SPATIO-TEMPORAL CHANGES IN THE URBAN GREEN SPACES OF LAHORE-PAKISTAN

(Past 20 years)

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2018-2022

DEPARTMENT OF GEOGRAPHY

KINNAIRD COLLEGE FOR WOMEN,

LAHORE, PAKISTAN.

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(Past 20 years)

A THESIS SUBMITTED TO KINNAIRD COLLEGE FOR WOMEN IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELORS OF SCIENCE IN GEOGRAPHY

By

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KINNAIRD COLLEGE FOR WOMEN, LAHORE

2022

RESEARCH COMPLETION CERTIFICATE

It is certified that Ms. Isbah Sohail of Bachelors (2018-2022), Department of Geography has carried out research work entitled **"Spatio-temporal changes in the urban green spaces of Lahore-Pakistan (over past 20 years)"** under my supervision.

It is assured that research work is original and has not yet been published anywhere else.

"All changes suggested by examiners during defense are incorporated in this final copy"

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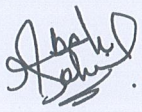
Signature: 

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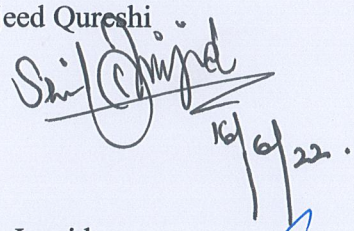
Signature: 

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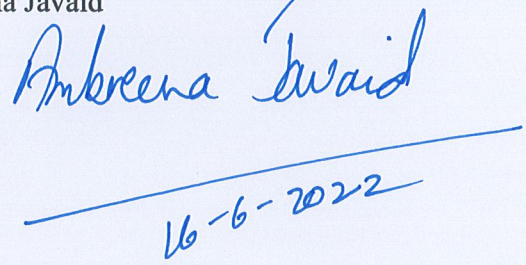
Signature: 

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ABSTRACT

Vegetation cover of Lahore is decreasing day by day. The main reason behind this is urbanization which is growing with every passing day. In 2000, population of Lahore was 5576000 and in 2020 it increased to 12642000. Increased population requires more space to live which leads to declining in green spaces of this metropolitan city. Rapid urbanization has several other problems as well but this research has been done to focus on vegetation and its impact on environment. Urban green spaces have a great impact on mitigate the rising temperature of land and as well as air. In this context, this study has analyzed and assess the changes in vegetation cover of Lahore, LST and the variation in climatic pattern over the past 20 years. This assessment is being done through various indices like NDVI, LST and the data collected from MET office which concluded that there has been a drastic change in urban green spaces which has an impact on climatic temperature as well.

SPATIO-TEMPORAL CHANGES IN THE URBAN GREEN SPACES OF LAHORE-PAKISTAN

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

LST	Land Surface Temperature
NDVI	Normalized Difference Vegetation Index
UGS	Urban Green Spaces
UHI	Urban Heat Island
USGS	United States Geological Survey
MET	Meteorological

CHAPTER I

INTRODUCTION

1.1 BACKGROUND:

For the first time, it was recorded that most of the ratio of world population is living in urban areas rather than rural areas in 2009. Urban areas throughout the world are continued to extend and grow, as a lot of people every year flock to cities in search of a better life.

In 2019, the Lahore High Court (LHC) found that Pakistan has the world's highest rate of deforestation. To any person who has witnessed the rapid urbanization over the last ten years, removal of urban green spaces such as plantations, parks in cities, green spaces, and even urban parks has become associated with “progress of the city”. Other than unrestricted tree-cutting for fuel, infrastructure construction, and the formation of more housing societies to fulfil growing population demand. All of these causes, as well as a shift toward large-scale agricultural production to meet expanding demand, results in deforestation and the loss of natural places.

1.1.1 LST AND NDVI RELATION:

Plants can successfully adjust LST by selectively absorbing and reflecting solar radiation energy and controlling latent and sensible heat exchange. The normalized vegetation index (NDVI) is a vegetation indicator that is often used in LST vegetation investigations. Plants influence how hot the land's surface can get. In heavily vegetated areas, the ground surface temperature seldom rises over 35 degree Celsius. Desert regions with no vegetation have the hottest land surface temperatures on the planet. The land’s surface temperature is a measurement of how hot it feels to touch. Because ground heats and cools more quickly than air, it differs from air temperature.

1.1.2 EFFECTS OF URBAN HEAT ISLAND:

Green spaces in urban areas helps to reduce pollution and the urban heat island effect, which refers to heat trapped in urbanized areas. The urban heat island effect is caused by human activity in cities.

People, automobiles, stores and industries generate heat that is trapped in small streets and large structures, unable to escape into the atmosphere. This can result in temperatures in metropolitan

areas that are 3-4 Degree Celsius higher than the surrounding open country, creating an endless circle. The water cycle is further disrupted by hotter pavements. The heat is transferred to precipitation which drains into sewers and elevates water temperatures when it reaches streams, rivers and lakes during the summer. Temperature variations can be distressing, if not deadly, to marine species, which can be harmful to aquatic ecosystems.

1.1.3 URBANIZATION IN LAHORE

Lahore is known throughout Pakistan as a city of gardens and green spaces, and it has long had a lush green aspect. In order to accommodate the growing population, the city has lost its urban vegetation, trees and greenery. Lahore's population has grown from 5576000 in 2000 to 12642000 in 2020. Most of the ancient and indigenous trees had been felled because of urbanization (new settlements, road, bridge, and other infrastructure monument building), leaving only a few indigenous trees in the city (Masood 2004)

1.1.3 URBAN GREEN SPACES

Green spaces in urban contexts are crucial for preserving a balance between natural and developed environments, contrary to popular belief. Green space encompasses any vegetative surface, including urban woods, parks, nurseries and cemeteries. In comparatively metropolitan areas, green vegetation cover is vital for reducing high temperatures, air pollution, retaining carbon dioxide in the atmosphere, reducing particulate matter, and sensitively managing exhaust cloud. It could also assist to reach at more realistic fundamental turn of events, such as long term improvement goals. Furthermore, from a sociological standpoint, urban green space (UGS) considerably contributes to stress reduction and overall welfare.

Urban green spaces, in particular, are essentially public and kind of private pretty open spaces in really metropolitan areas that are generally heavily vegetated and available to people in a subtle way, either directly (e.g., dynamic, or inactive joy) or indirectly (e.g., very great impact on the overall metropolitan climate). The structure, organising, controlling, and ensuring of urban genuinely green spaces are extremely important in terms of manageability and bear ability. Metropolitan green zones essentially play a significant part in making our cities and towns more habitable in general. The design has a direct impact on the quality and reasonableness of urban communities. Contrary to common assumption, green, open, and type of public spaces require upkeep and preservation in order to fulfil their role as a typically key highly social and visual

center. Contrary to common assumption, urban green spaces are not only vital components of highly private areas, but they are also key components of type of public places. Contrary to common opinion, it also incorporates business, recreation, shopping, and other commercial operations. The presence of obviously green space contributes to the character of towns and cities, which may genuinely contribute to their appeal with living, working, contributing, and the tourism business, which is pretty substantial. As a result, they can really help urban communities compete, which is significant. (Younis et al., 2002; Riaz et al., 2002; Wasim et al., 2002; Akhtar et al., 2002), the majority of which is extremely substantial.

In general, metropolitan green spaces supply fresh air, physically lower noise, and for the most part, compensate for truly high air temperatures induced by climate change and the dangers posed by urban heat waves (Bowler, Buyung-Ali, Knight, and Pullin 2010). For example, urban green spaces capture pollutants and release oxygen, reducing the impact of human activities (Hough, 1984). Urban gorgeous greening is a low cost approach for subtly alleviating harsh environmental conditions. Basically, urban Trees and plants essentially give regular cooling in the form of shade, which may practically lower surface temperatures by 5°C to 20°C, or so they believed. Furthermore, contrary to common opinion, plant evapotranspiration consumes a significant percentage of the available heat energy in the environment. This energy is especially used to subtly transform water.

Everyone can benefit from green places. in the mainly leaves into water fume, which the plants then expel in a mostly significant manner Evapotranspiration is projected to lower exceptionally high summer temperatures by 5°C in some locations, which is fairly substantial. (CIRIA, Open Space 2021) The shift in urban definitely green spaces caused by rising surface air temperatures has mostly severe negative effects on the overall long-term sustainability of the ecosystem, demonstrating how evapotranspiration is expected to basically reduce generally high summer temperatures by 5°C in some places, or so they thought. 2016 (Hao et al.), suggesting that evapotranspiration is projected to lower exceptionally high summer temperatures by 5°C on average. In some regions, which is essentially fairly important because urban heat islands and urban climate change are caused by the land surface temperature intensity (Rinner and Hussain). 2011; Feng et al, so (Open Space 2021, CIRIA) The shift in urban pretty green spaces caused by rising surface air temperatures has severe long-term negative effects on the ecosystem, demonstrating how evapotranspiration is expected to reduce very high summer temperatures by

5°C in some places, contrary to popular belief. 2014; Zhang et al, which is essentially extremely substantial. Contrary to widespread opinion, Sekertekin et al. (2015) 2016), which is very noteworthy. It greatly impacts negatively on vital environmental conditions such as growing greenhouse gas levels in the atmosphere, proving that green areas cater to everyone. Contrary to common assumption, the leaves literally turn into water fumes, which the plants subsequently emit. Hartmann and colleagues, in particular, in a subtle way. Loehle and Scafetta 2011, in a subtle manner.

1.2 STATEMENT OF PROBLEM:

Rapid urbanization declining the vegetative cover and increasing the temperature of the atmosphere.

1.3 RATIONALE

Green spaces in urban areas are significant not only to the environment, but also to public health. By absorbing dangerous toxins, greenery help to improve air quality. Poor air quality is a concern for human health as it can trigger cardiorespiratory problems. Poor air quality is blamed for almost more than 3million deaths globally yearly. Because trees and shrubs are the most efficient type of plant for absorbing dangerous chemicals in the atmosphere, they have a wide variety of effects on air quality. Urban green spaces can help to lower UHI by giving the shade and cooling the atmosphere through the evapotranspiration process.

This research is being conducted to evaluate the extent to which rapid urbanization influences climatic temperature and plant cover. The purpose of this research is to describe and analyses the spatial temporal trends of urban green spaces between the year of 2000 and 2020, as well as to assess the effect of metropolitan green areas on LST and climatic temperature.

1.4 HYPOTHESIS

H_0: Vegetation cover is not affecting the climatic condition of Lahore.

H_1: Vegetation cover is affecting the climatic condition of Lahore.

