ASSESSING THE LAND USE AND LAND COVER (LULC) CHANGE OF TWIN CITIES- ISLAMABAD/RAWALPINDI AREA

FINAL YEAR DESIGN PROJECT UG 2024

by

(**Leader -** CMS-356441 Capt Asad Ullah)
(**Member 1** - CMS-356444 Capt Zain Arshad)
(**Member 2** - CMS-356436 Capt Mansoor Abbas)
(**Member 3** - CMS-356463 Capt Faisal Tariq)

Department of Water Resources
Military College of Engineering, Risalpur
National University of Sciences & Technology, Islamabad, Pakistan

This is to certify that the

Final Year Project Titled

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(**Member 1** - CMS-356444 Capt Zain Arshad)
(**Member 2** - CMS-356436 Capt Mansoor Abbas)
(**Member 3** - CMS-356463 Capt Faisal Tariq)

is hereby presented to Military College of Engineering, Risalpur Cantt in partial fulfillment of the requirements for the undergraduate degree

in

Bachelors in Civil Engineering

Maj Ali Khan
(Instr)
Department of Water Resources
Military College of Engineering, Risalpur
National University of Sciences and Technology, Islamabad, Pakistan

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of BECE thesis written by

by

(**Leader -** CMS-356441 Capt Asad Ullah)
(**Member 1** - CMS-356444 Capt Zain Arshad)
(**Member 2** - CMS-356436 Capt Mansoor Abbas)
(**Member 3** - CMS-356463 Capt Faisal Tariq)

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Signature: ____________________

Name of Advisor : Maj Ali Khan

Date: ____________________

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ASSESSING THE LAND USE AND LAND COVER (LULC) CHANGE OF TWIN CITIES- ISLAMABAD/RAWALPINDI AREA

was conducted by

(**Leader** - CMS-356441 Capt Asad Ullah)
(**Member 1** - CMS-356444 Capt Zain Arshad)
(**Member 2** - CMS-356436 Capt Mansoor Abbas)
(**Member 3** - CMS-356463 Capt Faisal Tariq)

under the supervision of

Maj Ali Khan

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Department of Water Resources, Military College of Engineering, Risalpur Cantt in partial fulfillment of the requirements for the degree of Bachelor in Civil Engineering.

Student Name: Capt Asad Ullah Signature:________
Student Name: Capt Zain Arshad Signature:________
Student Name: Capt Mansoor Abbas Signature:________
Student Name: Capt Faisal Tariq Signature:________

Supervisor Name: Maj Ali Khan Signature:________

AUTHOR (S) DECLARATION

We

(**Leader -** CMS-356441 Capt Asad Ullah)
(**Member 1 -** CMS-356444 Capt Zain Arshad)
(**Member 2 -** CMS-356436 Capt Mansoor Abbas)
(**Member 3 -** CMS-356463 Capt Faisal Tariq)

hereby state that our BECE thesis titled

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Student Name: Capt Zain Arshad — Signature:____
Student Name: Capt Mansoor Abbas — Signature:____
Student Name: Capt Faisal Tariq — Signature:____

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DEDICATION

To our parents, whose unwavering love and support have been the cornerstone of this journey, and to our teachers, whose guidance and encouragement have ignited the flame of knowledge within us. This research paper is a testament to your belief in us & the values you've instilled, shaping us into the persons we are today

ACKNOWLEGEMENT

We begin by expressing our gratitude to the Almighty Allah for bestowing upon us the strength, wisdom, and perseverance needed to successfully accomplish this research assignment. Without His blessings, this endeavor would not have been attainable. We extend our sincere appreciation to our esteemed advisor, Maj Ali Khan, whose unwavering support, encouragement, and guidance have been instrumental throughout the entirety of this research endeavor. It is through his continuous motivation and guidance that we have reached the culmination of this scholarly pursuit. We also extend our deepest gratitude to our families, classmates, and seniors for their unwavering support, well-wishes, and invaluable prayers, which have served as a source of strength and inspiration throughout this journey.

