

The used materials in the urban environment are asphalt, concrete, and brick. Also, the roofs are usually with tar and gravel or red/brown tiles. Those materials have very low albedo and high impermeability; this makes the urban areas hooter and contributes to the urban heat island effect. To reduce the heat alternative options should be adapted. Replacing the traditional materials with new materials will contribute to improving the UHI effect in Tirana. The cost happens not to be

always higher with, but it is crucial to raise awareness on the effect materials have on the urban heat island effect.

3.2.4. Anthropogenic heat in city level

Additionally, Municipality of Tirana reported in 2018 that 31% of total vehicles in Albania used for public transportation, operate in the city of Tirana.

The building era indicates thermal isolation due to the materials used in that era. Therefore, air conditioners and other tools are used to cool down the indoor environment during summer or to warm up during winter. Hence the extensive use of AC makes the building release more heat in the environment.

During the site visits, it was observed that every house/apartment has at least one air conditioner.

3.3. Legal framework

Albania aims to adhere to the EU. Hence the institutional framework, policies, and plans have to adopt following the EU laws and regulations. Environmental and climate change law is already transposed from EU legislation but not yet adapted. According to Progress Report 2019, Albania has made some progress toward climate change. To improve its environment, and related to UHI the below measures should be taken into consideration:

- Adaption of the law on climate change and accompanying decision;
- Adoption of a national strategy on climate change following the EU 2030 framework;
- Development of a National Energy and Climate Plan in line with Energy Community Recommendations;
- Efforts regarding effort sharing, geological storage of CO2 and GHG form land use, land-use change, and forestry;
- To adapt and mitigate climate change effect.

Also, Albania has signed two important agreements, Paris and Kigali Agreements. Albania signed the Paris Agreement on 22 April 2016.
It aims to strengthen the global response, to the threat of climate change in the

context of sustainable development, and efforts to eradicate poverty by:

- Holding the increase in global average temperature to well below 2 °C above pre-industrial level;
- Perusing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impact of climate change; (Paris Agreement 2015).
- Albania signed the Kigali Agreement on 18th January 2019. The measures that this agreement implies and are related to the heat effect are:
- Countries who signed it are expected to reduce the manufacture and use of Hydro-fluorocarbons (HFCs)[1] by roughly 80-85% from their respective baselines, till 2045.
- This phase down is expected to arrest the global average temperature rise to 0.50 °C by 2100.

1 HFCs or hydrofluorocarbons, are super greenhouse gases, manufactured for use in refrigeration, air conditioning, foam blowing, aerosols, fire protection, and solvents. (https://eia-global.org/campaigns/Climate/what-are-hydrofluorocarbons)

Methodology

This chapter will discuss the method used for data collection, measures to select the case study, and the limitations of this research. It is a combination of the site visit, observations, GIS data processing, and interviews with residents in the case study areas and resulting in elaboration of measures for three areas (the case studies). In the end, conducts the interviews with experts, NGOs, and institutions to build upon possible strategies that will be elaborated in the next chapter.

4.1. Research Strategy

This section explains and compiles all the variables of this research. It describes the goals to be achieve, and the ways to respond to research questions. 4.2.

Table 3. The Research strategy of the thesis;

Objectives	Research Questions	Sub objectives/ Questions to be answered	Required Data (quantitative)/ Information (qualitative)	Data Collection Techniques	Analytical Procedures
Objective 01 Adapt mitigation strategies of UHI in Tirana. (District scale)	Research question 01 What strategies are adequat fo the contex of Tirana	1.1. What are the priorities of future development in Tirana?	1.1. Priorities for the future development of the Municipality of Tirana.	1.1. Documents and development strategies. (qualitative)	Literature Review (UHI effects and impacts, and mitigation dichotomy) Literature Review (strategies and tools that mitigate UHI and what is their cooling effect)
		1.3. What strategies are aligned with priorities of development?	1.2. Measures that indicate the mitigation of UHI.	1.2. Mapping the causes of UHI in neighborhood scale (on the case study) and consulting with theory what is their contribution in UHI formation. (qualitative-quantitative)	
				1.3. Literature Review (qualitative), and Open-end interviews (qualitative-quantitative)	

Objectives	Research Questions	Sub objectives/ Questions to be answered	Required Data (quantitative)/ Information (qualitative)	Data Collection Techniques	Analytical Procedures
		1.2. How can the heat load be reduced in Tirana?	1.3. Strategies that should be taken into consideration for early phases of the urban design process of neighborhoods (e.g. green roofs) to adopt to overheat and strategies that can be implemented to improve the current situation in neighborhoods.		Updating through GIS (Land use data) Discourse Analysis (different approaches that researchers and professionals of related fields have for heat load as a manmade phenomenon)
Objective 02 Propose mitigation tools regarding the UHI strategies to reduce the heat. (Neighborhood scale)	Research Question 02 What tools can mitigate UHI in the residential neighborhoods of Tirana?	2.1 What measures help to select adequate mitigation tools?	2.1. Data about different materials used in neighborhoods and how do they contribute to UHI formation.	2.1. Assumptions about the impact of materials in UHI formation by consulting theory. (qualitative-quantitative)	
		2.2 How much is UHI reduced when applying the selected mitigation tools?	2.2 Tools and technologies are available in Tirana.	2.2. Research on the availability of technologies in the market in Tirana. (qualitative)	
		2.3 What is the impact and the effect when UHI improved?	2.3 Measures for UHI mitigation tools	Assumptions about the cooling effects of tools on UHI mitigation by consulting theory (qualitative-quantitative)	
Objective 03 Understanding the scale of the problem in neighborhoods with different urban typologies of Tirana.	Research Question 03 How the scale of the problem does differ depending on neighborhood urban typology?	3.1. What is the current scale of UHI in neighborhoods?	3.1. Meteorological data for the last 30 years. (e.g. Bologna case. Information on UHI causes on the selected cases studies (GHG, loss of urban forest coverage, low albedo and impermeability of materials, thermal properties of materials, neighborhood size and urban morphology, and anthropogenic heat) 3.1 and 3.2 Theories, papers , and/or books that explain the concept of UHI and its causes.	Literature review (qualitative) 3.1. Documents and reports, that records the temperature changes in Tirana and effects of overheat as well (e.g. no of deaths because of heat load). (quantitative) 3.1. and 3.2. Observations (qualitative-quantitative) Open-end interviews with residents of the areas and experts (institutions, NGO) (qualitative-quantitative)	
		3.2. What are the causes and effects of UHI?			

Source: the author

4.2. The theoretical foundation

This research integrates site visits observation, and open-end interviews with experts and citizens to collect all the necessary information for analyzing the problem and give recommendations to reduce the heat load in neighborhoods. It relies on twenty-eight interviews with the residents of the selected case studies, five interviews with experts working in institutions and/or NGOs, and observations of the three case studies.

4.2.1. Open-end interviews with experts and citizens

The main research question, this research looks into is to propose different tools to mitigate the UHI in different neighborhoods. Therefore, to make this research relevant the open-end interviews with institutions, experts, and NGOs are conducted. As institutions have their priorities for future implementation projects, the new development strategies should include mitigating measures of UHI. As the experts, know and work in the context, their suggestions/proposals are important to be part of the recommendations.

On the other hand, talking about this phenomenon with institutions, and experts is an indication to make them think about the issue in future urban planning.

Open-end interviews with residents aim to include people in the process. Including the people in the process adds value to this research. Firstly, this helps to understand how familiar people are with the concept of UHI or if they just feel the thermal discomfort, because of temperature increase. Additionally, it helps to understand better the relation between UHI and anthropogenic heat (energy released form buildings). The second important reason is to take their suggestions for further proposals to reduce the UHI in their neighborhoods.

Questions on open-end interviews are related to anthropogenic heat, released from the buildings and vehicles, possible solutions, and proposals to reduce the thermal discomfort. Transportation is included as specific questions as in researches done lately in Tirana, it is the main contributor to air pollution, which is directly related to urban heat island effect.

The interviews are conducted with the help of families during the COVID-19 pe-

riod. People were allowed to move freely from 5 AM to 5 PM due to the lockdown in Albania. After finishing the interviews, my sister helped on conducting them on the selected cases studies.

4.2.2. Site Visits and Observations

Through site visits, observations, and photography important information on materials used in buildings and spaces, the height of buildings, distances between the buildings, typologies, greenery, connection with natural elements, and public infrastructure are collected. Before going to the site visits and after consulting the literature review, a chart of indicators was kept in mind.

This information helps to analyze deeper the scale of the urban heat island effect and the causes. The above indicators help to analyze the problem of UHI vertically and horizontally. The land-use changes and the high rise buildings with very small distances in between create urban canyon, where the air remains trapped and creates problems with air circulation and lower the permeability.

The first two areas where analyzed physically, while the third area 'L' was observed through Google Street View and Google Photos, as it was not the possibility to visit the site due to the lockdown situation, that started from 9 of March 2020.

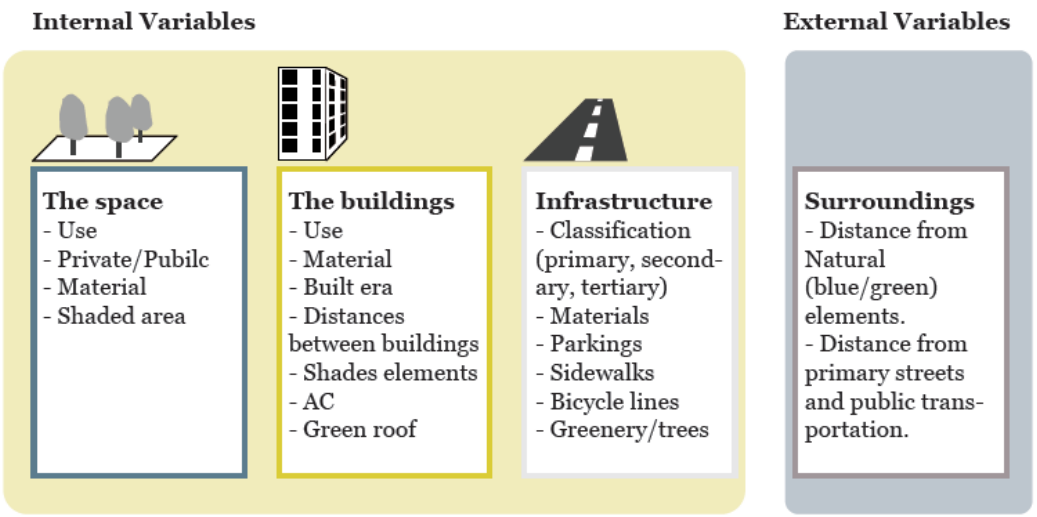


Figure 18. Variables to analyze the UHI on site visits;
Source: the author.

4.3. Data and Methods

This research relies on a mixed method of data collection. Analyzing the study areas goes in two different directions, data on the ground and open-end interviews. The first aims to understand the scale of the problem of urban heat effect on different residential neighbourhoods by analyzing the typologies, density, morphology greenery, and height of buildings. And open-end interviews with institutions, experts, NGOs and residents to understand the priorities for future interventions regarding UHI and how familiar are people with the problem despite the thermal discomfort they do feel.

Also, open-end interviews as a qualitative data collection method will bring together different ideas form researchers/ institutions and citizens for mitigation tools due to heat stress. Open-end interviews are conducted in two different ways. The first interviews are face to face (discussions) and are being recorded with the approval of the interviewed person. The interviews conducted after 9th of March, are conducted online as video calls, social media messages , and emails.

On ground analysis for the selected case studies (dens high rise, high rise middle

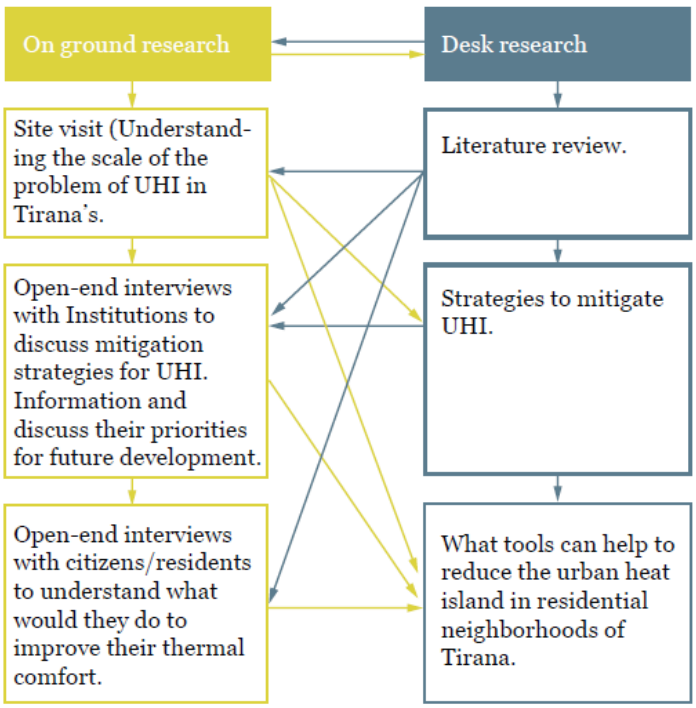


Figure 19 Data collection method;
Source: the author.

dense, and low rise dense area) is conducted in different ways due to the COVID-19 situation. Only the one case study was observed online through Google street view.

4.3.1. Selection of strategies

As the method used is a mixed-use, the mitigation strategies are a compilation of literature review, by learning from a similar case with, open-end interviews with citizens, and experts and analysis of urban morphology and typology.

To be able to propose tools that reduce the heat effect, firstly are selected possible strategies. Those strategies are extracted from the research field and literature review and are adapted to the context of Tirana. Also, looking into the possible options and relying on the implementation capacities by searching on technologies that are currently used in this context.

4.3.2. The case study selection

The case studies are located in the city of Tirana as this city suffers from the heat effect. The rapid urbanization in Albania indicated the transformation of its environment from natural/agricultural to build environment as a need to accommodate 30% of the population of Albania.

Also, Tirana is important, from the economic and social point of view, as many activities are focused on this city. The information is richer in Tirana than other cities as many projects are developed there.

To select the case studies, measures such as development units proposed on General Local Plan, building ratio, morphology, surface, building materials, heights and typology, greenery, distances form public transportation, and the distances from natural elements (parks and water elements) are taken into consideration.

Three case studies are respectively chosen. The first case study is a high dens neighborhood, located near the city center. The second case study is a middle-density neighborhood located a bit farther from the city center. The third case study is a low dens neighborhood located near the natural elements.

The Islam Alla (refereed as IA) neighborhood is a high rise dense area, located near the downtown. Due to the pressure of development and high land value the area, faced rapid urbanization after ’90. Therefore, the urban fabric of this neighborhood has many layers. It is a diverse neighborhood in building typology and built era. It contrasts from single houses built before 1945 with adobe to multi-story buildings up to 12 floors build with reinforced concrete, glass, and other materials that are used nowadays in construction.

