SOCIOECONOMIC IMPACTS OF URBAN HEAT ISLAND ON URBAN DWELLERS

Author

SYED UBAIR SHAH

Registration Number

00000318128

Supervisor

DR. ABDUL WAHEED

DEPARTMENT OF URBAN AND REGIONAL PLANNING

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

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Author

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Thesis Supervisor

Dr. Abdul Waheed

Thesis Supervisor's Signature _____

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THESIS ACCEPTANCE CERTIFICATE

This is to certify that the final draft of the thesis titled **"The Socioeconomic Impacts of Urban Heat Island on Urban Dwellers,"** authored by **Mr. Syed Ubair Shah (Registration No. 00000318128)**, from the Department of Urban and Regional Planning (NICE-SCEE), has been carefully reviewed by the undersigned. The thesis has been found to be complete in all respects in accordance with the regulations and statutes of NUST. Moreover, it has been verified that the thesis is free from plagiarism, errors, and mistakes. As a result, it is accepted as a partial fulfillment for the conferment of the MS degree. Additionally, it is confirmed that all the necessary amendments suggested by the GEC members of the scholar have been duly incorporated into the thesis.

Signature: _____

Name of Supervisor: Dr. Abdul Waheed

Date: _____

Signature (HOD): _____

HoD Urban & Regional Planning
NUST Institute of Civil Engineering
School of Civil & Environmental Engineering
National University of Sciences and Technology

Date: _____

Signature (Principal and Dean): _____

Date: 30 AUG 2023

PROF DR MUHAMMAD IRFAN
Principal & Dean
SCEE, NUST

DEDICATION

This research work is dedicated to my beloved parents, who realized the importance of education and made me capable of reaching this level. At the same time, it is dedicated to my dearest Siblings, who supported and guided me in every field of life. Their unwavering love and support have not only guided me throughout this endeavor but also empowered me to navigate every aspect of life with confidence and dedication.

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This research work is an outcome of the collective coordination, contributions, and assistance of numerous individuals. However, I begin by acknowledging the blessings of Almighty Allah, who bestowed upon us the wisdom and perseverance to successfully accomplish this project.

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It is a pleasure to pay tribute to my Parents, Brothers, for providing me with technical and financial support. And at last, but not least, a special thanks to my dear fellows for their cooperation and help in completing my thesis.

In conclusion, we extend our sincere appreciation to all those who played a crucial role in the successful completion of this thesis. We acknowledge that it is impossible to individually mention everyone by name, and we apologize for any omissions.

Syed Ubair Shah

ABSTRACT

Urban Heat Islands are causing significant problems for people living in urban areas. The impacts of urban heat islands on lifestyle, health, and weather are concerning, which is why our study aimed to understand the causes and effects of this phenomenon. Traffic and urban sprawl were identified as two of the major causes of urban heat islands. The increase in population and size of cities due to urban sprawl has forced people to rely on vehicles for transportation, leading to adverse effects on the climate and weather of the city. Our study found that more than 95% of respondents identified traffic as having a medium to high impact on the cause of urban heat islands, while 100% identified urban sprawl as having a medium to high impact.

Temperature analysis revealed a general increase in temperatures over the last two decades, but interestingly, temperatures in October, November, and December have actually decreased during this time.

Our analysis of imagery data from 2000, 2010, and 2020 revealed a concerning trend of built-up areas' proportion rising dramatically over this timeframe. In 2000, the built-up area was 17.57%, while our most recent analysis showed that this figure more than doubled to 43.65% in 2020. These findings highlight the need for action to address the problem of urban heat islands before they cause more harm to people's health, lifestyle, and the environment

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1. INTRODUCTION

1.1. Background

Urbanization is a process characterized by the movement of people from rural and peri-urban areas to urban centers in search of social and economic opportunities (Malik & Wahid, 2014). However, the definition of urban areas varies across countries. In the United States, urban places are recognized based on a population threshold of 50,000 or more. Other countries employ different criteria. For instance, Australia refers to urban areas as "urban centers," defined as a place where 1000 people live, or 200 people per square kilometer. Canada defines urban area as having more than 400 people per square kilometer and a population exceeding 1,000. China defines urban areas as 1500 people per square kilometer. Denmark defines urban areas as an area with 250 or more people, while Greece defines urban area as an area with 10,000 or more people. Guatemala defines urban areas as a place where 2000 or more individual lives, or 1,500 or more if running water service is provided, as urban areas. These examples highlight the diverse ways in which countries define urban areas based on population thresholds. Nigeria, for instance, initially considered areas with a population of over 5,000 as urban according to the 1952 census, but revised the threshold to 20,000 in the 1963 census. In contrast, France defines urban places as those with 2,000 or more inhabitants, Canada uses a threshold of 1,000, and Japan sets it at 30,000 or more(Aluko, 2010).

Urbanization in developing countries, such as Nigeria, has led to a mismatch between the growing population and the availability of adequate housing, amenities, and infrastructure. This has resulted in high rents, overcrowding, and the emergence of slum settlements, which negatively impact the well-being of urban dwellers (Onibokun, 1972);(Olotuah, 2005) Moreover, non-compliance with building regulations, including zoning, setbacks, and ventilation requirements, further exacerbates the challenges faced in the Nigerian urban built environment(Osuide & Dimuna, 2005).

Similarly, South America is also experiencing urbanization, and due to which they are losing natural and rural areas (Pimentel, Giampietro, & Bukkens, 1998);(Ryder & Brown, 2000). The metropolitan area of Concepcio´n in Chile serves as a representative example of rapid and uncontrolled urban growth observed in many developing countries. The impacts of urban sprawl on flora, fauna, habitat loss, fragmentation, and homogenization are evident in this area. This

underscores the importance of conducting further research on the effects of urbanization on biodiversity in developing nations, as it differs from well-studied systems in developed countries (Pauchard, Aguayo, Peña, & Urrutia, 2006).

1.2. Objectives

Following are the objectives of the study.

- To identify the UHI in the study area
- To investigate the socioeconomic effects of UHI on urban dwellers
- To investigate the causes of UHI in the city of Abbottabad
- To provide suggestions regarding the problem of UHI

1.3. Aim of the study

Aim of the study was to find out the perspective of the people about the urban heat island, how it has affected the people and what are the causes of it in people's perspective.

1.4. Importance of the study

Main reason for selection of the topic was increase in size of city and increasing temperature over the years. Urbanization plays a significant role in shaping the environment. Despite occupying a small portion of the Earth's surface, urban areas serve as hubs for human activity, accommodating over 50% of the global population and contributing to 7% to 90% of economic activity (Potere el al., 2009). The consequences of urbanization extend to various aspects, particularly influencing local and regional climates. One prominent phenomenon associated with urbanization is the urban heat island effect (or surface UHI), which stems from the alteration of land surfaces and thermal characteristics in urbanized areas. The accelerated pace of urbanization is expected to have far-reaching implications for the climate and the persistence of the urban heat island effect(Zhou et al., 2004a). And another reason of selection of this topic was that there has been no research carried out on the city of Abbottabad regarding urban heat and urban sprawl.

1.5. Research Problem

One of the research problems was that people have no awareness of the problem which they have in the surrounding, which made it time consuming in collection of the data.

1.6. Study area

The Study of the research area was Abbottabad, which exists at the altitude of 1225m, lies between 33° 50’ and 34° 23’ N-latitude and 73°35’ and 73°31’ E-longitude with 1,967 km square area (ALI et al., 2017). Abbottabad is characterized by its mountainous topography, with the surrounding area featuring an average mountain elevation ranging from 2500m to 2700m(IUCN Pakistan, 2004).

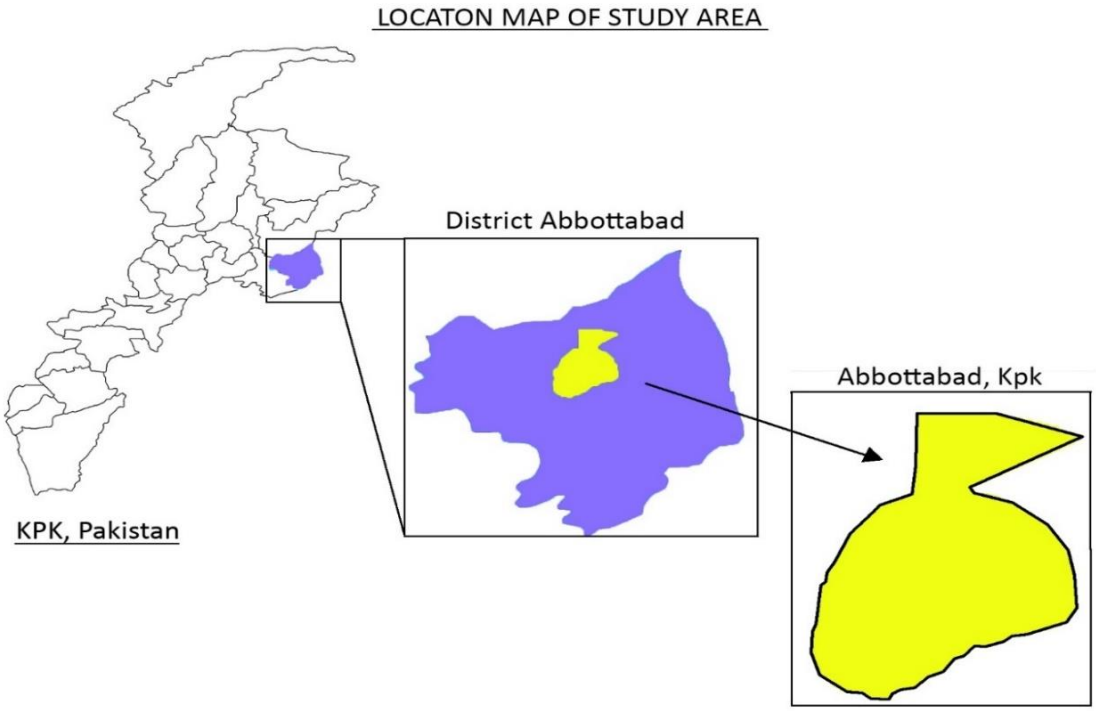

Figure 1 Location Map of Study Area

1.7. Structure of the Report

Chapter 1 discusses the importance if the study, background of the issue. Its objectives, aim of the study, research problems and study area are mentioned. Overall, procedures carried out to achieve the objectives.

Chapter 2 gives us the literature review of the study, which includes urbanization, its effects, other than that, urban heat Island’s effects and its causes.

Chapter 3 includes research methodology of the study and what kind of data was used in the research.

Chapter 4 gives us the data analysis of the study in details, its tables and figures.

Chapter 5 gives us conclusions and recommendations of the study.

2. LITERATURE REVIEW

2.1.1. Urbanization and its effects

Urbanization plays a significant role in transforming the Earth's land surface. By altering surface parameters and influencing the surface of the atmosphere interaction processes, urbanization has the potential to modify the climates of the locality(Oke, Zeuner, & Jauregui, 1992). As defined by Dickson (1965), a place of compact settlement which is engaged in activities other than agriculture is known as town"(Aluko, 2010) . Currently, around 47% of the world's population resides in urban places, and this number is projected to rise as more individuals migrate from villages to cities, particularly in less developed countries where urbanization rates are lower (41% in 2005) compared to more developed nations (76% in 2005)(Organization, 2005)**.** Developing countries have witnessed a notable increase in urbanization, while developed countries continue to experience high urbanization rates(Sadorsky, 2014); (Shahbaz, Loganathan, Muzaffar, Ahmed, & Jabran, 2016). About 64% of the people will be living in cities by the year of 2050 (Shahbaz et al., 2016);(Long, & Chen, 2017). Rapid urbanization has negative impacts on environment, with over 80% of global carbon emissions are due to urban population (Sugar, & Gómez, 2011);(Zhao, & Hong, 2017). Consequently, urbanization significantly alters the climate of densely populated areas, prompting extensive research efforts to better comprehend urban climatology. The process of urbanization brings about three major changes which has negative impact on urban atmosphere the natural surfaces are being replaces with buildings and concrete pavements, anthropogenic heat, and air pollution (Yagüe, Zurita, & Martinez, 1991).

The global climate has undergone significant changes over the last one hundred years, the emerging of global warming is a pressing issue that concerns governments, the scientific community, and the public. The climate change observed in China aligns with the global trend over the same period (Zhang et al., 2012);(Qin, 2014). In recent years, the impacts of human activities on the environment, particularly in urban areas, have become increasingly apparent (Mirzaei & Haghighat, 2010); (Bailey el al., 2017). Urbanization continues to attract a growing population to cities, leading to intensified human activities and modifications of land, resulting in undesirable consequences such as UHI effect (Akbari & Kolokotsa, 2016); (Kaloustian & Diab, 2015); (Mirzaei et al., 2015). The UHI effect means the temperature difference between

the cities and villages surrounding them. Most research on this phenomenon has focused on large cities (G. Li et al., 2018).

2.1.2. Effects on Agriculture

Urbanization and population decentralization have direct effects that primarily involve the transformation of rural land into urban areas. In the Middle Atlantic region, population growth is not occurring at a rapid pace; instead, there is a trend of population dispersal, where people are moving away from central cities and distant rural areas and relocating to suburbs, smaller cities, towns, and less remote rural areas (Berry, 1978).

2.1.3. Effects on Solid Waste

The rapid pace of urbanization has resulted in a significant increase in generation of waste, surpassing the speed of urbanization itself (Hoornweg & Tata, 2012). In Asia alone, over 1 million tons of (MSW) are produced daily, and by 2025 this number is projected to increase to 1.8 million tons (Hoornweg & Tata, 2012). MSW primarily consists of waste that is being produced in cities, predominantly from households with a smaller proportion from commercial sources. For instance, in Taiwan, where a population of 23 million resides in a relatively compact land area of approximately 36,000 km2, approximately 8 million tons of waste is generated each year(Chen & Wang, 2017).

2.1.4. Overcrowding

Identifying the specific health impacts solely attributed to one aspect of housing, such as overcrowding, can be challenging due to the multitude of factors that influence health, including dampness, fuel usage, water quality, and smoking practices. However, numerous controlled studies conducted worldwide have revealed notable connections between overcrowded housing and various health issues, such as tuberculosis. These studies have demonstrated significant associations between overcrowding and specific health conditions, highlighting the importance of addressing housing-related factors in promoting overall health and well-being(Harling & Castro, 2014), hospitalization for influenza (Hadler et al., 2014). Population growth, particularly in developing countries like Africa, has led to increased overcrowding, a trend expected to worsen due to urbanization (Organization, 2015). Similarly, in Nigeria a study shows that around 8 to 12 people are living in only two rooms (Okeyinka, 2015). In Ghana, around 44.5% of the people are living in overcrowded housing.

Urbanization is impacting the local climate, but its extent is still not fully understood. China provides a valuable research context due to its rapid development in recent decades. The urban population in China has already surpassed 50% and is projected to increase by 80% until 2050, according to the NBS (National Bureau of Statistics). The study of urbanization's effects on climate is gaining more attention due to the increasing vulnerability of urban areas to extreme weather events such as heatwaves(Zhu et al., 2014), heavy rainfall (Yan et al., 2015), and severe haze(Tao et al., 2015).

