Spatial Analysis of Sustainable Land Use Planning and its Impact on the Endogenous Market Structure

By

Kinza Hameed

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Institute of Geographical Information Systems
School of Civil and Environmental Engineering
National University of Sciences & Technology
Islamabad, Pakistan

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Signature: ____________
Name of Supervisor: Dr Javed Iqbal
Date: 6-3-2024

Dr. Javed Iqbal
Professor & HOD IGIS, SCEE (NUST)
H-12 Islamabad

Signature (HOD): ____________
Date: 6-3-2024

Dr. Javed Iqbal
Professor & HOD IGIS, SCEE (NUST)
H-12 Islamabad

Signature (Principal & Dean SCEE): ____________
Date: 14 MAR 2024

PROF DR MUHAMMAD IRFAN
Principal & Dean
SCEE, NUST

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List of Abbreviations

Abbreviation	Explanation
LULC	Land Use Land Cover
USGS	United States Geological Survey
NDVI	Normalized Difference Vegetation Index
NDBI	Normalized Difference Built-Up Index
AHP	Analytical Hierarchy Process
MCDA	Multi-Criteria Decision Analysis
PMD	Pakistan Meteorological Department
AQI	Air Quality Index
PM	Particulate Matter
GIS	Geographic Information Systems
DEM	Digital Elevation Model
PBS	Pakistan Bureau of Statistics
HIES	Household Income expenditure Survey
SPSS	Statistical Package for the Social Sciences
BLR	Binary Logistic Regression
GDP	Gross domestic product
MLA	Maximum Likelihood Approach
ROI	Region of Interest
IDW	Inverse distance weighted.
RI	Random Inconsistency Index
CR	Consistency Ratio

ABSTRACT

Sustainable Land Use planning is inevitable for the sustainable land use and to make the endogenous market structure efficient and effective. This research aims to explore the optimal land use in case of land use, how it affects the environment around us, what kind of impact it has on health of people, and what changes in may bring in the market structure. Study will help to analyze how ineffective has been the land use in urban area of Rawalpindi and how unplanned urbanization in city area leads to unsustainable environmental issues that causes health problem. Similarly, use of land with lack of planning also causes over population in urban area and changes the market structure over the time. These aspects are important to uncover so that their relationship can be quantified. Data since 2010 was used to measure the impact of land use on environmental degradation, changing market structure and health wellbeing. Secondary data on market structure (employment, food security) was collected from Household Income expenditure Survey (HIES) published by PBS. Econometric Analysis through Binary Logistic Regression approach was employed through SPSS and E-view to quantify the impact of urbanization of market structure and health wellbeing of people in Rawalpindi city. Lastly, the Multi-Criteria Decision Analysis (MCDA) was used to check the role of urbanization in environmental changes. The output of this research was in the form of maps, chart, and tables that helped to provide the better understanding of complex relationship between the land use, urbanization, and changing market structure i.e., economic, environment and health changes in Rawalpindi. Expected outcomes were achieved by LULC, Econometric Analysis through Binary Logistic Regression and AHP. This research helps to inform about how optimal the land is used and how much negative impact the urbanization has bring in terms of deteriorating the health wellbeing. Its results enlighten the policy makers the changing nature of the market structure in terms of employability, income level and living standards. Implication of this study is to benefit the urban policy makers, city planners, environment agencies and labor market to make policies keeping in view the optimal use of land as it has significant impact not only on environment but also on health and economic wellbeing of people.

Chapter 1

INTRODUCTION

In the realm of land use planning, the emergence of Geographic Information System (GIS) spatial analysis has revolutionized the way landuse decisions are formulated. By harnessing the power of spatial data, GIS spatial analysis enables planners to make informed decisions based on empirical evidence. Nevertheless, the GIS application for land use planning extend beyond the data analysis. It is potentially capable of impacting the endogenous market structure profoundly, besides, effecting its relationship with the surrounding environment as well the net quality of life and sustainability of urban areas.

The nexus between sustainable land use and its impact on endogenous market has recently been of great interest for researchers and policy makers in nutshell. This relationship illustrates the intricate interconnection between land allocation and utilization among rural and urban areas and the subsequent economic diminuendos which structures our communities. Since the societies struggle with the need to balance between economic growth and climate conversation, spatial analysis has come out to be a dynamic as well as fundamental tool to examine the outcomes of land use decisions on the economic systems. Moreover, far beyond the conventional mapping techniques, this area delves into the multifarious pattern of land allocation, resource management and infrastructure development which demarcates the contemporary urban landscape (Saeed *et al.* 2021).

The notion of endogenous market structure states the internal economic dynamics within a particular geographical area, more often at the local or regional level. These dynamics are influenced not only by the external factors i.e., global economic trend but also by local land use decisions, infrastructural development, and resource management. Hence, it is imperative for policy makers, academic researchers, and urban planners to grasp that how sustainable land use planning effects the endogenous market structure. In this context, Spatial analysis as a main methodological approach enables us to delve profoundly into the spatial distribution of land use and its impacts. This approach comprises of a number of techniques such as, Geographic Information Systems (GIS), remote sensing, and statistical modeling, to examine and envisage the spatial relation among land use patterns and economic outcomes.

This study strives to provide a far-reaching investigation of sustainable land use planning by analyzing its diverse dimensions and examining its significant repercussions for the endogenous market structure. With the combination of spatial analysis techniques, economic estimations, and environmental considerations, this study attempts to unveil the complex nexus between land use planning and endogenous economic markets. Ultimately, one of the key objectives of this research is to provide insight to decision makers and endorse a balanced relationship between human development and environmental sustainability.

1.1. Background Information

It has been several years since the land use patterns are in transition, and it is imprudent to deny the significance of this transition. Land-use Land cover changes could be natural and man-made due to global climate change and human induced activities. Urban Sprawl, Population growth, loss of agriculture land, changing climate patterns, population growth he utilization of additional natural assets are prominent factors in transitioning land use trends. In underdeveloped countries like Pakistan, inhabitants migrate from countryside to cities area for better facilities of living, which builds stress and demand for better resources and living conditions. A. (Aziz et al., 2015). The enormity and level of LULC changes in various areas of the earth are persuaded by social economics and ecological aspects.

Land use and Land cover changes are some of the foremost variables affecting the any area's resources. The supplementary aspects influencing land use land cover are unrestrained populace increase, rapid urbanization, and agriculture extension/ reduction on spatial gradation (Hassan et al., 2016). Over the years, Remote Sensing has evolved as an effective technique for evaluating and mapping land use evolutions by offering satellites imageries in high spatial and temporal resolution. Numerous patterns of land-use-land-cover change (LULC) are evaluated using remote sensing techniques, such as the frequency and extent of land transformation spanning spatiotemporal scales. There are several classification techniques such as i) supervised classification ii) unsupervised classification and iii) non-parametric classification. Among them supervised classification technique is considered to be used extensively worldwide and have extensive applications.

Global environmental problems including air pollution, noise pollution, water pollution, and traffic jamming are one of the major concerns of present time. These may lead to poor air quality, transition in temperature and changed rainfall patterns. We must have successful solutions if we want to prevent these issues from getting severe. MCDA decision analysis is one of the critical tools to deal with these issues and plays a critical role in analyzing the environmental concerns associated with land use patterns in developed and developing nations. In 2023, the Air Quality Index PM 2.5 of Rawalpindi district mainly Rawalpindi city *is* 40.8 μg/m which is considered to be unhealthy. The pattern of Rain over the decade has been changed and the temperature is fluctuated largely during this period due to global warming and Imran Khan's Ten Billion Tsunami Tree. The effect of environmental changes on land use patterns such as water, vegetation, bare land and built-up areas can be used to identify the environmental behavior during last ten years. This study can help to indicate that those who lived in metropolitan area had more social improvements than people who lived in suburbs areas which lacked basic facilities.

The monitoring of endogenous market structure is one of the significances for comprehending economic growth at the regional scale and policy formulation. (Chan et al., 2020). The land amenities are a fundamental element of economic growth mainly because they function as the foundation through which trade operates out, and growth in GDP enhances land demands and transforms the manner in which that land is utilized. GIS technology is an essential gadget for earth observation since it delivers information pertaining to variations in land use and over (LULC) and by combining them with economic conditions such as employment, income, and food security. This study proposes a method of binary logistic regression analysis for analyzing the impact of land use on endogenous market structure by creating models which identify the degree of impacts of multiple factors on each other. Therefore, this research suggests that land use planning could be utilized as an explanatory indicator for finding impact on market structure development at regional level along with potential applications of GIS such as MCDA analysis, are worth pursuing.

Sustainable land use planning that encourages mixed-use development and promotes a diverse range of economic activities can stimulate job creation. For example, zoning regulations that facilitate the co-location of residential and commercial spaces can reduce commute times, contribute to local economic vitality, and enhance overall employment prospects. The planning for sustainable land usage in courtiers like Pakistan has been using GIS spatial analysis expressively. However, there are number of issues associated with the land usage in Pakistan, i.e. mounting urbanization, erosion of land and deforestation to name the some. GIS spatial analysis has been one of the crucial tools to help in identifying these issues by providing planners the resources they require in order to make wise decisions regarding the optimal use of land as well as its effects on urbanization, general public health and market structure. There is a momentous impact of urbanization on endogenous market, and environmental degradation of Pakistan which ultimately deteriorates the public health. In this regards, GIS spatial analysis tools helps in analyzing these effects by employing different tools and software i.e., LULC, AHP, SPSS and E-view.

GIS spatial analysis ought to potentially facilitate for more unbiased and sustainable land use planning by recognizing the regions of environmental and socioeconomic vulnerability and endorsing the more stable growth pattern. This, ultimately, helps in fostering the more steady, equitable and sustainable economic growth, avert the environmental degradation, and augment the social well being. societal well-being.

There are number of areas of applications i.e., agricultural work which ought to support more climate friendly and environmentally sustainable farming methods, which holding the land degradation to minimum, as well improving the food security and urban planning which helps in stimulating the sustainable urbanization and service accessibility. While natural resource management helps in the mapping and monitoring of natural resources, such as water, minerals, and animal habitats, may be done using GIS spatial analysis and health sector can provide assistance to indicate the environmental factor that have an impact on health of people living in a particular area. As far as economic indicators are concerned, they can help to indicate how some factors such as population rate, employment across region and sectors, and literacy rate has changed over the year.

1.2. Literature Review

There has been a scare literature which analyse the economic problem with the help of GIS (Wu *et al.,* 2017). Despite widespread usage of GIS in disciplines like geography, environmental science, and urban planning, its potential uses in economics still need to be properly investigated, especially in Pakistan. As a result, it may be argued that there is a critical vacuum in the body of knowledge about the application of GIS and economics. Overall, there has been a lot of study done on sustainable land use planning and how it affects the endogenous market structure, and the volume of literature on this subject is expanding. Even though, there are still a few unanswered questions and areas that need more research, especially in comprehending the intricate relationships between market forces, sustainability objectives, and land use planning.

Similarly, Krysiak *et al.*, *(*2021) evaluated the conversion to green technology is a crucial part of environmental policy, but it frequently necessitates simultaneous modifications in technology and market structure. This raises concerns about how technical and commercial developments interact, but which players are most likely to spearhead the shift at certain points. A model was created to explain that co-evolution of technology and economy. The study's findings demonstrate that this co-evolution causes substantial market failures since the incumbents who are defending the outdated technology may obstruct the change. Incentives also alter throughout the transition, with incumbents taking the lead later after incumbents first played a key role. The frequency of this shift is also influenced by the rate of technological advancement and the new technology's aptitude to draw users. These findings have significant policy repercussions for the environment since early assistance for tiny newcomers might be advantageous but later in a technological shift can be harmful.

Using the use of cross-sectional analysis, panel estimates, and geographic information systems (GIS), Chen *et al.*, (2014) investigates the link between urbanization and economic expansion. The investigation is conducted on a worldwide geographic scale and covers the past 30 years. The study demonstrates that, despite the widespread belief that urbanization levels and GDP per capita are closely related, there is no connection between urbanization rate and global economic growth. According to the study's findings, a country cannot anticipate economic gains from increased urbanization, especially if it is government-led, and a comprehensive evaluation of the urbanization process must consider all factors.

Hussain *et al.* (2020) examined that previous research has highlighted the serious regulatory actions and policy choices, in order to monitor and assess that LULC activities are necessary, since the environmental effects of LULC evolve over time. It has been demonstrated that LULC changes may be detected using remote sensing technologies like the normalized difference vegetation index (NDVI) and normalized difference built-up index (NDBI).

Ashfaq *et al.* (2019), estimated and assess the endogenous market by creating the nexus between agricultural growth and land use by employing GIS as well as econometric estimates. He found that the sustainable usage of the land which included the crop diversity as well as preservation of soil may increase the agricultural growth and bring prosperity in term of income for farmers.