The second neighborhood, Magnet (refereed as MG), has a central location as well, with less than 2km from downtown. It was mainly urbanized after 1990,

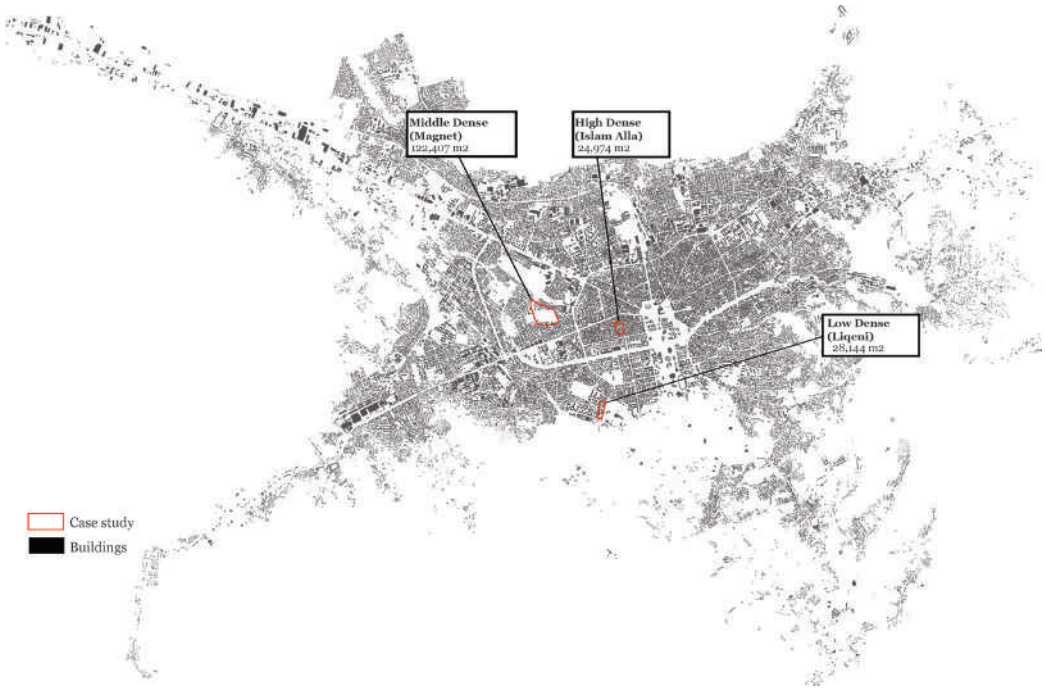


Figure 20. Cases studies location;
Source: the author.

and the main building typologies are single houses and multi-story buildings, built mainly after 2010. The area has high rise buildings with a lower density than the first case study. Also, the green index is higher in this neighborhood, including private and public spaces.

The third case study, Liqeni (refereed as L), is located less than 1 km from The Artificial Lake of Tirana and The Park of Artificial Lake. Building typology is mainly single houses up to 4 floors with backyards. Also, the distances between buildings consider urban planning standards. All those characteristics make this area less affected by UHI. The air temperature is lower compared with the first

two areas during summer.

The selected case studies are chosen as representative cases of the urban areas of Tirana.

4.4. The limitation of the research

Generally, the urban heat island effect is a complex problem, and despite the preparations to analyze the problem in multidimensional aspects, there were some limitations. The novelty of the concept in the context of Tirana leads to a scarcity of information. Hence, important information related to the causes of UHI such as urban forest covers loss official data, GHG at the local level, tools to measure the temperature in the selected case studies, etc., led to some limitations.

This research analyses three case studies and compares the scale of the problem of UHI between them. Therefore, the very first comparison would have been the comparison of the air temperatures, but the tools to measure it were a limitation. Also, February-March (the fieldwork period) was not an appropriate time to do such measurements as the hottest month in Tirana is August, and January is the coldest. The measure would have given important information about the scale of UHI in different areas.

The mixed-use methodology makes the proposals to come through qualitative information such as open-end interviews. Therefore, the current situation of COVID-19 limited the collection of information in the due time. The fieldwork was planned from the 16th of February to the 21st of March, but from the 9th of March, Albania went in lockdown due to COVID-19. The data collection approach changed to online data collection to collect the information that was left. Subsequently, it was needed to extend data collection by the end of April, beginning of May.

The number of interviews was affected as well because of the situation. From 45 planned interviews with the residents, only 28 could be conducted. Therefore, not all research questions may not be sufficiently answered. To fill the gap, it relied on literature review and data collections on-ground and online.

Figure 21. Islam Alla neighborhood
Source: the author.

Case studies

This section will discuss the finding after all the data collected during the fieldwork. It will compare the scale of the problem of the UHI in between three different neighborhoods. After setting the variable for case study selection, the analysis extends to ventilation, urban morphology, loss of urban forest cover, impermeability of materials, and albedo.

5.1. Urban Heat Island causes in the "Islam Alla" neighbourhood

This neighborhood is located near the city center (600m) and it's a traditional neighborhood from the development point of view. It is well connected with infrastructure, and the distances form public transportation lines are less than 500 m. It is 110 m away from Kavaja Street, which is a big artery, and 320 m away from the third ring road (a very important road for the circulation of the city that collects a lot of traffic jams). Therefore, as it is surrounded by important streets, it indicates the air pollution, and farther worsening of the UHI. The smallest distance from a natural element is 320 m, from the river of Tirana.

5.1.1. Ventilation

Islam Alla area is very flat, and the maximum altitude is only 102.4m over the sea level. The strongest wind in the city of Tirana comes from the East North-East direction, and it reaches a maximum of less than 12 km/h (3.3 m/s). It is not a strong wind, and the urban morphology blocks it, instead of using this breeze to

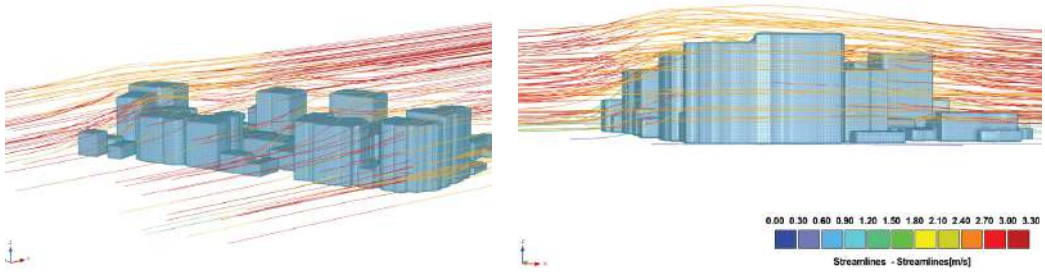


Figure 22. Wind Flow
Source: the author, Simulation with RWind tool

ventilate the neighborhood. Considering the climate conditions is a good strategy to reduce the heat effect. Unfortunately, only two narrow paths have good ventilation, and the rest doesn't have any ventilation.

5.1.2. Urban morphology

The streets in this neighborhood are narrow and in some parts, there is a lack of sidewalks. Materials used are asphalt, and tiles for sidewalks. Furthermore, a problem in this area is also the lack of parking for residents and visitors. However, it's not allowed to park in the streets people use to do it. Some multi-story buildings have underground parking, but they are rare in this dense area.

Different types of land use have e different impact on the heat effect due to the heat they release. The main category of land use is residential and the second important is commercial use. The commercial units are usually the first floors of the multi-story buildings (one to four-floors), and they are usually services such as bakery, mini-market, hairdresser, medical clinics, bar-café, etc. Also, in sporadic cases, the commercial units are found separated from the residential buildings, on to four-floor buildings (only one hostel and some small shops).

5.1.3. Loss of urban forest cover

There are not many public spaces in this area. The materials used in those few public spaces are asphalt, tiles, or in few cases green, or soil. The majority of green spaces are privately owned, such as backyards for private houses. The green surface has been reduced as the built surface has increased every year. In

Figure 23. Loss of urban forest cover, 2002-2019, Islam Alla;
Source: Google Earth, adapted by the author.

2002 the green surface was 4,468 m² while it was 3,997.69 m² [1] in 2009 (2% of green cover lost from 2002), and in 2019 the greenery reduced to 3, 684 m²(2% of green cover lost from 2002). Within the area, there are no water elements, but the river of Tirana is only 0.3 km away. However, this doesn't help to fresh up the area, as the urban canyon doesn't allow the breeze to reach.

Almost, all the green spaces are backyards of private houses. The only public green space is within the territory of a public school. So, the neighborhood doesn't fulfill the legal provisions for green index and public spaces.

5.1.4. Impermeability of materials and albedo

Materials used in buildings and infrastructure have a big impact on the heat effect as different materials have different impermeability and albedo. The majority of buildings have been built after 2000, and they consist of multi-story buildings up to twelve floors. The first floors are usually commercial units and the upper floors are residential. Materials use on those buildings are reinforced concrete. This material has a low albedo, and high impermeability, so it absorbs a lot of solar radiation and contributes to the UHI creation. However, there are also many single houses, and the materials used on those buildings vary from adobe to reinforced concrete depending on the building period. The other materials used on buildings are bricks and concrete. Bricks are mainly used on buildings built from 1945-1990, and concrete on buildings before 2000 [2]. Unfortunately, there is no proper passive design building in the area, but after 2000 in some of the constructions were used ventilated facades and in a few of them were thermally

1 Measured in Google Earth Pro.

2 Method to classify the building period: before 1960 includes all types of buildings built till 1960. Before 1990, includes all the buildings during the period 1945 -1990. After 1990, includes all the buildings that were built after 1990, but closer with 1990 (1990 – 1994) while the period before 2000 includes building more close to 2000 (from 1995 to 2000). After 2000, includes all the buildings from 2000 to 2009. The period after 2010, includes the buildings built from 2010 till now.

Figure 24. coverage of the IA neighborhood;
Source: the author.

Table 4. Materials of Land coverage of Islam Alla

	Material	Use	Area	Albedo
Surface coverage	Asphalt	Streets	2,835.87	0.25 – 0.30
		Sidewalks	976.21	
		Parking	346.80	
		Playground	748.46	
		Car wash	110.10	
		Walking path	189.13	
	Grass	Backyard	3627.37 (GIS)	.05 – 0.20
		Leisure	56.29	
Buildings materials	Adobe	Commercial Unit	74.65	0.34 – 0.36
	Brick	Mixed use (apartments and commercial)	3,168.73	0.20 – 0.40
	Concrete	Mixed use (apartments and commercial)	5,384.80	0.10 – 0.35
	Reinforced concrete	Mixed use (apartments and commercial)	3,737.10	

Source: the author.

insulated. As the numbers show FAR 57%, street coverage 14 % and public and leisure space coverage 29%, the area is very dense. Building coverage is layered in different eras. Twenty-three buildings are single houses, built before 1960, and

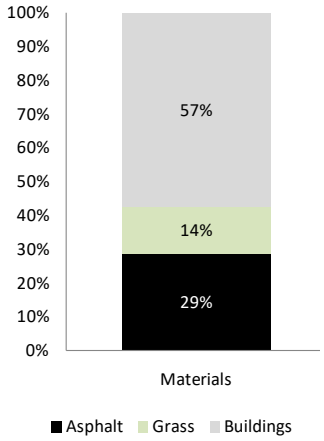


Figure 25. Land coverage main materials IA
Source: the author.

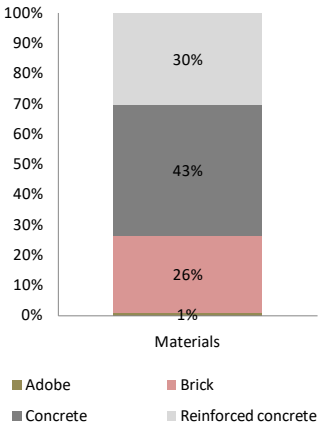
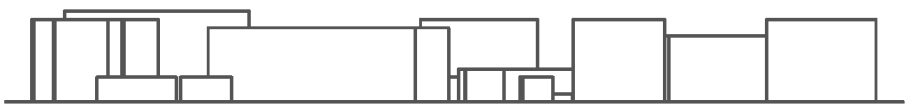


Figure 26. Urban Canyon main materials IA
Source: the author.

almost all of them reconstructed after 1990 or they are demolished and rebuild in the same parcel, three buildings are built from 1945-1990 and one building after 1990 (1996), thirteen buildings are built before 2000 and one building after 2010. The amortization of buildings increases the heat released in the atmosphere.

Due to different uses of the buildings and the short distances in between them it an urban canyon is created. Also, the majority of the buildings are mixed-use, so the first two to three floors area are usually commercial and the upper floors are used as living units (apartments). The area has forty-nine commercial units organized as single buildings or in mixed-used buildings, two schools, and one kindergarten, two institutions, and one health care center. The anthropogenic heat realized differs depending on the activities they have.

A-A´



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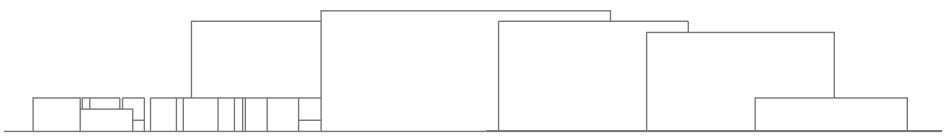


Figure 27. Section of urban canyon IA
Source: the author.

5.1.5. Further proposals for development

Islam Alla" area is subject to further changes, proposed in GLP, as a detailed local plan, due to future interventions. As in the border of this area is proposed a second ring road, the morphology of the neighborhood is expected to change too. Referring to GLP the second ring road will be only for pedestrians and bicycles, therefore it will be a linear corridor. In the future, the road coverage will increase from 14% to 22.6%. Also, the public space will increase from 11.8% to 30%. All the proposed changes refer to standards specified by Local Regulation and Provisions. Furthermore, for the new constructions, developers should plan 30% of the space for recreational activities, which includes green areas too. Thus, the green is supposed to increase in the upcoming years.

Further development controls are proposed for the area. It is very important to mention that the proposed FAR is 3.5, while the existing FAR is 2.15. Thus, the proposed HEI is up to nine floors, the same as the existing. However, COV doesn't change much; it reduces from 57% to 45%, because of the new building typologies proposed for this area. As some of the areas are already consolidated, but others are still not, from the urban point of view, the aim of "Detailed Plans" is to redevelop them. Whereas the private single houses are subject to redevelopment, the multi-story buildings will remain the same. The new typologies are planned the same as the consolidated ones, single houses, rowhouses, linear, or towers. Proposed interventions are consolidation, restructure, and re-development, depending on intervention and how space is organized now.

Further proposals are related to parking and street lighting. As for the moment the street light is missing, it will be an integrated part of the road of the neighborhood. Also, there is no parking in the area, therefore the cars park along the streets or in the backyards in case of private houses. In new proposals is included dedicated parking for residents or visitors.

As this area has the pressure to develop further, and transform, this research, can help to reduce the UHI effect by recommending possible tools that can be used in new developments. The proposals are related to built materials, an increase of greenery, and distances between the existing buildings and the new ones.

Figure 28. Magnet neighborhood
Source: the author.

5.2. Urban Heat Island causes in the "Magnet" neighborhood

Referring to (ASIG Geoportal), the elevation of the area is 89-92m above the sea level. The Magnet area is located in the western part of the city and it is almost 2km away from the city center. It is well connected with infrastructure and is 300 m from the Third Ring Road 400m from "Kavaja Street" and only 1 km from the Fourth Ring Road. Being close to the main roads makes the area have polluted air that impacts directly the UHI.