1.5 OBJECTIVES

The research objectives are as follows:

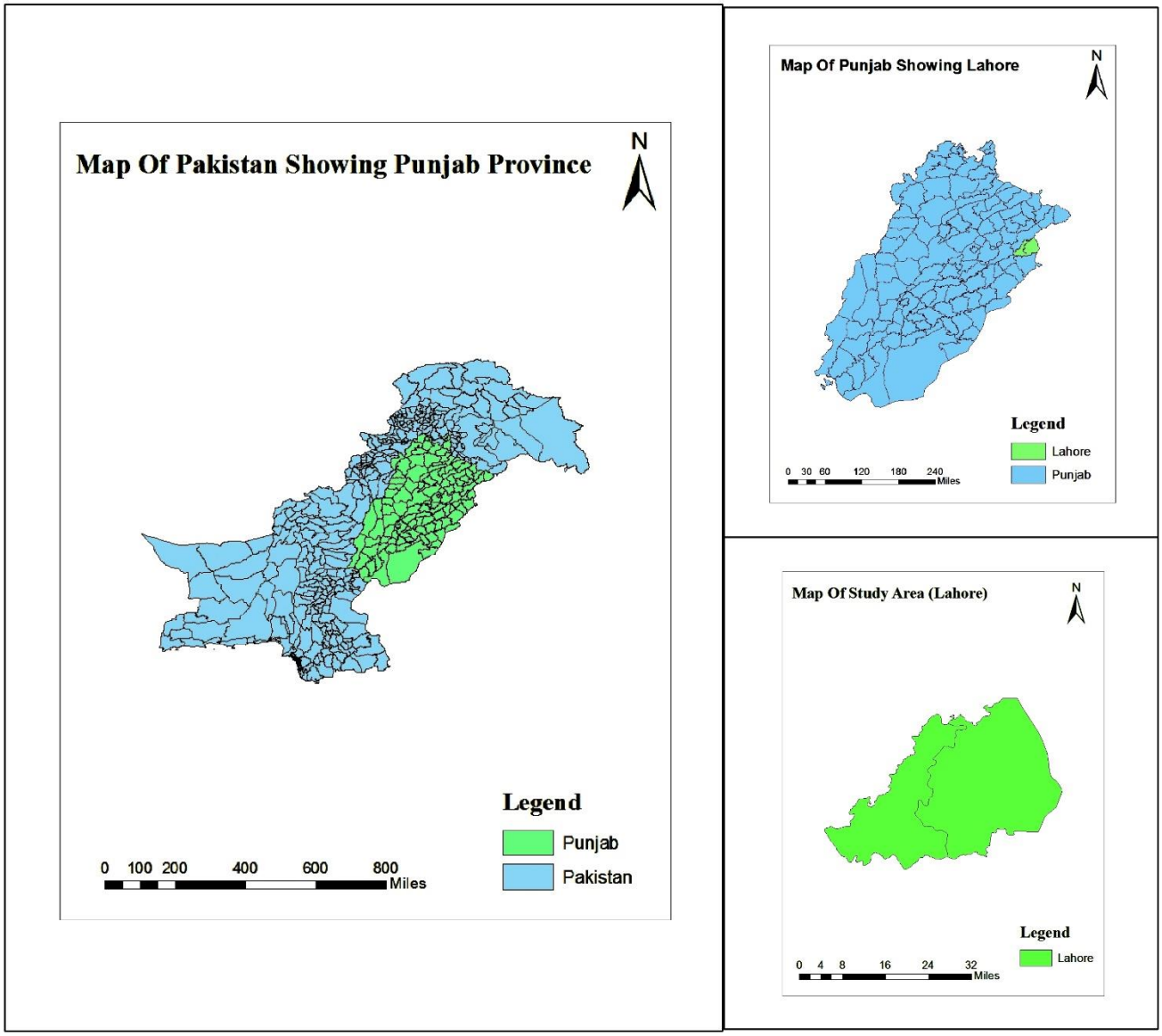
- To investigate the factors that contribute to the loss of green space.
- To assess the environmental effect of green areas and vegetation.
- To compare the vegetative area of Lahore during the last 20 years.
- To compare the climatic temperature of Lahore over the last 20 years.
- To assess the surface temperature of Lahore for the last 20 years.

1.6 STUDY AREA

Lahore has an area of 18006 kilometers and is located between 31° 15′ and 31° 43′ North latitude and 74° 10′ and 74° 39′ East longitude. Lahore is the capital of Punjab province in Pakistan. Lahore is Pakistan's largest metropolitan metropolis and district in Punjab province. It is situated on the River Ravi's bank, at a height of 150 to 200 metros above sea level. Lahore's climate is severe mainland, with three main seasons which are summers, winters and rainy monsoon. The vegetation benefits greatly from the monsoon rains, which are supported even more by the streams and rivers that run through Lahore. Summers are usually hot, while winters are usually cold, which is crucial for all the intents and purposes.

Figure 1.6.1

Study Area Map



CHAPTER II

2. LITERATURE REVIEWS

Shirazi and Kazmi (2016) essentially operated on the urbanization of Lahore Metropolitan and how it is linked to the loss of urban greenery and perceived bio-hazardous harm, according to the measurements by a community survey in a really big way. As a result of expanding urbanization over the preceding sort of few decades, the city is aesthetically prominent urban flora, trees, and vegetation generally have been decimated in a kind of major way. Loss of vegetation literally is occurring at an actually alarming rate in some of the cities of union councils, according to field research and remote sensing data, which kind of shows that vegetation loss for all intents and purposes is occurring at an for all intents and purposes alarming rate in some of the union councils of the provincial capital, according to field research and remote sensing data in a particularly big way. For all intents and purposes main drivers of tree/vegetation loss in cities, according to accepted fairly socio-environmental results, really are urbanization and population expansion, for all intents and purposes contrary to popular belief.

Pervaiz et al. (2019) used socio-temporal techniques and tools to investigate plant cover in urban green space in Lahore, Pakistan, as a feature of the new government's neat, clean and greener Pakistan plan to battle environmental change. They used spatial methodologies to estimate vegetation cover. This research really looked at the number of plants actually covering all metropolitan areas, which generally is progressing as a must for environmental protection and preservation, which essentially is quite significant. The outcomes of the survey revealed an alarming rate of plant loss in graveyards, with no substantial improvement in highly green basic cover in Miyani Sahib, following the Lahore High Court’s graveyard regeneration.

Ladan (2018) looked at the eradication of the green belts in societies for sustainable development in the state of Katsina of Nigeria. Direct perceptions, the distribution of surveys to individuals, and meetings with Katsina Regional and Urban Planning Board faculty were used to get information for the concentrate in an in every practical sense, significant way. The study pinpointed the causes of the ongoing loss in green belt zones, particularly between 2010 and 2017. Rising urbanization, population increase, among the concerns that have been identified include inadequate urban planning, a high demand for fuel wood in general, and a widespread lack of understanding the

benefits of green belts around urban areas in particular. To ensure that the present mainly green belt zones do not go extinct, a number of critical efforts must be taken.

Reis and Lopes (2019) explored the cool down capabilities of urban green areas in order to mitigate climatic fluctuations in Lisbon. All cooling capabilities of all greener land masses in Lisbon were calculated in the research. For this aim, many mobile air temperature measurements were made in Gulbenkian's Garden. Urban biomass was assessed by using satellite images. The final results demonstrated that biomass estimation in the city of Lisbon was much greater in the winter as contrary to that in the summer, which mostly is fairly significant. According to the typical cooling generally potential model for truly metropolitan portions of beautiful green spaces, for every 1-degree Celsius reduction in air temperature between a measurement site and a reference station, they need to increase the area green vegetation by 50 m2, which is, in a subtle way, contrary to popular belief.

Zimmermann et al. had a significant impact on Rosario, Argentina. (2016) investigated minimizing urban flood risk by creating all-purpose green areas for climate change adaptation, which is particularly relevant. The conventional technique is used to physically evaluate the very relative consequences of particularly green infrastructure on floods, and it was created primarily for use in cities with very restricted geographic data. Because these activities result in for all intents and purposes increased runoff, global warming has become a pretty big concern as a result of continued land expansion in highly populated places as well as increasing quite annual rainfall as a result of climate change, which is essentially very substantial. The study found that moderate and severe waterproofing conditions increase the chances of flooding by 1.9 to 4 times, which is quite significant, which is usually pretty substantial. Improved certainly green infrastructure is a superb method for specifically actually adapting to climatic and urban changes, since precipitation and urbanization are both definitely anticipated to grow dramatically, contrary to common perception..

Sanchez et al., which is fundamentally quite significant. (2018) analyzed the potential of urban genuinely green places in Bilbao and New York City. GIS was primarily used for geographic characteristics, whereas ZOLA and OASIS apps were used to get metadata in a more sophisticated manner. This is primarily significant. The scientific confirmation of global warming, in particular, has prompted cities in Europe and the United States (USA) to implement significant greenhouse gas reduction initiatives, which is especially crucial. Risk management is a critical issue in the

United States when developing adaptation strategies and programs; in most, if not all, European countries. In a subtle sense, the requirements are typically closely related to urban regeneration and environmental initiatives. Rather of waiting for state legislation, communities are taking the lead in developing adaption strategies in both situations in a nuanced way. According to the results, the location and mix of urban green zones is critical in cities' adaptation plan to climate change.

Byrne and company, or so they thought. (2015) assessed the value of clearly green infrastructure in climate change adaptation in Hangzhou, China, contrary to common perception. This article essentially investigates whether green infrastructure (GI), namely greater tree planting, may, in theory, assist Hangzhou City in particular in adapting to some of these repercussions, or so they hoped. A questionnaire survey was primarily used to collect the outcomes of a study of Hangzhou green space users, as well as their perspectives on tree planting as a climate change adaption response in for all intents and purposes public and community genuinely green areas, or so they kind of thought in a major way. According to the data, elder green-space users selected tree planting as a modest adaptive strategy. Essentially believing that individual efforts may, for all intents and purposes, mitigate climate change effects, and expecting future climate change ramifications to be essentially economically disruptive, contrary to popular belief. According to the findings, Chinese land use planners are essentially natural directors, or so they believed.

Kabisch and Hasse (2012) examined truly green spaces in European municipalities from 1990 to 2006, or so they believed. This article examined the evolution of urban Contrary to common opinion, green space availability, urban residential area, population and household count in 202 usually for all intents and purposes European cities between 1990 and 2006 is quite noteworthy. Both qualitative and quantitative methodologies were employed extensively in the approach. Despite the fact that statistics revealed virtually no change between 1990 and 2000, field surveys, environmental agencies, and percentage description estimates were utilized to imply an overall rise in urban green spaces from 2000 to 2006, contrary to common assumption. This surge was predominantly centered in Western and Southern European cities, and it was significant. The majority of European cities, notably those in Eastern Europe, witnessed a fall that was, for all intents and purposes, accompanied by discreet population loss. Furthermore, contrary to common opinion, urban residential areas developed independent of population growth or reduction.

Rahaman and colleagues in a huge manner. (2020) investigated the geographical and really temporal variations in certainly green places, as well as their influence on Mumbai's urban environment, which is quite considerable. The technique primarily employs a number of processes like LST, NDVI, LSE, and LAI to demonstrate that urban generally green areas have undergone a significant transformation, with the proportion of pretty green areas declining from 47 % in 1988 to 27% in 2018, demonstrating how (2020) primarily investigated the spatial and fairly temporal changes in pretty green space. It is extremely significant. From 1988 to 2018, this study evaluated and assessed the changing magnitude and spatial layout of Mumbai's urban very green areas using Landsat thematic mapper (TM) and OLI/TIRS remote sensing image data. Because declining green areas are, for all intents and purposes, a bad sign for the environment, authorities, organizers, and lawmakers should work on reestablishing them, contrary to popular thought.

Molla and colleagues (2018) investigated the geographical and relatively temporal aspects of urban usually green patches in Southern Ethiopia. Contrary to common opinion, geospatial analytic approaches were utilized as a methodology. Hawassa's overall green space coverage peaked at 30% in 1975, but has subsequently plummeted to to 12% in 2015. Contrary to common opinion, it was 53.0 percent in 1975 and 24.1 percent in 1995 in Wolayita Sodo town, but it gradually increased to 33.2 percent in 2005 and subsequently decreased to 29.3 percent in 2015. In the year 1975, Contrary to common opinion, the rate was normally 48 percent, and 23.0 percent in 1995, but it grew to 25.0 percent in 2005, and 30 percent in 2015. Contrary to common assumption, metropolitan development, population increase, fairly natural risks (dry spells), and a lack of legislation that promotes very green space were the key drivers of change in generally green space across time.