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C. LIST OF ACRONYMS / ABBREVIATIONS

LULC	-	Land Use Land Cover
ANN	-	Artificial Neural Network
GIS	-	Geographical Information System
CNN-CA	-	Cellular Neural Network Cellular Automata
MSS	-	Multispectral Scanner System
TM	-	Thematic Mapper
NDVI	-	Normalized Difference Vegetation Index
USGS	-	United States Geological Survey
DEM	-	Digital Elevation Model

ABSTRACT

Changing land use and land cover (LULC) poses a serious threat to the ecosystem and has broad ramifications for sustainable development, resource management, and city planning. Modelling and projecting LULC change dynamics in the Islamabad and Rawalpindi districts is the main focus of this research, which aims to better understand the implications of these changes. Using GIS, socioeconomic data, and remote sensing data, the study examines LULC patterns across history, builds predictive models, and projects potential future outcomes. Natural landscapes have been profoundly changed by human activity, particularly in areas like Southeast Asia where the effects of climate change and population increase are particularly severe. The ability to understand the effects of changes in land use and land cover (LULC) is crucial for achieving sustainable development, especially in terms of effective water management. Geographic information systems (GIS) and remote sensing were utilized to observe changes in land use. Additionally, cellular neural network cellular automata (CNN-CA) modeling was employed to predict future changes in land use and land cover (LULC) using GIS. This research looked into the Islamabad/Rawalpindi catchment region's LULC fluctuations from 1990 to 1995, 2000 to 2005, 2010 to 2015, and 2020. Predictions for the years 2030, 2040, and 2050 are also included in the study report. Landsat satellite images were used to monitor the changes in land usage. In order to classify Landsat images, we used maximum likelihood supervised classification. Water bodies, built-up areas, vegetation, and barren lands (including agri-based lands) are the four main categories described by the wide classification in the research domain. A considerable decrease in dense forests was seen between 1990 and 2020, whereas a big fall in barren regions and a rapid increase in build-up land utilization were both shown by 2020. In addition, the results of the CNN-CA simulations will show that other classes will be displaced by urban areas in 2030, 2040, and 2050. However, dense woods are expected to drastically decrease throughout the anticipated years. The article effectively showcases the notable land use change trend in the Islamabad/Rawalpindi watershed region by presenting LULC patterns and future forecasts. The data could provide valuable insights for the administration of land use and future planning in the region.

***Keywords**:* Land use and Land Cover LULC; Geographical information system GIS; cellular neural network cellular automata (CNN-CA).

1. CHAPTER 1 – INTRODUCTION

1.1 GENRAL BACKGROUND

Globally speaking, the main cause of the change in land usage is the enormous rate of population increase. Particularly in developing nations, the major causes of the sharp changes in land cover are extensive urbanisation and the conversion of natural regions into industrial or agricultural fields. Deforestation, land degradation, and the loss of watersheds are putting a significant pressure on river basin hydrological regimes and processes. Having access to data sets that span several time periods is crucial for assessing how land's spatial features have changed. The pattern of the main LULC changes may be easily explained by using multi-temporal datasets. With the development of computer technology and the launch of Landsat satellites, tracking the developments and improvements over the past few decades has become much easier. When combined with a GIS, remote sensing has allowed for the effective identification of a wide range of environmental variables, such as plant coverage, urban development, forest transitions, and, most notably, variations in LULC changes across certain time periods. More precise and economic data assessment is provided by remote sensing and GIS methods than by other conventional methods and surveys, it has been noted.

Urbanisation, population increase, and economic development are three of the many drivers of land use and land cover (LULC) change, which is a multi-faceted and ever-evolving process. Problems with environmental deterioration, resource depletion, and sustainable development have become more apparent in the Islamabad and Rawalpindi regions as a result of this transformation in recent years. For efficient urban planning, management of natural resources, and preservation of the environment, it is critical to comprehend the trends and causes of LULC change in this area. By using state-of-the-art remote sensing and GIS techniques for LULC change prediction and analysis, this study aims to tackle these difficulties.