5.2.1. Ventilation

MG area is well ventilated in the southern part of it and no very good ventilated in the northern part. Almost, in all of the multi-story buildings receive are crossed by a wind corridor that fresh up the neighborhood. Unfortunately, the multi-story buildings block the wind corridor, and the wind doesn't reach the single houses. Buildings with a good ventilation and urban morphology that follows the wind are built after 2010.

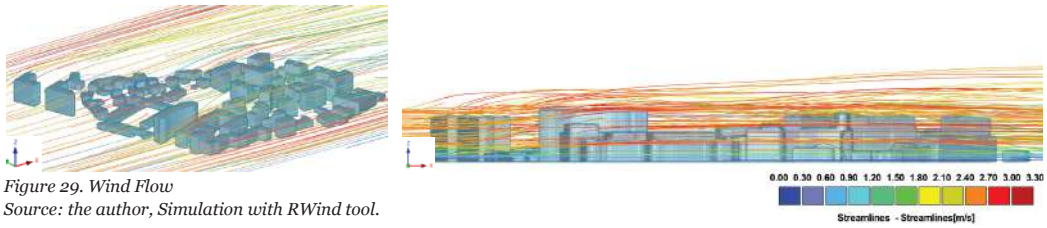


Figure 29. Wind Flow
Source: the author, Simulation with RWind tool.

5.2.2. Urban morphology

The infrastructure materials are asphalt for the streets and gravel and gray/red tiles for sidewalks. Some of the streets are quite narrow and there is no space even for sidewalks. The parking's spaces are underground at most of the cases in the buildings built after 2010. The private houses use their backyards to park. Also, in some streets, there are parking's along the road.

This area was urbanized mainly after '90 due to the pressure of development. The process of urbanization, which is common in other areas as well, went through a step by step development process. The first residents came and build their single houses, in general no very spacious and majority of them 1 floor. Later on fami-

ly members living in the small hometowns joint them. So the area transformed from a green area to a build environment. It kept expanding under the pressure of development and densification still continues to accommodate the needs for housing. Now, the morphology of the area contrasts itself by having single houses in one side and multi-storey buildings in the other side. So, today this is the new face of the area and yet more is expected to change.

Regarding the building era, it belongs to three different periods. Before 1990, there were only two buildings built, a factory and a multi-storey apartment building. Single houses were built after 1990, following by multi-storey buildings after 2000 due to high demand on housing. Densification process continues and many of the single houses have been replaced to high rise buildings. After 2010 a housing complex was build in this area by transforming the left green spaces to buildup areas. The buildings are up to 13 floors. This area has a big contrast of building typologies from single houses up to 3 floors to multi-storey buildings op to 13 floors.

5.2.3. Loss of urban forest cover

The greenery of the area has been reduced during years and this is clearly shown through Google Earth maps from 2002 to 2019. Due to the need for housing the natural environment converted totally to a build up area after 2010. Even Though the process of transformation started after 1990, till 2010 in the center of the neighborhood there was still a green area around 35, 932 m2, which transformed to a residential area. The green surface in 2002 was 52, 281 m2, and in 2009 this surface reduced to 51, 577 m2 (reduced 1% from 2002) till 2019 the green loss continues and the green surface reduces to 36,658.3 m2 (reduced with 28% from 2009). Even thought the new urban area has many spaces planned and

Figure 30. Loss of urban forest cover, 2002-2019, Magnet;
Source: Google Earth, adapted by the author.

used for urban farming inside the building block, the green area in this neighborhood has been reduced.

5.2.4. Impermeability of materials and albedo

The built materials used here do not have a lot of variation. Bricks, concrete and reinforced concrete are used in buildings of different eras. The bricks are used on buildings built during the period 1945-1990. The single houses were built with concrete, which is not a good material for Mediterranean climate like in Tirana.

5.2.5. Further proposals for development

Referring to the future developments proposed in GLP, this area is classified for a Detailed Local Plan. The proposed developing controls allow this area to densify more in the future; with a COV 45%, and FAR 3. Thus, more multi-story buildings will build in the future.

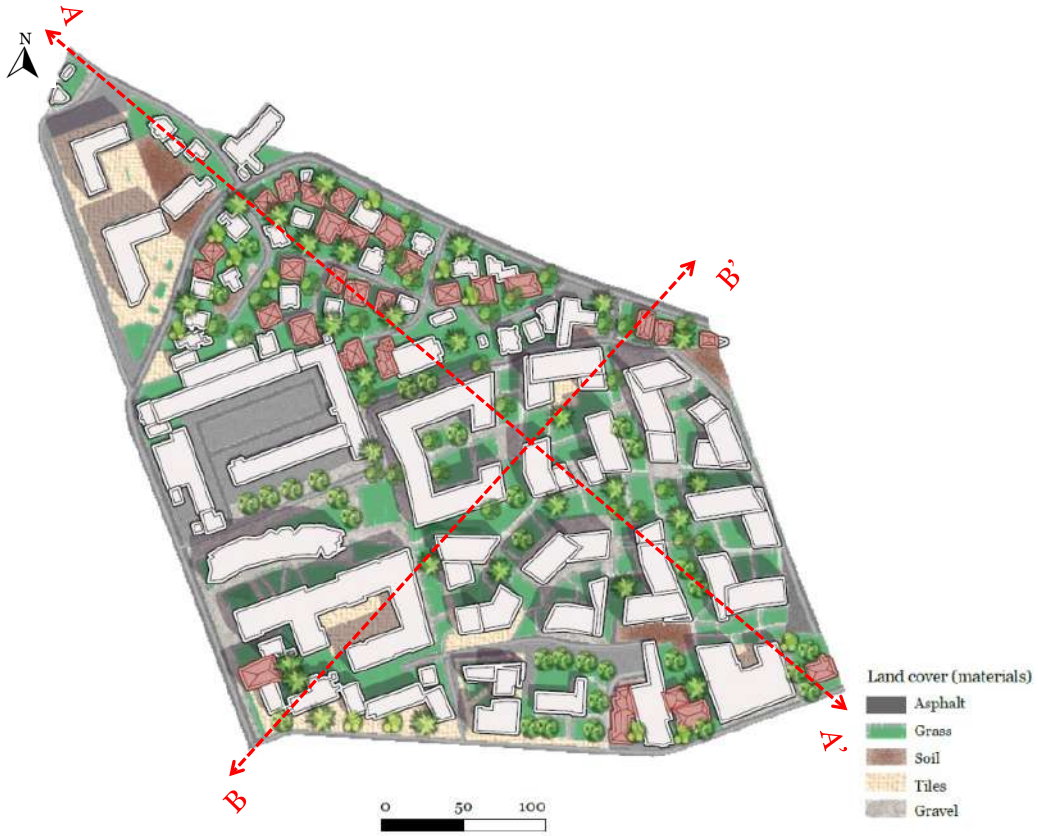


Figure 31. Coverage of the MG neighborhood; Source: the author.

Table 5. Materials of Land coverage of Magnet

	Material	Use	Area	Albedo
Surface Coverage	Asphalt	Street (9%)	11,134.36	0.05 - 0.20
		Parking	10,114.59	
	Grass	Leisure (31 %)	20,167.98	0.05 – 0.20
		Backyard (9%)	16,490.32	
	Gravel	Walking path	12,063.42	0.08 – 0.20
		Parking	989.02	
		Backyard	569.42	
		Walking path	209.63	
		Square	912.19	
		Sidewalk	62.62	
	Tiles	Square	912.19	
		Sidewalk	2,779.83	
		Walking path	1,794.37	
		Backyard	206.28	
Buildings Materials	Brick	Apartments	1012.65	0.20 – 0.40
		Factory	4564	
		Mixed-use	630.49	
		Commercial Units	54	
	Concrete	Apartments	9447.01	0.10 – 0.35
		Mixed-use	1267.41	
		Commercial units	499.03	
		Institutions	413.7	
	Rein-forced Concrete	Apartments	1924.14	
		Mixed-use	18561.95	
		Commercial units	544.8	

Source: the author.

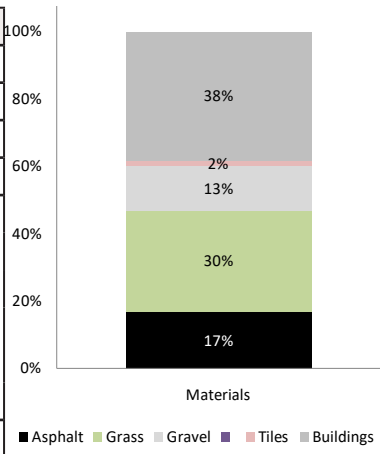


Figure 32. Land coverage main materials MG
Source: the author.

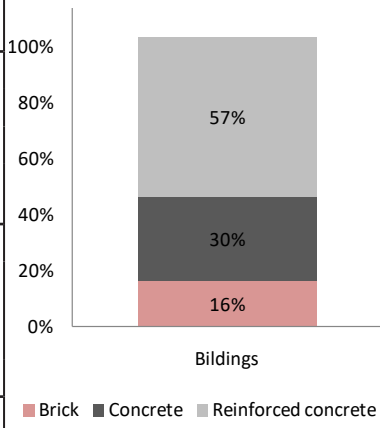


Figure 33. Urban Canyon main materials MG
Source: the author.

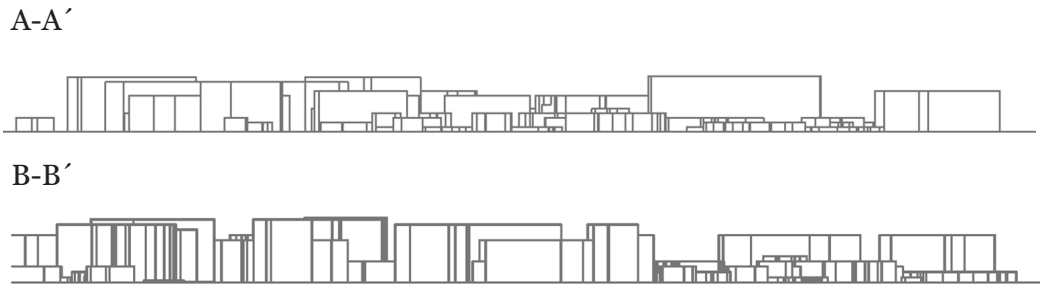


Figure 34. Section of urban canyon MG
Source: the author.

Figure 35. Liqeni neighborhood
Source: Google Street view, 2016

5.3. Urban Heat Island causes in the" Liqeni" neighborhood

The third area, Liqeni, is located near the Lake and the Park Tirana and it is 105m above the sea level (ASIG Geoportal). Its location, low-rise buildings, greenery within the neighborhood and the morphology of the area help to have a lower urban heat island effect in comparison with the two other areas.

5.3.1. Ventilation

"Liqeni" has a better ventilation compared to the other case studies. In the Northern part of this area buildings receive more wind due to the fact that the buildings follow the wind direction and do not block each other. The Southern part is less ventilated as its not in the wind direction. Nevertheless, it receives wind which improves the ventilation of the area, and to reduce the heat load during summer. On the other hand, located near the Park and Artificial Lake of Tirana helps the neighborhood to have a better thermal comfort indoors and outdoors. Also, as the buildings are not more than 6 floors high, they don't block the wind but create ventilation corridors.

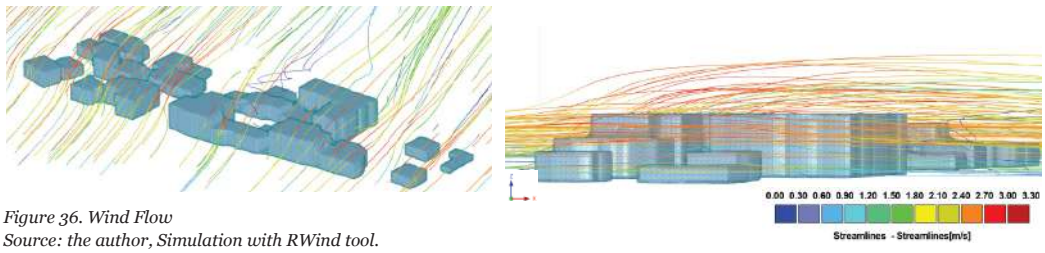


Figure 36. Wind Flow
Source: the author, Simulation with RWind tool.

5.3.2. Urban morphology

Liqeni has a good connection with infrastructure but in the other hand this indicates to have more air pollution. It is less than 200m away from the third ring road which is a highway. The streets inside the area use asphalt and the sidewalks are concrete tiles in light red/grey color. As in the other cases the materials used in infrastructure have very low albedo, which absorb the solar radiation and contributes to UHI creation.

The building typology is single houses and multi-storey buildings. More than 70% are single houses up to 4 floors with backyards. Therefore, the area has a

greenery inside more that the other cases studies. Also the material used in this area do not very much. They used mainly concrete or reinforced concrete, and as they are private houses the quality of the buildings is better.

5.3.3. Loss of urban forest cover

Regarding green spaces is has been reduce as in the other cases studies too. The green surface reduce form 15,344 m2 in 2002 to 6,867.17 m2 green 2009 (almost 25% of the green spaces lost in less than 10 years, this because many areas where under construction) and increased 9, 678.07 to m2 green 2019 (10% more than in 2009). As the majority of buildings are privately owned the residents maintain their green spaces themselves. The street greenery is lacking the secondary

Figure 37. Loss of urban forest cover, 2002-2019, Liqeni;
Source: Google Earth, adapted by the author.

Table 6. Materials of Land coverage of Liqeni.

	Material	Use	Area	Albedo
Surface coverage	Asphalt	Parking	1500.81	0.05 – 0.20
		Street	5420.29	
	Grass	Backyard	6653.22	0.25 – 0.30
		Leisure	3024.85	
	Gravel	Backyard	259.50	0.08 – 0.20
	Tiles	Backyard	179.24	0.10 – 0.35
		Parking	1054.77	
Buildings materials	Concrete	Mixed use (apartments and commercial)	611.53	0.10 – 0.35
		Apartment only	593.25	
		Commercial units	94.21	
		Institutions	968.12	
		Other	405.16	
	Reinforced concrete	Mixed use (apartments and commercial)	2193.79	
		Apartment only	2213.78	
		Commercial units	488.88	

Source: the author.

streets, but the main streets do have trees.