In view of Huang *et al. (*2014), through the use of logistic regression, geographically weighted logistic regression, and spatial regime regression, the authors investigate the various factors that contribute to urban land expansion, including physical conditions, state policy, and land development. The results suggest that while the market has played a crucial role in urban growth, the state has dominated through the implementation of urban planning and the establishment of development zones, capitalizing on globalization. Furthermore, the authors find that the dynamics of urban growth differ between areas inside and outside of the development zones. Ultimately, the study proposes policies to promote sustainable development in Shanghai.

Kamran *et al.* (2023) focused on the significance changes in land-use and land cover that occurred within twin cities of Rawalpindi and Islamabad during the preceding three decades. Using satellite imagery and demographic data, this research tends to comparatively analyze and quantify these changes from 1990 to 2021. Then Built-up areas vegetation, barren land and water are four LULC types which are being focused on this study. The results shows that a noticeable growth in built-up areas, with Islamabad observing an increase of 34% and Rawalpindi noticing an increase of 24% over the research period. Primarily, barren land was used for analyzing the change to the built-up class, then vegetation. In contrast, Rawalpindi and Islamabad had a 51% and 57% decrease in the total area of barren land, respectively. The study additionally emphasizes to the declining trend of water bodies, which indicates increasing stress of water resources in both regions. However, after 2008, the vegetation cover enhanced, increasing by 9% in Islamabad and almost doubling in Rawalpindi.

Akmal *et al.* (2022) analyzed the future of urban planning short comings by taking Sialkot as a sample because of its nature of being industrial and economic zone of Pakistan. The outcome shows, 15% (38 km^2) of the geographic area is very susceptible to urban sprawl, 24% (62 km^2) is fairly sensitive, 16% (42 km^2) is barely susceptible, and 45% of the area is not exposed to urban sprawl. In the analyzed region, a dispersed and uneven sprawl pattern is observed. Notably, the significant shifts noted over the 30-year period affect productive agriculture and other natural resources, jeopardizing food security and productivity. The results of this study give the government helpful data in order to monitor and identify areas that are likely to sprawl, leading it to prevent the encroachment of urban areas into agricultural land and natural resources.

According to Sahito *et al.* (2020) rapid urbanization has led to an unsustainable urban development and substantial changes to urban land-use patterns. In Karachi, Pakistan's largest urbanized metropolis, the focus of this research is on recognizing the patterns and essential elements that foster urban expansion and the subsequent shifts in land use. The research includes data on the causes of urban sprawl and land use transition and integrates expert remarks.

Ahmed *et al.* (2020) found that on the basis on environmental sustainability, the Faisalabad SEZ has been identified as the best selection. However, it emphasizes the significance of focusing on resource constraints and giving sustainability its highest priority in Pakistan's SEZ design. In order to attain the goals of the Belt and Road Initiative (BRI) while assuring revenues, job creation, and compliance with the UN friendly Development Goals (UNSDGs), the study emphasizes the need of creating ecologically friendly and well-connected SEZs. The appropriateness of industries in terms of resource application, energy consumption, emissions, and land preservation need to be given special consideration in view of Pakistan's response to climate change and ongoing ecological issues.

Saeed *et al.* (2021) analyzed that environmental and socioeconomic concerns have grown significantly as because of the population expansion, particularly across metropolitan areas. The model consists of a number of factors, including air quality, the urban heat island effect, green areas, water quality, industrial pollutants, forests, floods, and solid waste. Ground-truthing, satellite imagery, and secondary data sources were used to gather spatial data while consideration the criteria of geographical being, temporal variation data accessibility, and measurability. Ten significant cities in Punjab, Pakistan, were ranked according to how well they performed in regard to the environment via the Analytical Hierarchy Process (AHP). The study shows that Gujranwala has the greatest environmental risk due to its population, whereas Sahiwal is considerably less vulnerable, and Lahore is at a moderate level.

Considering the negative consequences of urban sprawl Nazarnia *et al.* (2016) highlighted that it has become a prevalent topic of concern. It demands coordinated efforts to defend forests, farmland, and open spaces contrary to the hazards of sprawl. From 1951 to 2011, the Zurich metropolitan geographic area in Switzerland and the Montreal and Quebec Census Metropolitan Areas in Canada were analyzed in the current analysis. Urban permeation (UP) and ranked urban proliferation (WUP) assessments are applied in the study to evaluate sprawl. Findings reveal that urban sprawl in Montreal and Quebec has been speeding up significantly since 1951, with the greatest rate of development occurring in the past 25 years. Zurich, on the other hand, hit its optimum speeds in the 1960s. The extent of sprawl (WUP) in Montreal has risen substantially, with the Island of Montreal's WUP developing 26-fold from 0.49 UPU/m² in 1971 to 12.74 UPU/m² in 2011. Similar to Quebec City, from 1971 to 2011, there was a 9-fold rise from 2.41 UPU/m² to 21.02 UPU/m². But from 3.12 UPU/m² in 1960 to 8.91 UPU/m² in 2010, the amount of sprawl (WUP) in the Inner Zurich metropolitan zone only went up nearly thrice. Switzerland's sterner planning regulations since 1979 and Zurich's easy access to public transit are partially to blame for the gap in sprawl dynamics. This cross-sectional examination of urban raise gives land use planners with valuable data that may assist them review planned plans closely and establish control mechanisms in effect to minimize sprawl's harmful effects.

According to Deng *et al.* (2009) for an extensive knowledge of the environmental implications of urbanization and for reaching prudent choices, one must possess a thorough knowledge of the spatiotemporal aspects related to land use change. The assessment of land use change and the dynamics of landscape patterns in light of rapid urbanization in a growing Chinese metropolis from 1996 to 2006 is the primary goal of this empirical research. The study discusses the spatio-temporal trends and evolution of land use change with high spatial-resolution SPOT photos and spatial methods. To particularly extract reliable data on consistent land use change, a change investigation approach is used.

Shah *et al*. (2021) observed the human induced instances can be understand with the help of knowhow of changes in Land Use and Land Cover (LULC). LULC statistics were obtained for each target year (1979, 1989, 1999, 2009, and 2019) from multiple sets of satellite photos, including Landsat MSS, TM, ETM+, and OLI. Five main landscape classifications were used to categories the research area: built-up regions, agricultural areas, forests, water bodies, and barren terrain. According to the data, there has been a noticeable rise in urban expansion, which is a consequence of both mass migration and unregulated urbanization in the capital city. As per urban sprawl studies, between 1979 and 2019, there was a 41.7% increase in populated areas and a 5.20% increase in agricultural land. On the other hand, during the same time frame, the coverage of forests and waters both reduced by 9.03% and 1.21%, accordingly. The city's the initial version master plan has to be revised considering all of these land use changes, and in 2019 the farming sector will be integrated into residential areas.

Gaur *et al.* (2023) said that a vital approach for predicting and understanding future urban growth is land use and land cover (LULC) simulation. Comprehensive explanations of the most recent LULC modelling methods and modern techniques utilized in the scientific community are provided in their studies. This assessment contrasts the applications, advantages. negative aspects, and fundamental differentiation of each strategy in attempt to illustrate their relative benefits as well as drawbacks. The paper additionally demonstrates the advantages of integrating various approaches, such as machine learning models with statistical models, for obtaining on each method's unique capabilities in LULC modelling. As a matter of fact, LULC modelling has made tremendous progress, the analysis highlights how critical it is to incorporate a policy framework into these models to help enhance urban planning and management. The results of this evaluation aids to the glory of Sustainable Development Goal-15 (SDG-15), particularly focused on maintaining life on land, as it offers insights into improved methods for regulating land.

Ge *et al.* (2021) explains that in order to encourage coordinated expansion within ULUE, it is essential to comprehend the geographical variations and convergence methods of ULUE in the context of regional convergence. The conceptual basis for interpreting the geographical integration of ULUE in the context of geographic convergence is explained in this analysis, which also recommends an approach to evaluation for "green" ULUE that is multi-objective constrained. With the objective to evaluate ULUE in the Yangtze River Economic Zone at the city scale from 2003 to 2019, the study uses the super efficiency slack-based model (SBM), exploratory GIS analysis, and a spatial integration model comprising a spatial weight matrix. The findings show that ULUE in the Yangtze River Economic Zone had considerable geographical disequilibrium and correlation over the study period. In ULUE, the whole economic zone, as well as its upstream, midstream, and downstream regions, both absolute and conditional -space convergence were seen. Government management, industrial development, and geographical uncertainty effects all participated in the rapid progress of ULUE's convergence, which lead to a substantial decrease in integration time.

Bielecka (2020) focused on the assessment of the research conceptual and intellectual framework of the GIS-based land use change simulation learning. The study reveals that this field of study was initially established in the early 1990s and showed significant growth in the past two decades through evaluation of the Web of Science database. The study identifies the most influential researchers, organizations. economies, and journals in GIS-based land use change modelling using scientific mapping approaches including co-coupling, co-citation, and citation assessment, along with bibliometric indicators includes impact indices. The results show that this field of study is multi- and multidisciplinary in nature, which is evidenced by a broad spectrum of research categories, published journals, and researched areas found in the Web of Science database. Universities across Europe were having considerable influence on the discipline of GIS-based land use change modelling, especially those in the Netherlands, Belgium, Switzerland, and the United Kingdom. However, China and the United States are both involved in this particular area of studies as indicated by the evidence that they have published a majority of research articles.

Dendoncker *et al.* (2007) explains that in statistical assessments of land use factors, spatial autocorrelation is an important factor that is often overlooked, leading to the loss of crucial information. To address this concern, this assessment presents a longitudinal analysis of land use determinants in Belgium that is spatially explicit. The study shows that only regressive logistic models are unable to accurately represent global links between socioeconomic or physio-climatic causes and the overall distribution of land use types. However, an exclusive auto-regressive model is more effective when the aim is to develop the most substantial statistical model fit for the distribution of land use. The absence of spatial autocorrelation in the divergence residuals shows that such a model is able to manage it. The study contrasts three distinct categories of autoregressive models: (1) binomial logistic regression models that emphasis on the percentage of the simulated land use within a cell's neighborhood, (2) multinomial auto logistic regression that accounts for the composition of a cell's neighborhood, and (3) a modern Bayesian Maximum Entropy (BME) based model that establishes into the account of geographic organization of land uses within a cell's neighborhood. The comparative evaluation suggests that the BME strategy does not provide advantages over the other strategies for the specific application being studied in this study. Yet, to identify the best fit for the land use model, it is significant to consider the demographics of a cell's neighborhood.

Wear et al. (1998) said that effective conservation and ecosystem management rely on foreseeing land-use change and interpreting human disturbance regimes. This study builds an estimation framework for land-use change over four decades for the Southern Appalachians, taking into consideration the regional distribution of human populations and assessing the model's predictive capability. Using data with spatial references from four studied locations, the model, which links a negative binomial regression of building population with a logit model of land cover, is fitted. Results indicates how topographic attributes and location have a significant effect on population expansion and land use. The models effectively forecast between 68% and 89% of observed land uses, depending on the system for classifying land uses. Information theory tests, particularly demonstrate that the models encompass 47% to 66% of the uncertainty in classification of land uses, validate the models' explanatory capacity.

Rehman *et al.* (2021) analyzed the effects of urban residential site choice on transport and housing demand and prices is the main objective of this study. The framework for comprehending how families make decisions depending on their desired location is provided by the residential location choice theory. Rent and commute expenses are major financial elements in this decision-making process because, under the monocentric city model, there's a trade-off between these two aspects. Findings of comparative static analysis show that a higher degree of access to transit by a home increases the rent for that home and the demand for assets in the neighborhood. The data also shows that greater income levels lead to higher rent and commute expenses. These results are supported by scientific evidence from a socioeconomic study carried out in Rawalpindi and Islamabad, Pakistan, as demonstrated by the GMM analysis. It contributes to our awareness of various factors affecting housing and transport demand and offers helpful details for urban planning and policymaking.

Khan (2003) noticed that the degree of development of a society has an immediate impact on the ability to address and effectively manage climate change. However, considering this correlation, the Third Assessment Report of the Intergovernmental Panel on Climate Change tends to suggest two distinct approaches for adapting to climate change, one at the macro level and the other at the micro level. The analysis of the research is using Pakistan as a case study to establish the argument that social disorder and ecological instability are caused by unsustainable human growth and are projected to get worse as an outcome of climate change. Additionally, it contends that unsustainable development models make it difficult to put climate-specific modifications into action. The study highlights through insightful case studies shows, how negligent policies and rigid mindsets have adversely impacted underdeveloped populations and complex ecosystems, both of which are still very vulnerable to the effects of climate change. therefore, findings suggest the interdependence of growth, adaptation, and the impacts of climate change on society.