1.2 PROBLEM STATEMENT

The catchment region of Islamabad and Rawalpindi has experienced tremendous changes in land use and land cover (LULC) in the last several decades as a result of fast urbanisation, population expansion, and economic development. These changes, driven by a multitude of factors, are reshaping the landscape, impacting the environment, and influencing the quality of life for residents. Understanding the dynamics of LULC change and its potential implications is imperative for sustainable urban planning, environmental conservation, and informed decision-making by local authorities and policymakers.

The implications of these changes are manifold. Firstly, they affect the environment, altering ecosystems, biodiversity, and natural resources. Urbanization can lead to habitat loss, fragmentation, and degradation, impacting local flora and fauna. Changes in land cover, such as increased impervious surfaces like roads and buildings, can affect hydrological processes, leading to issues like increased runoff, flooding, and changes in water quality.

Understanding the dynamics of LULC change is essential for sustainable urban planning and environmental conservation. By analyzing past trends and projecting future scenarios, policymakers and local authorities can identify areas of concern, anticipate potential challenges, and formulate strategies to mitigate adverse impacts. This may involve measures such as land-use zoning, green infrastructure development, conservation initiatives, and sustainable development practices. Furthermore, informed decision-making by stakeholders is crucial for balancing economic development with environmental protection and social equity. Engaging with local communities, conducting participatory planning processes, and incorporating diverse perspectives can help ensure that urbanization is managed in a way that promotes resilience, sustainability, and inclusivity.

In summary, the dynamics of LULC change in the Islamabad/Rawalpindi catchment area underscore the complex interplay between urbanization, environmental conservation, and quality of life. Addressing these challenges requires a holistic approach that integrates scientific knowledge, policy interventions, and community engagement to foster sustainable development and enhance the well-being of both present and future generations (El-Tantawi et al., 2019).

1.3 RESEARCH OBJECTIVES

CA is a suitable and often applied model for LULC simulation. For this region, the combination of CNN-CA has been applied to forecast LULC changes. Such a research must be done, and the results may be useful to regional water authorities and politicians in deciding what to monitor and plan for the future. As such, the land cover change scenarios for the Islamabad/Rawalpindi watershed region were projected in this work using CNN-CA simulation up to 2050. Urbanisation is therefore one of the potential obstacles to the region's sustainable growth, so the sustainability of the environment in and around the Islamabad/Rawalpindi catchment area is crucial.

The purpose of this study is therefore to investigate the changes in LULC in Pakistan's Islamabad/Rawalpindi catchment area between 1990 and 2020, with the particular goal of quantifying the amount and contributing factors of land use in this area during the specified period. The projected LULC changes in the Islamabad/Rawalpindi catchment region were assessed using CNN-CA modelling for 2030, 2040, and 2050.

1.4 RESEARCH SCOPE

The thesis begins with Chapter 1 discussing the major concept of LULC change and its effects. Chapter 2 builds upon the general outline of the thesis, giving a deeper insight into the literature review conducted to support the thesis. Moving to Chapter 3, the thesis explains the methodology used in the research, firstly identifying CNN-CA simulation was used to assess the land cover change scenarios for the Islamabad/Rawalpindi catchment area until the year 2020. Chapter 4 will address the forecast and prediction part, in which already assessed data and CNN-CA simulation will be prepared and tested. The CNN-CA simulation was utilized to forecast the future land use and land cover (LULC) changes in the catchment area of Islamabad/Rawalpindi for the specified years 2030, 2040, and 2050. Chapter 5 will discuss results and reasonings. Chapter 6 includes the reference material used to conduct the research.

2. CHAPTER 2 – LITERATURE REVIEW

2.1 GENERAL BACKGROUND

Progressive Land use and land cover (LULC) are critical components of the Earth's surface, playing a pivotal role in shaping environmental, social, and economic dynamics. Understanding changes in land use and land cover is essential for addressing a myriad of global challenges, including urbanization, biodiversity loss, climate change, and sustainable resource management. The literature on LULC encompasses a wide range of disciplines, from geography and ecology to urban Planning and remote sensing, reflecting the interdisciplinary nature of this field.