5.3.4. Impermeability of materials and albedo

The building materials used in this neighborhood are similar to the other case studies. Their impermeability is high, and albedo is low. In this area, the urban morphology helps to reduce the UHI, as the coverage with asphalt and concrete is

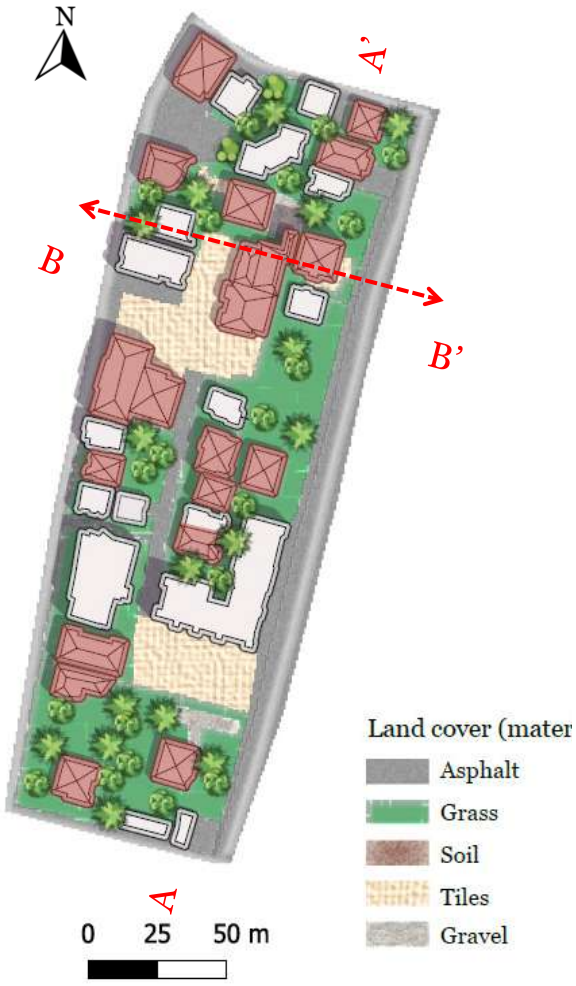


Figure 38. Coverage of the L neighborhood; Source: the author.

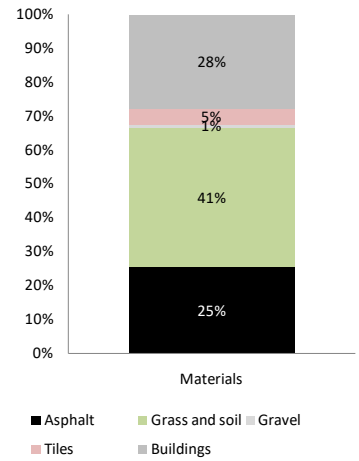


Figure 39. Land coverage main materials L Source: the author.

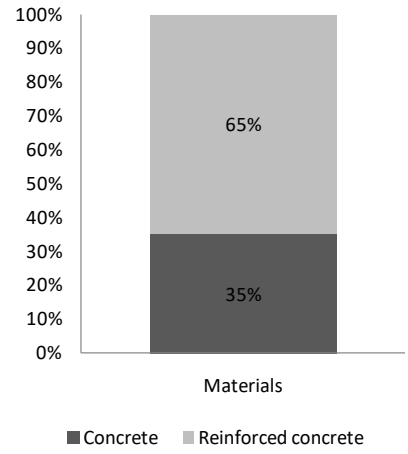


Figure 40. Urban Canyon main materials L Source: the author.

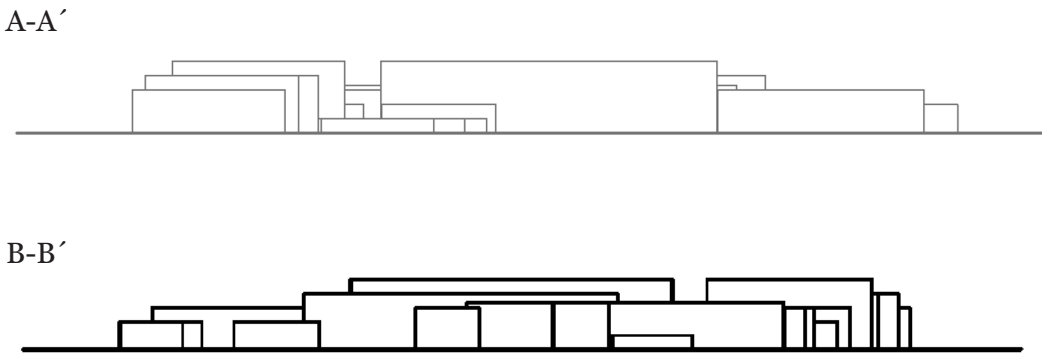


Figure 41. Section of urban canyon L
Source: the author.

almost 60%, and the other part is covered with green. Also, the increase of green index lowers the heat effect in this neighborhood.

5.3.5. Further proposals for development

Referring to the GLP proposals, the intensity of development in this area will remain low, which means that new development will be more or less at the same height as they are already. Based on development controls, COV 45%, FAR 1.6, proposed in the GLP, it shows no pressure of development in the future. At this moment, the neighborhood has a good connection within the area, and the street coverage is 20%, while the space used for leisure (including the public green areas) covers 11% of the area. Also, considering those proposals, the building typology will be similar to the existing, single houses. Considering all that is mentioned above, there are possibilities to improve the UHI effect.

Comparing the scale Urban Heat Island effect in the neighborhoods of Tirana

This chapter will discuss all the findings of the analysis and reflection on the urban heat island effect in different neighborhoods of Tirana. The same subheadings and key terms will be used from the literature review and findings chapters to organize the discussion in a comprehensive and easy to understand way.

6.1. Embracing the climate conditions

The scale of the urban heat island effect differs from one neighborhood to a neighborhood. This, because the main causes that indicate this phenomenon differ as well.

As the data about the temperatures for the selected case studies were not possible to be measured, the temperatures for the city of Tirana will give an idea about the climate conditions. Also, as the size of the city is not too big, the micro-climate doesn't differ much in the selected areas.

Acknowledging the climate conditions is a good path to follow that can lead to the right solution, regarding urban morphology, building typologies, and suitable materials, to develop in a climate-responsive way.

From the result of the analysis, the good or bad ventilation in the selected case studies reduces or improves the thermal discomfort outdoors, and indoors.

From the selected case studies, the wind analysis shows that the “L” case has better ventilation than the two other areas. Also, the distances between the buildings make the wind to flow within the area. Furthermore, the “L” neighborhood is closer with green and blue elements, as it is located near the Park and Lake of Tirana, which helps to reduce the UHI effect. While, the “IA” neighborhood is near the Lana River, but the dense urban canyon, doesn’t allow the wind to flow within the area. The “MG” neighborhood has also good ventilation, especially in the North-East. The buildings, built after 2010, have considered the climate conditions.

6.2. Land coverage and urban canyon

The urban morphology differs from a dense neighborhood located near the city center to a neighborhood located farther. Also, a neighborhood built recently, with material that doesn’t absorb much solar radiation, and releases less heat in the environment.

Nevertheless, the urban morphology plays a big role in the scale of the UHI too. Distances between buildings are often very narrow in some areas. The result of the analysis shows that the IA neighborhood is a dense area, because of the pressure of the development, and the high land value. Therefore, an urban canyon was created, and the land-use was converted from natural to build-up environment, which led to a bigger heat effect if compared with the other neighborhoods. From single houses to multi-story building up to twelve floors, the IA neighborhood is very diverse. In between two high rise buildings, it is now normalized, to find a single house, two to three floors, not well ventilated, that doesn’t receive enough sunlight, and with its skyline is blocked. In Tirana, the paintings of buildings are colorful and the IA case study is a representative case of it.

The situation looks better in the MG neighborhood, as a part of this area is built after 2010. Hence, the developers were more aware of the problems they had to avoid and the restrictions to follow. In the MG neighborhood, the multi-story buildings are located in the Sothern part and single houses in North and North-East.

Therefore, having a more diverse building typology, that is not mixed, the heat effect is better compared to the IA area. Furthermore, in the majority of the cases,

the distances between buildings are wider, if compared to the IA case study. The MG area has less variety of color range, as the buildings of residential complex Magnet are painted with white color. Thus, solar radiation is not absorbed but reflected.

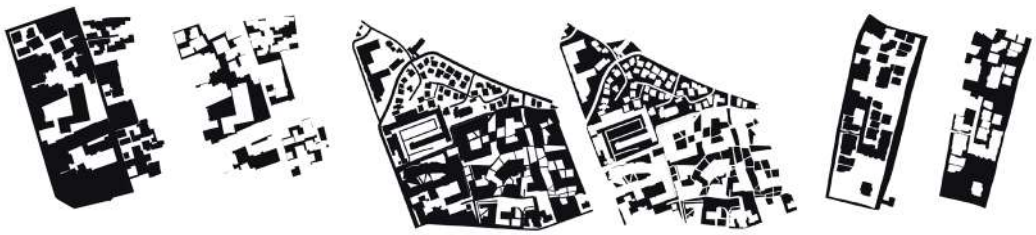


Figure 42. Solid vs Void analysis, to understand the urban morphology;
Source: the author 2020

In the third case study, L neighborhood, the urban morphology is low dens. The building typology plays an important role to reduce the heat load. On the other hand, in this neighborhood, the buildings don't exceed the height of six floors, and the majority of them are single houses. Further, the distances between buildings follow the regulations, except for sporadic cases.

The building typology of the L area is more suitable to have better thermal comfort unless the materials used in the buildings are climate responsive and the distances between them don't create an urban canyon. Materials used in all the case studies are not innovative and not sustainable for the environment. The results shows, that the most common materials used in all case studies are concrete and bricks.

However, comparing the materials in the selected case studies, the situation is better in the "L" and "MG" case study than in the IA. The two first areas are developed later than the "IS" neighborhood, so the material used and the technologies, improved thermal comfort. Also, the IA neighborhood has the biggest land coverage with asphalt (28%) and concrete (57% covered by buildings). Other materials used are the roof tar and gravel (when it's a multistory building) or red tiles (some of the private houses), asphalt for the streets, and concrete tiles for the sidewalks. The green spaces have the smallest surface coverage, only 15% in the "IA" case study, 30% in the "MG" neighborhood, and 41% in the "L" neighborhood. Even though the "L" neighborhood has more green spaces, it cannot be accessed by all residents and users as they are the backyards of single houses.

Because of all mentioned above, the analysis shows that heat stress is higher in the IA neighborhood.

6.3. Impermeability of materials and albedo

The “IA” neighborhood is covered by 57% by building (concrete/ brick) and 28% by Asphalt. Those elements are highly known for their impermeability. Concrete and highly- performance concrete (HPC) are well known for their durability owing mainly to their low permeability. Asphalt is usually more permeable than concrete and it absorbs more sun. Therefore in hot climates recommended as it start melting and releasing oils in the environment. This indicates directly the UHI.

38% of the “MG” neighborhood is covered by buildings (concrete/bricks) and 17% of the area is covered by asphalt. The other used materials are gravel, green and concrete tiles. Those materials that have a higher permeability cover 40% of the area.

The green spaces cover 41% of the “L” zone, indicating a high permeability in this area. However, concrete and asphalt together cover more than 50% of the area. To reduce the heat effect in this area strategies related with infrastructure can be followed.

The “IA” case study has the lower permeability of the selected areas. While the “L” neighborhood has the best probability, as 41% of its surface is covered by green. The “MG” neighborhood has a good permeability in general. In the future developments this can be improved by following strategies that recommend permeable and durable materials.

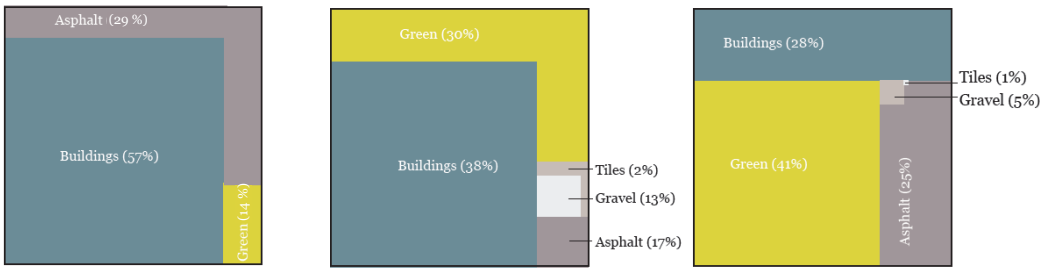


Figure 43. Comparison of land coverage for the selected case studies; Source: the author 2020.

6.4. Loss of urban forest cover

The “L” neighborhood has the biggest surface of greenery among the three case studies, while the “IA” neighborhood has the smallest. On the other hand, the “MG” neighborhood has had the biggest loss of urban forest in the last 30 years, if compared with the other two. Due to the change of an open green field into a building block, “MG” zone lost 29% of its greenery form 2002 to 2019. However, having still many buildings as single houses, people use to have backyards, and this increases the green index in the neighborhood. Further, the multi-story buildings, built after 2010, have created urban farming lands in between the buildings. On the other hand, as “L” have the majority of buildings as single houses. Hence the green index is higher than in the two other case studies.

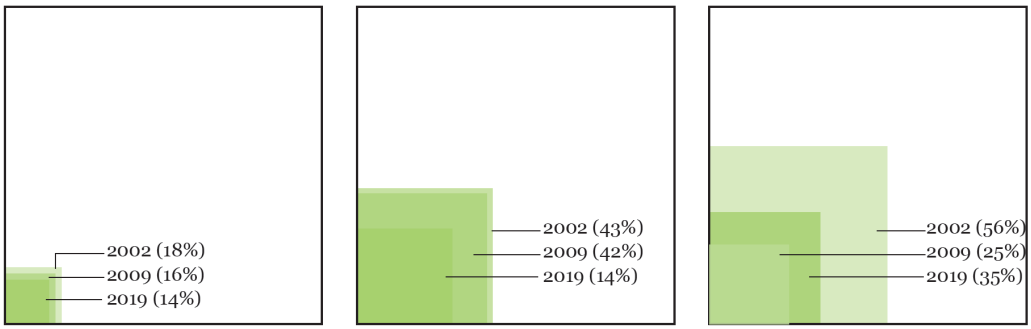


Figure 44. Loss of green coverage from 2002 to 2019 (comparison between neighborhoods); Source: the author.

6.5. Anthropogenic heat

Denser the neighborhood, bigger the anthropogenic heat, and the scale of the urban heat island effect. Anthropogenic heat is directly related to the heat released from human activities. The result of the analysis shows that the anthropogenic heat is higher in the IA neighborhood, rather than in “MG” and “L” neighborhood.

The analyses of this research are based on two elements regarding the anthropogenic heat. The heat released from vehicles, causing air pollution, and buildings, as the extensive use of AC-s plays a big role in the anthropogenic heat.

All the selected cases studies have mixed-use land use. The buildings are mixed-use as well, residential and commercial. In the first case study, the IA neighborhood, almost all buildings are all mixed-used (first floors commercial and upper

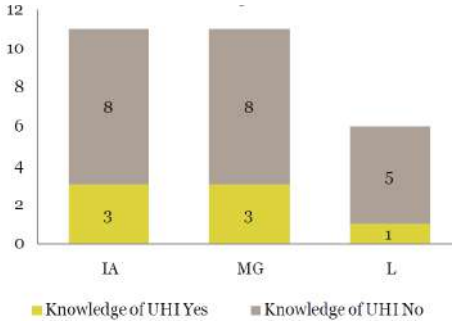


Figure 45. Knowledge of people about the UHI; Source: the author.