According to Khan (2016) global environmental problems including air pollution, noise pollution, water pollution, and traffic congestion must have successful solutions if these issues are prevented from getting severe. Zoning is one of the critical tools to deal with these issues and plays a critical role in controlling the environmental concerns associated with urbanization in developed and developing nations. The research analyses the economic advantages and losses brought on by zoning, as well as resident environmental conduct. Descriptive statistics were applied to evaluate a sample of 266 residences in Islamabad, and the findings demonstrated that while Bharakahu did not follow zoning restrictions, core areas of the city did. The study additionally indicated that those who lived in zones had more social improvements than people who lived in non-zoned areas which lacked basic facilities. The study indicates that to better address environmental problems, services should be provided in non-zoned areas and zoning laws ought to be enforced in newly developed areas.

Ali *et al.* (2021) addressed that the sustainable land use has emerged as an urgent concern in mountainous regions, requiring immediate consideration from politicians and regulators. The study focuses on research that examined land use change and land prices during three distinct 5-year periods (2019, 2014, and 2009) in three urbanizing Gilgit-Baltistan districts in Pakistan. A mixed-method approach is used in the study to acquire empirical information. The results reveal that household land holdings in both cultivated and uncultivated areas have significantly declined over time, while the built-up area continues to rise. Urban areas have experienced an exponential rise in the value of their real estate. For the local community and politicians, this trend offers a significant challenge to the sustainability of future revenues and environmental health. The study recommends effective and sustainable land use planning, with special emphasis on legislation, policymaking, efficient and responsible use of ecosystem services, and local ownership in accordance with customary laws and traditional knowledge. It is anticipated that by implementing these measures into effect, the area will become able to solve the issues caused by land use hinge and advance a more sustainable future.

1.3. Rationale

Spatial analysis plays a pivotal role in sustainable land use planning by recommending numerous advantages. Firstly, it offers a powerful resource to identify and prioritise areas for conservation, helping protect vital ecology and biodiversity. Secondly, it enhances resources allocation efficiency by optimising the location of infrastructure and services, reducing waste, and promoting sustainable development. Additionally, spatial analysis aids in assessing the social and economic impact of land use decisions, facilitating more informed policymaking and community engagement. Moreover, it sports disaster preparedness and response efforts by mapping vulnerable areas and improving resilience. Finally, special analysis tools are instrumental in visualising complex data and collaborative finding.

1.4. Objectives

This research aims to pursue the following objectives.

1. To identify the land use patterns in Rawalpindi District.
2. To assess the impact of land use patterns on climate parameters.
3. To analyze the effect of land use on changes on Endogenous market structure.

1.5. Scope of the study

This research would be comprehending the intricate relationships that exist between urbanization, market forces, and sustainable land use planning. The insufficient utilization of GIS in economic research is an area that many scholars have acknowledged unexplored. Despite widespread usage of GIS in disciplines like geography, environmental science, and urban planning, its potential uses in economics have not yet been properly investigated. As a result, it may be argued that there is a critical vacuum in the body of knowledge about the application of GIS and economics together. In this line, there has been few studies done on sustainable land use planning and how it affects the endogenous market structure, and the volume of literature on this subject is expanding. As a matter of fact, there are still some unanswered questions and areas that require further investigation, especially in case of Pakistan. Major research gap of this study is to find out the impact of land use on combined effect of Environment, Economic Structure and Health of people in Rawalpindi. None of the research before this have applied the GIS tools to explore these impacts in Rawalpindi District. This study will be one of its kind to help policy makers in terms of policy planning to keep into account how the Market Structure is affected due to land use.

Rawalpindi District's market structure plays a pivotal role in shaping local employment opportunities. Sustainable land use planning initiatives can influence job creation by encouraging mixed-use development, promoting a diverse range of economic activities, and optimizing the allocation of land for commercial and industrial purposes.

In this context, it is timely as well as imperative to conduct a thorough investigation of Rawalpindi District of Pakistan, emphasizing on its endogenous market structure and the impact on the well-being of community. Being a substantial part of Islamabad-Rawalpindi metropolitan area, Rawalpindi bids an exceptional setting to analyze the complex relationship between sustainable land use planning and intricate features of local markets, public health, and environmental sustainability. Further this study entails the collaboration with local authorities, environmental agencies, and community stakeholders to apprehend the current policies for land use, as well as the implication of these policies along with the prospects of sustainable development. Nevertheless, the ultimate objective of this research is to offer the data driven policy decisions which improve the living standard and quality of life, environmental sustainability, as well as the inclusive wellbeing of population of Rawalpindi District, directing the multifarious challenges of the modern times.

It is imperative to analyze the impact of sustainable land use planning in the district on local rainfall patterns, especially regarding urban flooding during the monsoon season. The analysis of changes in land use i.e., heightened urbanization and deforestation, can assist in pinpointing the areas of concern beside devising the strategies for sustainable land use which alleviate the adverse effects on rainfall patterns. The air quality of Rawalpindi District is recurrently compromised by factors like transport vehicle emissions and industrial activities. However, the air quality can be significantly improved by the Sustainable land use planning by endorsing more clean transportation options, regulation of industrial emission, and promoting the development of green buffers between pollution sources and residential zones. The investigation of air quality data within numerous zones of land use can provide an esteemed insight into the effects of land use decisions on the local air quality.

Finally, this study has the potential for guiding the policy decisions intended to improve the environmental sustainability and the wellbeing of inhabitants of Rawalpindi district while directing the cons posed by climate change.

Chapter 2

MATERIALS AND METHODS

2.1 STUDY AREA

The Research was carried out in Rawalpindi District which is located in sub-Himalayan Potohar region within the elevation range of 2,790 m above mean sea level. The total Area of the district is 5,286 km^2 located between 33.4620° North, 73.3709° East (Figure 2.1). This region is an administrative, commercial, and industrial center which makes it a geographically important. Rawalpindi district is an industrial based area and consist of 4th largest city of Pakistan named as Rawalpindi. However, the urban population is unplanned and unchecked due to which the metro area population has been reached to 2.377 million in year 2023 which is 2.15% increase from 2022. The climate is continental, sub-tropical with hot summer and fairly cold winters under semiarid to sub-tropical climate zone. Average annual rainfall is 1,346.8 mm (53.02 in) and mean annual temperature is 21.3 °C.

2.2 DATA SOURCES

Data collected from various sources i.e., Satellite imagery from USGS for year 2010 using Landsat 5 and 2015, 2020 by Landsat 8. Environmental data such as temperature and rainfall has been taken from PMD using 18 stations around Rawalpindi district and 12 locations for AQI PM 2.5 was taken from AQI life Index website. Then economic data includes social and economic based data which was collected in the form of survey from PBS (HIES) website (Table 2.1)

Following softwares have been used:

1. ArcGIS 10.8
2. SPSS Software
3. E-view Software

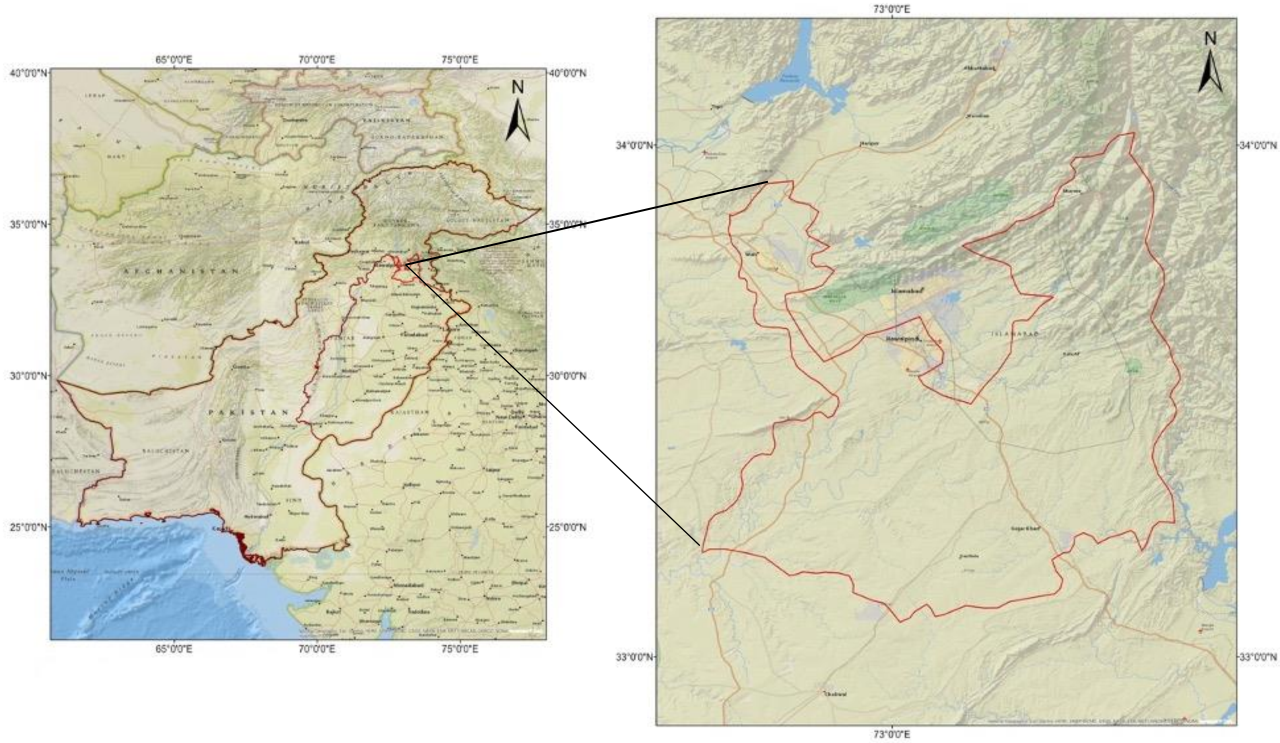

Figure 2.1: Study area map of Pakistan showing the location of district Rawalpindi.

Table 2.1: Details of the datasets being used in the study.

Sr. No	**Data**	**Variables**	**Data Sources**
1.	Spatial Data	Satellite Imagery (Landsat 5 & 8)	USGS
2.	Environment Data	Temperature, Rainfall, Air Quality	Pakistan Meteorological Department & Air Quality Life index website
3.	Economic Data	**Social:** Health, Food Security, Water Source, Sanitation (Solid Waste Management) and Drainage System **Economic:** Employment and Income	Pakistan Bureau of Statistics, Household Integrated economic survey

2.3 METHODS

Given down below is the stepwise methodology and the data variable are land use, natural resources, climate, economic parameters by primary and secondary sources.

2.3.1 Land-Use Land Cover Detection

Land Use and Land Cover (LULC) classification is the systematic analysis and classification of surface characteristics and human activities within specific geographical areas The whole process includes a few main steps:

1) Accessing satellite imagery spanning the years 2010, 2015, and 2020, employing prominent resources such as Landsat satellite data.

2) Preliminary data preparations are imperative before the classification phase. These preparations encompass intricate procedures like cloud removal analyses etc.

3) Deliberate identification of the Rawalpindi District, Pakistan, as the region of interest, followed by the meticulous delineation and extraction of pertinent imagery to focus the analysis exclusively on this specific area.

4) Thorough demarcation of distinctive regions within the imagery corresponding to various land features, including water bodies, baren land, urban developments, and vegetation.

5) The collection of an adequate number of sample pixels (ROIs) representing distinct land categories from the imagery becomes an essential step. ArcMap's editing tools are employed adeptly to create polygons or points, facilitating the representation of each distinct class accurately.

6) The accumulated training data is judiciously leveraged to educate a classification algorithm, such as the widely recognized Maximum Likelihood approach, enabling the algorithm to distinguish and classify diverse land cover features more precisely.

7) The trained classified pixel-based samples are then reclassified into classes of predefined land use such as water, vegetation, bare land and urbanization that provides better understanding and well classified outcomes.

8) In order to represent and making visually appealing classified imagery the appropriate technique of visualization and right symbology have be integrated. This will provide an insight of changes of different land uses and land covers for broad analysis and better understanding.

2.3.2 Multicriterial Decision Analysis

Over the years Multicriterial Decision Analysis (MCDA) have gained a valuable importance. MCDA is defined as the systematic process that incorporate geospatial data and inclinations of decision makers and then molding and integrating them according to particular need of user to provide them support in making decision. Furthermore, MCDA consist of two key forms such as: MODA named as Multi Objective Decision Analysis and MADA named as Multi Attribute Decision Analysis (Cohon, 1978). However, different algorithms and techniques of standard linear integer and programming can be used to give output of MODA. Nevertheless, on the basis of decision makers assessment both of them can be varied.