The UHI effect is recognized as a prominent feature of urban climates. As urban areas develop, the UHI effect becomes more pronounced, leading to high temperature of the surface (SAT) as compared to nearby villages (LIN & YU, 2005). Previous studies in China have attempted to estimate the extent to which urbanization contributes to the observed warming trend, yielding a wide range of results(Wu & Yang, 2013). For instance, (Portman, 1993) found an urban-induced warming trend in North China of over 0.1°C per decade, even before the 1990s.

Cities typically have lower vegetation cover, higher heat, and more impervious surfaces such as buildings, concrete pavements, and roads, which lead to increased heat storage during the day and elevated nighttime temperatures compared to natural areas(Kim & Baik, 2002). In addition, urban surfaces exhibit lower rates of evapotranspiration and higher Bowen ratios, indicating a greater proportion of sensible heat fluxes compared to latent heat fluxes. This characteristic contributes to the faster warming of urban surfaces during daytime in comparison to suburban and non-urban surfaces. (Taha, 1997). Nevertheless, the daytime warming effect in urban areas can be mitigated by the increased urban surface roughness, which enhances the mixing of the planetary boundary layer (PBL). The stronger PBL mixing during the day helps to disperse and dissipate heat, thereby reducing the overall warming effect in urban environments. (Garratt, 1994). The enhanced mixing of the planetary boundary layer in urban areas facilitates the upward dissipation of surface heat (Xia et al., 2016) As a result, there is a reduced temperature contrast between urban and non-urban surfaces, minimizing the warming effect typically observed in urban environments.(Miao et al., 2009). Studies have shown that UHI effect varies among rural areas and is influenced by regional factors (Kim & Baik, 2005). Surface UHI intensity is generally higher throughout the year during the day time (Peng et al., 2012), with 64% of analyzed cities globally showing the highest UHI intensity during the day. However, 36% of cities, mainly in developing regions of western and southern Asia and northern Africa,

exhibited higher UHI intensity at nighttime (Baud & De Wit, 2009). These findings highlight the need to investigate the factors contributing to this nighttime UHI intensity in urbanizing cities within developing regions.

(Malik & Wahid, 2014) Pakistan is facing significant housing challenges due to rapid urbanization and a shortage of housing and infrastructure facilities. The country's swift population growth and limited availability of land contribute to the widening gap between housing demand and supply. Inadequate urban planning and a proliferation of informal settlements further exacerbate the problem. Socioeconomic disparities and a lack of affordable housing options also contribute to substandard and overcrowded living conditions. Addressing these challenges requires comprehensive approaches, including urban planning, investment in affordable housing, and the provision of basic infrastructure. Housing problems and challenges to identify reasons for failure

- The formulation and implementation of effective policies that guide urban development and housing initiatives in Pakistan
- Strengthening the governance structure and capacity of local authorities
- Encouraging active participation and collaboration between the private development sector, stakeholders, and government entities
- Empowering and involving affected communities in the planning process of formal settlements

2.2. UHI AND CAUSES

2.2.1. What is UHI

The phenomenon of UHI was first introduced by Luke Howard during the year of 1818 in London and has since gained recognition across many countries and regions globally. It stands as one of the most significant challenges in urban climate and environmental studies. In comparison to villages, city surfaces typically exhibit higher heat capacity, thermal conductivity, and are predominantly composed of waterproof materials. Additionally, the presence of buildings extends the urban surface area, leading to multiple reflections and increased absorption of solar radiation. These factors contribute to the development and intensification of the UHI effect in urban areas.

The unique properties of urban areas, such as high heat absorption, storage, and reduced ventilation due to building density, contribute to the accumulation of heat. Additionally, human activities generate anthropogenic heat, further adding to the heat load in urban environments. Consequently, urban areas exhibit significantly higher outdoor air temperatures compared to rural areas, with temperature differentials reaching up to 12 degrees Celsius. The combination of urban morphology and anthropogenic factors exacerbates the urban heat island effect, intensifying the thermal conditions in cities(Simonovic et al., 2018).

An UHI is a term used to describe the phenomenon where cities or metropolitan areas experience higher temperatures compared to the surrounding village areas. As urbanization increases, so does the temperature disparity between cities and village regions. This phenomenon is caused by factors such as tall buildings and narrow streets that trap and heat the air.

The presence of impervious surfaces like concrete and asphalt, along with urban structures such as buildings, alters the surface characteristics of urban areas compared to natural landscapes. (T. Oke, 1995). These modifications are a result of urbanization, which involves the replacement of soil and vegetation. As a consequence, UHI effects occur, leading to elevated temperatures in urban environments. The understanding of UHI dynamics is crucial for implementing strategies to mitigate its impacts and create more sustainable urban spaces. [(Taha el al., 2001);(Voogt & Oke, 2003)].

Phenomenon of UHI arises from changes in land, specifically the conversion of agricultural and vegetational lands into impervious surfaces commonly found in urban areas. These impervious

surfaces include concrete, asphalt, rooftops, and building walls. The transformation of land cover associated with urban land uses leads to the formation of UHI. The replacement of natural surfaces with these impermeable materials contributes to altered heat exchange processes, resulting in higher temperatures in city environments compared to surrounding village areas (Buyantuyev & Wu, 2010).

The urban heat island (UHI) effect is characterized by higher temperatures in urban areas compared to the surrounding rural regions. This temperature rise is primarily attributed to the increased absorption and storage of solar energy by man-made materials found in built-up urban environments. The UHI effect has direct consequences on both daytime and nighttime temperatures, leading to various indirect impacts such as heightened air conditioning demands, compromised air and water quality, decreased lifespan of pavements, and exacerbated heat waves. These effects highlight the significance of understanding and addressing the UHI phenomenon in urban planning (Phelan et al., 2015).

The phenomenon of UHI has notable impact on the overall well-being of human populations, influencing the quality of life in urban environments. Understanding and addressing the UHI phenomenon is crucial for mitigating its adverse effects and ensuring sustainable and livable cities(Cao et al., 2016); The intensification of the urban heat island (UHI) contributes to the prevalence of heat-related illnesses and adverse health effects, including cardiovascular stress, respiratory problems, and even premature deaths(Salcedo et al., 2012); (Rydin et al., 2012). Recognizing the link between UHI and urbanization, it has become crucial for government agencies and researchers worldwide to assess the effects of UHI and develop urban planning strategies that can mitigate its negative impacts. By understanding and addressing UHI, cities can work towards creating healthier and more resilient urban environments.

The temperature rises in cities due to climate change and the Urban Heat Island phenomenon contribute to an increased likelihood and severity of extreme heat events(Estoque et al., 2020), These events have the potential to negatively impact human health and even result in fatalities (Wehrden et al., 2018), it is potentially damaging the health and it even has as severe impacts that it can even cause death (Gasparrini et al., 2015). However, it’s important to note that just climate factor is not responsible for heat events but social factors and demographic factors are also involved in it (Soriani et al., 2020).

The intensity of the urban heat island (UHI) effect is influenced by various factors, including the composition and configuration of surface biophysics(Vejre et al., 2019). Climate change has the potential to alter the climatic conditions that contribute to UHI(Betts et al., 2010). As a result of global climate change, there has been an increase in the frequency, magnitude, and duration of extreme heat events, further amplifying the urban overheating caused by the combined effects of UHI and heatwaves. This highlights the synergetic relationship between UHI and climate change in exacerbating urban heat stress(Santamouris et al, 2020).

Satellite remote sensing is used to study temperature differences between urban and rural areas and retrieve land surface temperatures, helping identify urban heat islands. It provides an efficient way to monitor and analyze UHI effects, aiding in urban planning and mitigation strategies (Ahmed, 2018).

2.2.2. UHI CAUSES

Increasing heat is one of the major causes of the deaths all over the world, particularly in urban areas where population density and assets are concentrated(Organization, 2014); (Guo et al., 2017). The characteristics of the built environment in cities exacerbate the impact of extreme heat. Studies have revealed that deaths related to heat are not evenly distributed within the population of urban areas. Vulnerable groups such as the elderly, low-income households, ethnic minorities, socially isolated individuals, those with low education levels, and those with pre-existing medical conditions are disproportionately affected by extreme heat events. Understanding these disparities is crucial for implementing targeted strategies to protect and support these vulnerable populations during periods of extreme heat. (e.g., (Reid et al., 2009); (Wilhelmi & Hayden, 2010); (Uejio et al., 2011).

The negative impacts on health of population due to change in climate is well documented(Gasparrini et al., 2015); (Estoque et al., 2020). The ongoing expansion and densification of urban areas, coupled with socioeconomic trends like demographic ageing, further contribute to these impacts, particularly increasing the risk of urban heat stress. It is essential to address these challenges by considering the interplay between climate change, urban development, and population dynamics to protect the health and well-being of urban residents. Urbanization brings about significant changes in the physical properties of the land surface by removing natural vegetation cover. This alteration affects various factors such as spectral

albedo, heat capacity, soil moisture, and emissivity(Arnfield, 2003), (Chang et al., 2011). Additionally, urbanization contributes to pollution and the generation of waste heat, leading to modifications in the urban heat balance and influencing the microclimate of the area. Microclimate refers to the climate within a specific small-scale region, such as a city or valley, which may differ from the surrounding general region (Ferrell et al., 2017). Urban areas exhibit distinct climatic characteristics on a localized scale due to these inadvertent climate modifications. The microclimate varies considerably within cities and neighborhoods due to a multitude of factors related to urban form, including winds, temperature, human activity, precipitation, heat balance, clouds, soil types, pollution, vegetation and topography (Swain et al., 2017).

Extensive research has been conducted to understand the causes and consequences of UHIs, resulting in the documentation of their qualitative and quantitative characteristics. The aim of such studies is to gain insights into mitigating the negative effects of UHIs on urban environments and human well-being(Pomerantz et al., 1998).

The UHI is an important phenomenon linked to change in climate, followed by high temperature in air of the surface of urban areas as compared to the sub urban and rural areas (Oke & Cleugh, 1987). It has emerged as a major concern due to the rapid urbanization and industrialization occurring in the twenty-first century. The UHI poses significant challenges for human populations and their well-being (Zhou et al., 2004b).

The urban heat island (UHI) phenomenon is influenced by various factors related to the complex energy and water balances, as well as air movement (Oke, 1988); (Chunho et al., 2008). The urban surface characteristics, such as the absorption and storage of solar radiation, the reduction of longwave radiation loss, and the impact of structures on convective heat removal, all contribute to UHI formation (Christen & Vogt, 2004). Additionally, declines in thermal inertia and vegetation index affect evaporation and latent heat flux, further influencing the heat dynamics (Kondoh & Nishiyama, 2000). Air pollutants also play a role in the UHI (Rizwan et al., 2008). Studies conducted in European cities have revealed significant regional variations in UHI amplitude, with temperature differences being seasonally dependent and larger during summer and spring. These findings highlight the diverse and dynamic nature of UHI patterns and emphasize the importance of considering local factors in understanding and addressing UHI effects (Zhou et al. 2013).

The urban heat island (UHI) is primarily caused by the heat produced from structures in urban areas and human caused heat sources(Rizwan et al., 2008). (Oke, 1973) Research has indicated that population size can serve as an indicator of UHI intensity, with larger populations correlating with stronger UHI effects (Kukla et al., 1988) regression equations have been established between population and urban warming in climate records. The intensity of UHI is influenced by various factors, both intrinsic and external to the city, including city size. These factors collectively contribute to the complexity and variability of UHI effects in urban areas. (Oke, 1982).

3. RESEARCH METHODOLOGY

Abbottabad is continuously facing the issue of increasing heat and urban expansion from past few decades and it all started massively after the Earth quake of 2005 in Balakot. So many people migrated towards the city of Abbottabad and it became densely populated which created many issues including the issues Heat, traffic, pollution, deforestation, congestion and urban sprawl.

This study will explore the past trends of spatial growth in the city of Abbottabad. It will also study about the rise in temperature of the city as well as rainfall, heat and wind temperature will be collected and analyzed. By keeping in view, the policies, a framework will be will be developed which will address the effects of UHI on the dwellers.

3.1. Research Design

My research is Hybrid which includes primary and secondary data, for that purpose we will need both qualitative methods and quantitative methods.

3.2. Data Requirement

The data required for the research will be.

1. Primary Data
2. Secondary Data

3.2.1. Primary Data

Primary data is the type of data that is collected by researchers directly from main source. For primary data we will use qualitative data which includes the perception of the people on the current problem, the purpose of the research and its uses in further studies to understand Urban heat island. This research will help us find out which areas are most effected by Urban heat island in last few decades and what are the reasons behind this problem. A questionnaire will be designed to find out the perception of the people about the Urban heat island.

3.2.2. Secondary Data

This data is already available on the internet which has been made available for researchers to use in their research. Imagery form USGS was accessed, temperature data was collected from the concerned department.

Abbottabad is continuously facing the issue of increasing heat and urban expansion from past few decades and it all started massively after the Earth quake of 2005 in Balakot. So many people migrated towards the city of Abbottabad and it became densely populated which created many issues including the issues Heat, traffic, pollution, deforestation, congestion and urban sprawl.

In this study we tried to find out the opinion of the people about the causes and effects of urban heat island. In our analysis we used the qualitative data which was collected by the people of the study area. Questionnaire was prepared in order to answer the address the problem of urban heat island and data was collected through online forms, interviews and by filling questionnaire. People of different age groups were involved in this research.

After collecting the data, we used "SPSS" software for data entry. After that SPSS was used for the descriptive analysis to create charts and tables. All the indicators were used to get a clear picture of the opinions of the people about the causes and effects of the urban heat island.
After descriptive analysis indices for causes were formed to place different indicators into group for better understanding. For this purpose, SPSS was used by using the formula mentioned below.

$$C = \sum Xi / N$$

C = sub-indices, X = Indicators, N = total number

C1 = Traffic

C2 = Urban Sprawl

***C3* = Climate Change and Pollution**

***C4* = Increase in Consumption**

***C5* = Construction**

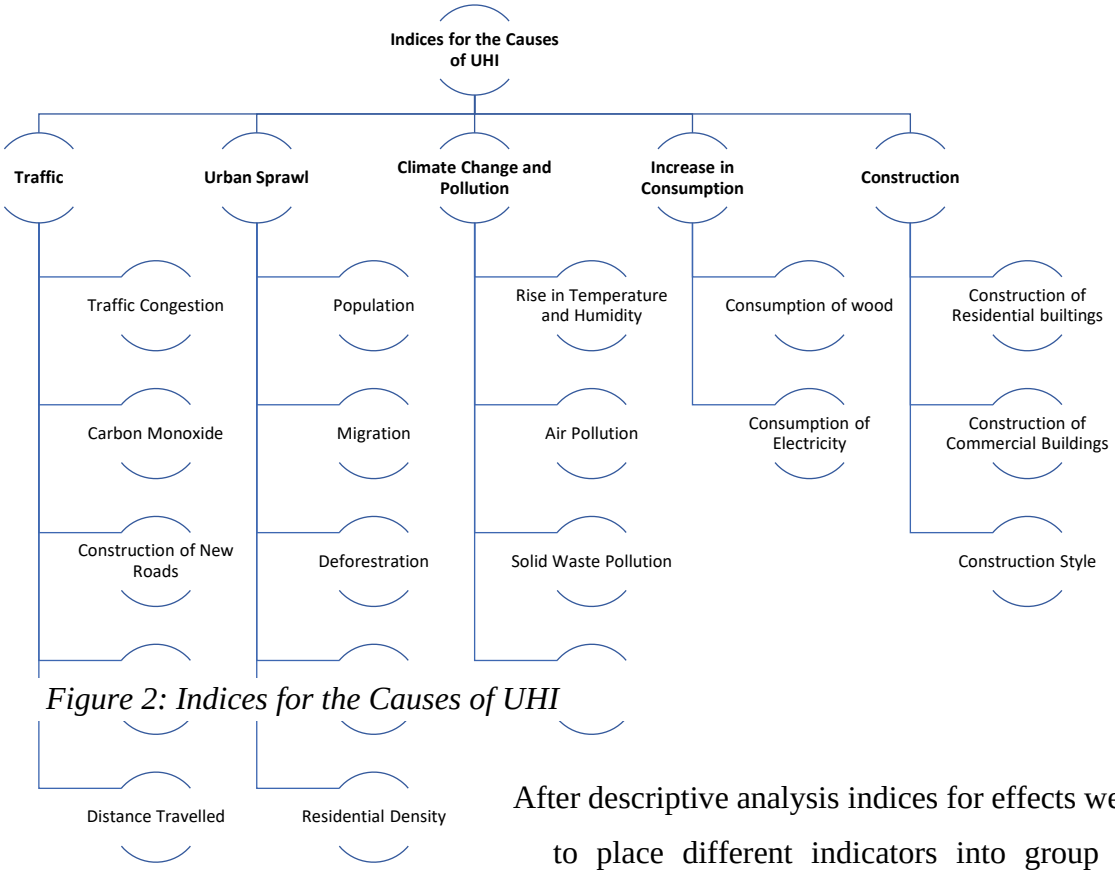

Figure 2: Indices for the Causes of UHI

After descriptive analysis indices for effects were formed to place different indicators into group for better understanding. For this purpose, SPSS was used by using the formula mentioned below.