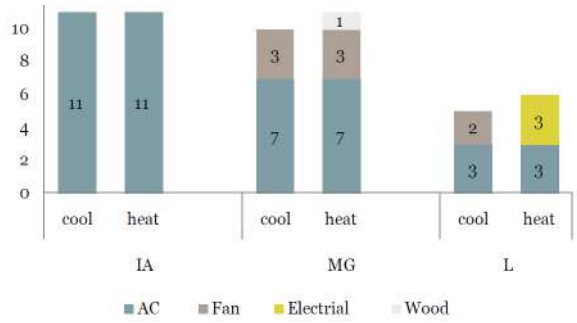


Figure 46. What people use to cool or heat their indoors; Source: the author.

Figure 47. What people use to cool or heat their indoors; Source: the author.

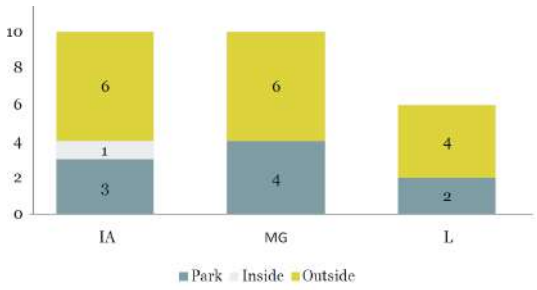


Figure 48. Places that people to spend free time Source: the author.

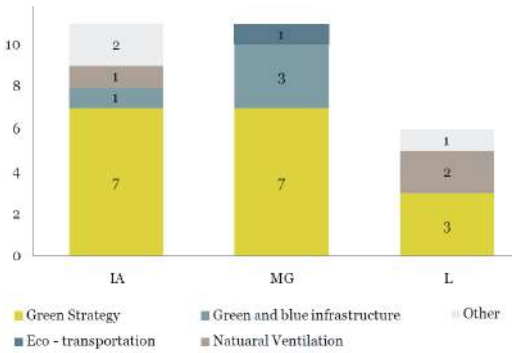


Figure 49. Suggestions from people to reduce the heat stress; Source: the author.

floors residential). Many commercial units are bakeries, hair salons, and markets. Those units use refrigerators and AC extensively, increasing the impact on the UHI.

Even though the "MG" neighborhood has the biggest no. of AC's used because it has to the biggest surface and the highest no. of inhabitants', but this area is less dense than the "IA". Also, the "IA" zone has more commercial units.

6.6. Thermal discomfort and people's perceptions

In this sub-section, are discussed the results of interviews with the residents of the case studies. In the three zones are conducted 28 interviews, 11 in the two first areas, and only 6 in the "Liqeni" zone, as it was not possible to do more due to COVID-19 restrictions. From all the interviewers, only 25% have heard of the urban heat island phenomenon, while they are familiar with the thermal discomfort. In the first area, Islam Alla, 27 % of interviewers live in apartments that are built before 1990, and 27 % in buildings built after 2000. To cool or heat their indoors, all the residents of this area use AC as an alternative. The majority of residents, 36%, pay more than 12,000 leke (100 euro)/month, and only 9% pay an average 3500 leke (29 euro)/month. The residents see the thermal insulation as a solution, and 55% of them have thought of it, while 11% have thermo-insulate their apartments/houses. While, in the Magnet neighborhood, 90% of residents live in apartments, and 63% of the residents use AC as an alternative to cool or heat their apartments/houses. People who live in this area pay an average of 6,000lek/month (50 Euro), and 54% of the interviews live in a thermo-insulated building. In the third case study, Liqeni, all the interviewers live in an apartment. To cool or heat their indoors, 50% of the residents use AC and 50% electrical tools as an alternative. The residents pay an average of 5,300 lek/month (44 Euro), for electricity, and 83% have thermo-insulated their apartments. Comparing the cost of electricity for the case studies is clear that the MG and L case studies have thermo-insulations and so they don't spend much on electricity. Of all the interviews, 32% would like to spend the free time in a park. Unfortunately, Tirana doesn't offer many green spaces, except for the park of "Liqeni Artificial". Also, the green space in the neighborhoods is very few. To reduce the heat effect, residents suggest greenery as a possible way. This indicates also, the information they have about this problem. The proposals are too general and not specific about the UHI. A fresher environment is directly related to more green spaces to them. Therefore, 63 % of people would like to add greenery, trees, and water elements within the neighborhoods, 55% of people use their private cars as a mode of transportation every day, but 36 % would like to have Tram or another sustainable alternative for transportation.

6.7. The scale of heat effect in different zones

To easily understand the scale of the urban heat island scale in the selected cases studies, the main discussed key point are summarized in a table. Below are compared the impact of urban canyon and the land surface coverage for the three zones.

Table 7. Comparison of selected variables for the selected cases studies

			IA (High-rise, dense area)	**MG (High-rise, middle dense)**	**L (Detached buildings)**	**Source of Info**
Elevation			102.4m	89 – 92m	105m	ASIG Geoportal (https://geoportal.asig.gov.al/map/?auto=true)
Land surface coverage	Buildings (internal variable)	Ground surface (%)	57%	38%	28%	Author (calculation through GIS)
		Use (commercial/ residential)	49 Commercial Units	65 Commercial Units	12 Commercial units	Site Visit
			2 school + 1 Kindergarten	2 institutions (public institutions)	1 Kindergarten + 2 schools	
			2 institution (Embassy of Bulgaria + Regional Department of Health Care)	N/A	1 Church and 1 NGO offices.	
			1 Health care center	2 dental clinics	1 dental clinic	
		Materials of buildings	Adobe/Brick/ Concrete/Reinforced concrete	Brick/ Concrete/ Reinforced concrete	Concrete/ Reinforced concrete	Archive of Institute of Construction and Site visit
	Infrastructure (sq & materials) (internal variable)	Road and sidewalks	28 % of the area Materials: Asphalt (street); Light/ Dark grey tiles less than 1% (sidewalks)	29% of the area Materials: Asphalt (street); Concrete/ light grey tiles/ Gravel (sidewalks)	31% of the area Materials: Asphalt; Concrete/ light grey tiles, Gravel (sidewalks)	Calculations of the author (GIS) And observations
	Soil & grass (internal variable)		15% (only one is as public space and one is a parking. The other green/soil spaces are backyards of private houses)	30% (majority of the spaces are public, but they are located inside the Eagle building complex. They can be accessed by all the residents of the neighborhood)	41 % (only grass)	Calculations of the author (GIS)

			IA (High-rise, dense area)	MG (High-rise, middle dense)	L (Detached buildings)	Source of Info
	Trees (internal variable)	43 (only in public spaces)	Not possible to get the no. from Google Maps (there are many new trees that are not seen from the map)	134 (including the private spaces	Google Maps	
Urban Canyon	Height of building (floors)		Up to 12	Up to 13	Up to 6	Site visit/ General Local Plan of Tirana (GIS database)
	Distances between buildings (smallest distance)		1.4 m (the smallest distance between two buildings, 3 and 11 floors). There are buildings next to each other without any distance too.	2.4 m (the smallest distance between a building 5 floor and a 9 floors building)	1 m (the smallest distance between two buildings, each of them is 3 floors)	Calculations of the author (GIS)
	GHG (SO_2, NO_2, O_3, LGS, PM10, CO, Pb)[1] (external variable)		NA	NA	NA	Ministry of Environment and Tourism (national scale)
	Air conditioners used (internal variable)		749[2]	1790	301	Calculations of the author
	Shading elements (internal variable)		Shading tends (apartment and commercial units)	Brise-soleil. Shading tends (apartment and commercial units)	Shading tends (apartment and commercial units)	Site visit
	Public transportation (internal and/ or external variable)		93m distance from the public transportation that crosses to "Kavaja street"	250m from the Ring Road public transportation line	455m from line that cross to "Liqeni i Thate"	Site visit/ Google Earth
			290m distance from the public transportation that crosses to "Gjergj Fishta Boulevard"	245m from the "Kombinat" public transportation line and other inter-urban connection lines (villages located in the west of city of Tirana)	400m from "Unaza e Re" public transportation Line	

[1] Data available only in city scale

[2] It is calculated by the author. The residential units are calculated as 1 per household (due to conversations, even in cases when they have more than one, the AC in sleeping room are not used much) for commercial units they vary according to the type of commercial units and the space they have. Bar-café for example uses many AC to offer a comfort indoor space for their clients

			IA (High-rise, dense area)	MG (High-rise, middle dense)	L (Detached buildings)	Source of Info
	Natural elements (green and blue) in the surrounding. (external variable)		360m from “Lana River	218m from open green fields	730m from “The Park of Tirana”	Google Earth
			463m from “The Youth Park”.	336m from “Lana River”.	466m from “The Artificial Lake of Tirana”.	

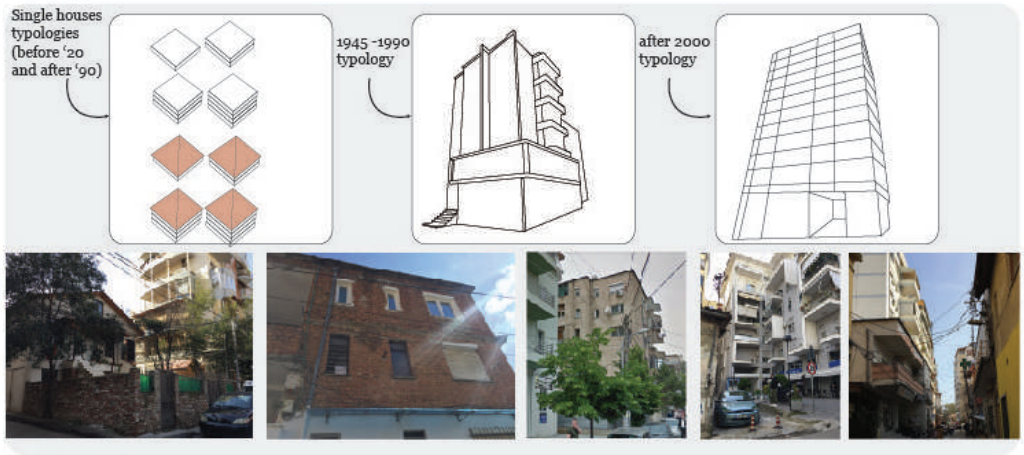
Source: the author

BUILDING typologies, materials, and building period in the IA (Islam Alla) area:

Building period	Before '45	Builded between '45 - '90	Apartments buildings builded after '90	Apartments buildings builded after 2000
Typology	Individual buildings	Apartments buildings up to 6 floors)	Apartments buildings up to 12 floors)	Apartments buildings up to 12 floors)
Use	Residential/Comercial/Mixed	Mixed (residential and commercial)	Mixed (residential and commercial)	Mixed (residential and commercial)
Materials	Adobe	Brick/Prifabricated concrete	Concrete	Reinforced concrete
Passive Designs	No	No	No	Ventilated facade (in some cases)

SPACES

Uses	Street	Sidewalks	Street greenery	Backyards
Materials	Asphalt	Tiles/Concrete	Trees	Grass/cocnrete/Tiles



Source: Author, 2020

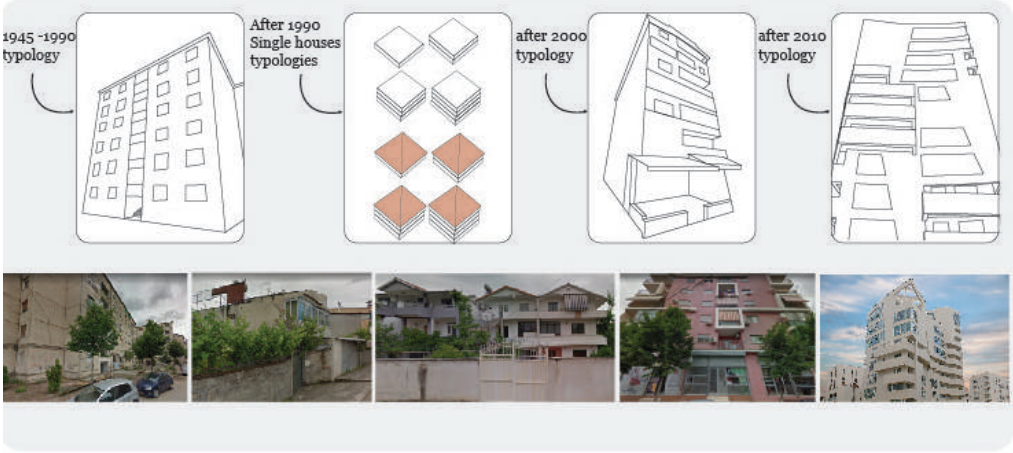
Figure 50. The main characteristics of „IA" case study
Source: the author and Google Street View, 2020, methodology inspired by (Vilma Picari and Sokol Dervishi, 2019)

BUILDING typologies, materials, and building period in the MG (Magnet) area:

Building period	Builded between '45 - '90	Apartments buildings builded after '90	Apartments buildings builded after 2000	Apartments buildings builded after 2010
Typology	Apartments buildings up to 6 floors)	Individual buildings	Apartments buildings up to 12 floors)	Apartments buildings up to 12 floors)
Use	Mixed (residential and commercial)	Residential and commercial	Mixed (residential and commercial)	Mixed (residential and commercial)
Materials	Brick/Prifabricated concrete	Concrete	Reinforced concrete	Reinforced concrete
Passive Designs	No	No	Ventilated facade (in some cases)	Ventilated and Thermal facade

SPACES

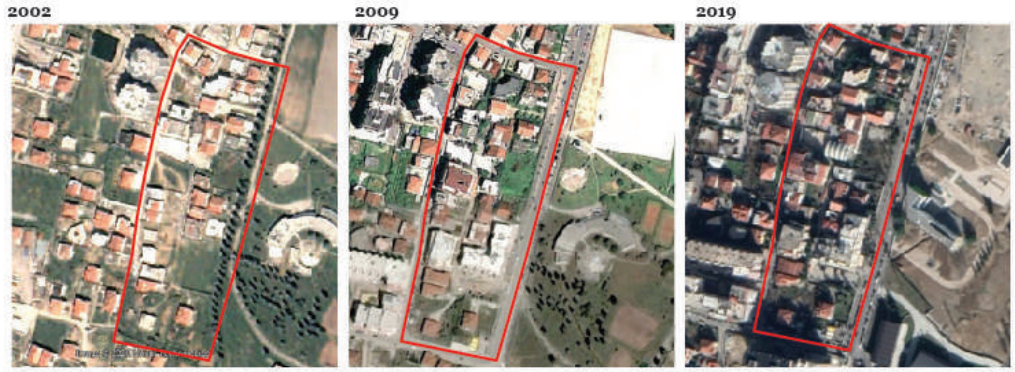
Uses	Street	Sidewalks	Street greenery	Public space	Backyards
Materials	Asphalt	Tiles-Gravel	Fountain	Fountain/Urban farming/Playground	Grass/cocnrete/Tiles



Source: Author and Google Street View, 2020

Spaces morphology, use, and materials in the MG (Magnet) area:

Figure 51. The main characteristics of „IA" case study
Source: the author and Google Street View, 2020, methodology inspired by (Vilma Picari and Sokol Dervishi, 2019)