2.1.1 COGNITIVE RESEARCH

The precision of Landsat Thematic Mappers' geometric accuracy was evaluated through a linear least-square comparison between digital images and geographic locations from 1:24,000-scale maps. In the case of a Landsat-5 image, they were 11.2 meters for the standard digital product and 10.3 meters (0.4 pixels) with additional linear corrections. An F-test indicated that skew and affine distortion corrections were not statistically significant. With a minor loss in digital-to-graphic conversion accuracy, the evaluated Landsat-5 picture nevertheless complies with National Horizontal Map Accuracy criteria for scales of 1:100,000 and below, despite possible problems such as map errors and digital image granularity. Landsat-4 pictures, taken with and without the Multispectral scanner and processed using a temporary software system, showed significant affine and skew aberrations.

For around thirty years (1982–2013), Landsat 4-5, built concurrently with a same design and furnished with the Multispectral Scanning System (MSS) and the Thematic Mapper (TM), worked together in observational roles. Understanding the need of data continuity in temporal analysis, studies on the coherence of TM and Landsat 4-5 MSS data are crucial. With the use of synthetic reflectance records obtained from a large collection of well-calibrated and geographically dispersed Hyperion hyperspectral profiles, this work first investigates the characterization discrepancies between Landsat 4-5 MSS and TM. Differences between MSS and TM in the normalised difference vegetation index (NDVI) were mostly caused by variances in the near-infrared area; variations in the red spectrum were quite small. Cross-validation tests were then used to validate proposed models for transforming MSS NDVI to TM NDVI.

Eight pairs of synchronized Landsat 5 MSS and TM observations were used to further assess the efficacy of these transformation models. Univariate models using ordinal least squares regression (OLS) reduced the median relative difference (MdRD) by 10% on average. The use of bivariate models, particularly transformation models based on ridge regression, often enhanced NDVI comparability. In cases when issues with data quality arise, such as in the 800-1000 nm MSS near-infrared channel, the only viable alternative is the univariate OLS regression model. Lastly, benchmarks derived from NDVI transition models from MSS to TM, which are built on various Hyperion hyper spectral profiles, offer valuable information.

Deep learning has completely changed the way satellite and aerial picture analysis and interpretation are done. The vast sizes and variety of objects in these photographs pose unique problems, but they also provide a wealth of opportunities for deep learning researchers to delve more into the subject. An extensive examination of several deep learning techniques adapted for the examination of aerial and satellite images is included in this resourceFor tasks like as object classification, segmentation, and identification, it incorporates a number of distinct models, methodologies, and structures. Pascal Memory tiling effectively enables software to manage significantly wider arrays of raster spatial data than what is ordinarily achievable, without the demand for specific computer resources. The enormous amounts of publicly available digital raster spatial data from sources like remote sensing make this capability even more important when used to GIS.

The scale of these datasets often surpasses the capacities of most applications on standard computer platforms. A tiled array class is constructed with syntax and usage similar to standard arrays, facilitating seamless integration with existing algorithms and applications. The research establishes a framework for categorizing operations on spatial data into small and large regions, representative of a wide range of operations in GIS.

2.1.2 LAND USE / LAND COVER DYNAMICS

One prominent theme in the literature revolves around the drivers of land use change, seeking to unravel the complex interactions between human activities and the environment. Land use patterns are influenced by key causes such as urbanization, agricultural growth, infrastructure development, and natural resource extraction. Researchers have utilized many approaches, such as remote sensing, GIS, and socio-economic surveys, to evaluate and simulate these transformations throughout the years.The integration of advanced technologies has significantly enhanced our ability to monitor and analyze LULC dynamics at different scales, providing valuable insights into the underlying processes driving landscape transformations.