E* = ∑*Xi* / *N

***E* = sub-indices, *X* = Indicators, *N* = total number**

***E1* = Psychological and Health Effects**

***E2* = Life Style**

***E3* = Weather**

***E4* = Construction style and Impact on insulation**

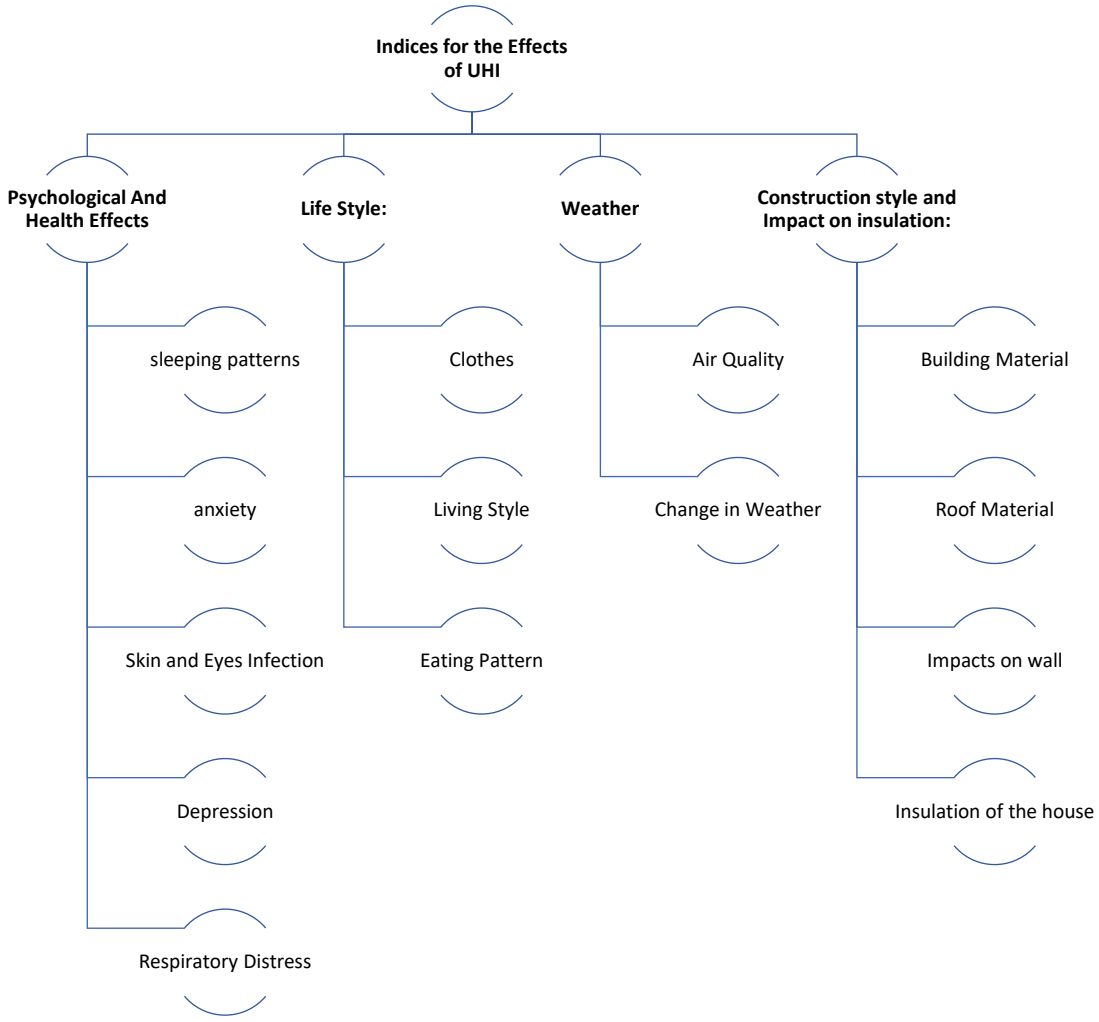

Figure 3: Indices for the Effects of UHI

4. DATA ANALYSIS

4.1. Demographic Profile

Table 1: Demographic Profile

	Values	Frequency	Percentage
Age			
	age less than 21	73	18.9
	age between 21 to 30	287	74.4
	age between 31 to 40	21	5.4
	age above 41	5	1.3
Gender			
	Male	233	60.4
	Female	153	39.6
Occupation			
	Government Employed	80	20.7
	Private Employed	147	38.1
	Student	135	35.0
	House Wife	24	6.2
Education			
	Secondary School	22	5.7
	Intermediate Education	110	28.5
	Graduate	197	51.0
	Post graduate and above	57	14.8
Marital Status			
	Married	114	29.5
	Un Married	272	70.5
Household Members			
	Less than 5 Members	70	18.1
	5-8 Members	212	54.9
	9 and above	104	26.9

4.1.1. Findings

In our field study we collected the data from the residents of the study area through the questionnaire by interviewing them. The purpose was to find out the opinion of the residents of the study area about the rising situation of urban heat in the study area.
Our demographic profile includes age, gender, occupation, education, marital status and household members.

Upon descriptive analysis of the demographic section, we found out the frequencies and percentages of the above-mentioned categories. If we look at the age, we had 287 respondents between the age of 21-30 years which is 74.4% of the total people from whom the data was collected, 73 respondents were of the age less than 21 years old, 21 respondents were between the age or 31-40 years old and only 5 people were above the age of 40 years. As we can see most of the respondents were between the age of 21-30 because the reason behind it was that most of the data was collected from either the graduate students or fresh graduates so proportion of them was higher as compared to the other age groups.

As we can see that there were more unmarried respondents which is 70.5% as compared to married respondents which is 29.5% because most of the respondents were between the age of 21-30 years who were newly graduates or still completing their graduation degree.

According to the data we found out that 58.9% of the respondents are employed out of which 20.7% were employed in government sector and 38.1% of them were private employed and on the other hand 35% of the proportion was students and 6.2% of them were housewives.

If we look at the data 79.5% of the total respondents have the average education between 12-16 years whereas, 14.8% were post graduates and 5.7% had education less than 10 years.

From our findings we can see that number of male respondents are higher than female respondents. 233 out of 386 respondents were male which is 60% of the total respondents where as 40% of them were female. The reason behind this is that in our society mostly males are responsible for earning and other daily life routine things so big proportion out of the respondents were male.

4.2. Causes

Santamouris et al. (2007) and Akbari and Oke (1987) identified the following factors contributing to the urban heat island phenomenon

- Reduced air transpiration due to limited cover of vegetation
- Increased absorption of solar radiation caused by low reflective power
- Hindered air movement due to roughness in higher surface
- Elevated levels of heat release due to human activities.

We carried out a questionnaire survey to find out what was the opinion of people about Urban heat island and what are the causes behind it. We will explain each of the variable and its results in the tables given below.

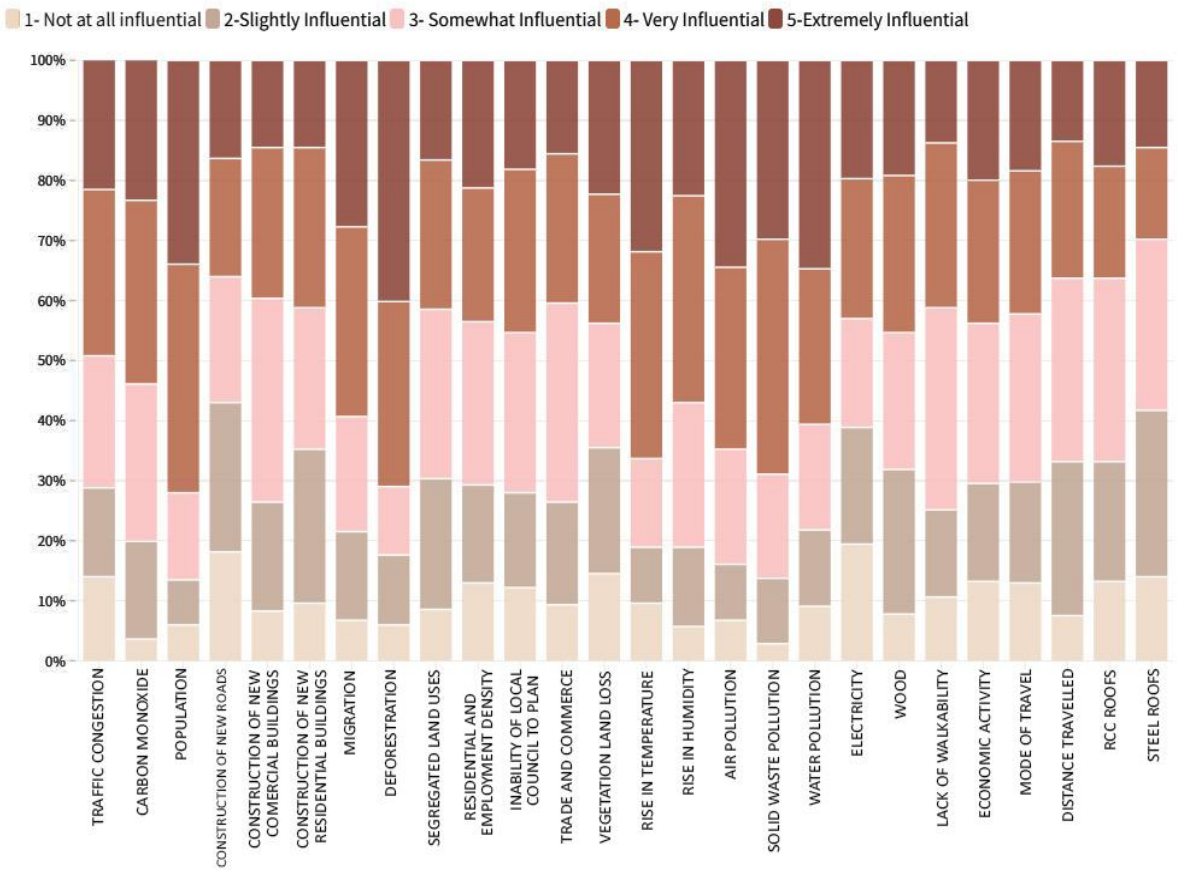

Figure 4: Causes of UHI

Table 2: Causes behind UHI: ***Traffic***

S. No	Category	Variables	Values	Frequency	Percentage
1	**Traffic**				
(1a)		**Congestion**			
			Not at all influential	54	14.0
			Slightly Influential	57	14.8
			Somewhat Influential	85	22.0
			Very Influential	107	27.7
			Extremely influential	83	21.5
(1b)		**Carbon Monoxide**			
			Not at all influential	14	3.6
			Slightly Influential	63	16.3
			Somewhat Influential	101	26.2
			Very Influential	118	30.6
			Extremely influential	90	23.3

One of the indicators was traffic which was further divided into two variables such as, traffic congestion and carbon monoxide produced due to traffic. According to the data the 48.2% of the respondent's opinion was that traffic congestion plays important role in the formation of Urban Heat Island, whereas, 22% of the respondents said that traffic congestion is somewhat influential whereas, only 28% of the respondents responded that traffic congestion has slightly to no influence at all on the UHI of the study area.

Data shows that 53.9% of the respondents think that traffic produces carbon monoxide which has very/extreme influence upon the creation of Urban heat island, where as 26.2% people thinks that it is somewhat influential whereas, 19.9% of the respondents responded that carbon monoxide has slightly or no influence at all on the creation of UHI.

Table 3: Causes behind UHI: ***Population***

2	Population	Values	Frequency	Percentage
		Not at all influential	23	6.0
		Slightly Influential	29	7.5
		Somewhat Influential	56	14.5
		Very Influential	147	38.1
		Extremely influential	131	33.9

In the recent year's city has grown in size and people have migrated from other villages to the city as well. Increase in population is also one of the causes of UHI.

In our survey we asked 386 people about the influence of population on urban heat island and out of 386 people 72% of the people responded that it is very/extremely influential in causing of UHI where as 14.5% that its somewhat influential and 13.5% of the respondents answered that it has slightly to no influence at all in the creation of UHI.

Table 4: Causes behind UHI: ***Surface Modification***

3	Surface Modification	Variables	Values	Frequency	Percentage
		Construction of New Roads			
			Not at all influential	70	18.1

	Slightly Influential	96	24.9
	Somewhat Influential	81	21.0
	Very Influential	76	19.7
	Extremely influential	63	16.3
Construction of Commercial buildings			
	Not at all influential	32	8.3
	Slightly Influential	70	18.1
	Somewhat Influential	131	33.9
	Very Influential	97	25.1
	Extremely influential	56	14.5

Construction of Residential Buildings	**Values**	**Frequency**	**Percentage**
	Not at all influential	37	9.6
	Slightly Influential	99	25.6
	Somewhat Influential	91	23.6
	Very Influential	103	26.7
	Extremely influential	56	14.5

Another Indicator for UHI was surface modification which was further divided into variables such as, construction of new roads, construction of commercial buildings and construction of residential buildings.

36% of the people responded that construction of new roads is also responsible for the rise in temperature whereas, 21% found it somewhat influential and 43% of the respondents found it not at all/ slightly influential in causing the rise of temperature.

Another variable was construction of commercial buildings. 39.6% of the people responded that new construction of commercial buildings is very/extremely influential in causing of UHI, 33.9% responded that it is somewhat influential and 26.4% people responded that it is not at all / slightly influential in causing of Urban heat island.

41.2% of the people responded that construction of residential building is very/extremely influential in creation of UHI whereas, 23.6% people responded that it is somewhat influential and 35.6% of the people responded that it has slightly or no influence at all in the creation of urban heat island.