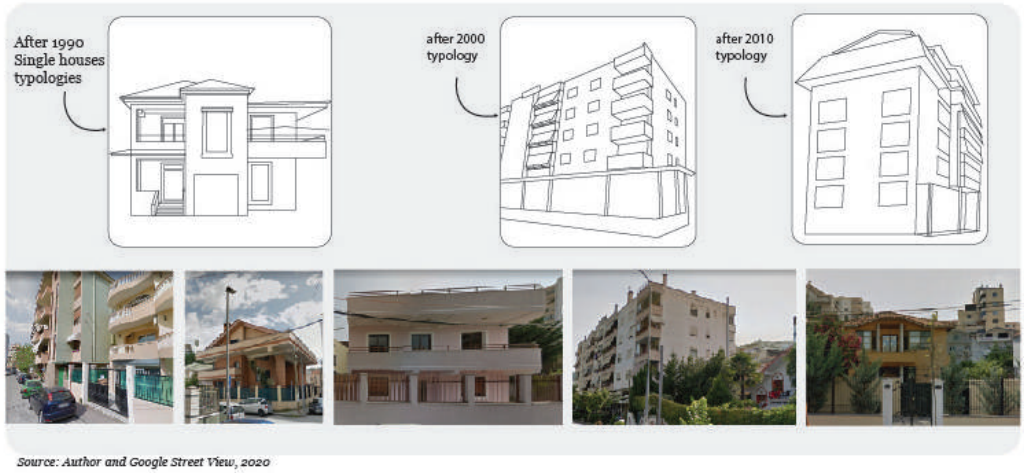


BUILDING typologies, materials, and building period in the L (Liqeni) area:

Building period	Single houses after '90	Apartments buildings and single houses after 2000	Apartments buildings builded after 2010
Typology	Individual buildings up to 4 floors	Apartments buildings up to 5 floors)	Apartments buildings up to 5 floors)
Use	Residential and commercial (in separated buildings)	Mixed (residential and commercial) and in separated buildings	Mixed (residential and commercial) and in separated buildings
Materials	Concrete	Reinforced concrete	Reinforced concrete
Passive Designs	No	Ventilated facade (in some cases)	Ventilated and Thermal facade

SPACES

Uses	Street	Sidewalks	Street greenery	Sportive complex	Backyards
Materials	Asphalt	Tiles/Concrete	Trees	Grass/Trees	Grass/cocnrete/Tiles



Source: Author and Google Street View, 2020

Figure 52. The main characteristics of „L" case study
Source: the author and Google Street View, 2020, methodology inspired by (Vilma Picari and Sokol Dervishi, 2019)

Reflections

In this chapter, I will go back to my findings from observation, open-end interviews with experts, and residents of case studies to articulate how the urban heat island can be mitigated in residential neighborhoods by using different tools. The recommendations are articulated by keeping in mind the context of Tirana and work but do not consider the ability of implementations due to lack of information on the capacities of stakeholders.

The first part of this chapter recommends the mitigation strategies, which are grouped into three categories. Furthermore, it cascades with recommending tools that are linked to the proposed strategies.

7.1. Mitigation strategies

The UHI effect is a result of urban/rural energy balance differences. The mitigation of this problem should start from the national scale and cascade to regional, city, and local scale. If we refer back to the climate condition, chapter 3, we might see that they are not really in favor of reducing the heat stress, especially because of the climate change.

Currently, the urban heat island effect is getting worse in Tirana, and no measures are yet taken. However, some small steps have started. The Municipality of Tirana, is incentivizing the people to do thermal insulation of their building. Hence, the process of permissions is simplified, and they support financially with 50% of the value of the insulation. To get permission for this process, the administrator of the multi-story building has to apply to municipality if all the residents agree upon. Also, the municipality is piloting the project of electric buses.

Still, there is more yet to be done. The process itself needs a good structure and base to work and to reduce the heat.

The first step, toward a possible solution this research would like to recommend, is to articulate some strategies that can help to reduce the heat load, starting with residential neighborhoods. Therefore, the main strategies are grouped into three groups: Greening and cooling, urban infrastructure, and reducing the anthropogenic heat.

The main results from open-end interviews with residents suggest using the green strategy as to mitigate the heat effect. Based on the results of interviews almost 70% of the sample think that greenery will reduce the heat load in the neighborhoods.

Also, transportation strategy is another suggested option is seen as a potential

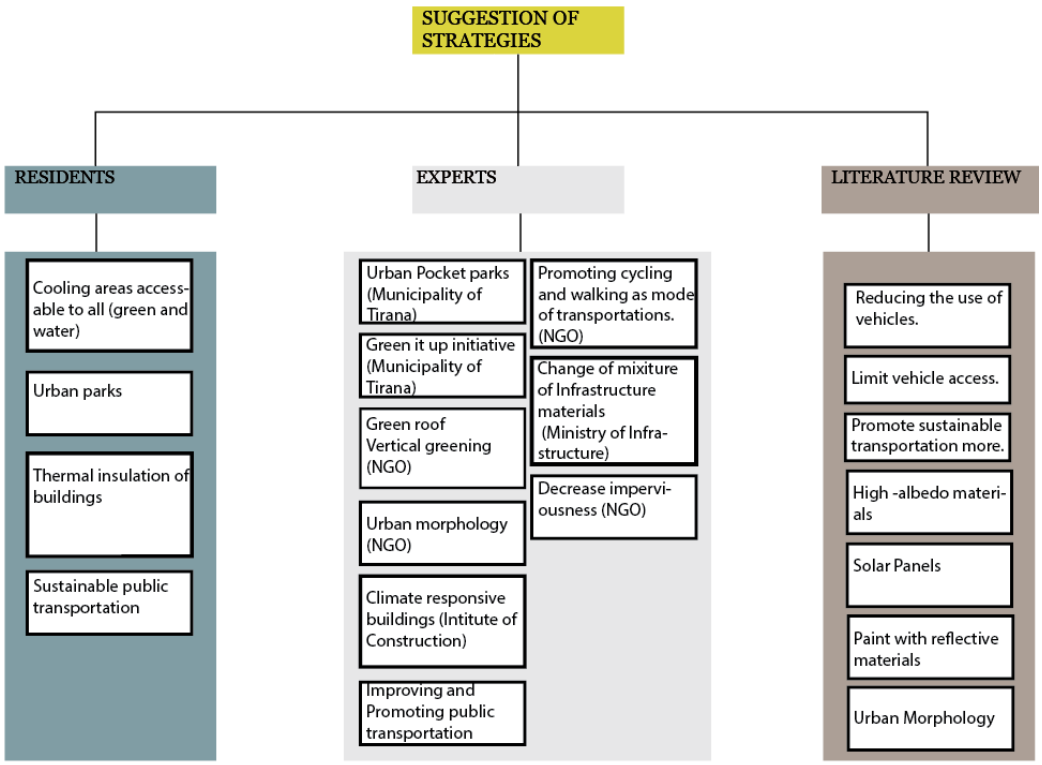


Figure 53. Grouping the strategies to mitigate the UHI;
Source: the author, collected form the interviews with residents and experts.

to reduce the heat, by residents of selected neighborhoods. The majority of the sample thinks that the current public transportation is not efficient and cause air pollution. On the other hand, "The Green Lungs for our cities" platform, says that this sector produces 21kt of pollutants per year. A possible suggested solution to plant Plantanus trees. The study calculates that 203,881 Platanus trees (as a typical tree in Tirana) at an age of 75 years old, in the city center (as one of the most polluted areas) can reduce the pollution load, produced from CO2 and PM10.

7.1.2. Strategies proposed, based on experts suggestions

While open-end interviews with experts and academics give more detailed proposals related to mitigation strategies. Their proposals go further and suggest firstly to build in the city (future developments) in a climate-responsive way. Climate elements such as wind are very important to be taken into consideration. Ventilation can reduce the heat effect and offer thermal comfort living spaces. Further, the materials used are important to 'bring back' the natural environment in the urban areas. The 'traditional way of building' with materials such as asphalt and concrete are not the solution for the future. Also, more green is needed and water elements as well. Hence, it is important is to combine the mitigation strategies and to give tools that can be implemented by residents (not depending always on institutional decisions) and institutions together.

The implementation is the neighborhood scale, which is related more to general recommendations and they can be implemented to neighborhoods with same characteristics. Hence, the general recommendations are detailed further as mitigations strategies of the heat effect related with green, and anthropogenic heat.

7.1.3. The selected mitigation strategies

Green strategy

The green strategy aims to increase the green index in the local scale (neighborhoods), and therefore in the city of Triana. Proposals for this strategy are connected with other prepossessed strategies. This strategy came a proposal of experts and residents that participated in the open-end interviews, as a possible way to mitigate the heat.

Infrastructure strategy

This strategy tends to improve the heat released from buildings and street and infrastructure. If we look back to the chapter 5, than we can argue about the impact of the materials used, in the urban heat island effect creation. Therefore, this strategy aims to reduce the UHI effect by proposing different interventions and materials.

Reduce the anthropogenic heat strategy

This strategy is related directly with two other strategies, as the anthropogenic heat is formed because of human activity. It aims to reduce the heat produced from the extensive use of ACs and the use of vehicles too.

7.2. Mitigation tools and the scale of implementation

This sub-chapter will link the mitigation strategies with tools by considering different scales of interventions.

7.2.1. National scale interventions tools

As mitigation is usually related to bigger scale, it is important to narrow down the proposal from national scale to neighborhood scale for an integrated intervention. Also, there is space for improvement in Albanian context.

Tools that help to achieve to reduce anthropogenic heat strategy are related with the revision and improvement of laws that prevent or to solve the problem at the moment.

- -Law enforcement about the use of vehicles,
- -Law enforcement for emission produced from industries.
- -Supporting the local government financially to implement alternative transport.
- National parks, natural protected areas and water bodies are managed at national level. Hence, the tools that help to achieve green strategy are:
- -Law enforcement for the damage of forests
- -Revision of Law for “Integrated management of water”,

To support the interventions at city scale the national measures should be taken first. Some of the laws are not up to dated. Therefore they do not help to process of implementation of tools at city scale or neighborhood scale.

- Revision of law for "Construction Materials" (2005).
- Supporting the local government financially to adapt new technologies in infrastructure.
- Law enforcement for use of materials not classified in the EU-standards.

7.2.2. Local scale interventions tools

To be able to implement tools that reduce the UHI in city scale, there are further steps to be considered. The general measures allow the tools for specific strategies to be implemented. Therefore below are the general tools that should be taken at city level to reduce the heat stress:

- Including the mitigation strategies in local policies.
- Reviewing the General Local Plan of Tirana and considering the UHI in the future developments.
- Strengthening the role of neighborhood/building administrator.
- Rising awareness about the heat stress problems.
- Mapping the UHI, and creating a database for the cities in Albania (local scale).
- Creating an assessment tool to track the UHI in Albania and offer possible solution to mitigate the effect (CE Urban Heat Island Atlas).

Tools to reduce anthropogenic heat

The anthropogenic heat at city level is produced from buildings and cars. Therefore, measures to reduce the urban heat island related with anthropogenic heat are:

- Limiting the access of vehicles, that emits more pollution than the standard allowed, to city center.
- Offering alternative mobility for citizens.
- Encourage residents to produce alternative energy (solar panel).
- Zoning the parking areas, and pricing due to location (has already started

by Municipality of Tirana only for the city center).

Tools to achieve the green strategy

At the city scale, vegetation helps to improve the thermal comfort indoors and outdoors. It create shades for buildings, improving the air temperature inside, and fresh up the outdoor spaces by cleaning the air and providing shades for the people. Vegetation reduces the near-surface air temperature 1-1.47 oC

- -Enforcing the regulation for developers to plan green areas for the residents.
- -Incentivizing the interventions in neighborhood scale that are related with reduction of heat such as, green facades, green roofs etc.
- -Encourage residents to take care of their green parks and to plant in their neighborhoods. (Urban pocket parks, initiatives).
- -Having a care taker (building/neighborhood administrator) for the shared areas.
- -Green it up initiative, as has already started from the Municipality of Tirana ("Dhuro një pemë" [Donate a tree], managed by APR https://aprtirana.al/une-dhuroj/dhuro-nje-peme/), it can develop further and become a strategy of UHI mitigation under the umbrella of Green strategy.

The measures for infrastructure are related with two important categories: buildings and street/sidewalks. Asphalt and concrete, whose impact into UHI is big, are the most used materials in Tirana.

Interventions on buildings (climate – responsive buildings)

- Encouraging the developers to build with materials that reduce the heat effect. Materials that do not have a higher cost such as painting with reflective materials.
- Enforcements to follow the standards of construction as recommended by law.

Streets/sidewalks

- -Cool pavement, can be archived by using materials that do not absorb

solar radiation and have a reflective topping.
- -Linear corridors are already suggested at General Local Plan of Tirana 2017-2030 and they aim to be green and only for pedestrians and bikers.
- -Decrease imperviousness will decrease the UHI as materials used have a high impermeability.
- -Green parking instead of asphalt has a higher permeability and absorbs less solar radiation.

7.2.3. Neighborhood scale interventions

Heat reduce in neighborhood scale will contribute to a cooler city. To make the living space more comfortable from the thermal insulation point of view is important to know the context, the microclimate, morphology of the area and the surrounding elements.

Morphology

Urban morphology, plays a big role when it comes the reduce of heat. If we go back to Chapter 4, the analyses of selected case studies, shows that the morphology can help to they have a good or bad ventilation.

Use of green tools

Currently, the green index in Tirana is lower as it should be by law. The neighborhoods lack green areas, and vegetation. The access of green spaces is offered by very few parks in the city. To improve the situation and to reduce the heat stress tools for residents can help:

- Green roofs are a suitable solution for single houses and multi-story buildings too. The implementation of such intervention
- Vertical greening can be an option for the dense residential neighborhood, where to increase the green index in another form of intervention is not possible. Suggested for the dens neighborhoods, similar to IA case study, were is difficult to intervene due to lack of spaces.
- Buildings and other cover materials
- Solar panels do not only help to produce electricity but work perfectly to reduce the heat absorbed by roof. As they do absorb the solar radiation, the

indoors air temperature is lowered when solar panels are used.

- Thermal insulation of buildings improve the UHI by making the indoors more comfortable and decrease the heat released from buildings.
- Insulated roofs, depending on the material they are made off, absorb a lot of solar radiation. There are not complicated techniques to insulate the roofs, to improve the thermal comfort indoors and outdoors.
- Paint with reflective materials can be a very simple tool, easily implemented by everyone. In this case it is important that people are aware of the problem and they can contribute to their houses and neighborhoods to reduce the heat stress.

Anthropogenic heat

The heat produced because of use of vehicles, and extensive use of ACs, at neighborhood scale, will directly improve if the green and infrastructure measures are taken in city scale. If a building has a green roof or insulated, it will decrease the money spent for heating, and it release less heat to the environment than a building that has a gravel roof.