Another critical aspect explored in the literature is the impact of land use and land cover change on ecosystems and biodiversity. Habitat fragmentation, loss of biodiversity, and changes in ecosystem services are often consequences of human-induced alterations to the landscape. Researchers investigate the ecological implications of land use changes, examining how shifts in land cover influence species distribution, migration patterns, and overall ecosystem health. Such studies contribute to our understanding of the delicate balance between human development and environmental conservation, informing strategies for sustainable land management and biodiversity conservation.

2.1.3 THE EFFECTS OF CHANGING LAND COVER AND USE ON BIODIVERSITY AND ECOSYSTEMS

In urban environments, the concern over both natural and human-induced environmental changes has heightened due to the adverse effects on the deterioration of the environment and human health. Recognizing the importance of effective planning and sustainable resource utilization, the study of Land Use/Land Cover (LULC) changes becomes crucial. Conventional methods such as demographic data gathering, and environmental sample analysis are deemed insufficient for the complexities inherent in environmental studies. Given the multidisciplinary nature of environmental issues and the challenges they pose, new technologies like satellite remote sensing and Geographical Information Systems (GISs) have become essential. These technologies play a vital role in providing data for studying and monitoring the dynamic changes in natural resources, facilitating effective environmental management.

The role of policy and governance in shaping land use decisions constitutes a significant focus within the LULC literature. Scholars investigate the effectiveness of land-use policies, zoning regulations, and conservation strategies in influencing human behavior and mitigating adverse environmental impacts. The interplay between government initiatives, community engagement, and private sector interests is a complex terrain explored in numerous studies. Evaluating the success or failure of different policy interventions provides valuable lessons for designing more robust and adaptive governance frameworks that can address the multifaceted challenges associated with land use and land cover changes.

2.1.4 REMOTE SENSING AND AVAILABILITY OF GEOGRAPHICAL DATA IN CONJUNCTION WITH GIS

The understanding of the worldwide physical processes affecting the Earth has been greatly aided by remote sensing. A current tendency is to improve interpretation by using GIS and the growing availability of spatial data. GIS is a computer hardware and software integrated system that can record, store, retrieve, modify, analyse, and display geographically related (spatial) information. Its function is to support decision-making and development-oriented management procedures.

Many fields can benefit from using GIS and remote sensing, such as agriculture, environmental studies, and integrated eco-environmental assessments. Because of the profound effects that LULC studies might have on the local flora and fauna, a number of academics have chosen to concentrate on them. Urbanization, industrialization, and massive population expansion have all been hallmarks of the fast development in the studied region throughout the last several decades. The primary objective of this paper is to detect and quantify LULC changes in the urban area of Rawalpindi/Islamabad from 1990 to 2020, employing satellite imagery and topographic maps, and to predict the behavior in 2030, 2040 and 2050.

2.1.5 SUMMARY OF LITERATURE REVIEWS

The research discusses the importance of understanding land use and land cover (LULC) changes and their implications, covering various topics such as the significance of LULC in global challenges, precision evaluation of Landsat Thematic Mappers, the coherence of Landsat 4-5 MSS and TM data, deep learning in satellite image analysis, Pascal Memory tiling for spatial data handling, and the drivers and impacts of LULC changes on ecosystems and biodiversity. It also touches on the role of policy and governance in shaping land use decisions and highlights the use of remote sensing and GIS for studying LULC dynamics. The paragraph concludes with the specific objective of detecting and quantifying LULC changes in the urban area of Rawalpindi/Islamabad from 1990 to 2020 using satellite imagery and topographic maps.

3. CHAPTER 3 - EXPERIMENTAL METHODOLOGY

3.1 STUDY AREA

Rainwater fed natural stream Islamabad/Rawalpindi passes through Rawalpindi. Following its feeding by its catchment basin in the Margalla Hills, which border Islamabad, Pakistan, the stream floods during the monsoon season. With the twin cities of Rawalpindi and Islamabad included, the study's catchment area is 1786.8 km2. Catchment area begins at the administrative border between Rawalpindi and Islamabad, near the IJP Road in Islamabad. In addition to coming from the Islamabad region, 11 major Rawalpindi City drains also feed Islamabad/Rawalpindi.