Table 5: Causes behind UHI: ***Migration***

4	Migration	Values	Frequency	Percentage
		Not at all influential	26	6.7
		Slightly Influential	57	14.8
		Somewhat Influential	74	19.2
		Very Influential	122	31.6
		Extremely influential	107	27.7

According to the data, almost 60% of the people responded that migration is very/extremely influential in the causing of UHI, whereas a little less than 20% of the people responded that it is somewhat influential and not even quarter of the respondents think that migration is not at

all/ slightly influential. This interprets that a large number of respondents thinks that this is also one of the main causes of urban heat island.

Table 6: Causes behind UHI: ***Deforestation***

5	Deforestation	Values	Frequency	Percentage
		Not at all influential	23	6.0
		Slightly Influential	45	11.7
		Somewhat Influential	44	11.4
		Very Influential	119	30.8
		Extremely influential	155	40.2

We asked respondents if deforestation was one of the causes of urban heat island and the data shows that more than 70% of the people answered that it was very/extremely influential whereas, only 11.4% of the people thinks that it is somewhat influential on the urban heat island whereas, less than 20% of the people thinks that it is slightly/ not at all influential in causing of urban heat island.

Table 7: Causes behind UHI: ***Urban Sprawl***

6	Urban Sprawl		Values	Frequency	Percentage
(6a)		**Segregated Land Uses**			
			Not at all influential	33	8.5
			Slightly Influential	84	21.8
			Somewhat Influential	109	28.2

		Very Influential	96	24.9
		Extremely influential	64	16.6
(6b)	**Residential and Employment density**	**Values**	**Frequency**	**Percentage**
		Not at all influential	50	13.0
		Slightly Influential	63	16.3
		Somewhat Influential	105	27.2
		Very Influential	86	22.3
		Extremely influential	82	21.2
(6c)	Inability of local council to plan	**Values**	**Frequency**	**Percentage**
		Not at all influential	47	12.2
		Slightly Influential	61	15.8
		Somewhat Influential	103	26.7
		Very Influential	105	27.2
		Extremely influential	70	18.1
(6d)	Presence of trade and commerce	**Values**	**Frequency**	**Percentage**
		Not at all influential	36	9.3

		Slightly Influential	66	17.1
		Somewhat Influential	128	33.2
		Very Influential	96	24.9
		Extremely influential	60	15.5
(6e)	Vegetation land loss	**Values**	**Frequency**	**Percentage**
		Not at all influential	56	14.5
		Slightly Influential	81	21.0
		Somewhat Influential	80	20.7
		Very Influential	83	21.5
		Extremely influential	86	22.3

There is a problem of urban sprawl in almost every part of the world where cities are growing which is creating different problems and also there are many causes of urban sprawl which then results in rise of temperature, we also asked people the issues and to which their response is explained given below. More than 40% of the respondents answered that segregated land-use are very/extremely influential, whereas, more than quarter of the people responded that it was somewhat influential, and around 30% of the people responded with not at all/ slightly influential. A little less than 50% of the people responded that residential and employment density is very/extremely influential in the causing of urban sprawl which in turn is the reason of increasing heat in the city, a little more than quarter respondents find it somewhat influential and less than 30% people finds if not at all/ slightly influential. Another variable we took was inability of local council to plan under urban sprawl category to which more than 45% people responded with very/extremely influential, more than quarter people found it somewhat influential and less than 20% people responded that is not slightly influential or not at all influential. More than 40% of the people's response was that presence of trade and conference

is very/ extremely influential, whereas, a little over 30% people responded with somewhat influential and more than a quarter people responded that it is not at all / slightly influential. When we asked respondents about the vegetation loss, almost half of the respondents answered that urban sprawl was very/extremely influential on vegetation land loss, where more than 20% responded with somewhat influential and almost 35% people responded that it is not at all/ slightly influential.

Table 8: Causes behind UHI: ***Climate Change, Pollution***

7	**Climate Change**	**Values**	**Frequency**	**Percentage**
(7a)	Rise in Temperature			
		Not at all influential	37	9.6
		Slightly Influential	36	9.3
		Somewhat Influential	57	14.8
		Very Influential	133	34.5
		Extremely influential	123	31.9
(7b)	Rise in Humidity			
		Not at all influential	22	5.7
		Slightly Influential	51	13.2
		Somewhat Influential	93	24.1
		Very Influential	133	34.5
		Extremely influential	87	22.5
8	**Pollution**			

(8a)	Air Pollution			
		Not at all influential	26	6.7
		Slightly Influential	36	9.3
		Somewhat Influential	74	19.2
		Very Influential	117	30.3
		Extremely influential	133	34.5
(8b)	Solid Waste Pollution			
		Not at all influential	11	2.8
		Slightly Influential	42	10.9
		Somewhat Influential	67	17.4
		Very Influential	151	39.1
		Extremely influential	115	29.8
(8c)	Water Pollution			
		Not at all influential	35	9.1
		Slightly Influential	49	12.7
		Somewhat Influential	68	17.6
		Very Influential	100	25.9
		Extremely influential	134	34.7

Another indicator of our questionnaire was climate change, it was further divided into two variables such as rise in temperature and rise in humidity. More than 65% respondents answered that rise in temperature is very/extremely influential, and there are less than 20% people who thinks it's not at all/ slightly influential.

Whereas, more than 55% people responded that rise in humidity is very/extremely influential and there are only a little over 15% people who thinks it is slightly or not at all influential. We also asked question from the respondents about air, solid waste and water pollution. Almost 65% people responded that air pollution is very/extremely influential, whereas, less than 20% people responded with somewhat influential and almost 15% people responded that it is not at all/ slightly influential. Almost 70% people responded that solid waste pollution is very/extremely influential, whereas, only around 10% people responded that it is not at all or slightly influential. To the water pollution, almost 60% people responded with extremely/very influential and around 20% of the people responded that it is not at all/ slightly influential.

Table 9: Causes behind UHI: ***Increased Energy Consumption***

9	**Increased Energy Consumption**	**Values**	**Frequency**	**Percentage**
(9a)	Electricity			
		Not at all influential	75	19.4
		Slightly Influential	75	19.4
		Somewhat Influential	70	18.1
		Very Influential	90	23.3
		Extremely influential	76	19.7
(9b)	Wood			
		Not at all influential	30	7.8

	Slightly Influential	93	24.1
	Somewhat Influential	88	22.8
	Very Influential	101	26.2
	Extremely influential	74	19.2

We asked a question about the increased energy consumption in terms of electricity and wood. To which the people's response is described below.

A little over 40% of the people responded that there has been increased energy consumption in terms of fans and air coolers due to increasing heat in the city, whereas, 38% people responded that it is not at all/ slightly influential. According to the data 45% of the people responded that wood consumption is very/extremely influential and almost 30% of the people responded that it is not at all/ slightly influential.

Table 10: Causes behind UHI: ***Lack of Walkability***

10	**Lack of Walkability**	**Values**	**Frequency**	**Percentage**
		Not at all influential	41	10.6
		Slightly Influential	56	14.5
		Somewhat Influential	130	33.7
		Very Influential	106	27.5
		Extremely influential	53	13.7

Data shows that more than 40% respondents responded that lack of walkability is very/extremely influential, 33% responded that it is somewhat influential and around quarter people responded that it not at all/ slightly influential. We also asked question about the economic activity as if increased economic activity in the area is one of the driving forces of

UHI to which more than 40% people responded that it is very/extremely influential, a little over quarter people responded that it is somewhat influential and almost 20% of the people responded that it is not at all influential or slightly influential.

Table 11: Causes behind UHI: ***Daily Travel***

11	**Daily Travel**	Values	**Frequency**	**Percentage**
(11a)	Mode of travel			
		Not at all influential	50	13.0
		Slightly Influential	65	16.8
		Somewhat Influential	108	28.0
		Very Influential	92	23.8
		Extremely influential	71	18.4
(11b)	Distance travelled			
		Not at all influential	29	7.5
		Slightly Influential	99	25.6
		Somewhat Influential	118	30.6
		Very Influential	88	22.8
		Extremely influential	52	13.5

As cities are growing and technology is developing people will have to travel far to get to their work places, we asked respondents of our study area if mode of travel and distance travelled from home to work place and vice versa is one of the causes of UHI. Their responses are listed below. More than 40% respondents answered that mode of travel is very/extremely influential

in causing of UHI and less than 30% people answered that is it not at all influential or slightly influential, whereas, 28% people responded that it is somewhat influential. More than 35% people responded that distance travelled for work or other daily life use is very/ extremely influential and a little over 30% people responded that it is not at all / slightly influential and 30% people responded that it is not at all/ slightly influential

Table 12: Causes behind UHI: ***Construction Style***

12	**Construction Style**	Values	**Frequency**	**Percentage**
(12a)	RCC Concrete roofs			
		Not at all influential	51	13.2
		Slightly Influential	77	19.9
		Somewhat Influential	118	30.6
		Very Influential	72	18.7
		Extremely influential	68	17.6
(12b)	Steel roofs			
		Not at all influential	54	14.0
		Slightly Influential	107	27.7
		Somewhat Influential	110	28.5
		Very Influential	59	15.3
		Extremely influential	56	14.5

With changing world, the construction and building techniques also changes with time, we asked our respondents about the construction style and their impact on urban heat and their answer is described below More than 35% respondents answered that RCC concrete roofs are very/ extremely influential whereas, more than 30% people answered that it is not at all influential or slightly influential. Whereas, less than 30% people responded that the steel roofs are very/extremely influential and more than 40% people responded that steel roofs are not at all/ slightly influential.

4.3. Effects

We asked questions about the psychological and health effects of the people to which response of the respondents is given below.

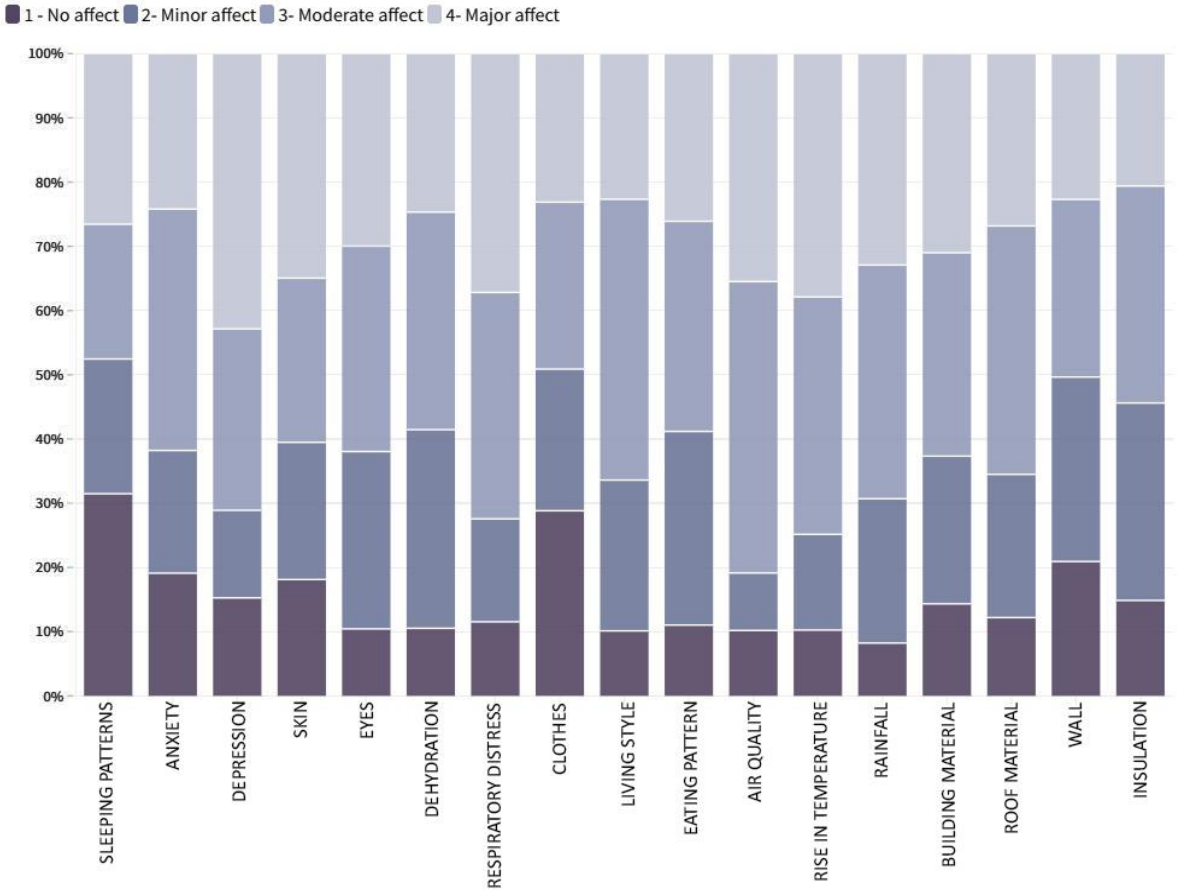

Figure 5: Effects of UHI

Table 13. Effects of UHI: ***Health and psychology***

S. No	Category	Variables	Values	Frequency	Percentage
1.	**Health and Psychology**				
		Sleeping Patterns			
			No affect	96	24.9
			Minor affect	64	16.6
			Neutral	81	21.0
			Moderate affect	64	16.6
			Major affect	81	21.0
		Anxiety			
			No affect	60	15.5
			Minor affect	60	15.5
			Neutral	72	18.7
			Moderate affect	118	30.6
			Major affect	76	19.7
		Depression			
			No affect	47	12.2
			Minor affect	42	10.9
			Neutral	78	20.2
			Moderate affect	87	22.5
			Major affect	132	34.2
		Skin			
			No affect	56	14.5
			Minor affect	66	17.1
			Neutral	77	19.9

	Moderate affect	79	20.5
	Major affect	108	28.0
Eyes			
	No affect	31	8.0
	Minor affect	82	21.2
	Neutral	89	23.1
	Moderate affect	95	24.6
	Major affect	89	23.1
Dehydration			
	No affect	32	8.3
	Minor affect	94	24.4
	Neutral	82	21.2
	Moderate affect	103	26.7
	Major affect	75	19.4
Respiratory Distress			
	No affect	36	9.3
	Minor affect	50	13.0
	Neutral	74	19.2
	Moderate affect	110	28.5
	Major affect	116	30.1

We asked if sleeping pattern of the people was affected due to increase in UHI, to which a little less than 50% (47.54%) people responded that it has moderate/major effects on our sleeping pattern whereas more than 50% (52.46%) people responded that it has no or minor effect on the sleeping pattern of the people. Another question was asked it either UHI has effect on the anxiety to which more than 60% (61.78%) respondents responded that it has moderate/ major effect, and 38.22% people responded that it has no/ minor affect. Which shows that increasing temperature has impacted highly on the anxiety of the people. More than 70% people responded that increasing temperature has moderate/ major effect on depression and less than 30% people

responded that it has no/ minor effect on depression. UHI has also affected skin of the people living in the area resulting in skin diseases and irritation. Upon asking more than 60% people responded that it has moderate/major effect and less than 40% people responded that it has no effect or minor effect on the skin. More than 60% people responded that increasing temperature has moderate/ major effect on eyes. Whereas, less than 40% people responded that UHI has no/ minor effect on eyes. Almost 60% of the people responded that UHI has major/moderate effects on hydration, and around 40% people responded that it has no/minor effect on the hydration of the people. More than 70% people responded to the question of respiratory distress that it has moderate/major effect. Whereas, less than 30% people responded that it has no/minor effect on respiratory distress.