Table 8.How can be implemented the mitigation tools at neighborhood level

Selected strategies	Tool	Who can implement it	Action of implementation	Difficulty of implementation
Urban morphology	Ventilation	Municipality[1] /Developer	Permission to build	Medium/ difficult[2]
	Orientation	Municipality/ Developer	Permission to build	Medium/ difficult
Green Strategy	Green roof	Residents/ Developers	Permission from municipality	Easy/medium
	Vertical greening	Developers	Permission from municipality	Medium/ difficult
	Solar panels	Residents	N/A	Easy
Buildings and other cover materials	Thermal insulation	Residents/ Developer	Permission from municipality	Medium/Easy
	Insulated roofs	Residents/ Developers	Permission from municipality	Medium/Easy
	Paint with reflective materials	Residents/ Developer	N/A	Easy
Anthropogenic heat	Reduce the use of vehicles	Municipality	Incentives from Municipality to Residents	Medium/ difficult
	Reduce the use of ACs	Residents	Encourage to apply green and building tools	Medium/ difficult[3]

Source: the author

[1]Municipality plays a big role while approving or not the plans of development.
[2] Difficult for the consolidate areas that are already built.
[3] In this case it might be difficult only if it is measures related with green strategy or buildings and materials are not achieved.

Table 9.The benefits implementing the tools at neighborhood scale.

Selected strategies[1]	Tool	Related with urban development	Additional benefits	Availability of technologies
Urban morphology	Ventilation	Yes	Decrease of heat released from buildings	Yes
	Orientation	Yes	Decrease of heat released from buildings	Yes
Green Strategy	Green roof	No[2]	Reduce of air pollution. Decrease of heat released from buildings	Yes
	Vertical greening	No	Reduce of air pollution. Decrease of heat released from buildings	Yes
	Solar panels	Yes	Decrease of heat released from buildings	Yes
Buildings and other cover materials	Thermal insulation	Yes	Decrease of heat released from buildings	Yes
	Insulated roofs	Yes	Decrease of heat released from buildings	Yes
	Paint with reflective materials	Yes	Decrease of heat released from buildings	Yes
Anthropogenic heat	Reduce the use of vehicles	Yes	Improve the air quality	Yes
	Reduce the use of ACs	Yes[3]	Decrease of heat released from buildings	Yes

Source: the author

[1] Those are already selected by the author, following the example of similar cities.
[2] This table will elaborate further with the stakeholders during research field.
[3] This measure is related with the building itself, but when apply at several buildings of a neighborhood the impact is in urban scale. Can be achieved if green and building measures are applied.

Towards a cooler city

8. Conclusion and further work

8.1. Conclusions

I started this research as a very individual perception. Every year more I felt like we were having only two seasons in Tirana, summer and winter, while its climate is the Mediterranean, which means four seasons. The springs and autumns temperatures increased. Living very near to the city center, in a dense neighborhood, it was very difficult to stand the heat during summer days, but I could still enjoy the late afternoons at my grandmother's house in the suburbs of Tirana.

With the help of residents of the selected case studies, experts, and site visits, I was able to understand better how the urban heat island does effect differs from one neighborhood to another, depending on the different characteristics of the neighborhoods that contribute to the problem. The recommendations of this research are a compilation of suggestions from literature review, residents and experts.

Also, this problem is worsen especially the last thirty years because of the rapid urbanization that Tirana has faced, having now one of a third of the population of Tirana. During this period the city of Tirana almost tripled itself. The main category of land use that changed was agriculture. The agriculture field were built and transformed to urban land. The land-use changes, and the transformation to urban land, are one of the main causes of the urban heat island effect.

Climate change and urban heat island effects have impacted Tirana. The climate conditions do not favor to improve those problems. Based on the future scenarios

of Ministry of Environment the temperatures in Tirana will increase annually at least 2,9 oC to 5,3 oC. Even though some measures to improve the climate change are taken at national level they do not cascade at regional and city scale, creating a gap, which makes it more difficult to mitigate the heat effect at the current situation. The process of policy transposition is still at the national level but the policies at city scale are not in accordance with them. The policies for the environment are already transposed from EU to Albania context but they still are not executed in the territories of municipalities.

Conclusions related neighborhood scale

Urban heat island effect is not a known phenomenon in Albania, but people are familiar with the thermal discomfort, and the majority of them are ready to contribute to change this problem (i.e. thermal insulation of their buildings, and increasing the green spaces in their properties and neighborhoods).

Based on the characteristics of the neighborhoods, the strategies and tools of UHI mitigation might differ as well. The dense neighborhoods, similar to the IA case study, can mitigate the UHI effect by implementing, green, infrastructure, and anthropogenic heat. As the problem in those areas is a result of urban morphology, lack of greenery, materials used to develop, and the density of population, improving the issue of UHI can be achieved by following all the recommended strategies and tools proposed in this research.

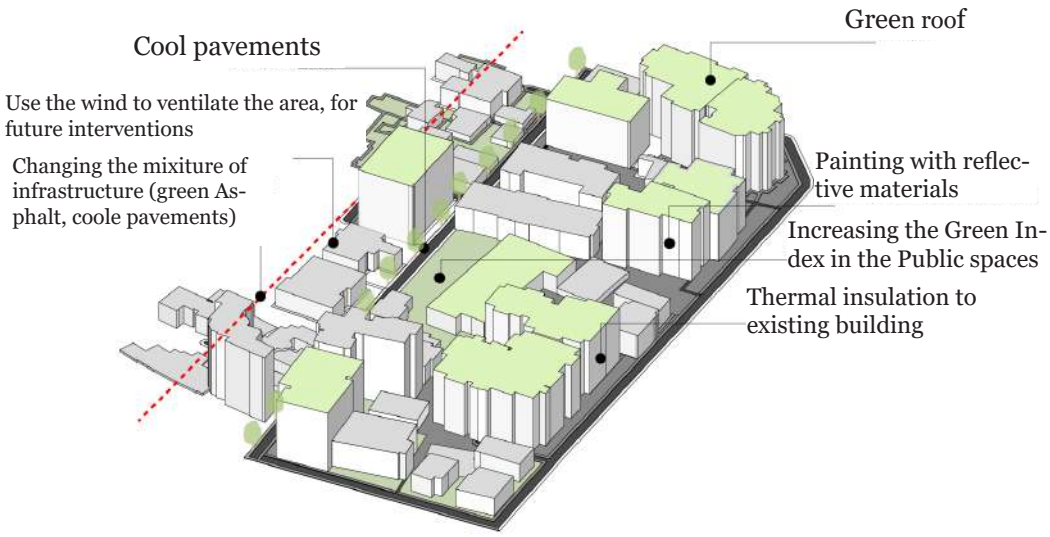


Figure 54. Mitigations tools for dense neighborhoods

Source: the author

Neighborhoods built more recently, similar to the MG case studies, do use materials that help to reduce the heat and their urban morphology in follows the climate conditions. Also, the green index in such areas tends to improve but there is still space for further improvements. The recommended strategies and tools to those areas are related to the change of materials used in infrastructure (street and sidewalks) and there is still space to improve the materials used on construction. Even though they do use thermal insulation and ventilated facades there is still space for improvement. Green roofs, solar panels, and green parking are the tools of green strategy suitable for this case. While the infrastructure can cause less heat stress is reflective materials and permeable materials are used. If all the above-recommended tools can be implemented the anthropogenic heat will be improved too.

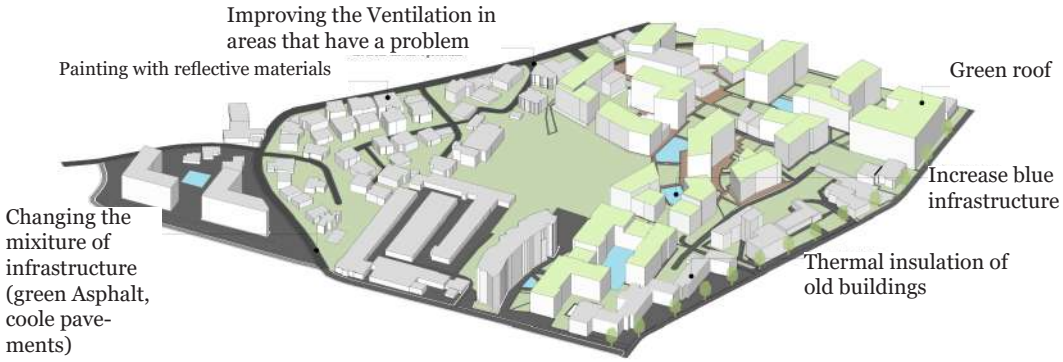


Figure 56. Mitigations tools for middle-dense neighborhoods

Source: the author

The low dense neighborhoods have a lower UHI because the urban morphology and green index are in their favor. Materials used are very similar in Tirana, the new developments tend to improve the materials and use ventilated facades and capotto system. This reduces the heat released from the buildings. As those neighborhoods are not dense, they are well ventilated. Furthermore, the green index helps to reduce the heat. The majority of buildings are single houses with backyards. The recommended strategies and tools for this typology related with green are accessible green spaces for all.

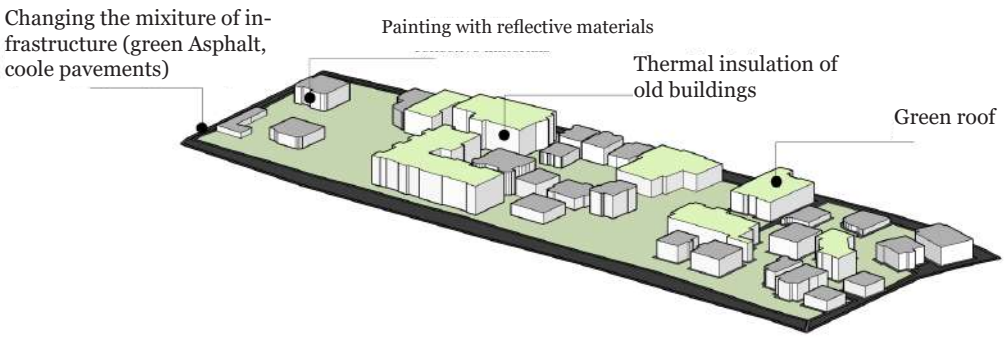


Figure 56. Mitigations tools for low-dense neighborhoods

Source: the author

Implications

To have a clear view of the problem, UHI, in a particular context it is important to do have data about the micro-scale (neighborhood). The measure of temperatures on a typical hot day, in August, in the case of Tirana, enriches the research and gives an exact measure of the problem. As the fieldwork was done during February-March, such data were not possible to measure. The climacteric data this research relies on are the temperatures, precipitation, and wind for the city of Tirana, for the last 30 years. Even though the micro-climate in Tirana might not differ much there might be slight differences.

This research relies on a mixed-use methodology, combining the site analysis with open-end interviews and literature review. Even though it takes into consideration the context, there are no simulations done about the case studies. Therefore the improved impact of the proposed strategies and tools is not measured. This might change or adapt the recommendations of this research if there is not a considerable impact on the improvement of the UHI.

8.3. Further work

This research is a first step towards the mitigation of the urban heat island effect. The second important step, in my opinion, is to make people aware of the problem. Their everyday activities help to improve the situation if measures of UHI are followed.

The proposed strategies and tools of this research can be discussed upon with institutions and experts, adapted, and become policies at the local scale (municipalities). Therefore, the revision of GLP and sustainable strategy of the Municipality of Tirana should be considered to address the problem of urban heat island effect too.

To mitigate the UHI effect is very important to have rich information. Afterward, a database for neighborhood-scale can help to share all the information and map the heat load at the city scale.

Annex

The structure of the open-end interviews. The main points of discussion.

Urban planning		
If UHI is already identified as a problem. Approach of new developments. Priorities of Municipality of Tirana/Ministries related with the UHI phenomenon and people's comfort?	Infrastructure	Understanding the materials that are usually used in infrastructure elements (roads/pavements).
		Priorities of Municipality of Tirana and new investments in infrastructure.
		Understanding the situation of public transportation and priorities regarding that.
	Greening	Greening standards per persons and the priorities to improve the situation in Tirana.
		Understanding if Municipality has incentives to improve the situation of greening and is citizens are engaged in the process.
	Buildings	Understanding the initiative of municipality for the insulation of buildings.
		Discussing possible incentives for residents that reduce the energy consumption and contribute towards sustainability.
	Anthropogenic heat	Vehicles role in the UHI phenomenon.

Municipality of Tirana

Greening

1. How many m2 green per person are currently in Tirana?

There is less than 10 m of green per person, which is very low and we are conscious about that. Therefore, referring to General Local Plan of Tirana, we aim to increase the green in the city at least by 10 m2/person.

2. What are the priorities of Municipality of Tirana regarding green areas?

To improve the greening situation in Tirana, Municipality of Tirana aims to increase the green within the neighborhoods and along the infrastructure corridors (called linear corridors).

Two ring roads (the second and the third, referring General Local Plan) will be green, which means that they are more sustainable oriented. Also, along those streets there will be only public transportation, bicycle paths, and pedestrian path (linear parks).

To increase the green within the neighborhoods we as a municipality aim to redesign the urban pockets. It's a bit complicated as it needs to be done in collaboration with community. That's the only way how it can work as the residents have to be responsible for their maintenance. Also, another problem that has postponed this implementation is the fact that the backyards of the residential buildings are usually used by residents to park. As long as they won't have a parking space they will not collaborate.

3. Are there incentives to encourage citizens to plant trees?

Again referring to General Local Plan of Tirana and the strategic priorities to improve the greening situation in the city of Tirana, the municipality has undertaken initiatives such as Orbital Forest. Regarding that, it has built the online platform where everyone can contribute to green up the city by planting a tree. In this platform you can chose to plan a tree in different pre-selected areas of the city. Afterwards, workers of green department can help you for free to plan your tree. This initiative started three years before.

The objective for this initiative was 100,000. From April 2017 till now 105,408 trees are being planted and it still goes on.

(https://aprtirana.al/une-dhuroj/dhuro-nje-peme/)

Infrastructure

1. What materials are usually used for infrastructure (roads/pavements)?

Regarding infrastructure, we are still behind as we still have basic problems, such as unpaved roads. As many people report the bad quality of streets the municipality is more focused into improving the quality of asphalt (paving) rather than adding new technologies which might be more realistic for mid or long terms interventions. So we still aim to provide the citizens with a better infrastructure (asphalt).

Also a new Bitumen polymer mixture has been introduced, which aims to improve the resistance of asphalt. During summer we have had many reporting's of asphalt damages' from residents, as a result of high temperatures.

In the other hand, the new dedicated lines of buses and bicycles use more ecological colors.

2. What priorities do you have regarding public transportation investments?

In Short terms, we aim to introduce the electric buses. The project is in the pilot phase and it will be implemented very soon. After the pilot project we aim to extend in other lines of public transportation.

Buildings

1. How does the permission for thermo isolation of buildings works and by whom is financed?

The caretaker of the residential building applies in municipality for permission. The process of permission lasts max 5 days, but we have proposed to Ministers Council to make it shorter and even less bureaucratic to support more the ones that want to have thermo isolation.

The cost of it is paid 50% by residents and 50 % by the community fund. The community fund was established by Municipality of Tirana and works with money from taxes. It was established in 2018, and it has supported more or less 10 thermo isolations of residential buildings in Tirana. Majority of those buildings belong to communist area, which were built between the periods '45- '90.

Materials used in new building have better quality and use ventilated facades. Also its an obligation for them not to build more 45% of the land which is subject of development. Therefore, the rest has to be used for public services/activities and streets for residents and citizens. Also, 10% of the new development land has to be green area.

2. Have you applied for funds to have a larger budget to support residents that want to make thermo isolations of their buildings?