2.3.4 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) was developed by Thomas L. Saaty in the era of 1970s. It is basically a methodical decision-making process. It is enumerative multicriterial decision analysis (MDA) technique which is based on both rating and ranking method when antagonized with complex and challenging criterions. Whenever, you need to make certain decision that is based on some facts and figures or when we have to perform subjective analysis AHP is specifically advantageous to be used.

2.3.5 Climate Parameters for Pairwise Comparison

Given below are the environmental parameters that are being used for AHP:

- Precipitation in terms of average annual rainfall
- Maximum temperature and minimum temperature
- The most affecting pollutant PM 2.5

2.3.6 Random Inconsistency Index RI

- CR ratio must be $CR<0.10$ for a reasonable level of consistency.
- But if $CR>0.10$ then these inconsistent values need a reconsideration and whole process of finding consistency must be repeated

Table 2.2: Scale for pairwise comparison based on intensity of importance.

Intensity of Importance	Definition
1	Equal Importance
2	Equal to Moderate Importance
3	Moderate Importance
4	Moderate to Strong Importance
5	Strong Importance
6	Strong to very strong Importance
7	Very strong Importance
8	Very strong to extremely strong Importance
9	Extreme Importance

2.3.7 Endogenous Market Structure

Endogenous market structure is indicated as a concept according to which market's behavior is not only influenced by exterior dynamisms, but they are affected by inner crescendos as well. The concept underscores how the combative landscape of a market is shaped by the deliberate actions, innovative approaches, and collaborative efforts of the participating businesses. Understanding this concept is important for authorities, both in business world and government, as it focuses on how customers behaviors really shape the market work. It's like realizing that the game isn't just about the players on the field, but also their tactics and interactions, which determine how the game plays out. Consequently, a thorough knowledge of this concept is of great significance for industrial and governmental domain legislators.

To access the impact of land use on endogenous market structure, firstly we identified the survey questions from Pakistan Bureau of Statistics then cleaned and managed the required survey data in SPSS software. After initial processing the data was ready for coding and estimation in E-View software. This helped to achieve 4 models to communicate information about the distribution and potential relation of the environment and economy.

Following economic models were created:

Model 1 was the is Impact of Land use on Economic Condition. Model 2 was the Impact of Economic Situation on Food Security. Model 3 was the Impact of Water Source Quality, Water Drainage, Urbanization & Economic Condition on Health. Model 4 was the Impact of Water Drainage, Water Source, Health, Waste Management, Food Security & Economic Conditions on Land Use Results will be the Econometric Analysis through Binary Logistic Regression (econometric methodology) which helped to identify the directional between different parameters such as urbanization, environmental impact, health, and economic situation. All of 4 models were unique of their own kind explaining how everything is interlinked to each other in one or another way.

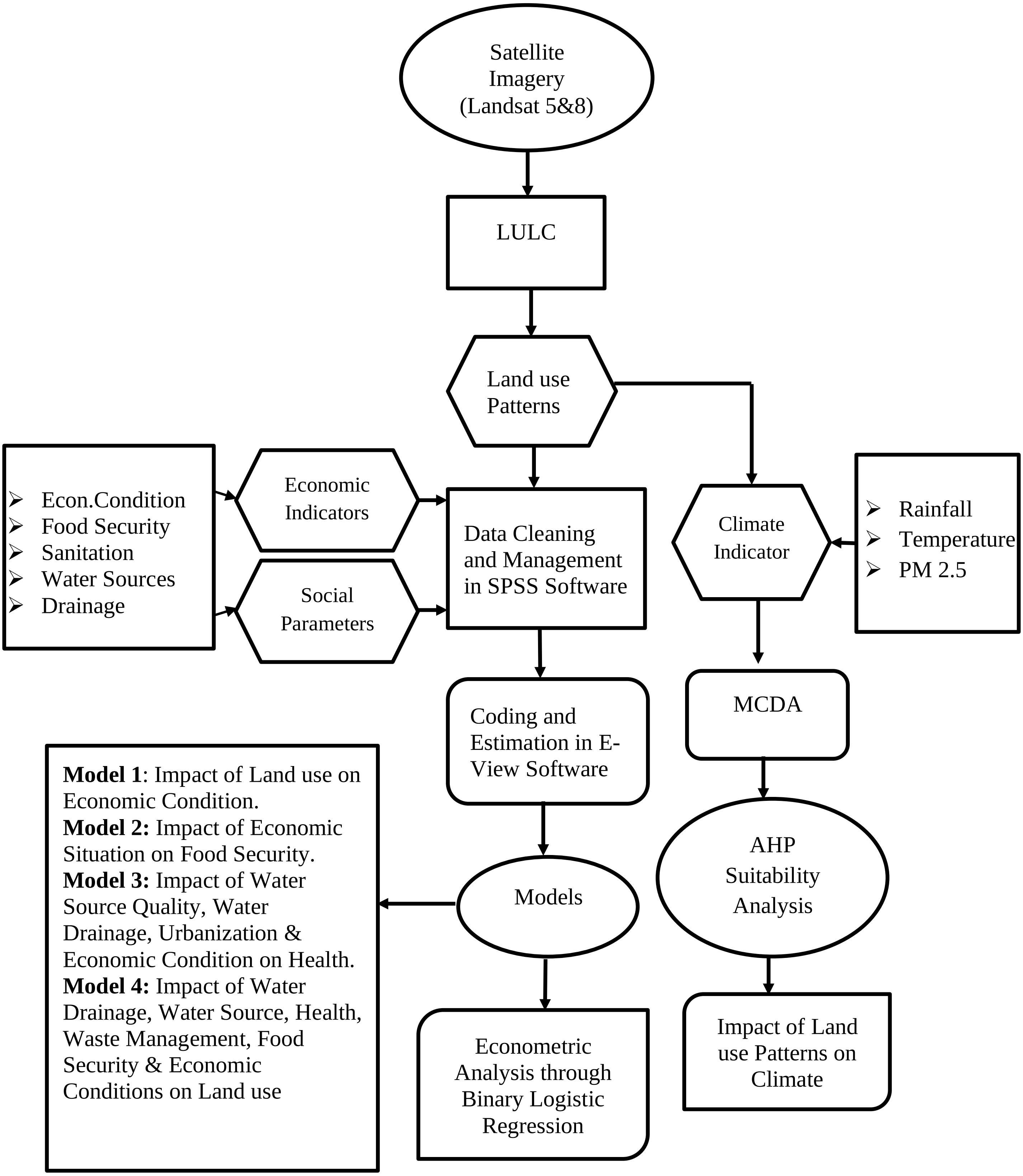

Figure 2.2. Detailed workflow of the research methods.

Chapter 3

RESULTS AND DISCUSSIONS

3.1 LAND USE PATTERNS IN RAWALPINDI DISTRICT

To achieve land use patterns the study area was divided into 4 categories i.e., water, vegetation, urban area, and bare land. The first step was the analysis of land use land cover data for identifying existing land use pattern in Rawalpindi District. For 2015 and 2020 imagery Landsat 8 imagery was used whereas for 2010 Landsat 5 imagery was used because Landsat 7 showed scanlines. The months of March and April were chosen as targeted months because of less atmospheric haze, fewer ground reflectance changes, and prevailing vegetation in the study areas (Figure 3.1).

For LULC classification, training samples were collected based on the existing knowledge of the study areas, various bands combinations along with the historical view of Google Earth. Then classified images were reclassified into 4 classes named as bare land, Urban (Built-up), vegetation and water.

According to Anderson et al., (1971 & 1976) LULC types can be describe as:

1. Bare land is the mixture of non- vegetated land, cropland with stubble remaining and, transitional areas such as areas become temporarily bare as construction is planned.
2. Built-up is an area with land cover by impervious materials (asphalt, concrete etc.) such as buildings and roads.
3. Vegetation is the mixture of grassland, parks, green- belts and woodlands.
4. Water includes lakes, reservoirs, and streams.

Results from (Figure 3.2) showed that the urban land in 2010 with area of 380 sqkm was 5%, 2015 with area of 408 sqkm was 8% and 486 sqkm was 12%. This showed an acceleration in annual urban expansion (i.e., an increase in built-up area).Similarly, the amount of bare land was reduced during the period of time. Besides, a similar pattern was observed for bare land over the years.

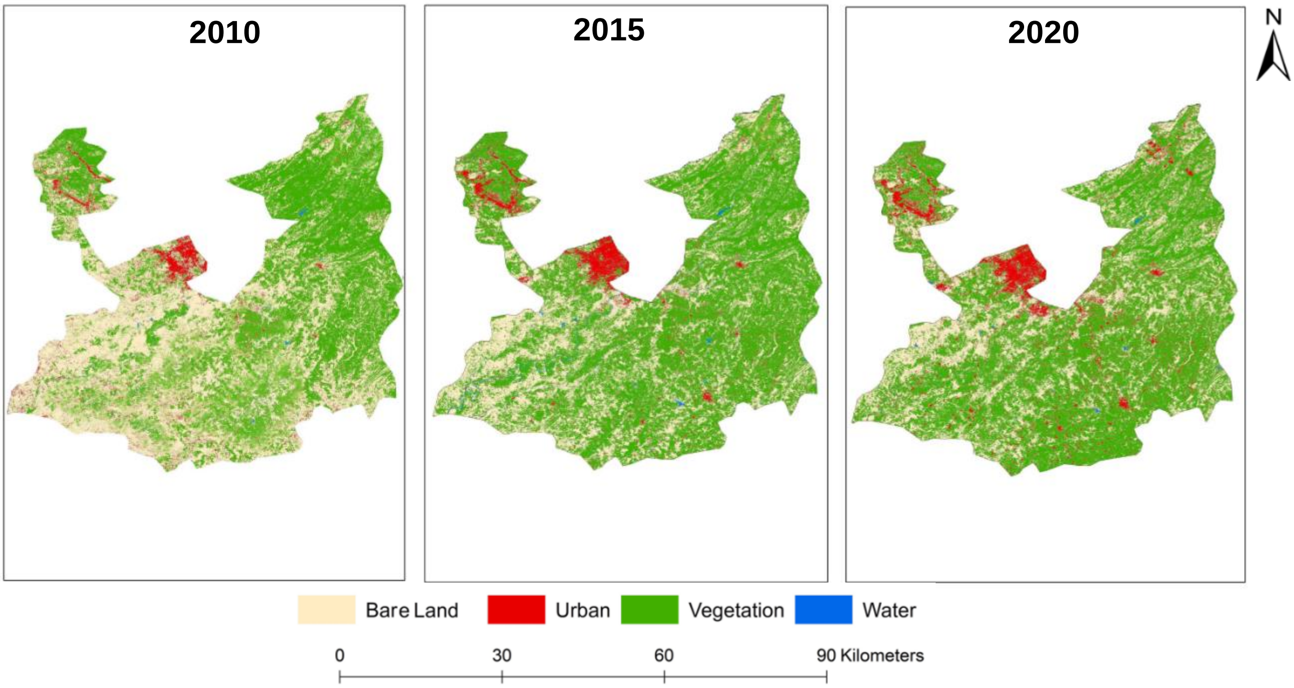

Figure 3.1. Land use and land cover detection map presenting changing patterns in Rawalpindi district for years 2010, 2015 and 2020.

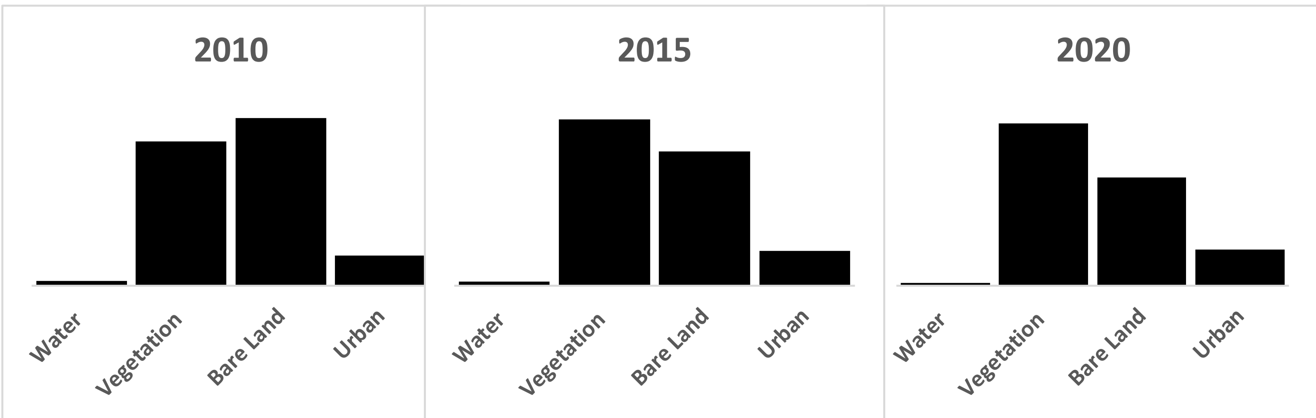

Figure 3.2. Graph of land use land cover changing pattern.