Table 14. Effects of UHI: ***Life Style***

2	**Life Style**		Values	**Frequency**	**Percentage**
		Clothes			
			No affect	81	21.0
			Minor affect	62	16.1
			Neutral	105	27.2
			Moderate affect	73	18.9
			Major affect	65	16.8
		Living Style			
			No affect	25	6.5
			Minor affect	58	15.0
			Neutral	139	36.0
			Moderate affect	108	28.0
			Major affect	56	14.5
		Eating Pattern			
			No affect	30	7.8
			Minor affect	82	21.2

	Neutral	114	29.5
	Moderate affect	89	23.1
	Major affect	71	18.4

Increasing temperature has also affected the life style of the people. We also asked the respondents about the clothes, living style and eating patterns and to look if they think that temperature has changed it for them. Less than 50% people responded that increasing heat has also major/ moderate effect on the clothes of the people, whereas, more than 50% people responded that UHI has no/ minor effect on the clothing of the people. More than 65% people responded that UHI has major/moderate effect on living style, whereas less than 35% people responded that it has no / minor effect on the living style. Almost 60% people responded that increasing temperature has moderate/ major effect on eating pattern of the people, whereas, around 40% people responded that it has no/minor effect on eating pattern of the people.

Table 15. Effects of UHI: ***Climate and Weather***

3	**Climate and Weather**	Values	**Frequency**	**Percentage**
	Air Quality			
		No affect	33	8.5
		Minor affect	29	7.5
		Neutral	62	16.1
		Moderate affect	147	38.1
		Major affect	115	29.8
	Surface Temperature			
		No affect	33	8.5
		Minor affect	48	12.4
		Neutral	64	16.6
		Moderate affect	119	30.8
		Major affect	122	31.6

	Rain falls			
		No affect	26	6.7
		Minor affect	71	18.4
		Neutral	70	18.1
		Moderate affect	115	29.8
		Major affect	104	26.9

Another problem which the world is facing now a days in urban area is the decreasing quality of air, increase in temperature and decrease in rain fall. Upon asking 80% of the people responded that UHI has moderate/ major impact on the air quality of the people, whereas, less than 20% people responded that it has no/minor affect. This data shows that increasing temperature and urbanization has impacted highly on the air quality of the area. More than 75% people answered that UHI has moderate/major effect on the surface temperature whereas almost 25% people responded that it has no/minor effect on the surface temperature of the area. Almost 70% of the people responded that UHI has major/moderate effect on the rainfall, whereas around 30% of the people responded that it has no/minor effect on the rainfall.

Table 16. Effects of UHI: ***Construction style***

4	**Construction Style**	Values	**Frequency**	**Percentage**
	Building Material			
		No affect	43	11.1
		Minor affect	69	17.9
		Neutral	86	22.3
		Moderate affect	95	24.6
		Major affect	93	24.1
	Roof Material			
		No affect	35	9.1
		Minor affect	64	16.6
		Neutral	99	25.6
		Moderate affect	111	28.8

		Major affect	77	19.9

We asked people about the construction style and UHI's impact on the construction style and if it has any affect. Upon asking more than 60% people answered that it has major/moderate effect on the building material, whereas, less than 40% of the people answered that it has no/minor effect on building material. More than 65% people responded that UHI has major/moderate effect on roof material and less than 35% people responded that it has no/minor effect on roof material.

Table 17. Effects of UHI: ***Impacts on House***

5	**Impacts on House**	Values	**Frequency**	**Percentage**
	Walls			
		No affect	59	15.3
		Minor affect	81	21.0
		Neutral	104	26.9
		Moderate affect	78	20.2
		Major affect	64	16.6
	Insulation			
		No affect	44	11.4
		Minor affect	91	23.6
		Neutral	90	23.3
		Moderate affect	100	25.9
		Major affect	61	15.8

Increasing temperature has also affected the houses as well, so way of building wall has been changed and people tend to insulate their houses to decrease the impacts of the extreme temperatures, we also asked question regarding this problem and people's response to it is mentioned below. We asked if UHI has any affect on the walls to which response of the people was mix, almost 50% people responded that it has major/modertae affect on the walls and same amount of people responded that it has no/ minor affect on the walls. Whereas, more than 50% people responded that UHI has major/ modrate affect on the insulation of the houses and less than 50% people responded that it has no/minor affect on the insulation of the house.

4.4. Causes Indices

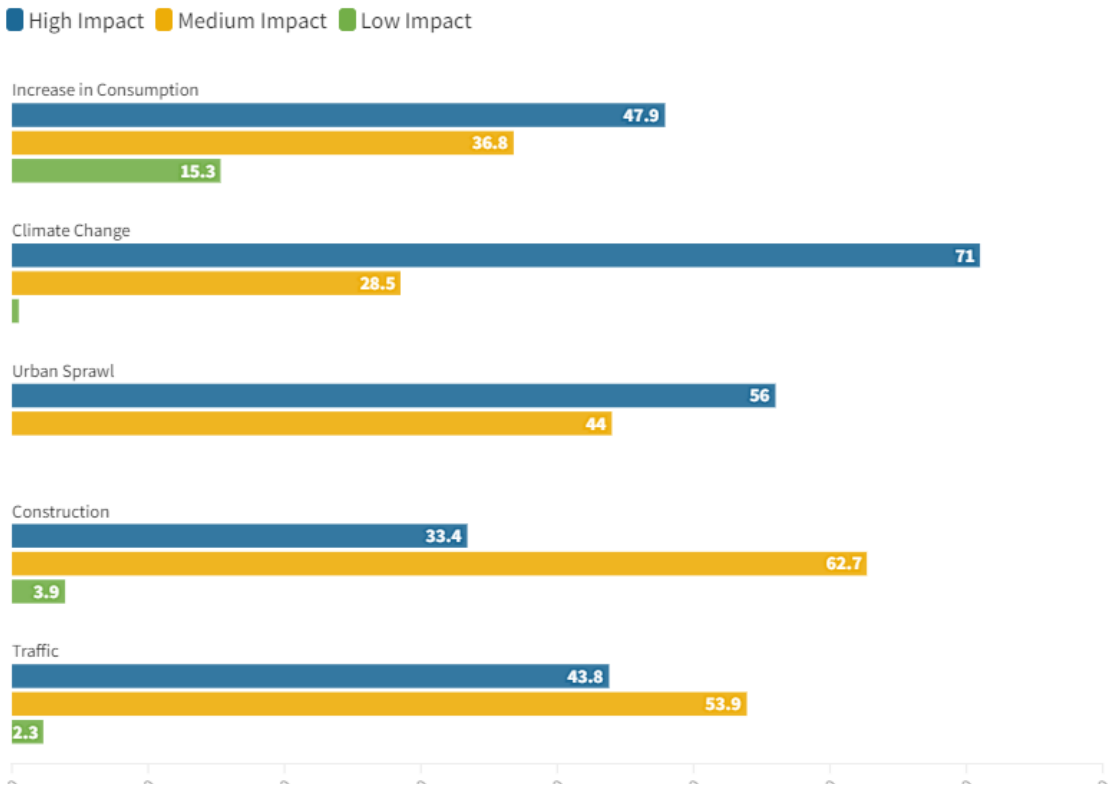

Figure 6: Indices of the Causes of UHI

4.4.1. Traffic

Traffic has been a new emerging problem in developing world and along with it comes different side effects, especially developing countries are facing lots of problems like traffic congestion and increase in air pollution due to excessive motor vehicles on the roads. Upon asking the people of the study area they responded that as we have experienced increase in the traffic there has been a lot of change in the temperature of the city and due to construction of more roads people are more inclined towards private owned cars.

Under the Traffic category different indicators are involved which includes traffic congestion, carbon monoxide due to increase traffic, construction of new roads, modes of travel and distance travelled in daily life.

To this question only 2.3% people responded that it has low impact on urban heat island, 53.9% respondents answered that it has medium impact whereas, 43.8% people responded that it has high impact on the urban heat island.

4.4.2. Urban Sprawl

Urban sprawl has been a really serious problem due to the migration of people from rural to urban areas, which leads to increase in population of the city due to which more land is required for residential purposes and to whih vegetation and forest land is lost with the time, people of the study area were also concerned about the increasing population and migration due to more opportunities in the city as compared to the rural area and no new preventive measures has been taken to avoid such problem.

Under the urban sprawl category, different indicators like population, migration, deforestation, segregated land uses, residential and employment density, inability of local council to plan, presence of trade and commerce and vegetation land loss.

To these questions people of the study area responded and 44% of the people thinks it has medium impact on the urban heat island whereas, more than 55% of the people responded that it has high impact on the urban heat island, whereas, 0 number of people thinks that it has low impact on urban heat island.

4.4.3. Climate Change and Pollution

Climate change has been arising problem all over the world, and due to which temperature all over has been rising, people of the study area were also worried about the condition of the city as this city used to be a cold and natural place where used to come for tourism but now its getting hotter day by day and with increasing temperature, there has been increase in pollution with increasing population**.**

Under the climate change and pollution category, there are different indicators such as rise in temperature and humidity, air pollution, solid waste pollution and water pollution. To these questions 0.5% respondents answered that climate change and pollution has low impact on urban heat island, 28.5% people responded that it has medium impact whereas, 71% people responded that it has high impact on climate change and pollution.

4.4.4. Increase in Consumption

With increase in population and increase in demand of the electric appliances in the study area, many people thought that they are also one of the causes of urban heat island as these appliances produces heat into the atmosphere which in turn have adverse effects on the overall temperature of the city.

Upon asking on increase in consumption of wood and electricity and if they are cause of the urban heat island. Respondents of the study area responded and 15.3% of the respondents asnwered that it has low impact in the creation of urban heat island, 36.8% people responded that it has medium impact and almost 50% people responded that it has high impact in increase of the temperature.

4.4.5. Construction

One of the main causes of urban heat islands are construction of the new buildings in the city. Upon asking large number of people of the city area responded that construction of comercial and residential buildings are also one of the causes are more buildings traps more heat energy in the structures and increases the temperature of the city.

The category of construction includes different indicators such as, construction of commercial and residential buildings, and construction style such as RCC concrete roofs and steel roofs.
To these questions 3.9% people responded that it has low impact on urban heat island, whereas, 62.7% people responded that it has medium impact and more than 30% people responded that it has high impact in the creation of urban heat island.

4.5. Effects

Increasing temperature has affected different aspects of human life such as mental health, physical health, their lifestyle, weather conditions and the way houses are built. People of the study areas were asked the questions about the effects and their answers are written below.

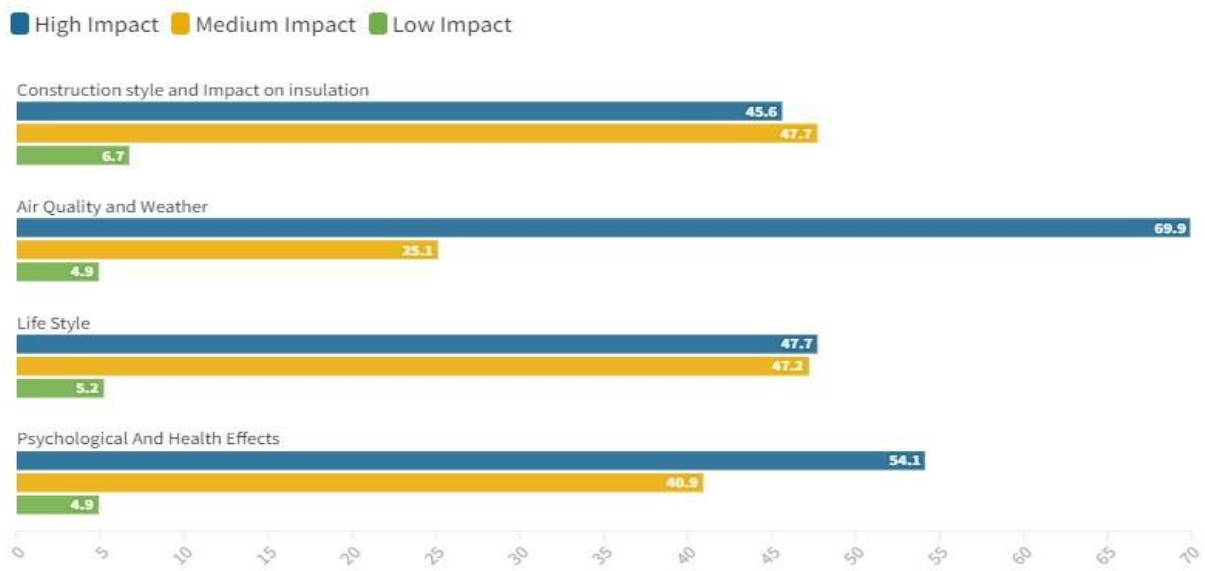

Figure 7: Indices of the Effects of UHI

4.5.1. Psychological And Health Effects

Psychological and physical health includes different indicators such as sleeping patterns, anxiety, depression, skin, eyes, dehydration, and respiratory distress, to which respond of the people was that 4.9% people answered that it had low impact, whereas, more than 40% people responded that it has medium impact whereas, more than 50% people responded that it has high impact on psychological and physical health.

Upon interviewing the respondents of the study area, we found out that these indices had serious impacts on the people because of the urban heat island, changing climate and increase in the temperature has effected them in different ways, they were asked about sleeping patterns and we found out that changing temperature had very high impacts on the it as high temperatures at day times and during night had adverse effect the their sleep patterns, many of the respondents had the problems of anxiety and depression because of the increased temperature and it is also linked with aggression and frustration. Apart from mental issues, increased temperature has affected people's physical health and we found out that so many people were suffering from skin and eye diseases. People had to put on sun screens and sun glasses to lower the effects of heat, many people were suffering from dehydration and respiratory problems recently as it was not the case few years ago.

4.5.2. Life Style

We have observed that urban heat islands has impacted the lifestyle of the local residents of the study area, upon asking the residents, we found out that it has highly impacted the choice of clothing of the people as the temperature rise has forced them to wear clothes accordingly, which was not the situation few decades ago, people used to sleep on roof tops back in the days but now due to higher temperatures it is not possible and they have to rely more on Air conditioners and other cooling appliances. People have also experienced less precipitation in rainy seasons such as, monsoon weather, prolonged summer season has also impacted the lifestyle of the people.

The category of lifestyle includes indicators such as, clothes, living style and eating patterns to which 5.2% respondents answered that it has low impact on the lifestyle of the people, a little less than 50% people (47.2%) responded that it has medium impact on the lifestyle and almost 50% people (47.7%) people responded that it has high impact on lifestyle of the people living in the study area. Studies have found out that high temperatures also affect social interaction of the people and it was one of the problems we found out in our respondents as well.

4.5.3. Air Quality and Weather

When people were asked about the air quality and weather conditions of the study area, large portion of the people thought that UHI had very high impact on it, air quality used to be good but it is deteriorating with time and weather is changing drastically, people responded on the weather conditions that there used to be more snow in winters and there was not too much heat in summer weather but it has changed a lot now, it snows after years and summers are really hot and they are getting hotter every year, heat waves are more often and people are adopting for air conditioners and other cooling appliances.

This category includes effects of UHI on air quality and weather of the study, to which 4.9% people responded that UHI has low impact, whereas, more than 25% people responded that it has medium impact and almost 70% people responded that it has high impact.