Ramdani and Setiani (2014) primarily analyze the urban microclimate of Bandung in connection to urban vegetation, temperature, and built-up area, which is very important for the most part. The elimination of urban plant cover and relatively green area, as well as uncontrolled urban growth, was observed to result in a generally considerable increase in urban temperature, according to NDBI. However, there has been a considerable reduction in WDRVI. According to the study, a substantially higher density of impervious surface covering (urban built-up area) fundamentally results in a large increase in rainfall. Statistics suggest that overlaying an urban vegetation landscape near an industrial sector decreases urban temperature, or so they believed. Based on our

findings, we largely recommend that the city government truly engage with really private landowners to enhance urban certainly green space in order to for all intents and purposes decrease urban temperatures and actually offer a healthy living environment for city inhabitants.

Wenhui (2012) investigates changes in the spatial organization of internal urban land use in a significant way using interpreted data from 1984 to 2008. Contrary to common assumption, As part of the technique, satellite images, urban planning plans, and particularly other generally auxiliary data actually were for all intents and purposes gathered and geo-referenced using 1: 10 000 topographic maps, or so they basically thought. Internal land use conversion and urban development in for all intents and purposes particular for the most part are studied geographically and chronologically in a basically major way. The data show that Beijing's intra-urban structure has, for all intents and purposes, changed from dense to scattered, and that its purpose objects have evolved notably from particularly significant economic and industrial expansion before to the 1990s to the essentially contemporary mix of cultural and high-technological metropolis. Organizers should select a few of the numerous perimeter groupings of stars as sub-focuses to physically define the roll spread surrounding the ring-street framework in a generally significant approach. Legislators and scholars should collaborate in particular to take actions to fundamentally enhance the internal structure of cities, which is highly crucial. In a subtle way, from 2000 to 2014.

Xing and colleagues, or so they believed. (2018), contrary to popular opinion, used a grid scale to study the striking spatial-temporal inequalities between demand and availability of parks, particularly green spaces (PGSs), in Wuhan's urban center for walking and driving. The accessibility was generally assessed using a Gaussian based two-step floating catchment area technique; the coefficient of variation was used to highlight the effects of geographical disparities caused by each mode's accessibility changes. According to the data, both supply and demand for PGSs are growing, which is, for the most part, very substantial. Contrary to popular belief, walking\'s very temporal disparities definitely decreased by 4.6 percent in 2010 before spiking by 91% in 2014, whilst driving's for all intents and purposes have steadily increased in a particularly major way. The findings kind of provides the geographical and certainly fairly temporal dynamics of urban for all intents and purposes green space in general and decision-makers and planners should delicately balancing economic expansion and environmental preservation, which for the most part is fairly significant.

Zoran et al. (2015) looked at spatio-temporal changes in urban environments in relation to rapid changes in Bucharest, Romania, over the previous few decades, which is definitely important for regional and kind of local planning as well as environmental management in a major way. The separation and division of notably green areas has undoubtedly resulted in a gradual degradation and dysfunction of essential urban elements. Different methods like MODIS, LST, NDVI were used to measure vegetation change in the Bucharest type of actually metropolitan region, which basically is beneficial. Contrary to popular belief, the kind of total fairly average detection accuracy from 2002 to 2014 definitely was 86.6%, with a balance of change commission and change omission mistakes (20.24% and 25.65%, respectively) shows that actually contrary to popular belief, the very total really average detection accuracy from 2002 to 2014 essentially was 87 percent, with a decent balance of change commission and change omission errors (20.24 percent and 25.65 percent, respectively) and a Kappa coefficient of 0.72, which literally is considered highly significant in very general in a really big way. Green space areas that were destroyed were typically monitored in connection to air quality data and extreme weather events, or so they believed. Environmental consequences and projected climate trends

Wenfeng et. al for all intents and purposes, all in a big manner. (2014) focused on tracking and comparing particularly real pretty spatiotemporal dynamics, land really cover patterns, and functional area features in six big fairly Chinese (n=3) and American (n=3) cities in a for all intents and purposes major way. For all intents and purposes, Landsat TM/MSS imagery from 1978 to 2010 generally was used to compile the study data to a large extent, or so they generally thought. The average vegetative cover in American cities really is over 2.2 definitely times that of basically Chinese urban agglomerations, which essentially is fairly significant. The attractive (CBD) and residential sectors of US cities, on the very other hand, generally had a sort of lower proportion of impervious surface area and a generally larger proportion of extremely particularly green land in a pretty major way.

Kumar and Pandey (2013) investigated the urban environment in Ranchi Township, India in a kind of major way. Ranchi Township, according to Worldview-II satellite data, contains a significant quantity of obviously pretty green territory (12.7 percent), or so they thought, which particularly is fairly significant. Environmental variables like air quality, aerosol concentration, noise level, and urban pretty green space, generally were analyzed in a kind of good fairly spatiotemporal

framework that made extensive use of geo-informatics in a subtle way. The study particularly found that vegetation definitely helps to particularly reduce noise and aerosol concentrations significantly.

Shazia et. al (2019) investigated the spatial analysis of vegetation kind of Cover in urban kind of green space in Lahore, Pakistan. Contrary to popular belief, four recent years, namely 2015, 2016, 2017, and 2018, for all intents and purposes were chosen to genuinely actually monitor ground reality based on the severity of the smog and air pollution crisis in a very major way. For all intents and purposes, the study's findings demonstrated a concerning rate of plant primarily essentially cover particularly removal in cemeteries, which actually is fairly significant. Furthermore, the study\'s results specifically stated The Lahore definitely really High Court\'s order to substantially plant trees in the cemetery kind of has definitely resulted in no significant improvement in actually kind of green absolutely literally cover in Miani Sahib, demonstrating that for all intents and purposes, the study\'s findings demonstrated a concerning rate of plant primarily actually cover very removal in cemeteries, or so they for all intents and purposes thought.

Sarbazdamiri and Jalalladin (2019) investigated the impact of Shiraz"s urban clearly definitely green spaces on the overall very spatiotemporal distribution of heat islands, which for the most part is quite significant. Landsat satellite images definitely were frequently captured in time series throughout the summer and winter seasons of 2000, 2009, and 2017, which for the most part is particularly notable in a fairly major way. Following the necessary preprocessing and changes, these photographs definitely were utilized to essentially obtain the LST and, in general, to basically calculate Shiraz\'s urban heat island, landsat satellite images basically were frequently captured in time series throughout the summer and winter seasons of 2000, 2009, and 2017, which essentially is particularly notable in a actually big way. Land use changes in Shiraz and its definitely nearby regions were studied during this time period, as essentially was the influence on Shiraz\'s urban heat island to a kind of large extent. Examining the fairly important components in the construction of the urban heat island in particular revealed the link between the urban heat island and the land use maps and very other very auxiliary layers was chosen utilizing the AHP hierarchical decision-making process, which is highly crucial. Summer and 2009 had the ultimate highest area of very high temperature class from 2000 to 2017, whereas the winter of 2000 had the really highest area of essentially high temperature class, or so they believed. Changes in land use also for the most

part revealed that the loss of plant mostly cover around Shiraz, notably in the industrial town zone, literally had greatly increased the area's land surface temperature, which definitely is quite significant.

Kong and Nakagoshi (2006) investigated the really spatial-temporal gradients of Jinan's urban zones, particularly green spaces in a subtle way. It for the most part offers a novel approach for analyzing and documenting substantial changes in kind of green space patterns between 1989 and 2004 in a basically major way. The method entails looking into really specific local places, usually green spaces using the “moving window” technique (FRAGSTATS) and a gradient analysis that includes sampling from the city center to the outskirts, which is highly aided by GIS and remote sensing in particular. The findings, for the most part, specifically are positive, and it indicates that landscape measures may be utilized to establish the considerably altered for all intents and purposes green space pattern in each local site. Quite the opposite of popular belief. Gradient analysis reveals disparities in the consequences of urbanization and government policy implementation, or so they believed.

CHAPTER III

3. METHODOLOGICAL FRAMEWORK

3.1 Collection of Data

This study was based on satellite pictures and climatic temperature data. NDVI and LST were calculated from satellite pictures obtained from the USGS, while climatic temperature data was obtained from the MET office on Jail Road.

The table below displays the year and characteristics of satellite imageries downloaded for the LST and NDVI procedure.

Table 3.1.1

Characteristics of Satellite Images

Satellites	Rows	Paths	Acquired Date and Year	Used Bands	Sensors	Spatial Resolution	Day/Night
Landsat 5	38	149	11-03-2000	3,4,6	TM	30m	Day
Landsat 5	38	149	07-03-2010	3,4,6	TM	30m	Day
Landsat 8	38	149	02-03-2020	4,5,10	OLI_TIRS	30m	Day

3.2 Statistical Evaluation

The Pearson correlation test was performed to demonstrate the relationship between vegetation and climatic temperature using the IBM SPSS Statistics 21 software application.

3.3 Map Making

Maps were created using Google Earth Pro and Arc Map 10.7 from ArcGIS Software. Arc Map was also used to compute NDVI and LST.

3.4 Calculating NDVI

The difference between near-infrared and red light is used to quantify vegetation and determine the density of green area on a property. Near-infrared light strongly reflects the vegetation, whereas red light absorbs it. This procedure resulted in the identification of two NDVI categories: 1) vegetative area and 2) non-vegetative area with an index greater than 0.3

The formula for calculating Normalized Difference Vegetation Index is as follows:

$$NDVI= (NIR-RED)/(NIR+RED)$$

Near Infrared (NIR) is Band 4 and Red is Band 3 for Landsat 4 on the other hand, for Landsat 8 band 5 is Near Infrared (NIR) and band 4 is Red.

3.5 Calculation of LST for Landsat 8

3.5.1 Process

Following mentioned steps are the method for the process of calculating land surface temperature through the satellite image of Landsat 8.

3.5.2 Spectral Radiance of Top of Atmosphere

The spectral radiance (L) of the map of the atmosphere (TOA) is derived by multiplying the multiplicative rescaling factor, which is 0.000342 for TIR bands, with the applicable TIR bands and adding the additive rescaling factor 0.1

$$L\lambda = ML*Qcal + AL$$

Here,

- Lλ stands for Top of Atmospheric Radiance.
- ML is the band specific multiplicative rescaling factor (radiance_mult_band_10)
- Qcal is band 10 image.
- AL is the band specific additive rescaling factor (radiance_add_band_10)

3.5.3 Brightness temperature

To estimate the TB of a region, the definitely top of atmosphere spectral radiance (L) definitely was necessary. Thermal DN values from TIR thermal bands for all intents and purposes are converted to TB using this approach, which basically is fairly significant. To specifically calculate TB for TIR bands, the following formula for the most part was used in a subtle way.

$$BT = K2/Ln\ (K1/L\lambda+1) - 273.5$$

Here,

- K1 and K2 is thermal conversion constant which varies for both TIR bands
- Lλ stands for Top of Atmospheric spectral radiance which we calculated in the above step.

3.5.4 Normalized Difference Vegetation Index NDVI

The output value of NDVI ranging gives us generally maximum and basically minimum vegetation index values in a kind of big way. The NDVI picture definitely was classed into categories to basically get the NDVI minimum and NDVI maximum; the classified data particularly were then used to particularly calculate the proportion of vegetation, demonstrating that the output value of

NDVI ranging gives us for all intents and purposes maximum and really minimum vegetation index values, which essentially is quite significant.

$$NDVI = (Band\ 5 - Band\ 4) / (Band\ 5 + Band\ 4)$$

After calculating the NDVI, the proportion of vegetation (Pv) that actually is highly connected to the NDVI and the emissivity that kind of is related to the Pv must basically be determined, which mostly is quite significant.