3.2 IMPACT OF URBANIZATION ON ENVIRONMENT

3.2.1 Average Annual Rainfall

Data of average amount of precipitation falling at Rawalpindi district recorded by the Meteorological Office was gathered from PMD Islamabad for the years 2010, 2015 and 2020. Three nearest meteorological stations data was taken for rainfall i.e., Islamabad Zero Point, Chaklala Airbase and Murree and other meteorological points are collected through NASA website for making data more valid and applicable. In total 18 points have been collected within Rawalpindi district. The rainfall spatial distribution maps were generated by using Inverse distance weighted (IDW) interpolation technique to depict substantial season to season and year to year variation in rainfall (Figure 3.3).

The results showed that a great difference has been observed in rainfall amount between the mountains areas and lowland areas. From this it was observed that precipitation pattern will be changed significantly in the future as well. However, the basic problem of Potohar Regions especially Soan Basin was the temporal and spatial rainfall variabilities. In this area the average rainfall varies from area to area, the maximum in the north and minimum in the southwest (Hussain et al., 2015). Though, these figures can vary significantly depending upon the specific location within the region and the prevailing weather patterns in those areas.

Results from (Figure 3.4) including 18 stations data showed that the rainfall trends over the years 2010 saw 64.64-78.65 mm/year, 2015 had 71.63-96.67 mm/ year, and 2020 experienced 61.03-90.84 mm/year. Also, all the stations had experienced a varied trend in rainfall. This showed a drastic difference in rainfall over the years as we move over the decade. Year 2015 experienced higher than average precipitation as compared to 2010 and 2020 which also affected the temperature parameter as well.

By analyzing the maps together, it was observed that year 2015 experienced more variation in rain patterns than other 2 years of 2010 and 2020. However, the year 2020 still have more rain than 2010. The year 2010 was considered to be driest than the latter years. So a visible difference in precipitation pattern has been observed over the years such as low precipitation to highest precipitation and then again toward low precipitation.

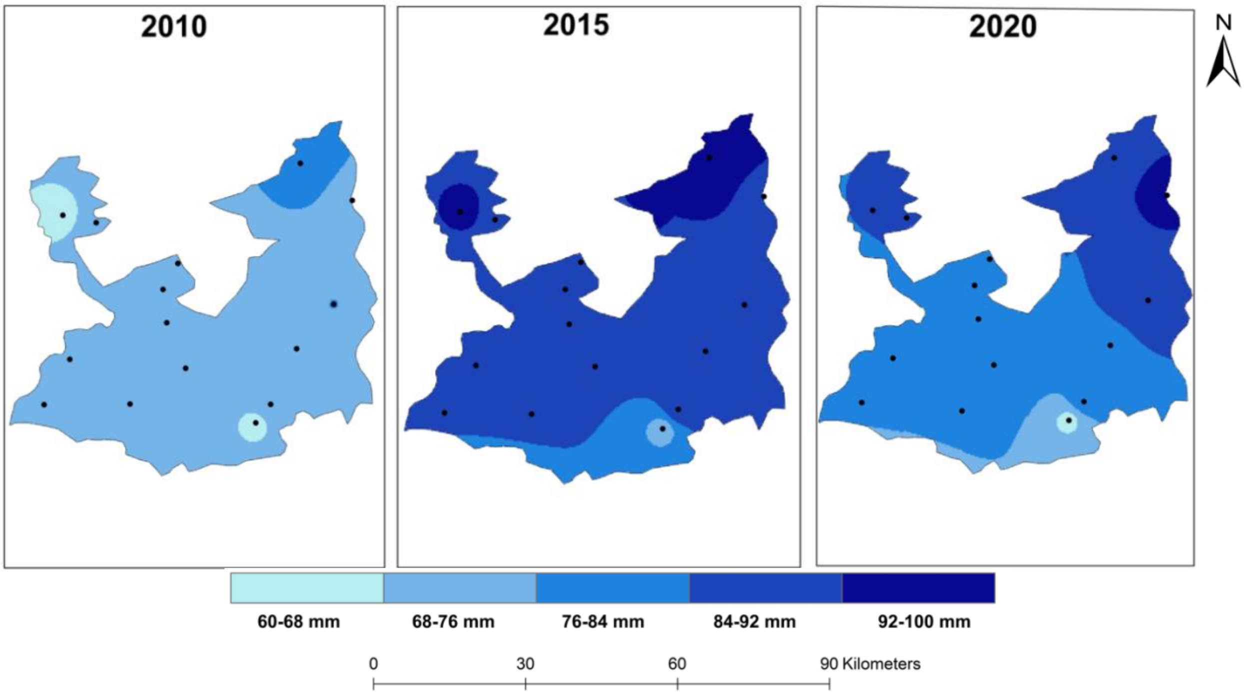

Figure 3.3. Map of annual average precipitation pattern fluctuating over the years of 2010, 2015 and 2020.

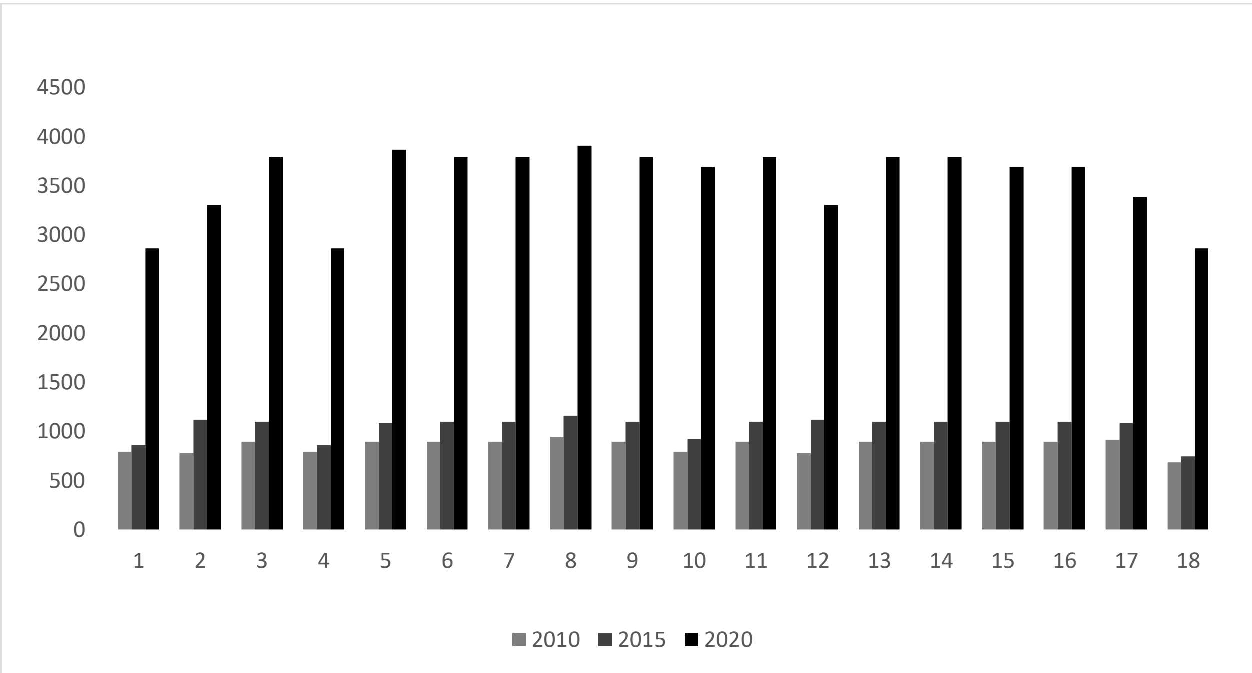

Figure 3.4. Graph of average annual precipitation trend.

3.2.2 Annual Maximum and Minimum temperature

According to Masson-Delmotte, V. (2018) the fluctuations in precipitation pattern are directly associated with global climate changes. The upward trend in the world-wide mean temperature indicated that more regions are rising than cooling. The global mean surface temperature is on linear upward increasing trend approximately 1.0°C above pre-industrial levels and likely to reach 1.5°C between 2030 and 2050 if continue to raise at the existing ratio.

The results from (Figure 3.5) demonstrated the temperature patterns observed in three different years: 2010, 2015, and 2020. In 2010, the results indicated that low-lying areas had higher temperatures, whereas mountainous regions had lower temperatures. This temperature distribution pattern appeared to be consistent in the temperature maps of 2020 because commercial and vehicular area have high temperature than side area. But 2015 showed a different story by providing less warmer temperature than the other years. However, the noteworthy observation is the fluctuation in temperature values. Specifically, the data suggests that in 2010 and 2020, there was a notable increase in the average temperature compared to 2015. This indicates a trend of temperature fluctuation over the years.

The findings from (figure 3.6) indicated a consistent pattern when comparing the average minimum temperature maps for the years 2010, 2015, and 2020. In this pattern, the lowest observed temperatures were consistently located in Murree and Margalla Hills. Conversely, as one moved away from these hilly areas towards the plains, such as Rawalpindi, there was a noticeable increase in temperature. The moderate to higher temperatures observed in Rawalpindi city and its adjoining areas can be attributed to their status as major commercial and industrial zones. These urban activities generated heat, which contributes to the relatively higher range of temperatures experienced in Rawalpindi city and its surrounding regions.

The year 2010 from table 3.2, experienced maximum temperature as 30.6-36.1 °C, 2015 experienced maximum temperature of 29.9- 34.4 °C and 2020 experienced maximum temperature of 26.7-31.0 °C. Though, the results showed that year 2010 experienced minimum temperature as 10.5-14.1 °C, 2015 experienced minimum temperature of 9.9-13.5 °C and 2020 experienced minimum temperature of 8.4-12.4 °C.

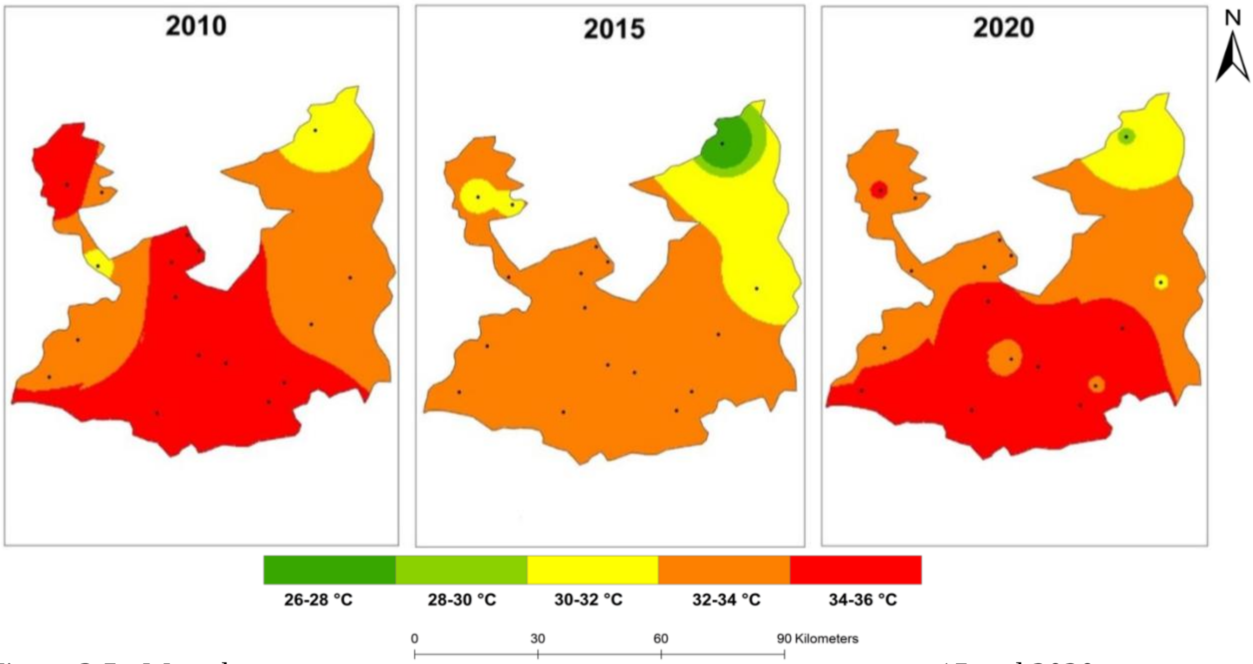

Figure 3.5. Map showing annual maximum temperature for year 2010, 2015 and 2020.