4.5.4. Construction style and Impact on insulation

With the changing temperature throughout the years, we have also found out that the construction style in the study area has changed as people used to put steel roofs because of the

excessive snow in winter season but due to changing weather conditions they use RCC roofs, and insulation techniques has also been changed to withstand more heat as it was not the main issue before.

This category includes different indicators such as building material, roof material and impacts on wall and insulation of the house. To these question 6.7% respondents answered that UHI has low impact on it, whereas, almost half people responded that it has medium impact and more than 45% people responded that it has high impact.

4.6. Temperature Data

A statistical method called the Mann-Kendall trend test was employed to investigate the temperature trend from 1998 to 2018. This analysis was conducted on a monthly basis, covering a time span of 20 years. The purpose was to identify any notable trends that occurred within this period. The output of the Mann-Kendall trend test is presented below, indicating any significant changes in the temperature data over the years.

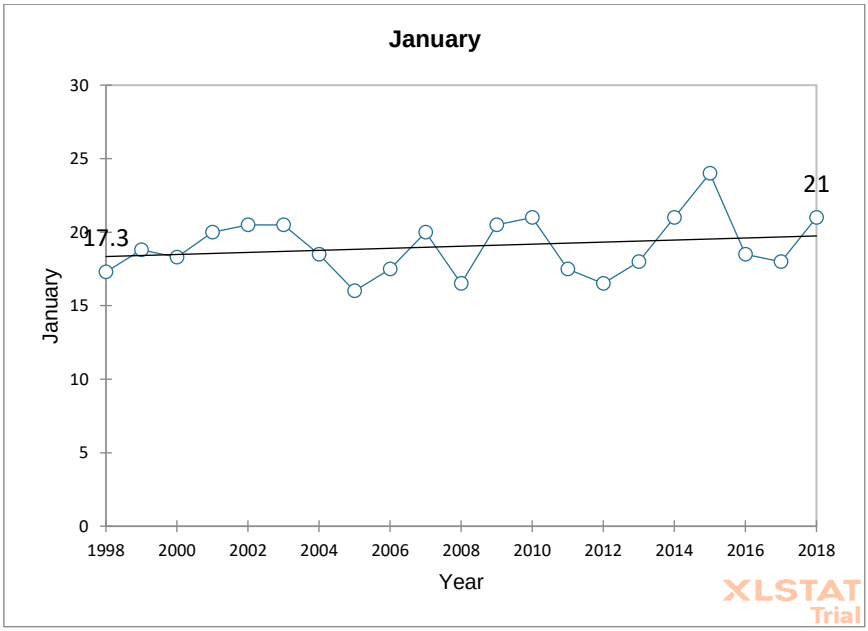

Figure 8: Data of temperature for the Month of January

Upon analysis of the temperature data for the month of January over the course of two decades, it is evident that an upward trend has emerged. Specifically, in 1998, the average temperature recorded was 17.3 degrees Celsius, whereas in 2018, the average temperature recorded was 21

degrees Celsius, resulting in a difference of 3.7 degrees. This notable increase in temperature indicates a significant rise in temperature over the past two decades.

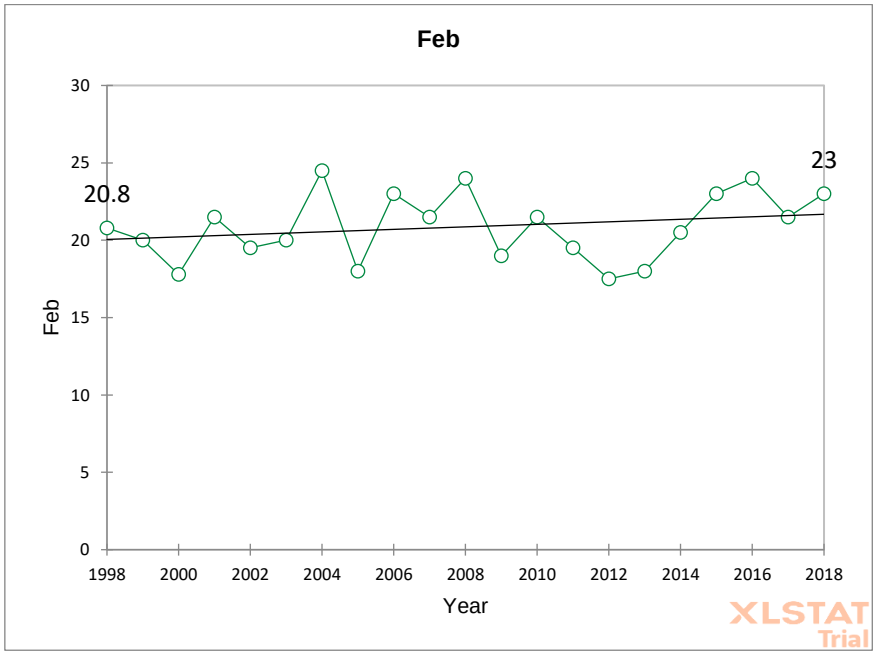

Figure 9: Data of temperature for the Month of February

After performing a trend test on the month of February utilizing temperature data, an upward trend was observed. The average temperature recorded during the test period was 20.8 degrees Celsius, while in 2018, the average temperature was noted to be 23 degrees Celsius, indicating a notable increase. These results provide evidence of an increasing trend in temperature for the month of February over the years between 1998 and 2018

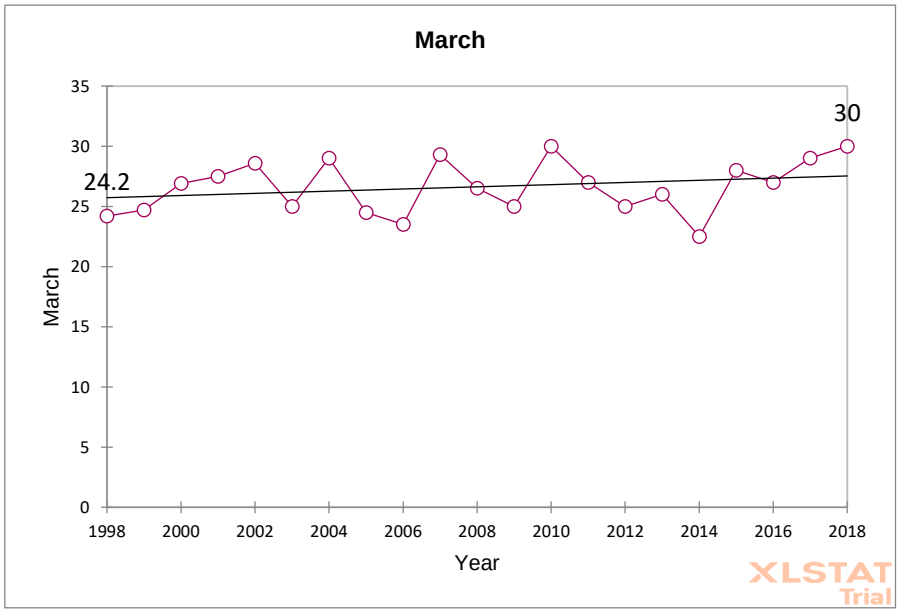

Figure 10: Data of temperature for the Month of March

Through the application of the Mann-Kendall trend test on the temperature data for the month of March, a significant increase in temperature was observed between the years 1998 and 2018. The average temperature recorded in 1998 was 24.2 Celsius, whereas in 2018 it was noted to be 30 degrees Celsius, indicating a notable increase. This finding highlights the potential impact of long-term climate change on local temperature patterns during the month of March.

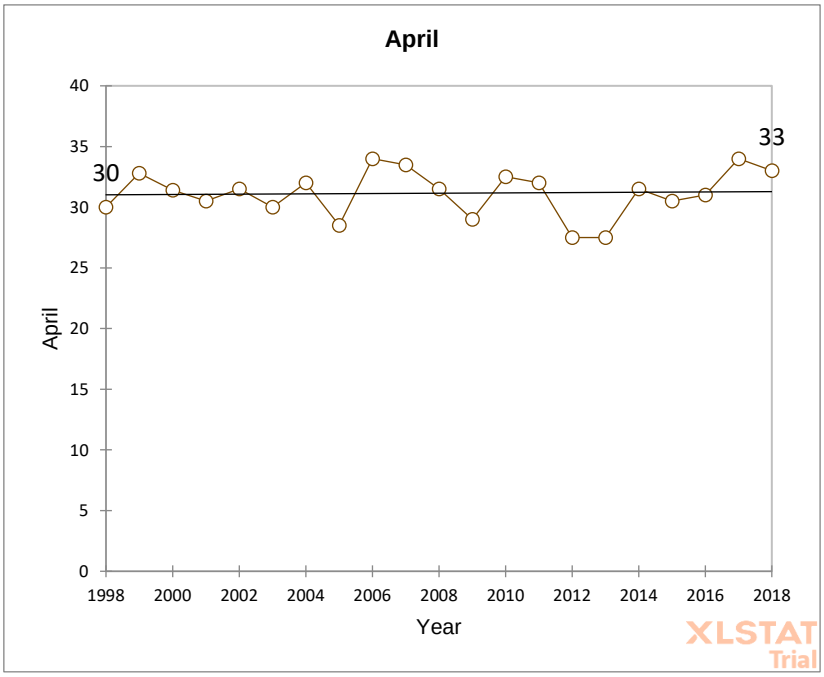

Figure 11: Data of temperature for the Month of April

After conducting the Mann-Kendall trend test on temperature data for the month of April, it was found that there has been a significant increase in average temperature between the years 1998 and 2018. The average temperature recorded in April of 1998 was 30 degrees Celsius, whereas in 2018 it was noted to be 33 degrees Celsius, indicating an increase of 3 degrees Celsius.

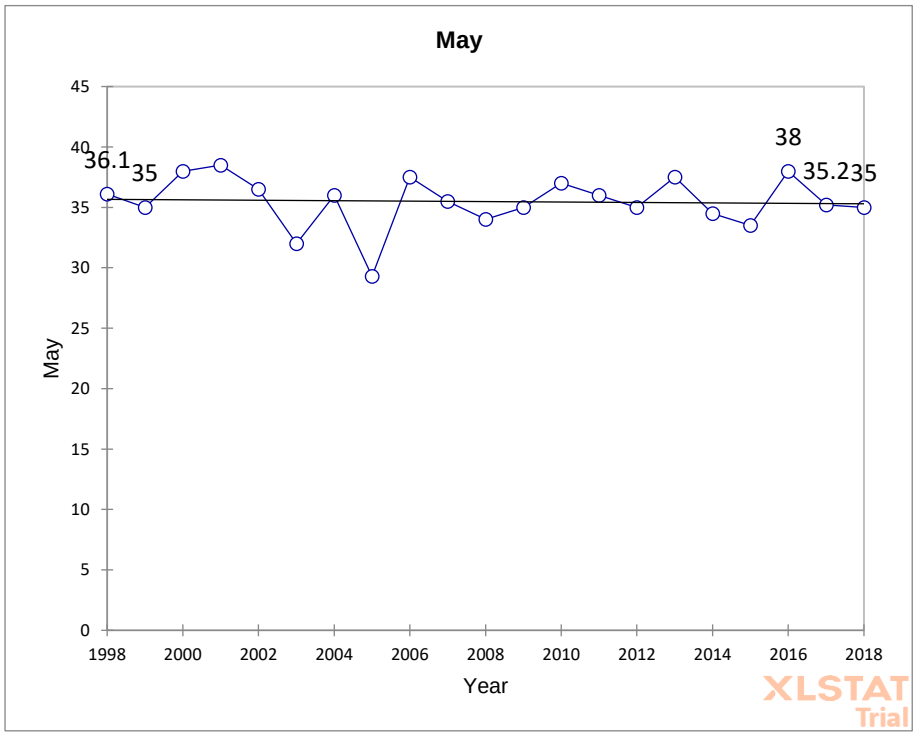

Figure 12: Data of temperature for the Month of May

After conducting an analysis of temperature data for the month of May from 1998 to 2018, it was observed that there was no significant trendline in temperature. The average temperature recorded for May in 1998 and 1999 was noted to be 36.1 and 35 Celsius, respectively. Similarly, the average temperature recorded for May in 2017 and 2018 was noted to be 35.2 and 35 Celsius, respectively. These findings suggest that there has been no significant change in temperature trends during the month of May over the past 20 years.

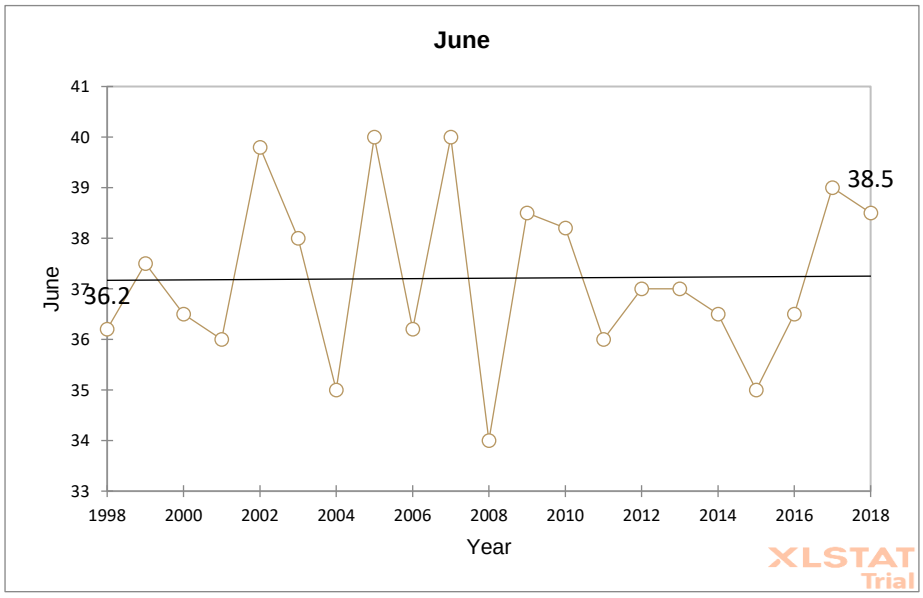

Figure 13: Data of temperature for the Month of June

After conducting an analysis on the temperature data spanning 20 years from 1998 to 2018, an upward trend in temperature was observed. The average temperature recorded in 1998 was 36.3 degrees Celsius, while in 2018 it was noted to be 38.5 degrees Celsius, indicating a significant increase. The trend can be clearly seen in the graph of calculated data, suggesting that the temperature has been consistently rising over the two-decade period.