Not yet, as this is only a starting point and needs to mature more before we apply.

3. Do you have incentives for residents that reduce the energy consumption and contribute towards sustainability?

Luckily, people have started to be me sensitive to greenery, and they think to add more green areas in their new developments. As a municipality we support them by simplifying the process of permission for new developments that are more sustainable oriented. In the other cases such as developments that still use gable walls (mure kallkani), we recommend them to make them green (walls/roof).

4. What about public institutions such as schools, as you can intervene directly, do you promote/implement sustainable solutions such as green roofs?

The municipality has been the first who applied (beside some sporadic cases) a green roof to promote it as a good example for the future. The implementation was a donation from a private company. The cost of it was 16, 000 Euro. Afterwards the Faculty of Architecture implemented a green roof. It's a better example and was implemented very well.

Nevertheless there are different cases they one should be approached differently. The last case we had was the restoration of a kindergarten. As it's an educational institution the built surface shouldn't exceed more than 30 % of the land, and the rest should provide space for learning, sports and entertaining. This case was approached differently as the kindergarten had to off the service for many children's. Therefore, we used the rooftop for the other needs and exceeded the build surface more than 30% to give the same opportunities to all children's.

The next intervention is the new building og Municipality of Tirana, which we aim to have a zero emission building.

Anthropogenic heat

1. How many vehicles are registered in Tirana?

The department of transport has the number of registered vehicles. On the other hand, in my opinion it is important to talk about the public parking.

After, practicing the paid public parking, the no. of vehicles near city center is reduced a bit.

It started to apply at the main streets and it extended to some of secondary streets. The cost of it differs from 1 euro to main streets to 0,40 euro to secondary streets. According to General Local Plan of Tirana the third ring is the one with majority of public parking's. Also, at Black Bird (Zogu i Zi) has planned to have parking, where people can park their cars and walk or ride a bicycle or use public transportation to access the city center. Tirana parking manages the public parking's (http://tiranaparking.al/).

After a monitoring from department of transportation it was discovered that people use cars in Tirana even for short distances such as 800m.

2. Are there electric vehicles in Tirana? Do you have incentive policies to encourage citizens to use electric vehicles?

For the moment there are only Green Taxi registered as there is still lack of infrastructure to have more electric cars. For all the taxies that apply for a license at Municipality of Tirana, as an incentive we proceed their applications.

Recommended strategies to reduce the UHI effect

1. Regarding the priorities that Municipality of Tirana has, what are the strategies that can be implemented to reduce the UHI effect?

The green strategy is already a priority of Municipality of Tirana to improve the quality of life in the city. Also there are initiatives in infrastructure as mentioned before, such as electric buses.

So, we opt more for infrastructure and greening as more realistic strategies to implement

in the context of Tirana.

Ministry of infrastructure and Energy

1. Is UHI already a problem in Albania?

There is not much said about it till know. It's a new concept worthy to be studied further, considering our climate zone.

2. Is there any strategy to release the high density of urban areas (especially the capital as it already suffers from high density)?

There are new areas in the edge of the city that will develop in the future, but this doesn't ensure the disassembling of the population in the city centre. Yet, Tirana is a dens city and the new developments in the extensions are not affordable for all. So, the ones that now escape to the noisy center belong to a group of people that can afford it, but those are the gated communities build only for a part of society. There are sporadic cases in the same areas, not part of the compounds, built by people who own the land.

3. Do you have priorities regarding new technologies for infrastructures future developments? If yes which ones?

Regarding transport and infrastructure, the used technologies are still old. So far, there are some ideas to change the mixture of asphalt. As Albania has a Mediterranean climate, dry and hot summers which indicates that asphalt melts and release pollutants in the air. This is still in the testing mode and will be piloted afterwards.

Also, there are priorities regarding public transportation. As the train connections were cut off long before, it was only one line working; a new line will start to operate very soon from Tirana to Rogozhina. The objective is to add more connection in the future with other cities as well.

Priorities of Ministry of Infrastructure Energy are more regarding energy.

NGO (Co-Plan, Institute for Habitat Development)

The aim of the interview: Air pollution is directly connected with heat effect and Tirana is

one of the most air-polluted cities in Europe. The most polluted areas in the city of Tirana and main contributors.

Understandings how familiar are experts with the UHI in their everyday life. Adequate strategies and tools to mitigate the UHI effect, based on the characteristics of the city.

1. What criteria did you used to select the monitoring points?

The main criterion of selection was to monitory the air in highly dense urban areas of the city.

2. In your research you have made estimation about the need of trees to reduce the air pollution. How was calculated?

Based on an alternative methodology we have, which measures the services that trees give to the ecosystem. Regarding this methodology, each tree gives a different contribution to the ecosystem due to age, diameter, and type. By having all those data we can calculate how much CO2 a tree absorbs, how much O2 releases, how much water it holds and how much NO2 and PM it absorbs with its crown. Also, we calculate how much kWH it will save to residential/commercial units when it shades the building.

To reduce the pollution caused from public transportation, natural solutions were taken into consideration such as trees, than to mitigate the air pollution in city center we need 203,881 platanus trees at 75years.

3. In your analysis there is a very important point related with air pollution such as Loss of urban forest cover, how have you calculated?

It is an estimation referred to the orthophoto changes from 2000 to 2018 and information from General Local Plan of Municipality of Tirana.

4. How is measured the air pollution, and why is further analyzed only the pollution caused by public transportation?

The pollution is measured in urban areas, and is caused by different sources. In the other hand, for the paper it was considered the estimation of air pollution caused from 305 buses of public transportation and not the measures of pollution in urban areas. As we had

no information how much this sector does contributes to air pollution we tried to answer it by making some estimations as explained before as we know that.

Interview for UHI

1. How much is Tirana familiar with the phenomenon of UHI? Is it a problem yet?

Urban Heat Island is yet a concept to be introduced in Tirana even-though it is affected at large by this phenomenon. This said, means that all citizens in Tirana are quite familiar with the phenomena especially during summer time and can identify the sources of such problem at a generic level but not link it ideally with the thorough UHI concept. ECSOs have channeled their efforts form time to time on explaining and pointing specific planning issues that increase the presence of this phenomenon in urban areas. Nevertheless, as many more environmental-related issues it is not well accepted and thus reflected on the sectoral plans and interventions supported by municipality.

2. What do you think contributes more to this phenomenon (Tirana)?

In my opinion I would rank first of all the continuous and increasing urban density within the exclusive area of Tirana (within the large ring of the city)! This in itself has contributed on increasing the imperviousness of the city. Whereas there is more and more asphalts and concrete-based surfaces (dark) that absorbs thermal energy to release it during night time and also increase the average temp. Both during night and day time. Another problem contributing to this phenomena in Tirana is related again with urban planning but now in the context of positioning the high dwellings. Given the fact that Tirana, in a topographical view, is situated in the lowest quota of the Tirana-field it makes it naturally difficult for air circulation to happen and even more if the natural air movement corridors are now blocked due to the positioning of new building. Whereas, now we are facing air circulation only within neighborhoods rather than on a city level.

3. Is it mainly an indoor or outdoor problem?

In all cases the outdoor influences the indoor area for this phenomenon even-though a significant part of pollution emissions source from the indoor activity. For Tirana, outdoor effect of UHI are practically unbearable from July to mid September whereas midday's offer a similar view of empty streets to the current on during the pandemic. This is mainly due to the fact that the heat created along the urban infrastructure is above 45-50

degree Celsius and surely combined with polluted air.

4. How important so you think such a problem in this context is?

Vital, as mentioned above during summer practically it is impossible to expose yourself within those conditions. There by children, toddlers, old people and those whom have a degree of medical condition cannot expose themselves in open places. This affects in large terms the city livability index, decreases the accessibility and therefore it impacts the socio-economic behavior from an individual to the whole community for the time said.

5. Which are the areas (neighborhoods) that you think suffer more from UHI?

All the area between the large-ring of Tirana to historic center (Skanderbeg square, boulevard, mother Teresa square and artificial park) As for neighborhoods I would underline (ZoguZi Area, Vasil Shanto, Shkolla Baletit, Ali Dem, 21-December, New Pazar, Brrylietc).

6. How can it be mitigated and who should be involved?

Given the current situation it seems impossible to mitigate such a problem but I think that the first step toward concrete measures should be revising the GLP of Tirana. Urban Greenery is one of the first and quick response measures that can reduce this phenomenon. On the other hand, there should be specific interventions to reduce the thermal absorbing surfaces (by materials used or simple color change) Last but not least, as mentioned above, people are aware of such problem because they are facing it. While we need to work in order to explain theoretically and practically the phenomena in order to be accepted and kwon they also should be involved in the drafting and decision making process for the measures needed in their neighborhood. Countries and cities that have achieve to mitigate this phenomena, used the concept of consensus rather that the majority since for society at large the environmental-related problems and sustainable solutions are not well-known and therefore not well-accepted.

7. What are the main strategies (realistic) to adapt in the context of Tirana?

- Increase the urban public parks within the city (not in its periphery)

- Increase the overall green index by planting trees, investing in green roofs and vertical green parks

- Improve the natural airing of the city

- Reduce overall pollution load emitted by transport, industry and construction

- Decrease imperviousness

Expert (Regional Environmental Center)

Aim of this interview: Understanding how familiar are experts in their everyday work with urban heat island effect. Also, knowing the current situation, what strategies do they suggest as a measure to mitigate the UHI.

1. Do you think the concept of UHI is well known in Tirana, among institutions, experts and citizens?

Unfortunately, urban heat island effect it not a familiar concept in Tirana. All its known is what people feel, the discomfort they have indoor and outdoor during summer season mainly, but also during winter (winter is not very cold in Albania).

Regarding that, in my opinion it is very important to speak about the phenomenon and to understand more the scale of the problem.

2. In your opinion what does affect more in the making of UHI?

I think, this is a problem that has been created from different factors together. First of all we have Mediterranean climate, therefore the summers are hot and dry and winter are mild and abundant. Having this, the development should have follow a climate responsive way. Only last year's developers have started to build thermo insulation constructions to have a comfort space indoor. Due to rapid urbanization we have a dens city and mixed used. As many people wanted to access the services many of them has chosen to live in the city center. Therefore the process of urbanization caused the so-called "concreting of the city". The change of the environment from natural to buildup is one of the major causes.

In the city center but not only usually first floors are used for commercial purposes and the upper floors for residential purposes. On the other hand, the heat that is released from commercial units, such as bakery, diary shops, markets, butcher's shop etc., is higher as they use more AC and refrigerators. Therefore, the heat stress is more present in areas like city center.

3. What strategies do you think can be followed in our context to mitigate the heat load?

In my opinion, at this moment more important to understand the scale of the problem itself. As I mentioned before, it's not much talked about it and I'm sure that in many institutions the concept is not known at all. Furthermore, as long as the problem is not known in its fullest than its understood, so proposing strategies without a deep understanding might lead only to a good theoretical exercise.

Institute of Construction

Aim of this interview is to understand how built environment contributes in UHI the building due to materials used in different periods of time in Tirana.

1. Which are milestones regarding the building materials used in Tirana?

The main periods that have made a change are before 1960. During that time the density of the city was low and the buildings were more organized as single houses. The second important period that made a change in the way of construction was 1961 - 1980 when apartments started to be organized on multi-storey buildings. The third important milestone was 1981 to 1990, as some new construction materials entered the market. From 1990 to 2000, the first decade of democracy, the densification of cities, especially Tirana due to the free moves of people. The last important periods of constructions are from 2001 to 2011 and 2012 and continue.

2. What types of materials are used in the construction of buildings during different times?

Materials used in Tirana are categorized due to different building periods. The first buildings, mainly single houses up to 3 floors, which date before 1920, are mainly built with adobe and stone. Before 1960 some multi-storey buildings were built. After 1960, which

includes the communist area as well is mainly used red bricks and silicate bricks. Those buildings do not have thermal insulation. Till 1978 main construction materials used were concrete structures bricks and prefabricated structures. Flat roofs of the buildings during those times used to be of concrete.

From 1990 to 2000 for the structures of the buildings were used only concrete. Typology of buildings during that time was single houses. As many people moved to big cities like Tirana, they built their houses in agriculture land. After 2000 reinforced concrete was used, this helped to improve the quality of the buildings. In the last decade, new constructions use ventilated facades and thermal insulation (not all of them).

3. Is there any new technology that market is aiming to adapt?

Yes, there is a tendency to adopt new technologies that are related to anti seismicity. Due to the problems that we had in September and November 2019, as a result of those two earthquakes, respectively 5.8 and 6.4 balle, reinforcement of steeliness steel will replace the structures of concrete structures of future developments. Concrete has a lower resistance compared to steeliness steel.

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نبذة مختصرة

تأثير جزيرة الحرارة الحضرية ليس ظاهرة جديدة ، لكنه لا يزال غير مألوف في ألبانيا. على الرغم من أن المدن تعاني من هذه المشكلة ، إلا أن الحكومة ولا المواطنون يفعلون الكثير. ومع ذلك ، فإن التعرف على الانزعاج الحراري فقط لا يكفي لتحسين الوضع. يجب النظر إلى المشكلة على نطاق أوسع. لذلك يهدف هذا البحث إلى اقتراح حلول لتقليل التأثير الحراري في الأحياء السكنية ، بعد فهم حجم المشكلة. لاستكشاف أسباب UHI ، قمت بتحليل الموقع ، والملاحظات ، والمقابلات المفتوحة مع الخبراء والمقيمين. تساعد طريقة البحث متعددة الاستخدامات على فهم المشكلة بشكل أفضل. كما يحلل المشكلة في الأحياء المختلفة ، حيث تميزت UHI بسبب خصائص الموقع. تمثل مناطق الدراسة المختارة ثلاثة أنماط مختلفة ، شاهقة الارتفاع ومتوسطة الارتفاع ومباني منفصلة ، خاصة المنازل الفردية. تتجسد المشكلة بطرق مختلفة في تلك المناطق حيث يختلف التشكل الحضري. من خلال أخذ المناقشة من مقياس الحي وفهم السياق الأوسع ، إلى مستوى المدينة والبلد ، أجادل في كيفية تطبيق الاقتراحات التي تأتي من المقابلات المفتوحة لحل المشكلة. الاستراتيجيات والأدوات المقترحة تأخذ في الاعتبار المناخ ، وتجلب تصورات الخبراء والمقيمين إضافة القيم إلى هذا العمل.

الكلمات المفتاحية: تأثير جزيرة الحرارة الحضرية ، الجوار ، التخفيف ، الاستراتيجيات ، الأدوات ، تيرانا.

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة ...

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث: مالفينا ديشا

التاريخ: اغسطس 2020

التخفيف من تأثير جزيرة الحرارة الحضرية في تيرانا
صندوق أدوات التدخل للأحياء السكنية

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

أعداد: مالفسنا ديشا

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لجنة الحكم

التوقيع

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تاريخ المناقشة:.....

الدراسات العليا

ختم الإجازة

أجيزت الرسالة بتاريخ:.....

موافقة مجلس الكلية .../.../...

موافقة مجلس الجامعة .../.../...

جامعة عين شـــــمس

جامعة شتوتجارت

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