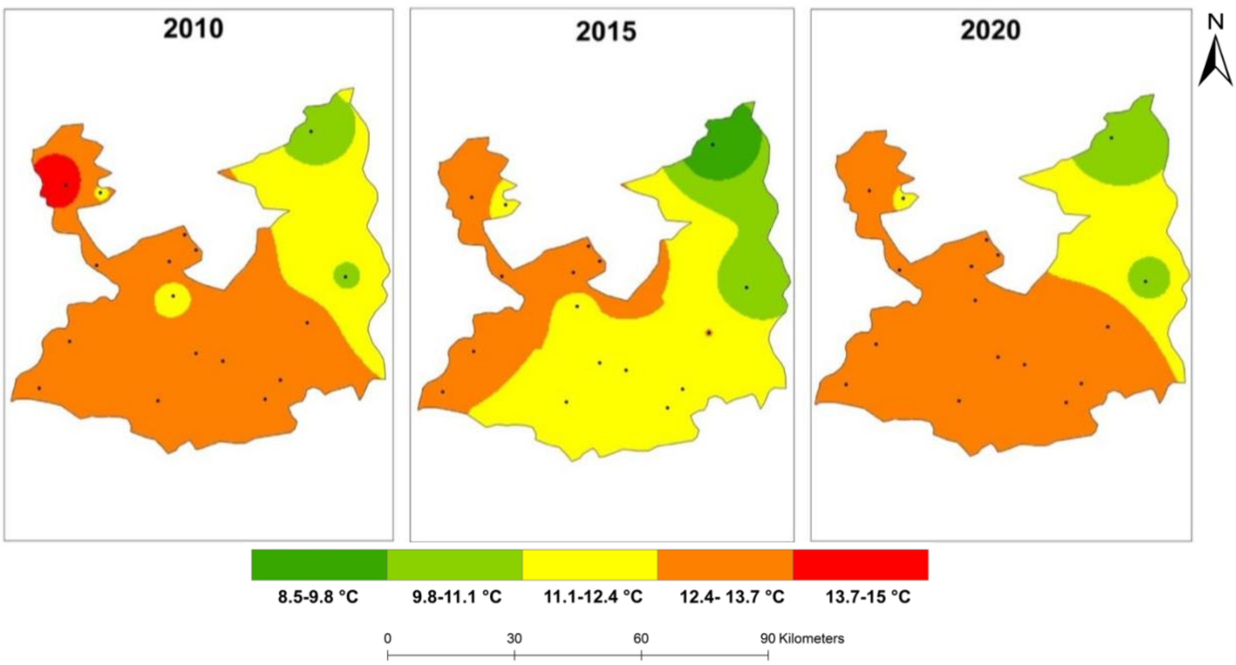

Figure 3.6. Map showing annual minimum temperature for year 2010, 2015 and 2020.

3.2.3 Average Annual Air Quality Index PM 2.5

Real time PM 2.5 pollution data was downloaded from Air Quality Life index website: https://aqli.epic.uchicago.edu/country-spotlight/pakistan/. PM 2.5 is one of the most harmful air pollutants During last decade, AQI Rawalpindi became 8.8 times higher than the WHO annual air quality guideline value.

PM 2.5 Pollutants

Particulate matter (PM), on the other hand stated as aerosols, embodies a combination of minuscule solid particles and minute liquid droplets that remain suspended in the atmosphere. Fine Particulate Matter denotes pollutant particles measuring less than 2.5 micrometers in diameter, capable of infiltrating the respiratory system and bloodstream, consequently leading to significant health ramifications. Primarily affecting the pulmonary and cardiovascular systems, exposure to such pollutants can induce symptoms including persistent coughing, respiratory distress, exacerbation of asthma, and the onset of chronic respiratory ailments.

The maps were created by using IDW Interpolation technique by interpolating these twelve locations. Results revealed that PM 2.5 concentration in 2010 ranges from 37.36-47.25μg/m^3, the year 2015 ranges from 35.15-44.36μg/m^3 and 2020 ranges from 34.94-48.82μg/m^3. It was concluded that Air quality around Rawalpindi city and its fringes was unhealthy, but it improved as we move towards Murree. AQI at mountains and peaks where rainfall was high, and temperature was low the AQI was healthy but sensitive for people with health conditions. However, In Rawalpindi city and adjoining areas demonstrate unhealthy and sever conditions as it was more vehicular and commercial area of whole Rawalpindi district (Figure 3.47)

As a benchmark for Pakistan, the national range for PM 2.5 levels often falls between 35-50 microgram per meter cube μg/m^3. The range allowed the comparison and assessment of air quality across different region within country. In Rawalpindi PM 2.5 varied in years 2010, 2015 and 2020 due to various factors including industrial activities, vehicular emission (carbon emissions) and weather conditions (precipitation rate, low and high temperature) (Figure 3.8). So, from recent report it was observed that PM 2.5 is affecting people more than the previous years. The changing pattern showed an alarming situation for Rawalpindi's air quality patterns changing over the years.

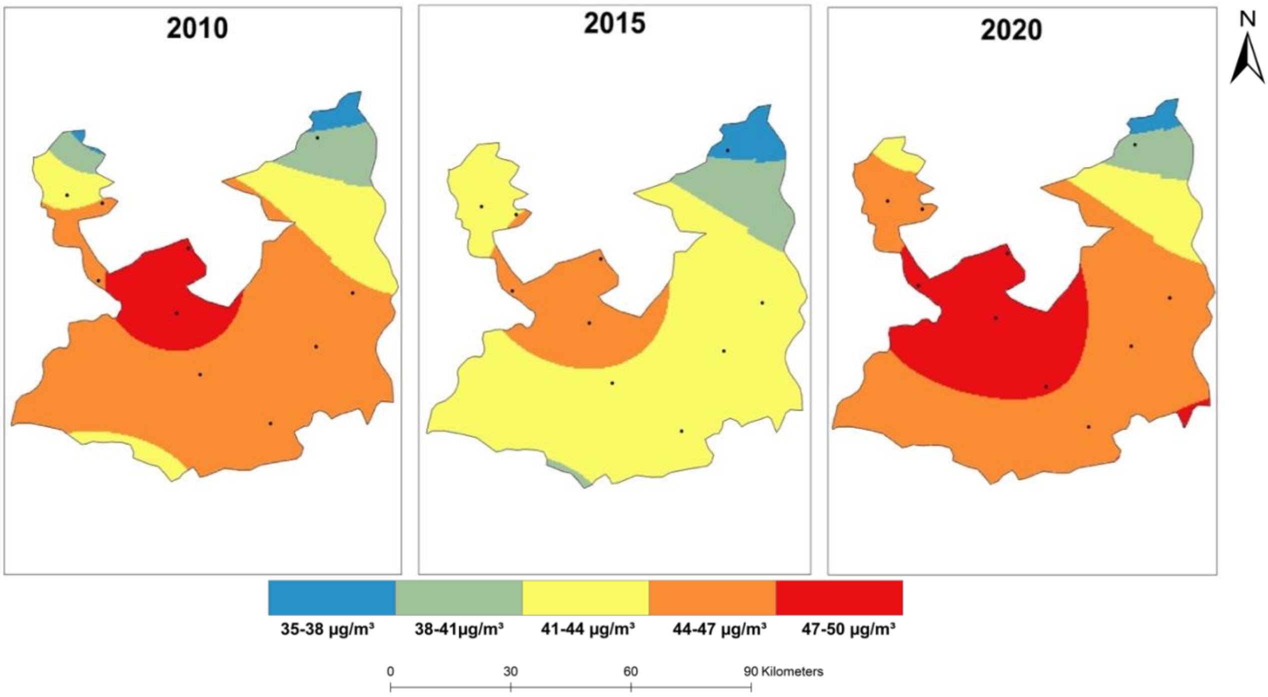

Figure 3.7. Map of variation of average annual PM 2.5 for year 2010, 2015 and 2020.

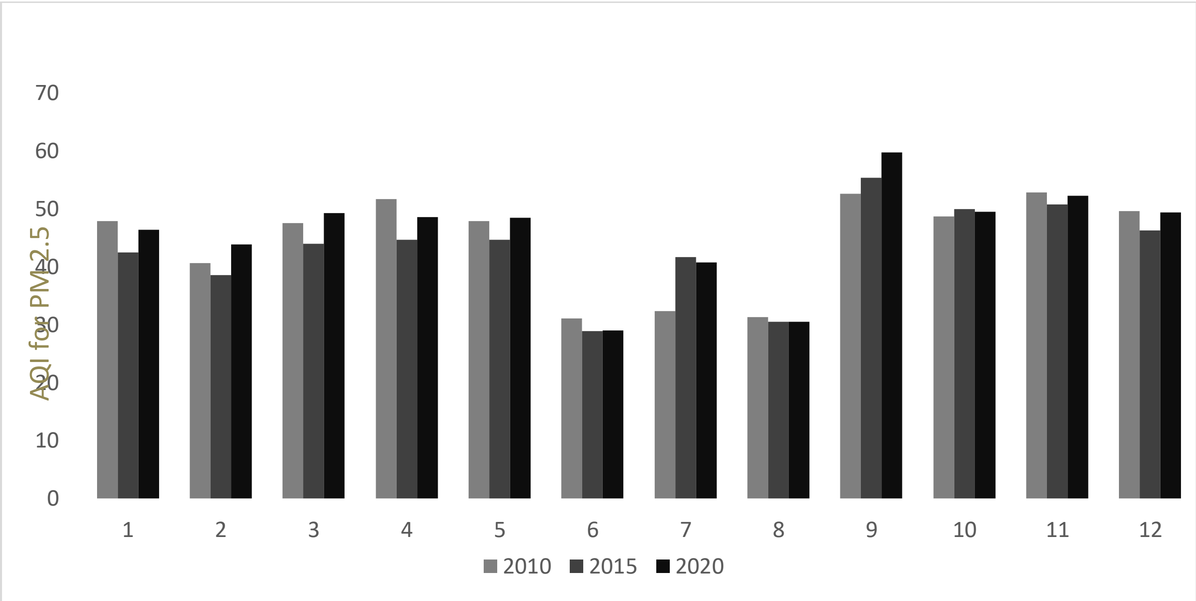

Figure 3.8. Graph of variation of average annual PM 2.5.

3.2.4 Implementation of Multi-criteria Technique

In order to assess the impact of land use patterns on environment climatic parameters such as temperature, rainfall and air quality have been used with satellite imagery to support and monitor climate changes over the year using 2010, 2015 and 2020 Landsat imagery. LULC and climate parameters were used to identify which factor was more affected by land use patterns and this process was carried out by multi-criterial decision analysis (MCDA) using Analytical hierarchy (AHP) process suitability analysis. The method we have used in our research is pair wise comparison by hit and trial. The pairwise comparison by hit and trial method helped to gain the required relative criterion pairwise comparison matrix. In general, there are three Methods of AHP i.e.,

1. Ranking Method
2. Rating Method
3. Pairwise Comparison.

In this pair-wise comparisons have been used to create a ratio matrix. In the context of AHP (Analytic Hierarchy Process) it takes pair-wise comparisons as input and produces the relative weights as output. It was developed by Saatay (1980).

3.2.4.1 Pairwise Comparison Matrix

We have employed pairwise comparison because we lack information regarding the ratings or ratings for specific parameters. We were uncertain about which parameter was being implemented. When we are unsure about which parameter holds greater importance, we resort to pairwise comparison. In this approach, we made an initial estimation and assign importance to a parameter in order to assess its Consistency Ratio (CR). According to the rule, if the CR is found to be inconsistent, we employ a trial-and-error method until the values become consistent. This method is utilized when we initially lack knowledge about which parameter should be assigned with greater importance. If we do possess knowledge about parameter importance, we opt for ranking or rating methods. For ranking or rating method expert knowledge is required to categorize the parameters and rate them accordingly. In case of environment parameter, we cannot say which parameter can be more effective, so we had used pairwise comparison and continued the process until we got the required consistency value.

Table 3.1. Pairwise Comparison Consistent Values w.r.t Maximum Temperature year 2010.

	Maximum Temperature 2010	AQI 2010	Rain 2010
Maximum Temperature 2010	1	0.333	0.333
AQI 2010	3	1	0.5
Rain 2010	3	2	1

AHP Results

Maximum Temperature 2010: 13.96

AQI 2010: 33.252

Rain 2010: 52.784

Compute

CR: 0.052

Table 3.2. Pairwise Comparison Consistent Values w.r.t Maximum Temperature year 2015.

	Maximum Temperature 2015	AQI 2015	Rain 2015
Maximum Temperature 2015	1	0.333	0.5
AQI 2015	3	1	1
Rain 2015	2	1	1

AHP Results

Maximum Temperature 2015: 16.92

AQI 2015: 44.343

Rain 2015: 38.737

Compute

CR: 0.018

Table 3.3. Pairwise Comparison Consistent Values w.r.t Maximum Temperature year 2020.