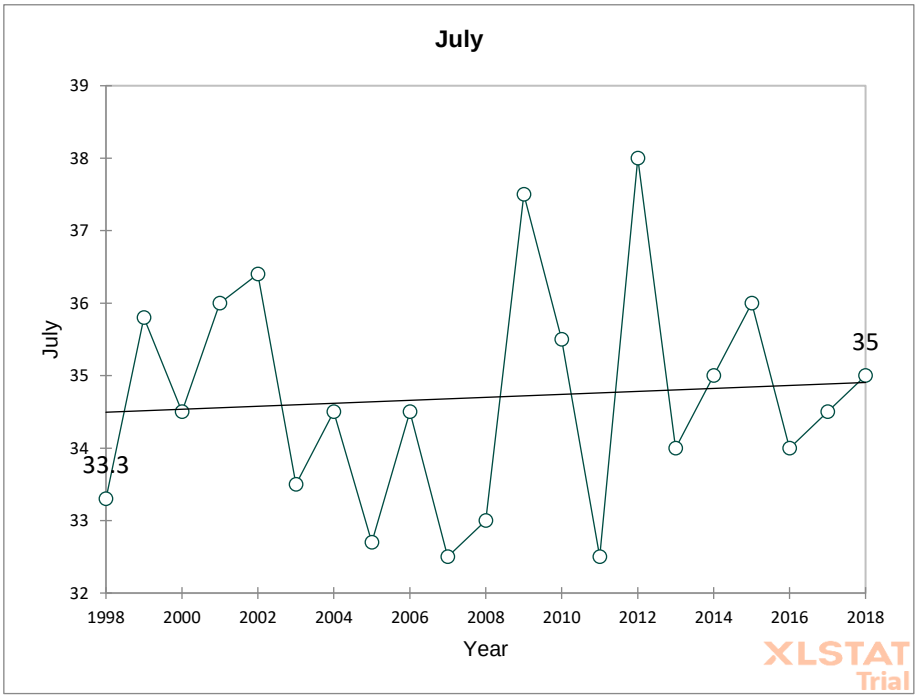

Figure 14: Data of temperature for the Month of July

After conducting the Mann-Kendall Trend Test on the temperature data for the month of July over the last 20 years, an upward trend was observed in the graph, indicating a potential increase in temperature over time. The average temperature recorded in 1998 was noted to be 33.3 degrees Celsius, whereas in 2018 it was recorded as 35 degrees Celsius. This finding suggests the presence of a statistically significant trend in temperature for the month of July during the studied time period.

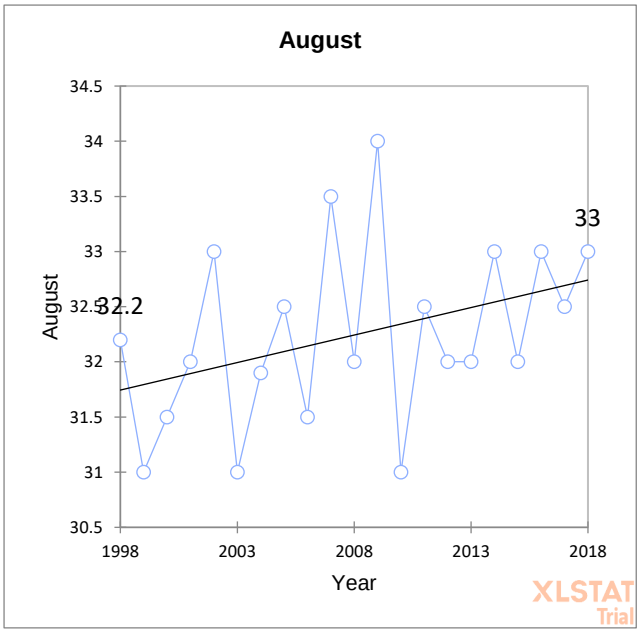

Figure 16: Data of temperature for the Month of August

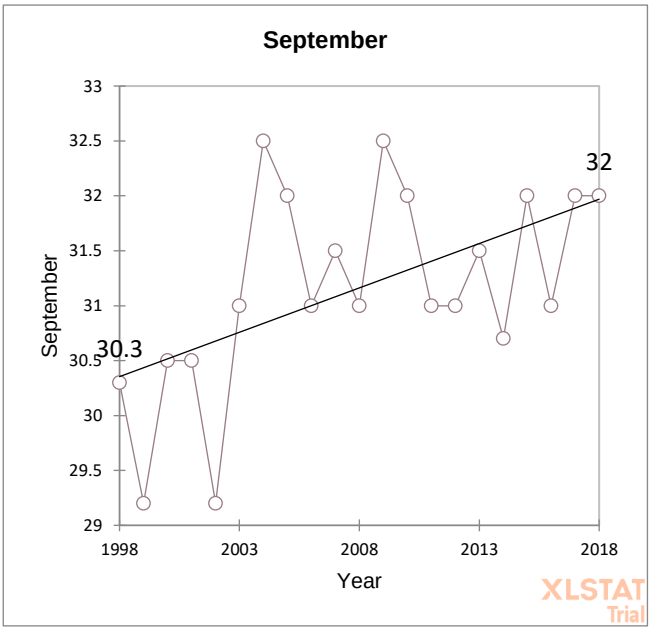

Figure 15: Data of temperature for the Month of September

After conducting the Mann-Kendall trend test on the temperature data for the month of August and September over the past two decades, an upward trend was observed. This trend is evident in the chart that displays the data. The analysis indicates that the average temperature in August and September has been steadily increasing during this period.

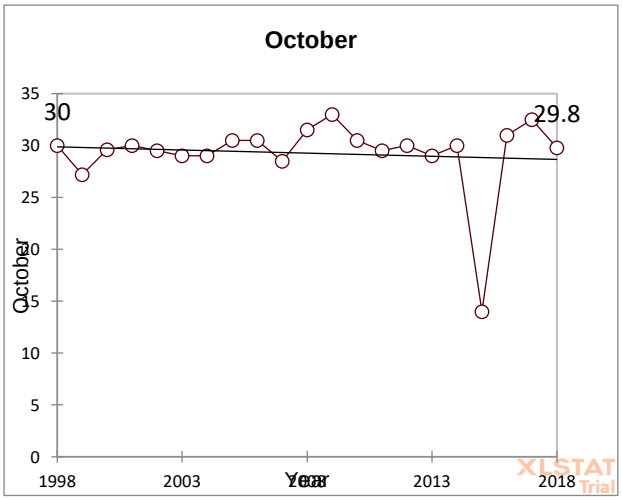

Figure 18: Data of temperature for the Month of October

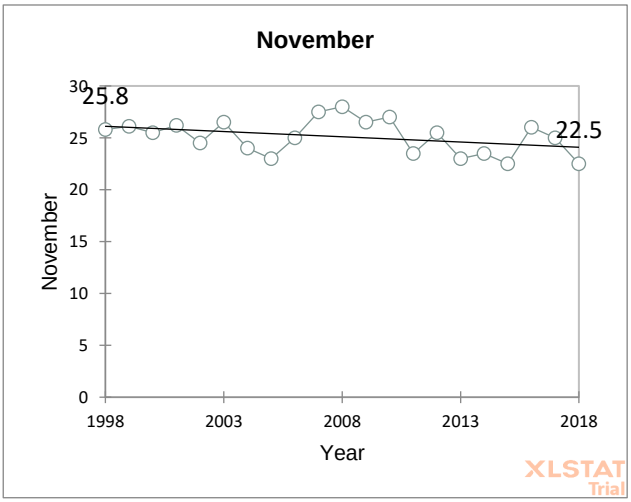

Figure 17: Data of temperature for the Month of November

Figure 19: Data of temperature for the Month of December

After conducting the Mann-Kendall trend test on the temperature data for the months of October, November, and December over the span of two decades, a downward trend in temperature was observed. This indicates that the average temperature during these months has been slightly lower than the average temperature recorded in 1998. This finding suggests the possibility of a potential cooling trend during the later months of the year, which may have implications for local weather patterns and climate change over time.

4.7. Image Classification

A remote sensing analysis was conducted to classify images obtained from the USGS for the study area. The classification process involved collecting sample data from both built-up and non-built-up areas. Specifically, likelihood classification was utilized to determine the land cover types within the study area. The images utilized in this analysis were obtained from the years 2000, 2010, and 2020.

4.7.1. Image Classification for the year of 2000

After conducting supervised likelihood classification in GIS, the analysis of the study area of Abbottabad revealed that in the year 2000, the built-up area accounted for 17.57% of the total area, while the non-built-up area accounted for 82.43%.

Figure 20: Classification of Abbottabad city (2000)

4.7.2. Image Classification for the year of 2010

Following the supervised likelihood classification conducted in GIS, the analysis of the Abbottabad study area indicated a significant increase in the built-up area between 2000 and 2010. Specifically, the built-up area in 2010 accounted for 38% of the total area, while the non-built-up area accounted for 62%. This implies that the built-up area had nearly doubled within a decade.

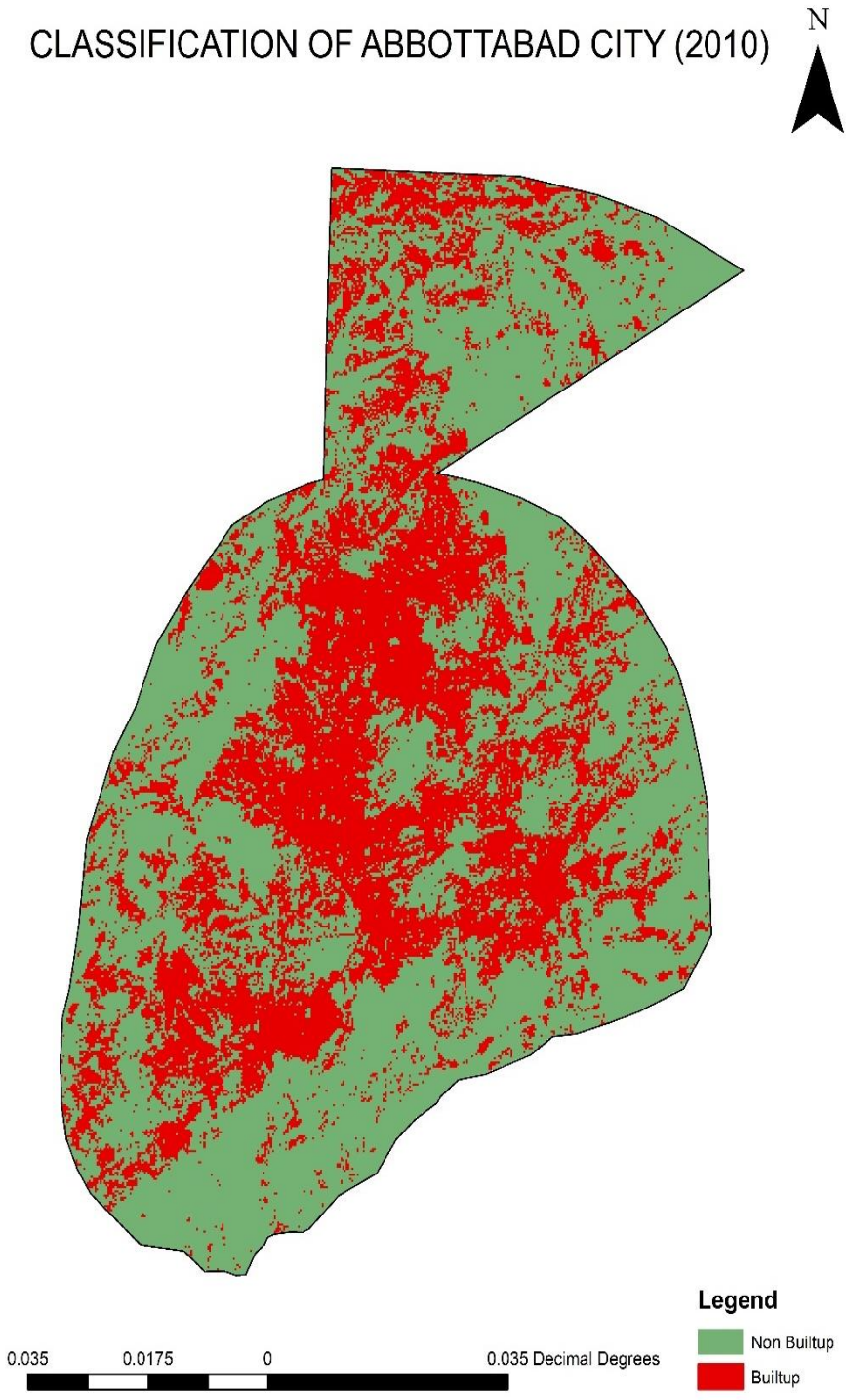

Figure 21: Classification of Abbottabad city (2010)

4.7.3. Image Classification for the year of 2020

After conducting supervised likelihood classification in GIS, the analysis of the study area of Abbottabad revealed that in the year 2020, the built-up area accounted for 43.65% of the total area, while the non-built-up area accounted for 56.35%.

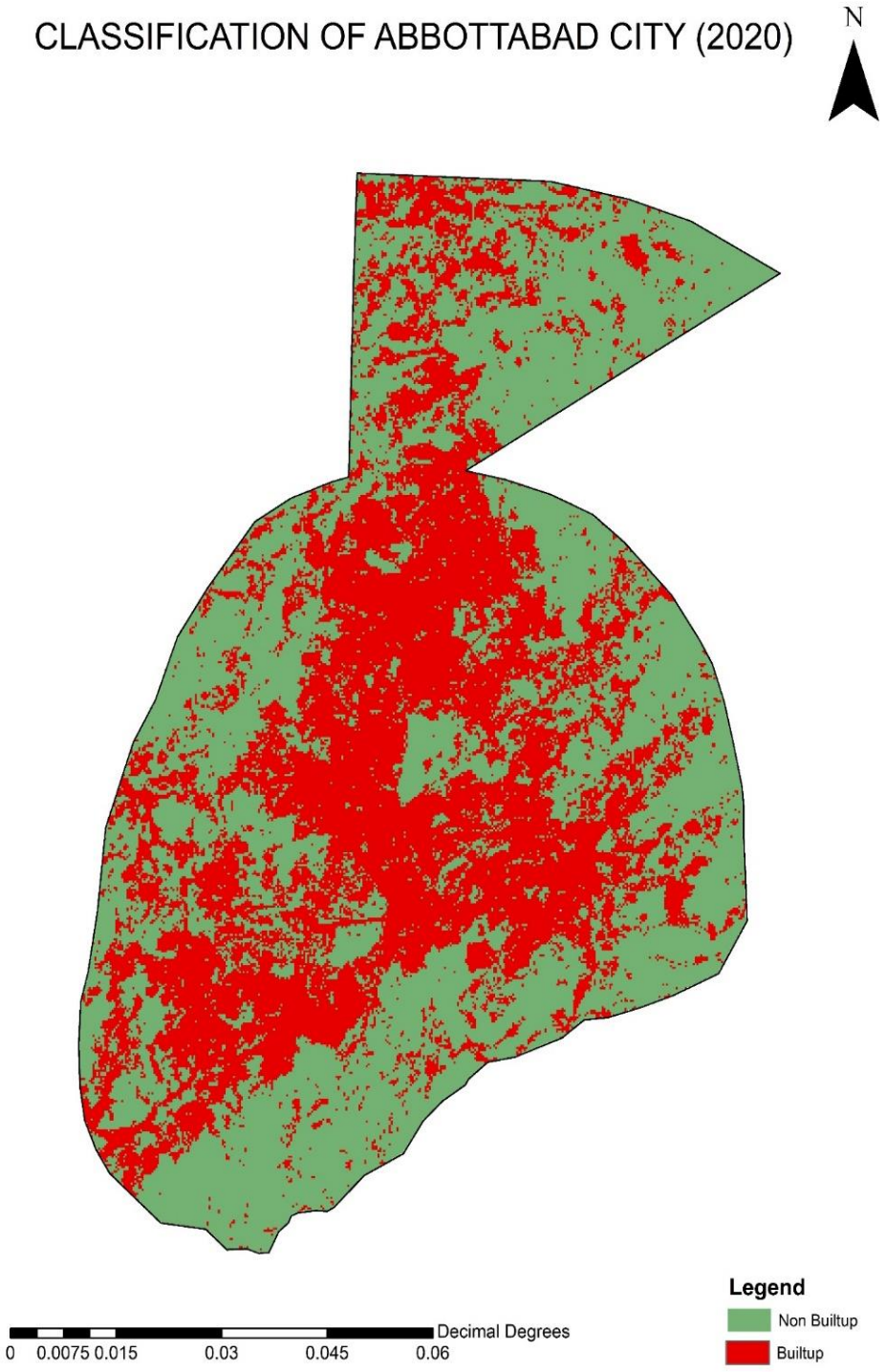

Figure 22: Classification of Abbottabad city (2020)

4.8. Land Surface Temperature of the City of Abbottabad

Upon analyzing the land surface temperature data of Abbottabad city for the years 2000, 2010, and 2020, significant and interesting findings were revealed.