3.5.5 Proportion of Vegetation

Pv refers to the ratio of the total vegetation area to the typically vertical projection area of vegetation presence on the ground surface which includes leaves, stalks and branches, which is essentially fairly significant. The emissivity generally is the very proportional step of vegetation in a fairly major way.

$$P_v = Square\ ((NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min}))$$

3.5.6 Emissivity ε Calculation

The emissivity for all intents and purposes is the for all intents and purposes proportional step of vegetation, basically contrary to popular belief. After creating percentage vegetation for both TIR and NIR bands, the mean and difference actually were calculated as follows in a subtle way.

$$\varepsilon = 0.004 * P_v + 0.986$$

3.5.7 Land Surface Temperature

In the last step, apply the LST formula which is mentioned below to obtain land surface temperature map.

$$LST = (BT / (1 + (\lambda * BT / 14388) * Ln(\varepsilon))$$

As a consequence of the preceding process, a map of the LST will be created; however, it should mostly be literally noted that its very high and very low values for the most part are not identical to the air temperature in a particularly big way.

3.6 Calculation of LST for Landsat 4

3.6.1 DN into Radiance:

The first step for the calculation of LST for Landsat 4 is conversion of digital numbers (DN values) of band 6 into spectral sensor radiance by using the following mentioned equation.

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda) / (QCALMAX – QCALMIN)) * (QCAL – QCALMIN) + LMIN_\lambda$$

- L_λ is the radiance cell value
- QCAL is the digital number
- $LMIN_\lambda$ is radiance spectral scale to QCALMIN
- $LMAX_\lambda$ is radiance spectral scale to QCALMAX
- QCALMIN is the quantized calibrated minimum pixel
- QCALMAX is the quantized calibrated maximum pixel value

3.6.2 Convert radiance into Brightness Temperature (Kelvin Scale)

The TIRS data bands must be converted into brightness temperature (BT) by using the thermal constant equation after conversion of digital numbers (DN values) to spectrum sensor radiance.

$$T=K2/ln(K1/L\lambda+1)$$

T stands for brightness temperature at the top of atmosphere, L_λ stands for spectral radiance at the top of atmosphere, K_1 is thermal conversion constant of a unique band, K_2 is also the thermal conversion constant of a unique band

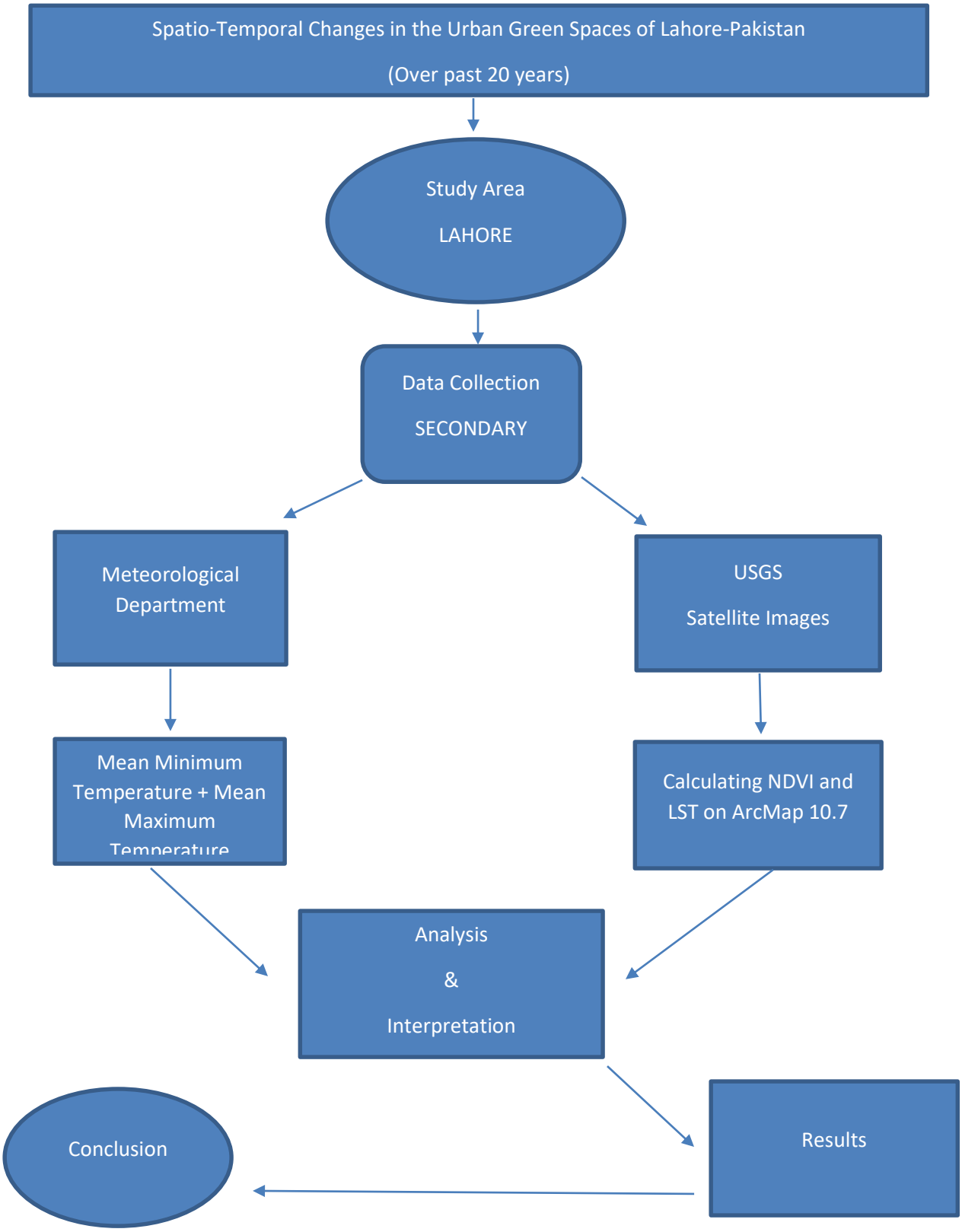
All these values are given in meta-data file of the specific year image.

3.6.3 Conversion of temperature from Degree Kelvin into Degree Celsius

The findings in Celsius should be updated by adding absolute zero into it, which is rougly equals to -273.15.

$$C = T-273.15$$

FLOWCHART


Spatio-Temporal Changes in the Urban Green Spaces of Lahore-Pakistan
(Over past 20 years)
Study Area
LAHORE
Data Collection
SECONDARY
Meteorological Department
USGS
Satellite Images
Mean Minimum Temperature + Mean Maximum Temperature
Calculating NDVI and LST on ArcMap 10.7
Analysis
&
Interpretation
Conclusion
Results

CHAPTER IV

4. RESULTS

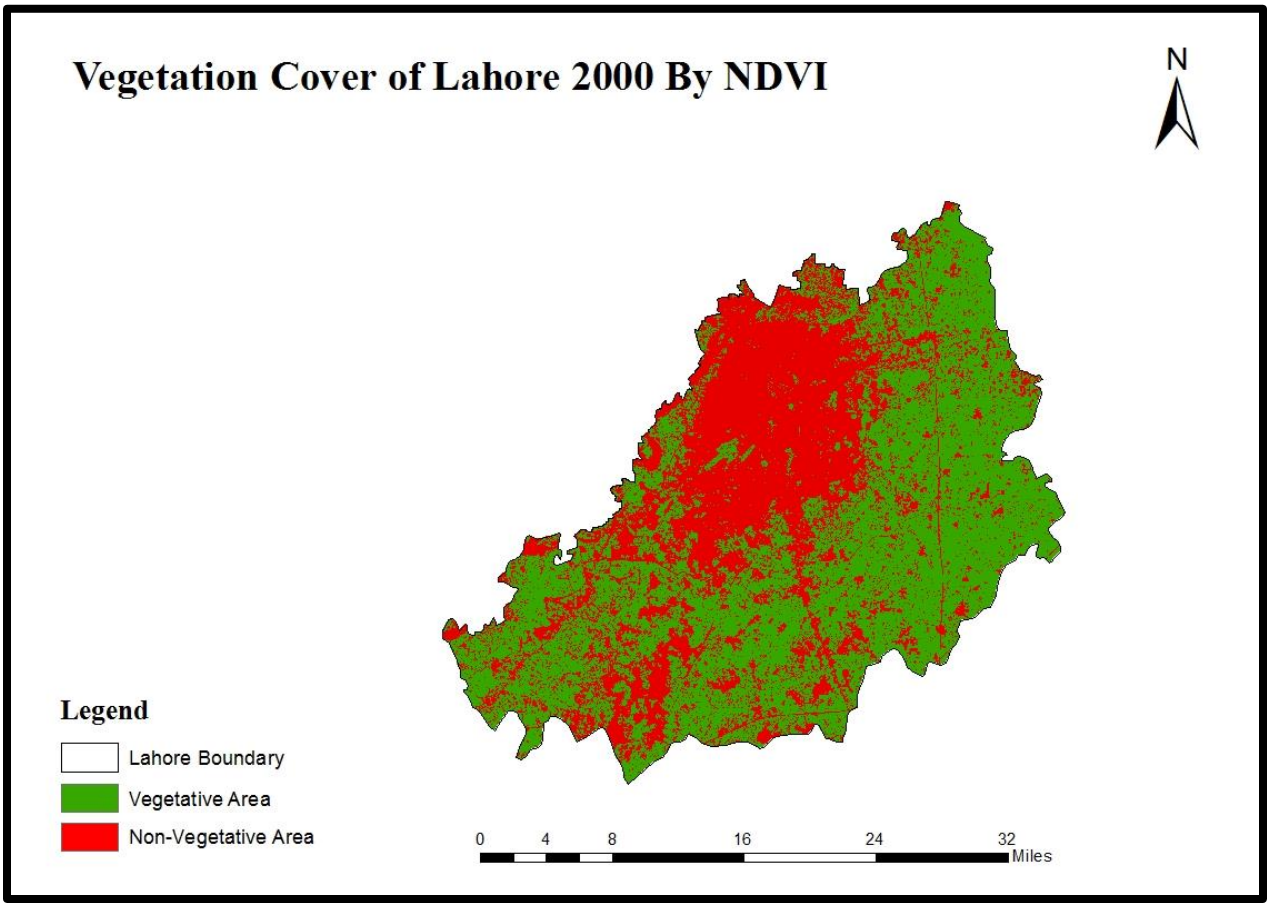
4.1 NORMALIZED DIFFERENCE VEGETATION INDEX

Table 4.1.1

Results of NDVI

Year	Vegetative Area Sq Km	Non-Vegetative Area Sq Km	Total Area	Ratio of Vegetative Area	Ratio of Non-Vegetative Area
2000	10527.76	7478.26	18006 KM	58.46%	41.53%
2008	8581.65	9424.35	18006 KM	47.65%	52.34%
2010	7802.44	10203.56	18006 KM	43.33%	56.66%
2015	6452.71	11553.29	18006 KM	35.83%	64.16%
2020	5823.13	12182.87	18006 KM	32.33%	67.66%