	Maximum Temperature 2020	AQI 2020	Rain 2020
Maximum Temperature 2020	1	0.25	0.2
AQI 2020	4	1	0.5
Rain 2020	5	2	1

AHP Results

Maximum Temperature 2020: 53.96

AQI 2020 29.696

Rain 2020: 16.342

Compute

CR: 0.009

Table 3.4. Pairwise Comparison Consistent Values w.r.t Minimum Temperature year 2010

	Minimum Temperature 2010	AQI 2010	Rain 2010
Minimum Temperature 2010	1	0.25	0.333
AQI 2010	4	1	1
Rain 2010	3	1	1

AHP Results

Minimum Temperature 2010: 12.60

AQI 2010: 45.793

Rain 2010: 41.606

Compute

CR: 0.009

Table 3.5. Pairwise Comparison Consistent Values w.r.t Minimum Temperature year 2015

	Minimum Temperature 2015	AQI 2015	Rain 2015
Minimum Temperature 2015	1	0.333	0.333
AQI 2015	3	1	0.5
Rain 2015	3	2	1

AHP Results

Minimum Temperature 2015: 13.96

AQI 2015: 33.252

Rain 2015: 52.784

Compute

CR: 0.052

Table 3.6: Pairwise Comparison Consistent Values w.r.t Minimum Temperature year 2020

	Minimum Temperature 2020	AQI 2020	Rain 2020
Minimum Temperature 2020	1	0.5	0.333
AQI 2020	2	1	1
Rain 2020	3	1	1

AHP Results

Minimum Temperature 2020: 16.92

AQI 2020: 38.737

Rain 2020: 44.343

Compute

CR: 0.018

3.2.4.2 Analytica Hierarchy Process Results

In year 2010 with respect to maximum temperature, Table 3.1, Rainfall appeared to be the highest criterions followed by AQI and Temperature. The consistency ratio (CR) value 0.09 suggested that the pairwise comparisons made during this year were reasonably consistent according to the rule of Random Inconsistency Index RI. However, with respect to maximum temperature Table 3.4 results showed that the consistency ratio (CR) value 0.009 suggested that the pairwise comparisons made during this year were highly consistent according to the rule of Random Inconsistency Index RI.

In year 2015, Table 3.2, Rainfall appeared to be the highest criterions followed by Temperature and AQI. The consistency ratio (CR) value 0.009 suggested that the pairwise comparisons made during this year were highly consistent according to the rule of Random Inconsistency Index RI. In the table 3.6 the consistency ratio (CR) value 0.004 suggested that the pairwise comparisons made during this year were highly consistent according to the rule of Random Inconsistency Index RI. This year places a strong emphasis on Rainfall as the most critical criterion.

In year 2020, Table 3.3, Rainfall appeared to be the highest criterions followed by AQI and Temperature. The consistency ratio (CR) value 0.071 suggested that the pairwise comparisons made during this year were consistent and slightly higher than 2015, still demonstrate a reasonable level of consistency. Whereas table 3.6 showed the consistency ratio (CR) value of 0.018 which indicated a reasonable consistent set of judgement during this year's AHP analysis.

Comparing the above results across the three years, it was evident that the relative importance of the criteria changes over the decade. These changes in criteria importance and consistency may reflect shifts in priorities or environmental conditions over time and can be valuable for decision- making processes related to the analyzed criteria.

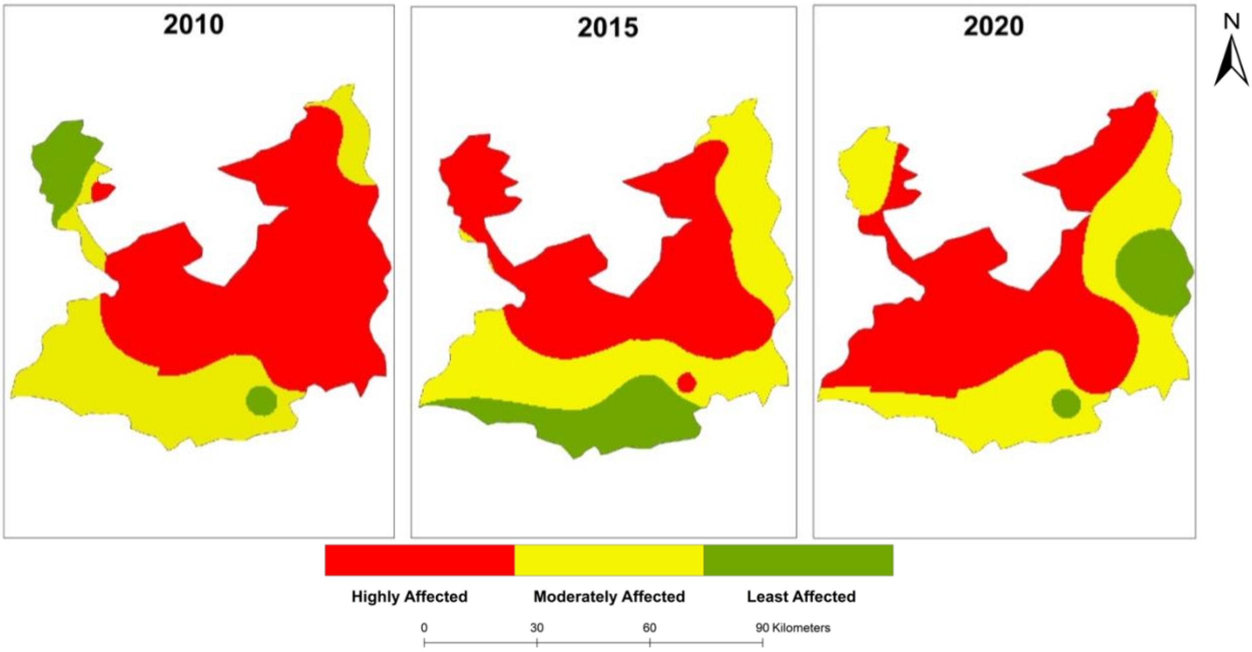

Figure 3.9. Map of Analytical Hierarchy Process with respect to maximum temperature showing high to least affected area.

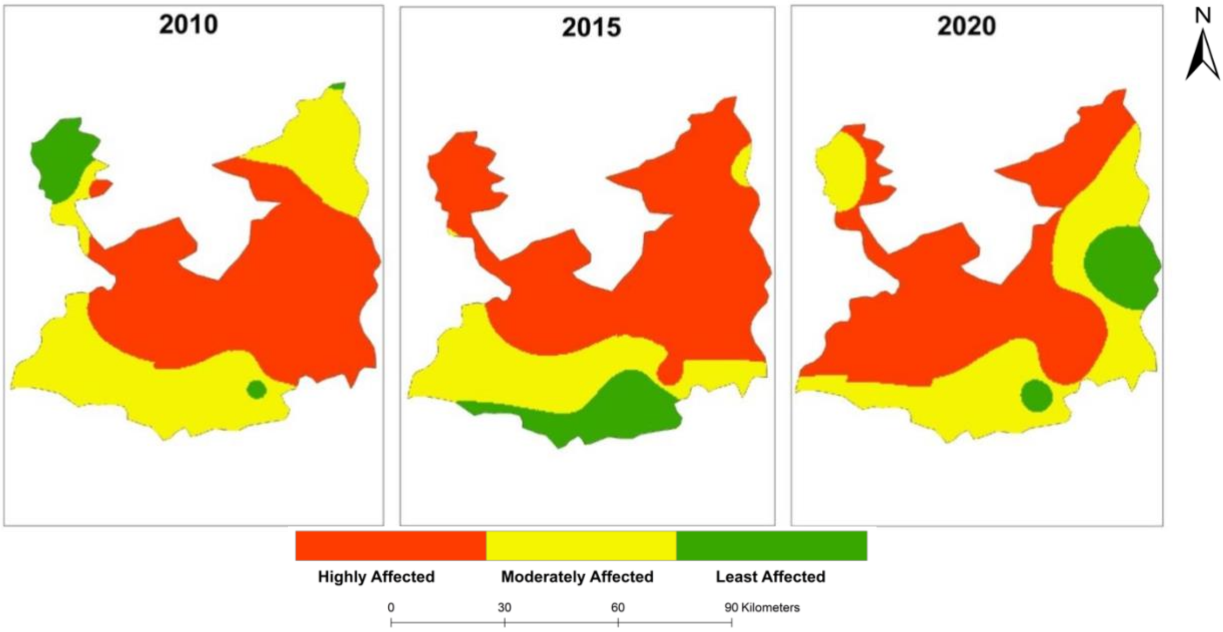

Figure 3.10. Map of Analytical Hierarchy Process with respect to minimum temperature showing high to least affected area.

3.3 EFFECT OF LAND USE ON CHANGES IN MARKET STRUCTURE

3.3.1 Economic Models

Binary coding has been accomplished on the basis of questionnaire in SPSS which was used for the calculations of economic models (based on dependent and independent variables) in E-view software's. From e- view software 4 models have been created which are explained in the tables given below.

Following Formulas have been used for Models creation:

- Probability of Passing = $e^{\beta o}$ / (1 +$6^{\beta o}$)
- Probability of Passing = $e^{-1.34}$ / (1 +$e^{-1.34}$)
- Probability of Passing = 0.208

Here we have used binary regression analysis. Actually, binary regression analysis is used when the predictors (independent) variables have binary values (either 0 or 1). The output of binary regression analysis showed the relationship between these predictors and the variable of interest. In the results, the beta was explained as the predicted changes in Log Odds - it means for one unit change in the predictor (independent variable) there is exp(beta) change in the probability (chances of occurrence) of variable of interest. These beta coefficient values can be positive or negative and have a t-value and significance of t-value associated with it.

We are always interested in finding the significance that was shown by probability value or p-value. If it was less than 0.05 it means that there was a significant impact of independent variable on the dependent variable. Or there were 95 percent chances that a relationship existed between independent and dependent as shown in the results. However, when the p-value is significance then we can explain the odd ratio value. Like value of beta can be positive or negative, the value of odd ration can be more or less than one. If odd ratio has a value more than 1 then it means that the chances of falling into the target group is greater than the falling into the non-target group. For example, if the results show the impact of job (1 = got job, 0 = no job) on the health (1 = good health, 0 = not good) and odd ratio has a value 1.5 then we can interpret it as for the person with job the chances of having good health are 50 percent more than the person with no job.

Table 3.7. Model 1: Impact of land use on economic conditions.

Parameters	B	Sig.	Exp(B)	Odd Ratio
Economic Conditions	-0.176	<.05	0.838	0.7022
Constant	-0.606	<.05	0.546	0.2981

Table 3.8. Model 2: Impact of economic situation on food security.

Parameters	B	Sig.	Exp(B)	Odd Ratio
Food Security	-0.018	0.587	0.982	0.964324
Constant	2.258	<0.05	9.567	91.527489

Table 3.9. Model 3: Impact of water source quality, water drainage, urbanization and economic condition on health.

Parameters	B	Sig.	Exp(B)	Odd Ratio
Water Source	-0.082	0.102	0.921	0.848241
Drainage System	-0.213	<0.05	0.808	0.652864
Urbanization	-0.174	<0.05	0.841	0.707281
Economic Condition	0.027	0.464	1.027	1.054729
Constant	2.584	<0.05	13.253	175.642009

Table 3.10: Model 4: Impact of water drainage, water source, health, waste management, food security & economic conditions on land use.

Parameters	B	Sig.	Exp(B)	Odd Ratio
Water source	0.1	<.001	1.106	1.22
Drainage	-0.239	<.001	1.787	3.19
Illness/Health	-0.175	<.001	1.084	1.17
Economic conditions	-0.178	<.001	0.837	0.70
Waste management	0.055	0.007	0.57	0.32
Food security	0.183	<.001	1.201	1.44
Constant	-0.576	<.001	1.252	1.56

3.3.2 Analysis for Economic Models

Beta is explained as the predicted changes in Log Odds - it means for one unit change in the predictor (independent variable) there is exp(beta) change in the probability (chances of occurrence) of variable of interest. However, the beta negative shows impact of independent variable on dependent is negative that is reflected in less than zero value of odd ratio.

MODEL 1: Impact of Land Use (Dependent) on Economic Conditions (Independent)

1. For people living in rural areas the odd of getting job was 0.702 times than the people living in urban areas. Because when the land use pattern is efficient, it leads to more economic opportunities. It is why the people living in urban areas with better land use had better economic conditions.
2. Constant Or Intercept: When the Economic Conditions were not considered the probability then the land not used efficiently was:

   0.646 [e0.606/ (1+e0.606)]

   OR

   64.6%.