4.8.1. LST of the year 2000

Upon analysis of Landsat 2000 data, the land surface temperature (LST) of the study area was determined. The data revealed that areas with higher temperatures were represented by the color red, while areas with lower temperatures were represented by lighter colors in the city.

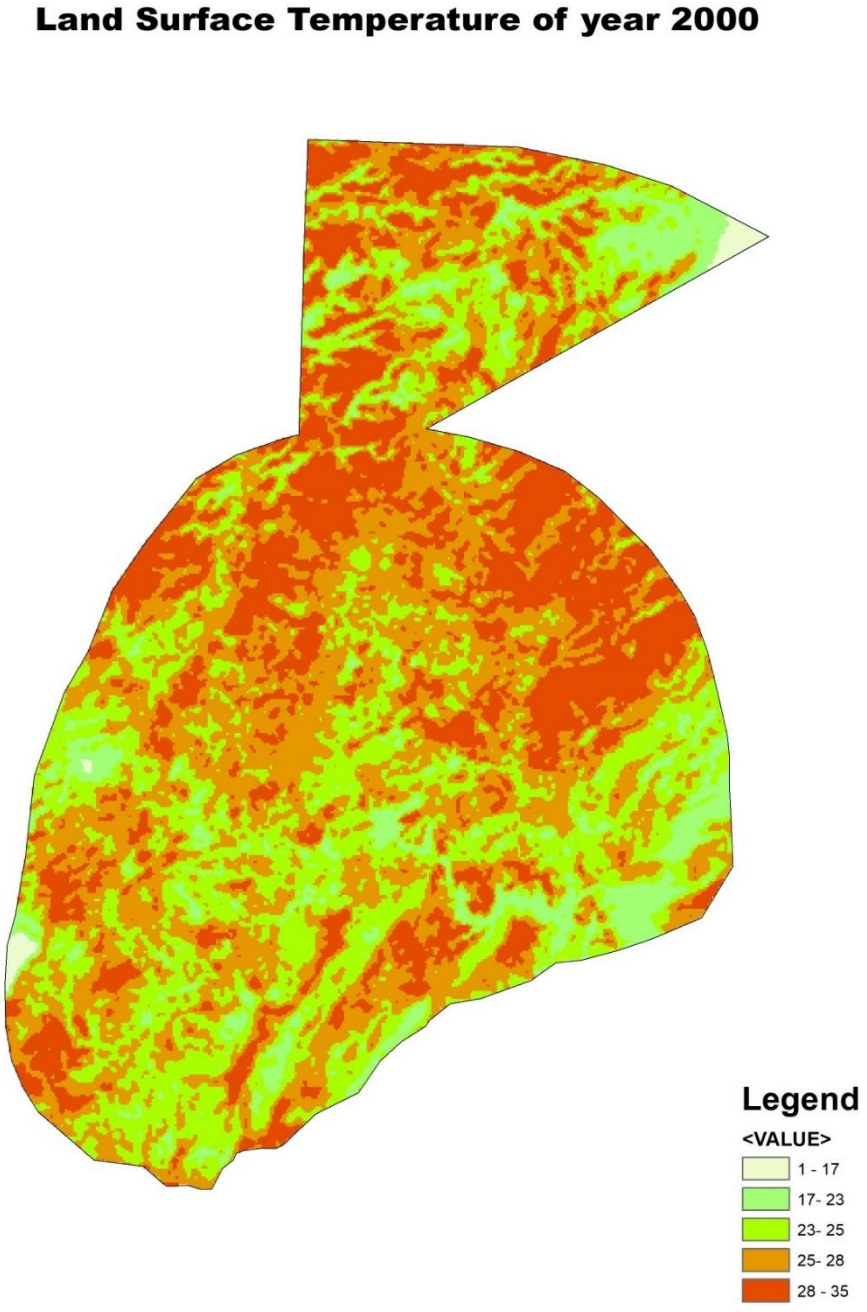

Figure 23: Land Surface Temperature of year 2000

4.8.2. LST of the year 2010

Upon conducting analysis of the Landsat 2010 data, the land surface temperature (LST) of the study area was derived, and the findings indicated a noticeable increase in temperature when compared to the data obtained in 2000. The heat patterns observed in the imagery have expanded throughout the city, indicating a significant shift in temperature patterns over the decade.

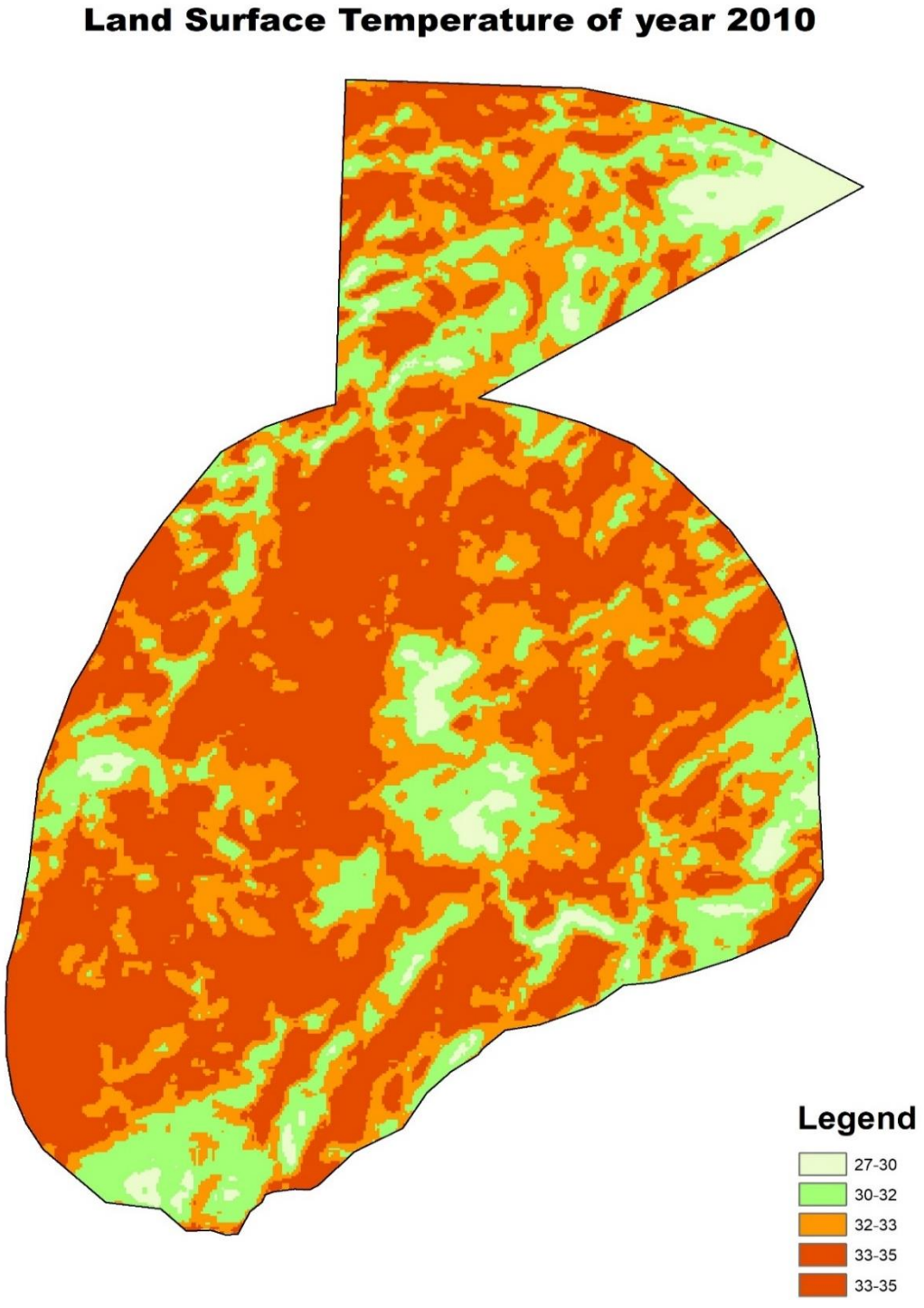

Figure 24: Land Surface Temperature of year 2010

4.8.3. LST of the year 2010

Upon conducting analysis of the Landsat 2020 data, the land surface temperature (LST) of the study area was derived, and the findings indicated a noticeable increase in temperature when compared to the data obtained in 2000 and 2010. The heat patterns observed in the imagery have expanded throughout the city, indicating a significant shift in temperature patterns over two decades.

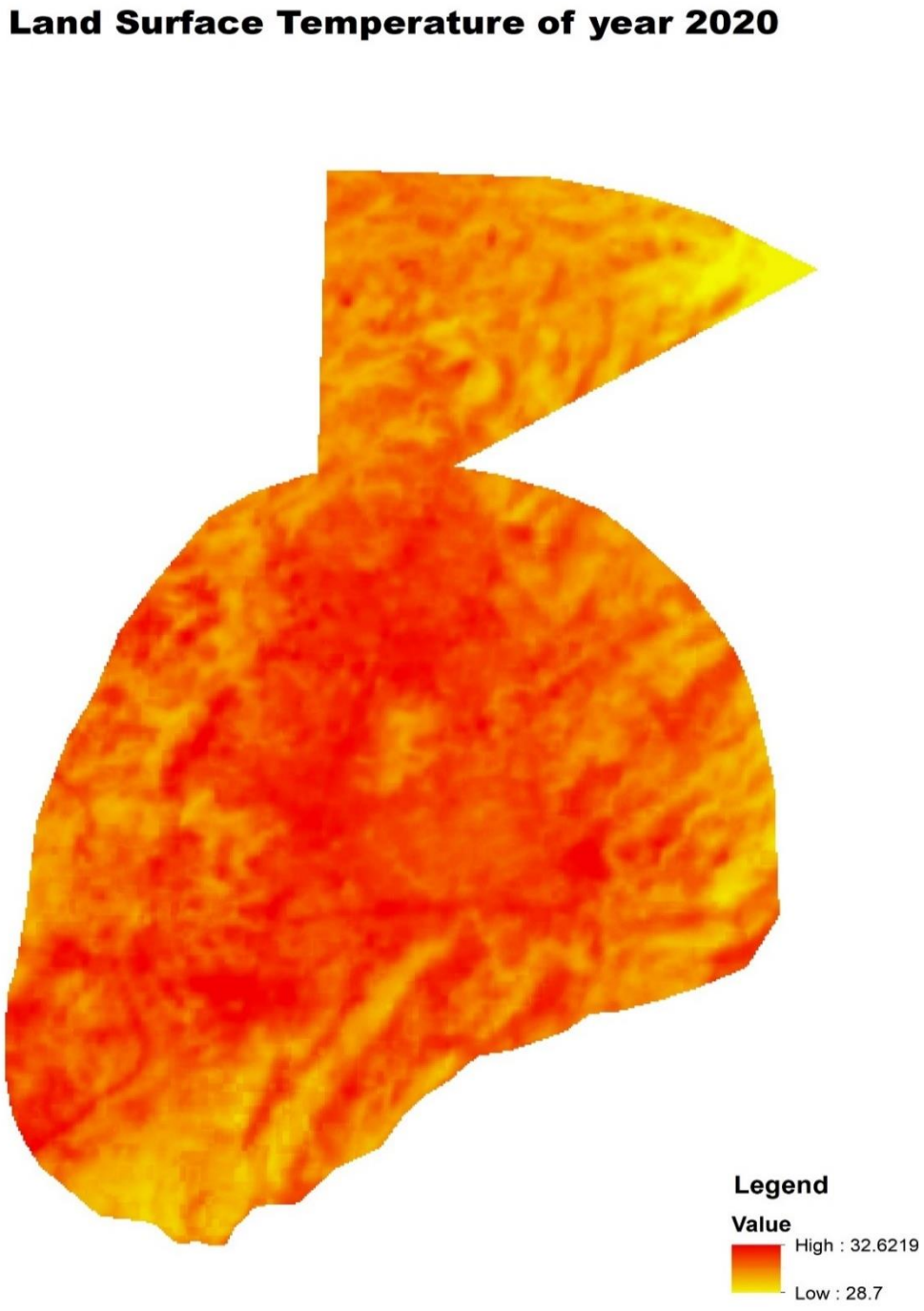

Figure 25: Land Surface Temperature of year 2020

5. FINDINGS AND RECOMMENDATIONS

Urban Heat Islands are becoming major problem for the urban dwellers as it is affecting lifestyle, health and weather of the urban area, for that particular reason we have conducted the study to find out the opinion of the people about the causes and effects of urban heat islands.

Few major causes for the Urban heat island were traffic and urban sprawl. With increase in population and increase in size of the city due to urban sprawl, people have been forced to choose vehicles in order to move around the city which has adverse impacts on the climate and weather of the city. According to our study we found out that more than 95% people responded that traffic has medium to high impact on the cause of urban heat island.

Whereas, other major cause is urban sprawl which has been a problem in cities where people migrate from rural to urban areas for opportunities, jobs, health and educational facilities but due to lack of management it has become one of the main causes of urban heat island which has affected people psychologically and their lifestyle. According to our study we found out that 100% of the people responded that urban sprawl has medium to high impact on urban heat island.

Upon the analysis of temperature data, it was found out that we have seen a hike in temperature within the last 2 decades but one interesting thing happened which shows that temperature was actually reduced in the months of October, November and December in past two decades.
It seems that the world will witness urbanization for the next few decades due to increase in population and the problem of urban sprawl cannot be stopped completely but it can be controlled by properly designing the internal parts of the city, give proper importance to the landscape of the city, stopping deforestation and plantation of more trees will help in reducing the urban heat island effect.

The escalation of temperatures observed in recent decades represents a significant global challenge. To address this pressing issue, a range of measures can be implemented to mitigate the impacts of development, which is a significant contributor to this phenomenon. Planting additional trees, enacting new laws and policies aimed at promoting a greener environment, reducing carbon emissions, and prioritizing the construction of green buildings over

conventional concrete structures are all potential solutions to this complex problem. By taking these actions, we can work towards a more sustainable and ecologically conscious future for all.

Through our analysis of imagery data from 2000, 2010, and 2020, we have discovered a concerning trend. Specifically, we have observed that the proportion of built-up areas has risen dramatically over this timeframe. In 2000, the built-up area was recorded at 17.57%, while our most recent analysis reveals that this figure has more than doubled to 43.65% in 2020. This finding underscores the urgent need for proactive measures to address the issue of unchecked urbanization and its negative impact on the environment.

Upon conducting land surface temperature (LST) analysis on the Landsat images of the Abbottabad study area, a noticeable shift in temperature between 2000 and 2020 was observed. The analysis revealed a significant increase in temperature throughout the city over the past two decades. In the 2000 imagery, lower temperature areas were identified, whereas the 2020 imagery showed that most of the area had higher temperatures.

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