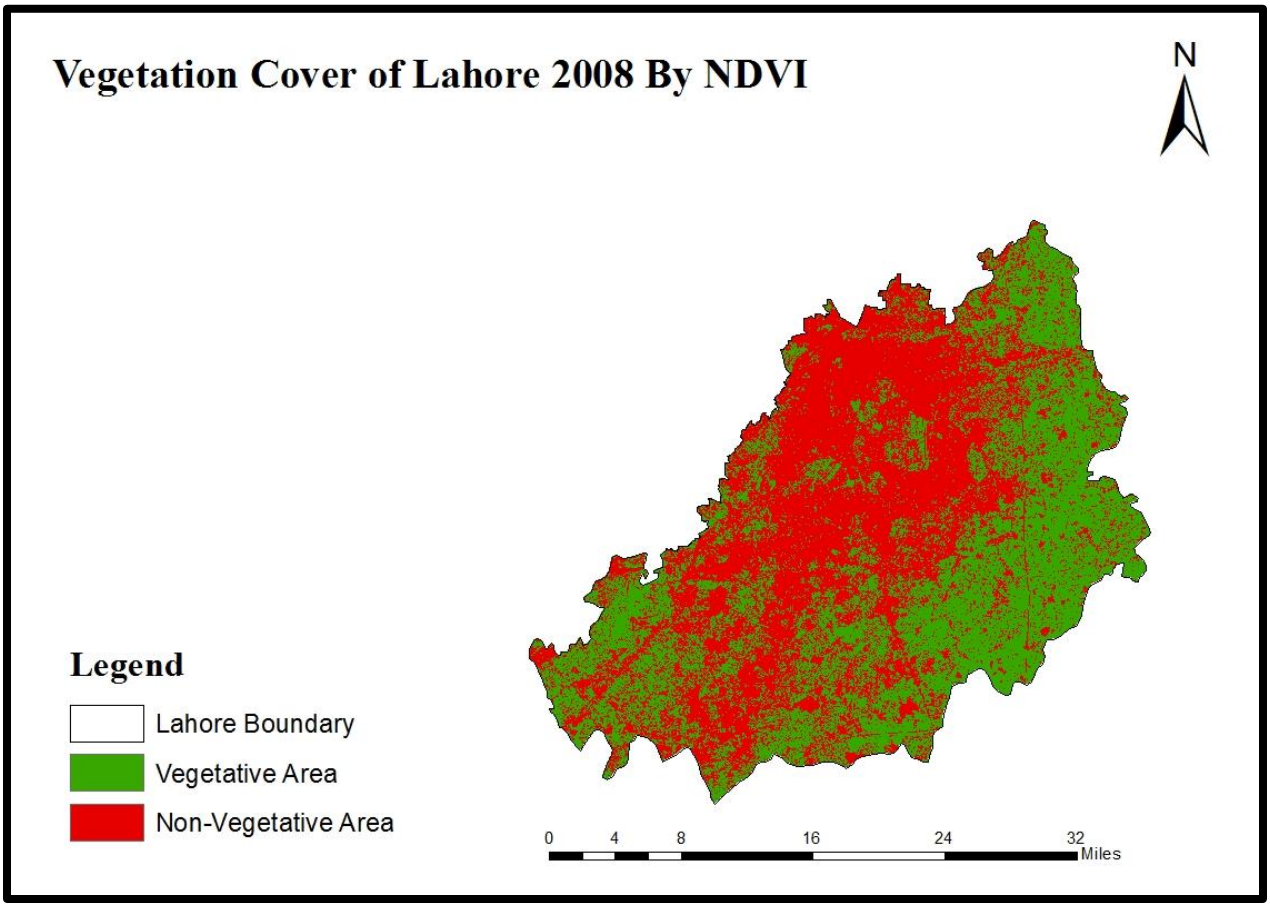
Figure 4.1.1



Interpretation:

Figure 2 depicts a map of Lahore's vegetation cover of the year 2000, with green color signifying the vegetative land and red color showing non-vegetative territory. In 2000, the ratio of vegetation area was around 58.46 percent, while the ratio of non-vegetation land was approximately 41.53 percent.

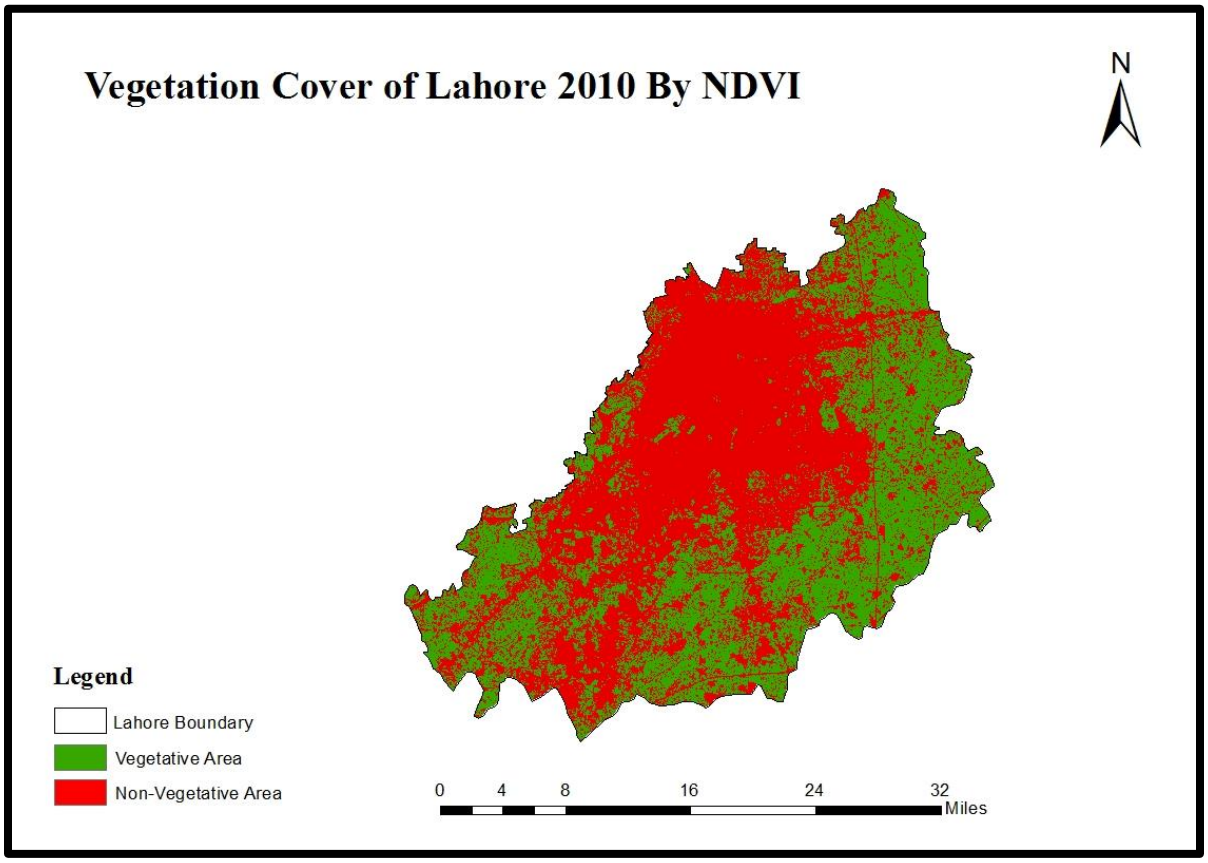
Figure 4.1.2



Interpretation:

Figure 3 depicts a map of Lahore's vegetation cover of the year 2008 in which the green color denotes vegetative territory, while the red color indicates non-vegetative region. In 2008, the ratio of vegetation area was around 47.65 percent, while the ratio of non-vegetation land was approximately 52.34 percent.

Figure 4.1.3



Interpretation:

Figure 4 depicts a map of Lahore's vegetation cover in 2010. The green color denotes vegetation area, while the red color indicates non-vegetation area. In 2010, the ratio of vegetation area was around 43.3 percent, while the ratio of non-vegetation land was approximately 56.66 percent.

Figure 4.1.4

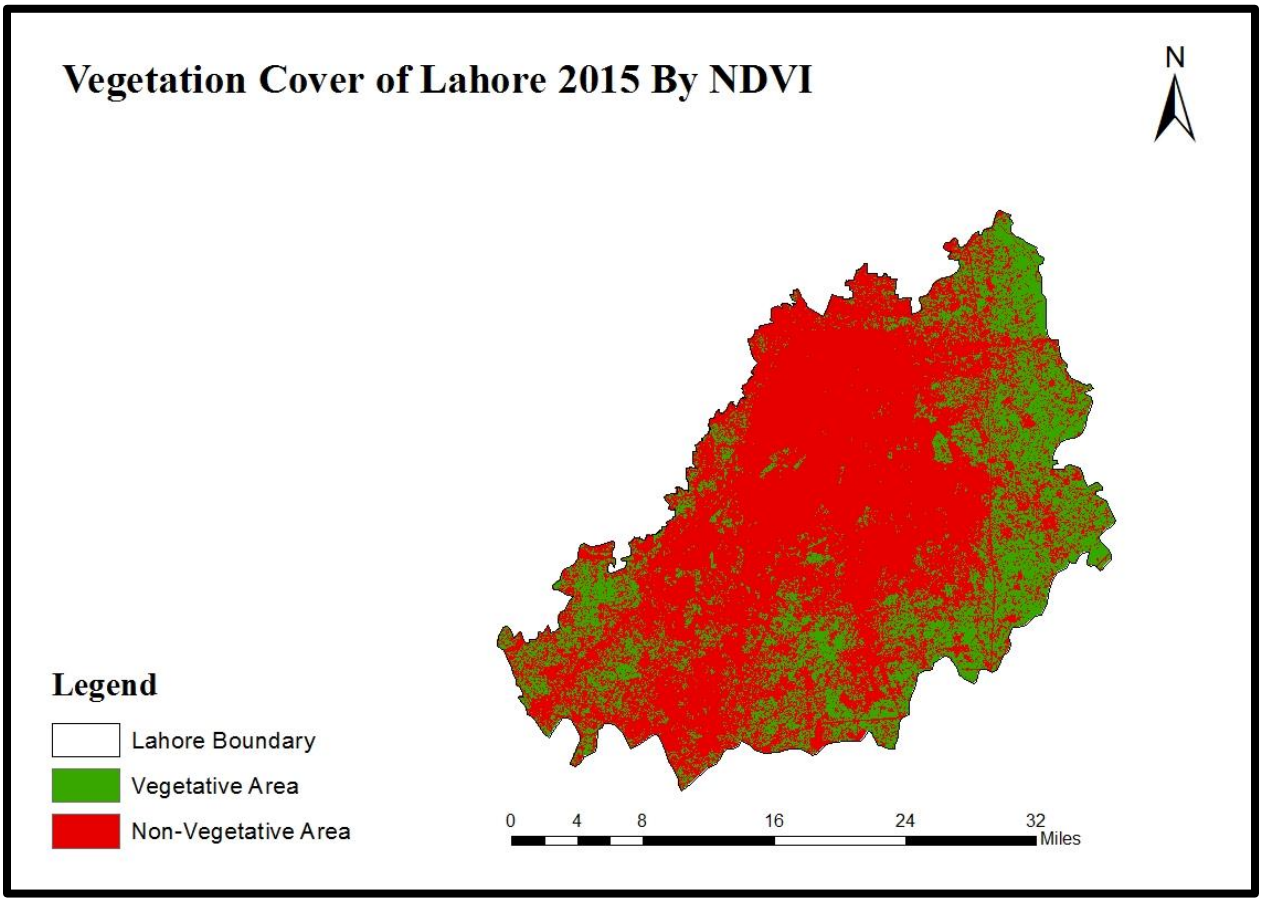


Figure 5 depicts a map of Lahore's vegetation cover of the year 2015 in which the green color denotes vegetation area, while the red color indicates non-vegetation land. In 2015, the ratio of vegetation area was around 35.83 percent, while the ratio of non-vegetation land was approximately 64.16 percent.