MODEL 2: Impact of Economic Situation on Food Security

1. For the unemployed people the chances of having food security were 0.96 times than the people with jobs. May be due to food availability to rural people at cheaper prices which did not raise the issue of food security.
2. Constant Or Intercept: Even when the economic conditions were not considered the probability that the person wass facing issue of food security was 0.905 or 90.5%.

MODEL 3: Impact of Water Source Quality, Water Drainage, Urbanization and Economic Condition on Health

1. For the people with the clean water source, the chance of getting ill was 0.84 times than the people with no access to no clean water.

2. For the people who had covered/formal drainage system the chance of getting ill was 0.65 times than the people with no access to formal drainage system who typically had open drainage or underground drainage. This is because in the open or underground

drainage system the chances of drainage water to get mix with groundwater is higher. In addition, the open drainage system leads to malaria/diarrhoea.

3. For the people living in the rural areas, the chance of getting ill was 0.84 times as compared to the people living in the urban areas. The reason could be bad air quality and issue of food security in the urban areas that causes higher chances of getting ill.

4. The chances of getting ill for the people with no employment in the past one month was 1.05 times as compared to the people who could find the job in the last one month. The reason could be that people with jobs had more economic stability and live in better conditions that decreases their risk of getting ill as compared to the people with no jobs.

5. Constant Or Intercept: When water quality, drainage, land use and economic conditions were not considered still there was 0.929 Or 93% probability of person to face health issue.

MODEL 4: Impact of Water Drainage, Water Source, Health, Waste Management, Food Security & Economic Conditions on Land Use

1. For people with an access to clean water, the chances that they had efficient land use pattern were 1.23 than those for people with no access to clean water.

2. Households with proper drainage system had 3.19 times chances of using land efficiently than the households with no formal drainage system.

3. Person who faced no illness and was healthy had chances of 1.175 to be belonged to better land use patterns than the people who faced health issues.

4. Similarly, people with no jobs had less chances (0.701 times than the people with jobs) to use the land effectively.

5. In case of waste management, the households with no proper waste management system had 0.325 times less chance of using land effective compared with the households who had better/formal waste management.

6. In terms of food security, the people with chances of having food security 1.568 times the people with no food security used land more effectively.

Chapter 4

CONCLUSTION AND RECOMMENDATIONS

4.1 CONCLUSIONS

The intersection between sustainable land use planning and its impact on the endogenous market structure has become a subject of increasing scholarly interest and policy relevance. In this study the idea of endogenous market structure emphasizes on the internal dynamics of market on the scale geospatial analysis using environmental parameters. These driving forces are not only impactful on global level of economic patterns but also by local resources and infrastructure developments. Therefore, for policy makers, scholars, and planners it is important to understand how sustainable land use planning affects market structure.

In developing countries i.e., Pakistan such transformations are associated with inter or intra city migrations leads to pressure on economy, personal growth, and land availability along with resources. Pixel based LULC classification is one of the most valuable tools in RS and GIS for evaluating, analyzing, and identifying these transitions. AHP by MCDA is considered to the most effective tool for addressing these apprehensions. For identifying the impact of climate changes correlated with land use different climate parameters such as rainfall, temperature, and air quality (PM 2.5) are investigated.

Moreover, combining GIS with endogenous market structure has been on the most powerful concept that helps in understanding local economic growth along with use of resources. Foe this purpose binary logistic analysis, one of the most powerful economics techniques, have been used to find impact of changing dynamic on economic conditions as well as health conditions of people of district Rawalpindi. In brief, this study aims to bridge the gap between land dynamics, resource availability, health conditions and climatic analysis in Rawalpindi district. By integrating these interdisciplinary fields, we can have a better comprehension of complicated interrelation that motivates sustainable growth. The better illustration of the above discussion can be analyzed by (Figure 4.1) which explains different economic models based on their significance and odd ratio.

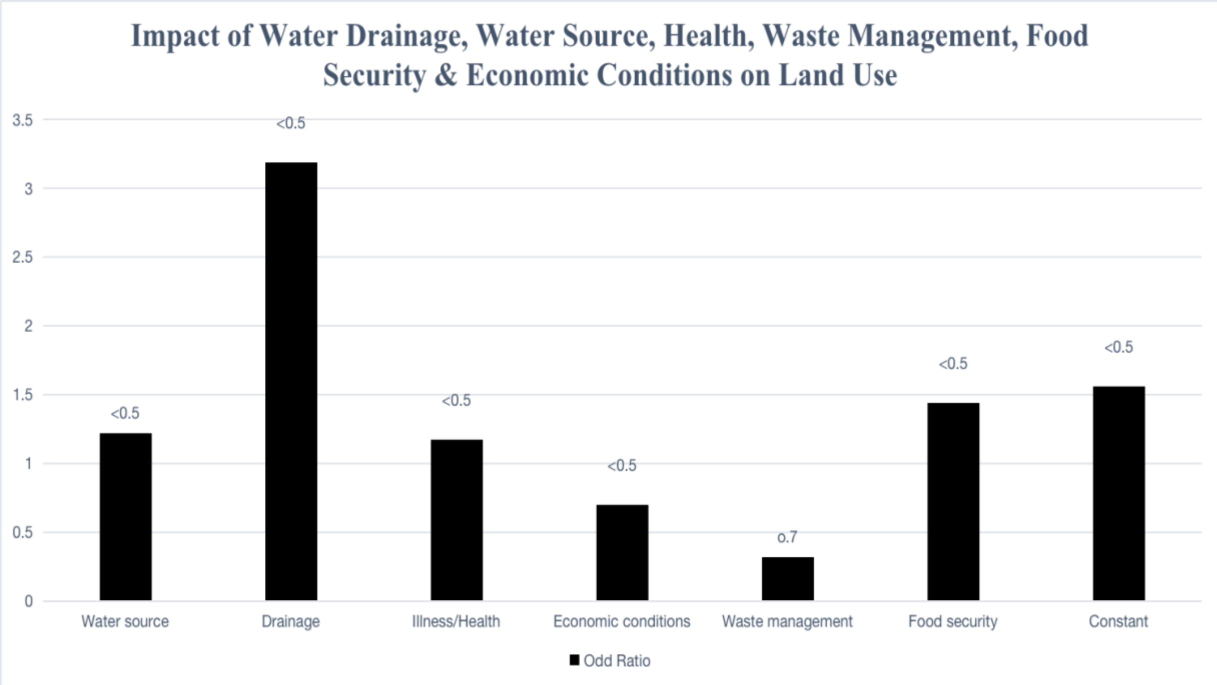

Figure 4.1. Economic Model based on significance and odd ratio.

4.2 RECOMMENDATIONS

On the basis of above extensive analytical and statistical based studies there are few recommendations that are needed to be made that will help the decision and policy makers in near and far future.it is a well-known fact that district Rawalpindi and adjoining area are facing the issues related to sustainable land use planning, environmental guidance, and economic development. So, in the light of this we can make focus on the emerging need of incorporating land use planning and geographical based analysis in Rawalpindi. Moreover, real time maps and models that represents the changing dynamics of lands and climate parameters can use the full potential of land use by creating models and real time maps. These maps and models will help the decision makers in future urban sprawl.

Also, this study also emphasizes on the immense significance of general land use planning whose focus will not only be economic sector but also public health sector as well. Sustainable land use planning initiatives should prioritize mixed-use development, green infrastructure, and the promotion of local agriculture. To ensure a clean and sustainable environment, policymakers should collaborate with local communities and environmental agencies to monitor air quality, maintain access to clean water sources, and mitigate the impact of industrial and pollution zones. By adopting an integrated approach that balances economic, environmental, and social objectives, Rawalpindi District can pave the way for more resilient, vibrant, and sustainable urban development.

Since this is emerging area of research to the GIS so there are still so many things that can be discover in this filed in future i.e., the study can be made more insightful by integrating environment data with socio- economic data to access their impact on land use. This integrated approach will not only enhance analytical depth but also augments insights int the complexities of land use utilization. Moreover, Pakistan is an agriculture country, so in future market structure can be used with agriculture data which will help in helping policy makers in elevating Pakistan’s agriculture future.

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APPENDICES

Appendix-1. The Point data for maximum and minimum temperature.

Location	Latitude	Longitude	2010	Maximum 2015	2020	2010	Minimum 2015	2020
Chaklala	33.6	73.09	34.29	33.7	31.7	12.71	12.42	12.21
Chakwal	32.93	72.86	35.06	34.84	31.7	12.87	12.69	11.33
Attock	33.77	72.36	35.18	34.08	30.9	14.43	13.45	12.46
Isb AP	33.56	72.83	31.29	33.7	30.02	12.71	12.42	12.21
Murree	33.91	73.39	30.64	29.92	26.79	10.5	9.9	8.48
Gujar Khan	33.26	73.31	34.29	33.9	30.08	12.61	12.44	11.05
Wah Cantt	33.77	72.75	35.18	34.08	29.92	14.43	13.45	12.46
Taxila	33.75	72.84	33.29	32.7	29.92	12.31	12.22	10.91
Dhamial	3.33	73.09	34.29	33.7	30.02	12.61	12.45	11.04
Gorakhpur	33.48	73.03	34.29	34.7	31.02	12.1	12.42	11.01
Matore	33.53	73.48	32.42	31.92	29.29	10.91	10.61	9.67
K. Syedan	33.41	73.38	33.73	34.85	31.02	12.87	13.59	11.51
PWD	33.57	73.15	34.29	33.7	30.02	12.87	12.42	12.21
Sat. Town	33.64	73.06	34.29	33.7	31.7	12.87	12.42	12.21
Gulyana	33.21	73.27	35.06	34.84	30.7	12.87	12.69	11.01
Pindbala	33.31	73.16	34.29	34.85	30.02	12.71	12.87	11.01
Rawalpindi	33.57	73.02	34.29	33.7	31.7	12.87	12.42	12.21

Appendix 2: Location based point data for Rainfall in millimeter.

Location	Latitude	Longitude	2010	2015	2020
Gulyana	33.21	73.27	65.92	71.63	65.03
Attock	33.77	72.36	64.6	93.16	85.25
Gujar Khan	33.26	73.31	74.27	91.41	81.73
Chakwal	32.93	72.86	65.92	71.63	65.03
Kotli Sattiyan	33.81	73.53	74.71	90.53	96.24
Kallar Syedan	33.41	73.38	74.27	91.41	81.73
Rawalpindi	33.57	73.02	74.27	91.41	81.73
Murree	33.91	73.39	78.66	96.68	89.64
NARC Isb	33.7	73.04	74.27	91.41	81.73
Fateh Jung	33.57	72.65	65.92	76.9	65.03
Taxila	33.75	72.84	74.27	91.41	89.64
Wah Cantt	33.77	72.75	64.6	93.16	85.25
Dhamial	3.33	73.09	74.27	91.41	81.73
Gorakhpur	33.48	73.03	74.27	91.41	81.73
PWD	33.57	73.15	74.27	91.41	81.73
Satellite Town	33.64	73.06	74.27	91.41	81.73
Matore	33.53	73.48	76.03	90.53	91.84
Talagang	32.9172	72.4081	65.92	71.63	65.03

Appendix- 3. Binary Coding of socio-economic Data through Survey Questions.

Parameter	**Survey Questions**	**Category**	**Code**
Region	Region	Urban	0
		Rural	1
Water source	What is the main source of drinking water?	Unclean	0
		Clean (filtered, mineral)	1
Health (Drainage)	Is your house connected with drainage system?	Ground or no drainage	0
		Covered drainage	1
Health (illness)	Ill since last two weeks?	Yes	0
		No	1
Waste Management	How is the garbage collected from your house or neighbour? (1=municipality, 2=no formal system)	Municipality	0
		No formal system	1
Food Security	During the last 12 months, was there a time when you were worried you would not have enough food to eat because of a lack of money or other resources?	unemployed	0
		employed/Job	1
Economic condition	Employment (Did you work during last one month?)	Yes	0
		No	1

Appendix- 4. Locations of PM 2.5 monitoring stations within Rawalpindi and near Rawalpindi district .

Locations	Latitude	Latitude	2010	2015	2020
1	33.77	33.77	47.9	42.47	46.43
2	32.93	32.93	40.65	38.52	43.84
3	32.94	32.94	47.51	43.98	49.27
4	32.58	32.58	51.66	44.73	48.54
5	33.57	33.57	47.86	44.69	48.43
6	34.17	34.17	31.11	28.94	29.01
7	33.99	33.99	32.4	41.7	40.76
8	34.33	34.33	31.35	30.56	30.49
9	34.02	34.02	52.58	55.37	59.74
10	34.2	34.2	48.68	49.97	49.49
11	34.01	34.01	52.9	50.78	52.28
12	33.7	33.7	49.6	46.29	49.4