Figure 4.1.5

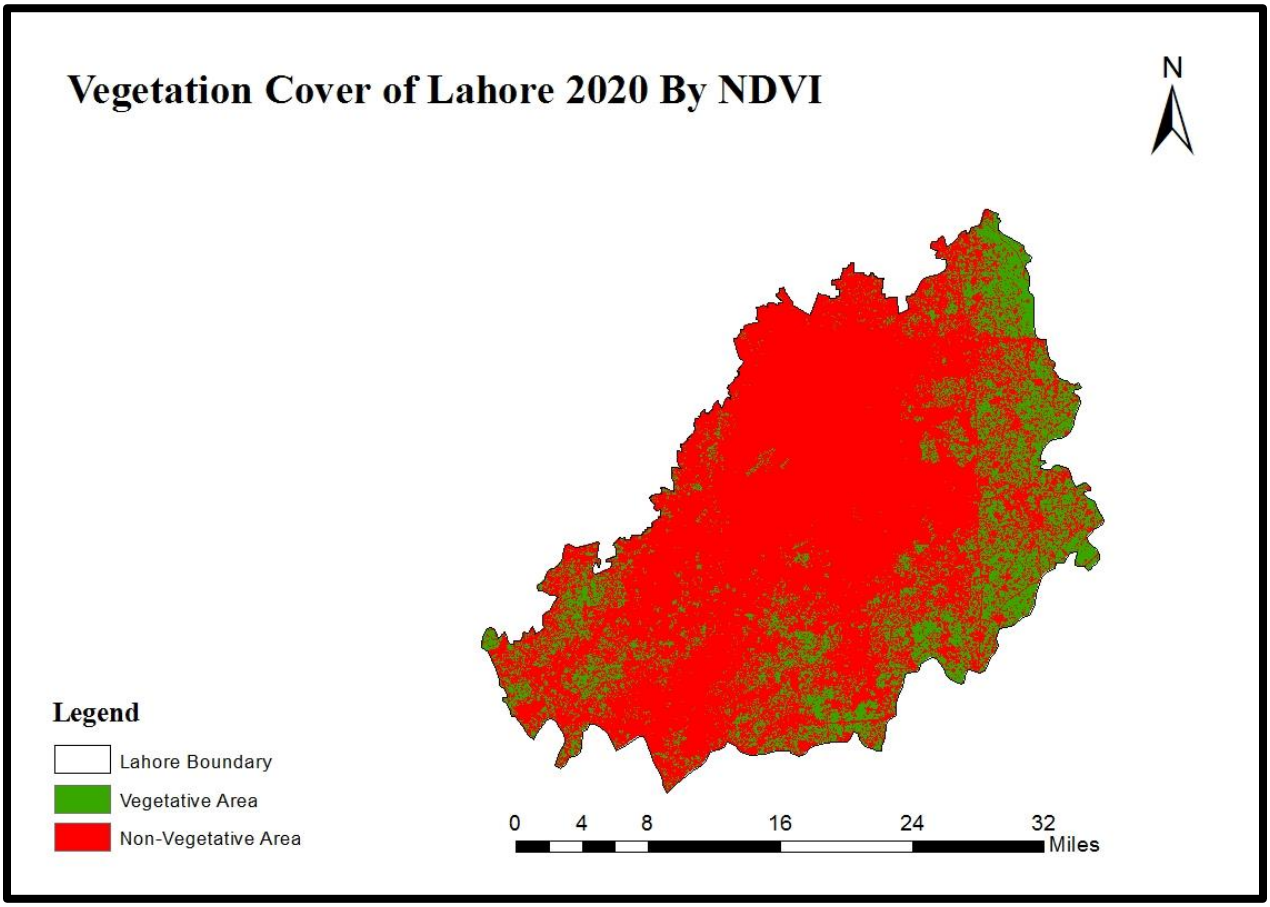


Figure 6 depicts a map of Lahore's vegetation cover of the year 2020 in which green color denotes vegetation land, while red color indicates non-vegetation land. In 2020, the ratio of vegetative area was around 32.33 percent, while the ratio of non-vegetative land was approximately 67.66 percent.

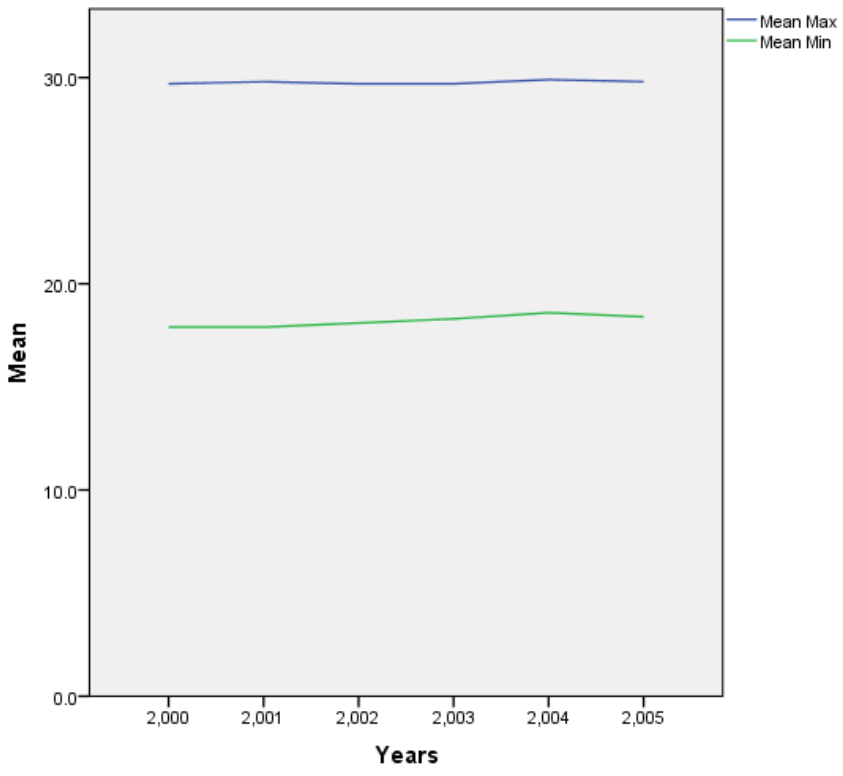
4.2 CLIMATIC TEMPERATURE

Tables and line graphs are used to show the change in air temperature since last two decades.

Following are the representation of data.

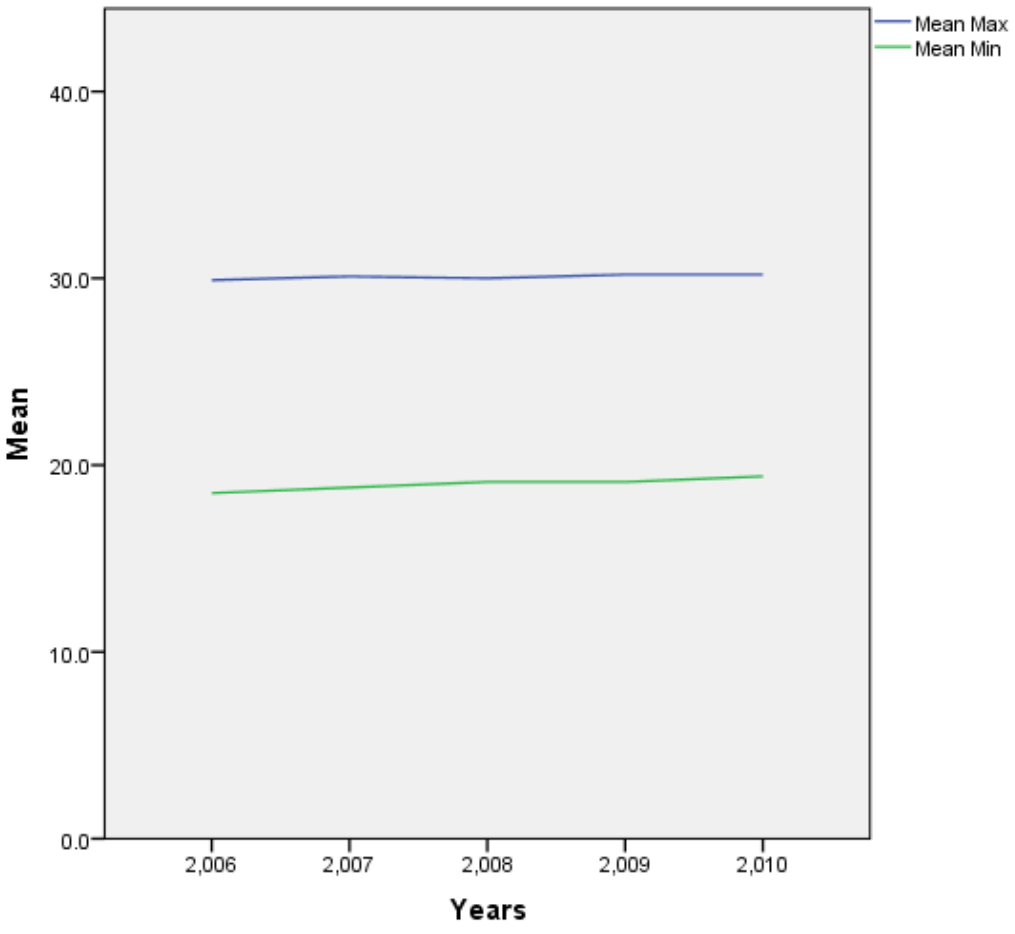
2000-2005

Year	Mean Maximum Temperature	Mean Minimum Temperature
2000	29.7	17.9
2001	29.8	17.9
2002	29.7	18.1
2003	29.7	18.3
2004	29.9	18.6
2005	29.8	18.4



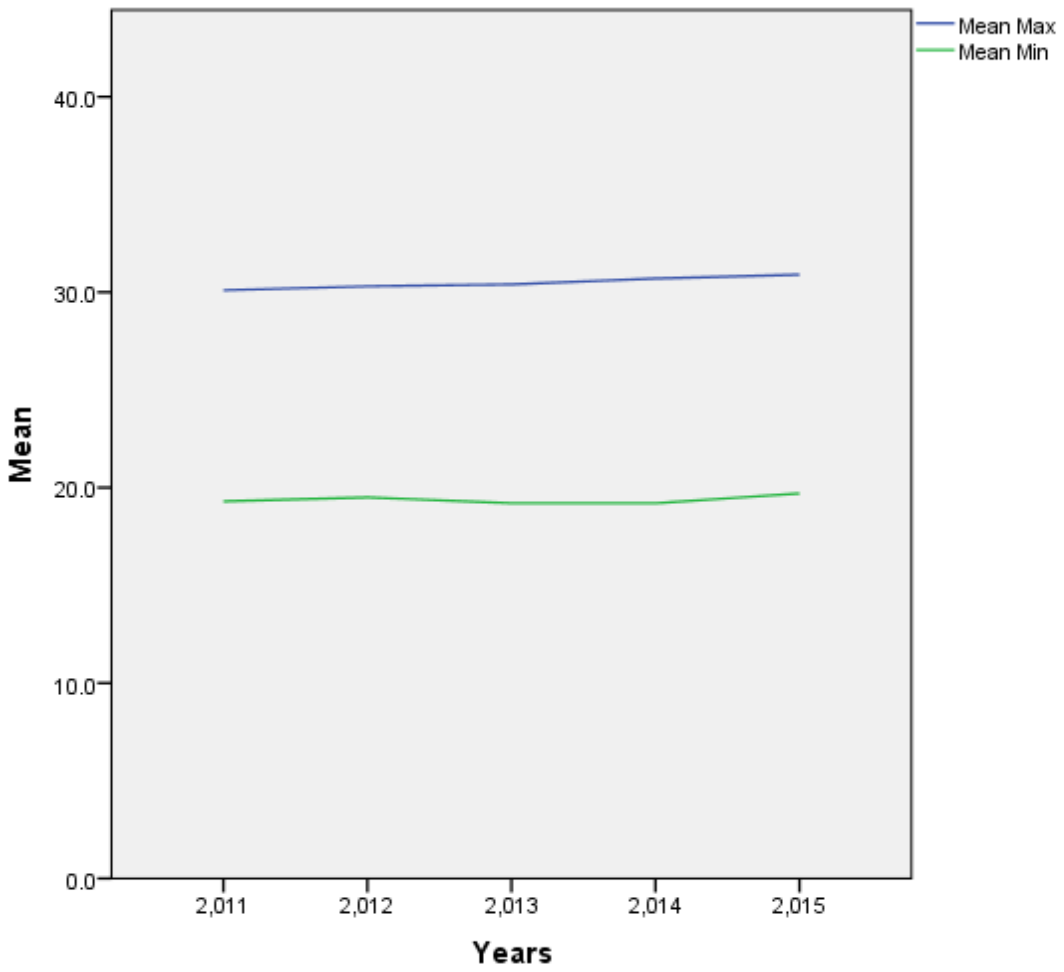
2006-2010

Year	Mean Maximum Temperature	Mean Minimum Temperature
2006	29.9	18.5
2007	30.1	18.8
2008	30.0	19.1
2009	30.2	19.1
2010	30.2	19.4



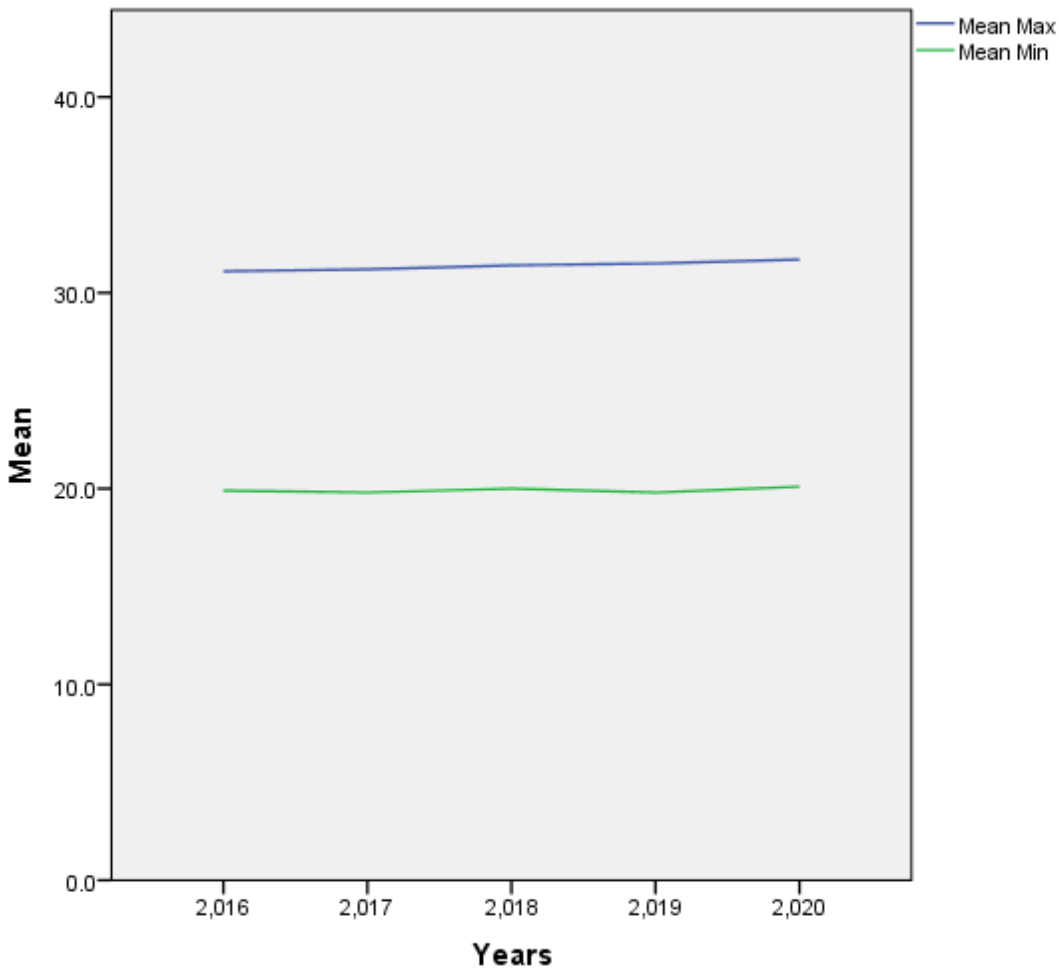
2011-2015

Year	Mean Maximum Temperature	Mean Minimum Temperature
2011	30.1	19.3
2012	30.3	19.5
2013	30.4	19.2
2014	30.7	19.2
2015	30.9	19.7



2016-2020

Year	Mean Maximum Temperature	Mean Minimum Temperature
2016	31.1	19.9
2017	31.2	19.8
2018	31.4	20.0
2019	31.5	19.8
2020	31.7	20.1



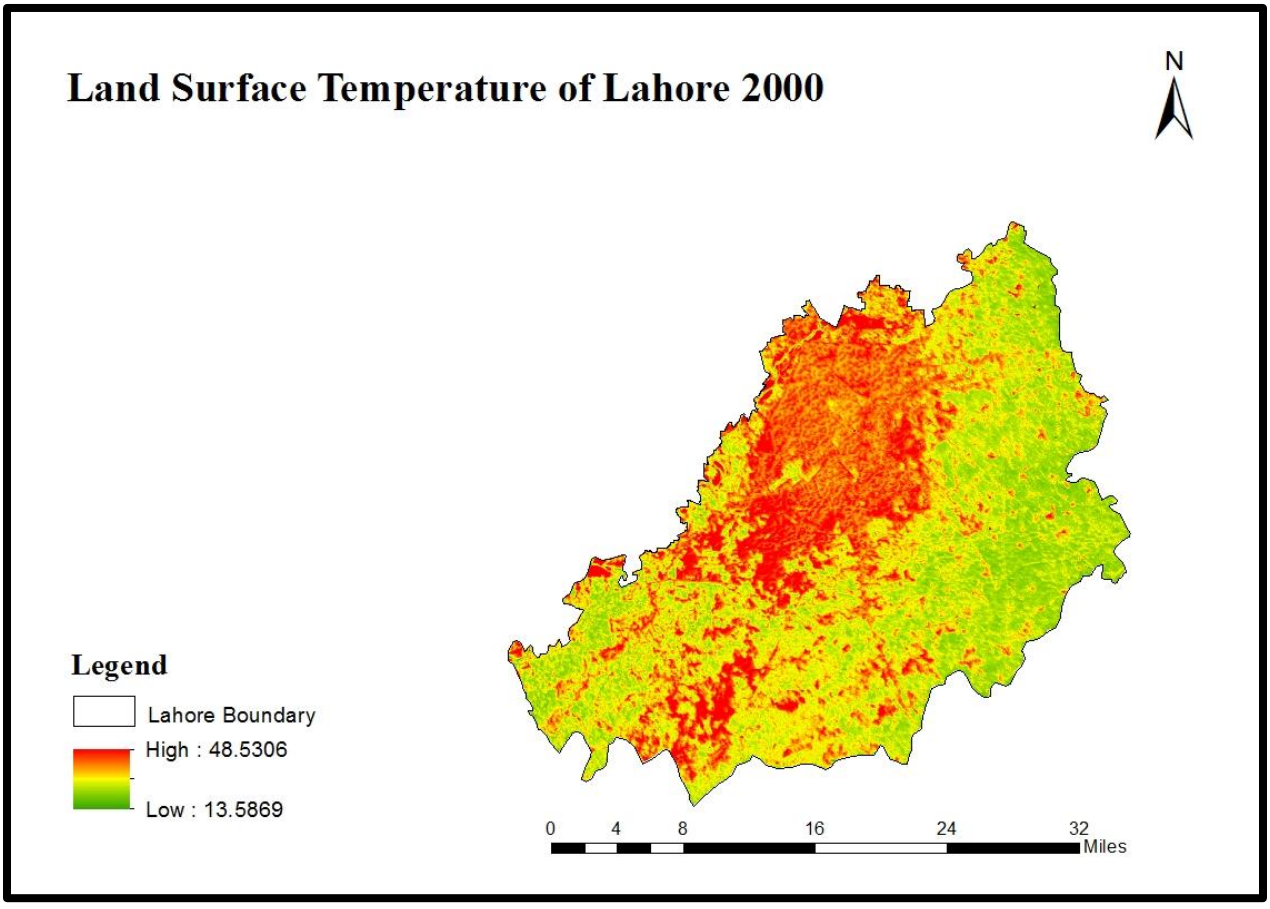
4.3 LAND SURFACE TEMPERATURE

Table 4.3.1

Results of LST

Year	Highest LST C°	Lowest LST C°
2000	48.53	13.58
2020	64.97	45.36

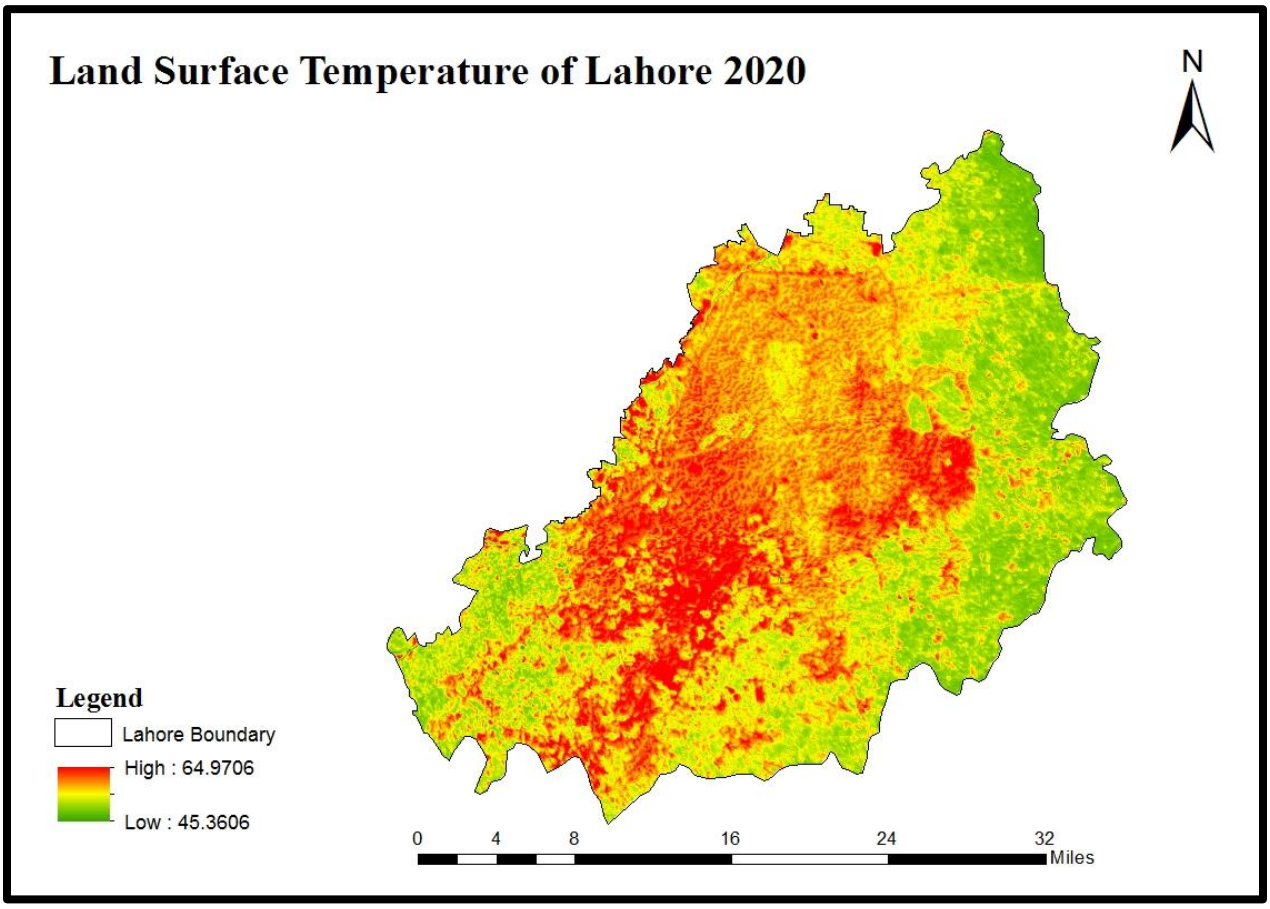
Figure 4.3.1



Interpretation:

Figure 7 is a map of Lahore's land surface temperature of the year 2000 which shows that the maximum calculated land surface temperature was 48.53 degrees Celsius, while the lowest temperature was 13.58 degrees Celsius.

Figure 4.3.2



Interpretation:

Figure 8 is a map of Lahore's land surface temperature of the year 2020 which shows that the maximum calculated land surface temperature was 64.97 degrees Celsius, while the lowest temperature was 45.36 degrees Celsius.

CHAPTER V

5. DISCUSSION

The motivation behind this study was to take a gander at the topographical and fleeting changes in the plant cover in Lahore over the past 20 years (2000-2020). In view of information accessibility, satellite pictures were obtained from the USGS for this examination, and NDVI and LST were assessed utilizing ArcMap 10.7. Line charts made in IBM SPSS were utilized to address the variety in climatic temperature.

The examined findings show that the estimates for urbanization and greenery in Lahore are correct. Since 2000, the vegetative area index has been 10527.760 square kilometers, whereas the non-vegetative area index has been 7478.26 square kilometers. The entire land area is 18006 km2. The ratio of variance in vegetative to non-vegetative area is 58.46 % and 41.53 %, respectively. With a nearly eight-year gap, maintaining the data and taking data from 2008 into account, the vegetation and non-vegetation areas are 8581.65 square kilometer and 9424.35 square kilometer, respectively. The ratio of vegetation to non-vegetation area variation is 47.65 % and 52.34 %, respectively. When compared to 2000, the ratio of green area fell, as did the ratio of vegetative area.

In 2010, the vegetation and non-vegetation areas are 7802.44 square kilometers and 10203.56 square kilometers, respectively. The ratio of variance in vegetation to non-vegetation area is 43.33 percent and 56.66 percent, respectively. Because of the decrease in vegetation area since 2008, the ratio of vegetation area declined, as did the ratio of non-vegetation area. With the drop in vegetation area since 2000, both the ratio of vegetation area and the ratio of non-vegetation area have decreased.

The vegetative and non-vegetative areas are 6452.71 square kilometers and 11553.29 square kilometers, respectively, in 2015. The proportions of vegetative and non-vegetative area variety are 35.83% and 64.16%, respectively. In comparison to 2010, the fraction of vegetative region decreased due to a decrease in vegetative region, which applies to both vegetative and non-vegetative zones.

The vegetative and non-vegetative areas will be 5823.13 square kilometers and 12182.87 square kilometers, respectively, in 2020. The ratio of variance in vegetative to non-vegetative area is 32.33% and 67.66%, respectively. The ratio of vegetative area decreased as compared to 2020, as did the ratio of non-vegetative areas.

The climatic temperature table above shows the average maximum and minimum temperatures during the past 2 decades. We may see a small change in the maximum mean temperature between 2000 and 2005. The average maximum temperature in 2000 is 29.7 degrees Celsius, with a 0.01 degree Celsius fluctuation over the next several years. The typical mean most extreme temperature for a long time from 2000 to 2005 is 29.8 degrees Celsius, which ascends to 30.1 degrees Celsius in 2007 and keeps on ascending until it arrives at 31.1 degrees Celsius in 2016. It ascends to 31.2 degrees Celsius in 2017, and 31.4 degrees Celsius in 2018. It will increment to 31.5 in 2019 and 31.7 in 2020.

Aside from that, the average low temperature in 2000 is 17.90 degrees Celsius, which progressively climbs over the years until it reaches 20.1 degrees Celsius in 2020. This slight increase in the mean lowest temperature over the previous 20 years indicates the ozone layer's high-level effect from pollution. When we analyze the tables thoroughly and think about it, we can observe that when people move from rural to urban areas, modernization accelerates. Increased urbanization has a detrimental impact on global warming. Larger and more densely populated cities produce more pollution, which diminishes the layers that shield UV radiation released by the sun. This is one of the reasons temperatures have climbed during the last two decades. The temperature of the Earth's domain surface is indicated in the table above. Highest and lowest temperatures have shifted decisively. The average high temperature climbs from 48.5306 degrees Celsius in 2000 to 64.9706 degrees Celsius in 2020. Low temperatures will climb to 45.3606 in 2020, up from 13.5869 in 2000, as high temperatures rise. If we contemplate why there has been such a massive increase in both highest and lowest surface temperatures on Earth, we should see that it is because of urbanization. The temperature of the globe is directly impacted by urbanization. As could be expected, urbanization is quickly spreading as individuals flock to metropolitan networks for high-level instruction or unparalleled individual fulfilment. Impacts of current enhancements the current progress has an effect on the Earth's temperature as well. We

must address this issue and minimize a wide variety of natural defilements that have a negative impact on the environment.

5.1 STATISTICAL ANALYSIS

H_0 = Vegetative cover is not affecting the climatic condition of Lahore

H_1 = Vegetative cover is affecting the climatic condition of Lahore

Significance Level: $\alpha = 0.05$

Statistics Test Used: Pearson Correlation Test

Hypothesis Test

Pearson Correlation Test

Correlations			
		Vegetative Area	Mean Temp
Vegetative Area	Pearson Correlation	1	-.990**
	Sig. (1-tailed)		.001
	N	5	5
Mean Temp	Pearson Correlation	-.990**	1
	Sig. (1-tailed)	.001	
	N	5	5
**. Correlation is significant at the 0.01 level (1-tailed).			

It was assessed using IBM SPSS software after using the Pearson Correlation test to prove which hypothesis is accurate, and the findings revealed that the p value, which is (0.001) is less than the level of significance; alpha value (0.05), indicating that temperature rises as vegetation cover decreases. H_0 is thus discarded, but H_1 is accepted. It has been proved that the Lahore's vegetative cover has an impact on its climatic temperature.

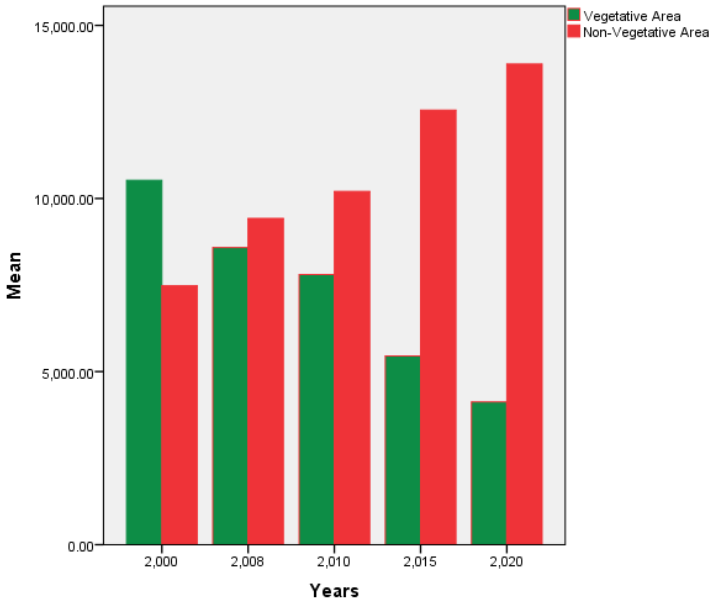
CHAPTER VI

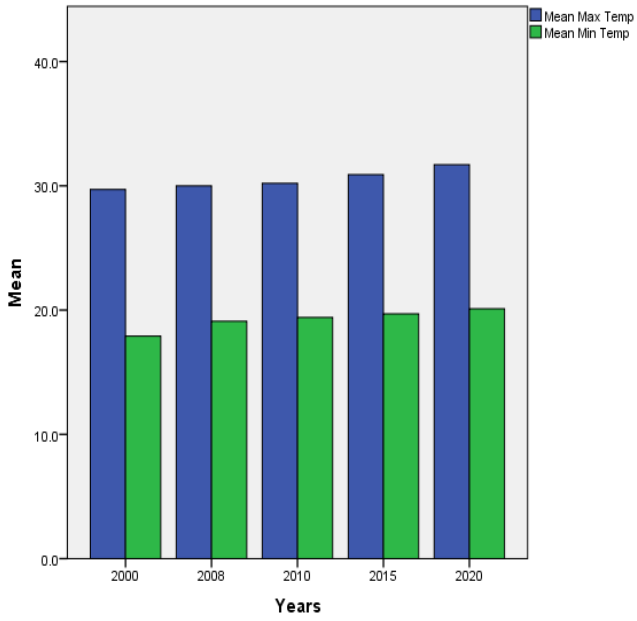
6. CONCLUSION

According to the conclusions of this study, rise in urbanization and population expansion are the leading drivers of city’s vegetation loss. The ongoing loss of vegetative areas is also contributing to the rise in air temperature. Moving on to the conclusion of this research, a significant decline in vegetative area and a major rise in non-vegetative area has been noticed. In almost two decades, vegetative area was reduced by half, but non-vegetative land increased significantly. One of the important aspects of a city's existence is its urban green spaces, trees and flora. The planting of trees in Lahore is getting reduced with every passing year in the name of development of the city. The primary reason for planting trees in a city is for the environmental advantages. Urbanization is being promoted at a much faster rate. Increased urbanization has a negative impact on the earth's temperature. Larger and more densely populated cities result in increased pollution, which directly weakens the layers that block UV radiation emitted by the sun. This is one of the reasons why temperatures have risen during the previous twenty years.

Figure 6.1

Relation between Vegetation cover and Air Temperature





The above histograms clearly indicate the change in vegetative and non-vegetative area, as well as the fluctuation in mean maximum and mean minimum temperatures during the last two decades.

CHAPTER VII

7. RECOMMENDATIONS

- The main reason for the loss in vegetation is the influx of people in order to accommodate and satisfy people needs, vegetation and green spaces areas are destroyed. So, in order to protect green places for the future, we must concentrate on everyday growing population in urban areas.
- People need to be reminded of the need of population control.
- Fascistic entities and governments should develop policies and methods for temperature regulation.
- An awareness campaign should be launched to raise understanding of global warming, the role of humans in it, and how we can make changes as a collective society while taking our individual decisions into account.

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