Together with its tributaries, which rise in Margalla Hills and include Saidpur Kasi, Kanitwali, Badar Wali Kasi, and Tenawali Kasi, the catchment area enters Rawalpindi city from the CDA area at IJ main Road and Khayaban-e-Syed. Within Rawalpindi City, the additional tributaries Nala Lai, Niki Lai, Dhoke Hassu Nullah, Dhoke Ellahi Bakhash, and PAF Colony Nullah enter the main Islamabad/Rawalpindi basin.

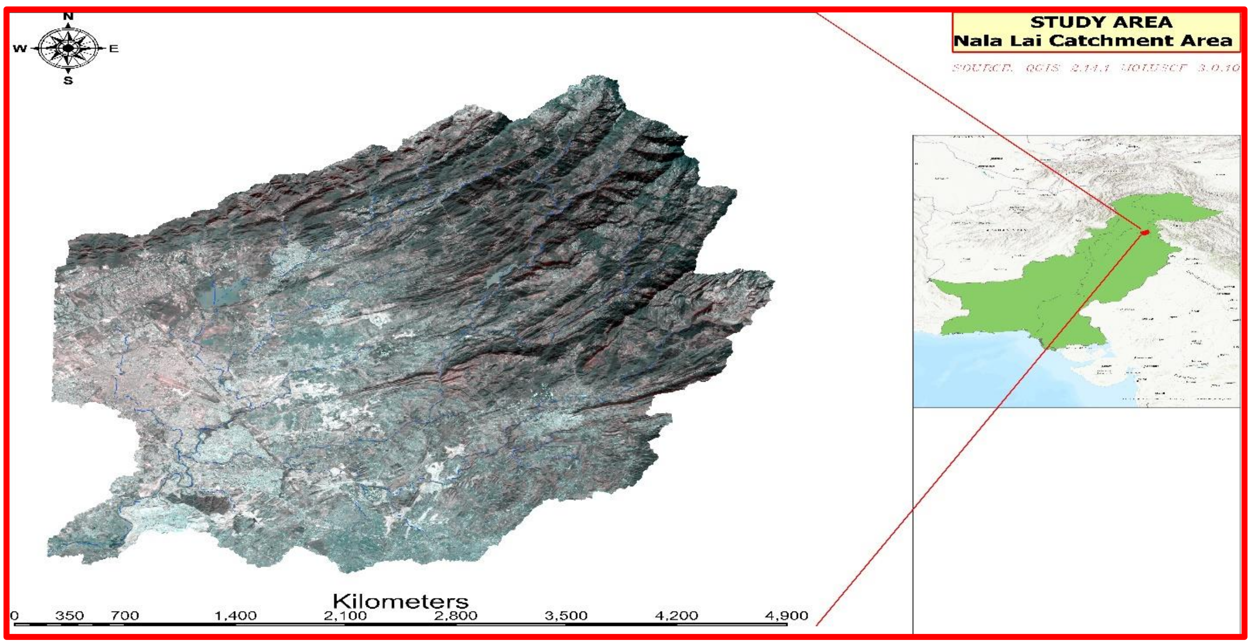


Figure 1: *Study Area*

3.2 EXPERIMENTAL PROGRAM

Located on the northeastern periphery of the Potohar plateau in the state of Punjab, Islamabad is positioned 14 kilometers to the northeast of Rawalpindi. It is situated at the geographical coordinates of 33°49′ north and 72°24′ east of Greenwich. The altitude range of Islamabad is between 457 and 610 meters. The overall area of the region is 906.50 square kilometers. The Margalla Hills are located in the northeastern and northern parts of the 3626 km2 Specified Green Area. The elevation data for this research region was derived from a Digital Elevation Model (DEM) obtained through the Open Topography website.The most accurate and comprehensive topographical map ever created of Earth's surface is the outcome of data collected by the radar system. Mainly moderate, lengthy highlands with mild to severe slopes make up the Islamabad/Rawalpindi catchment region.

Landsat photos obtained from the Landsat 5 satellite were used to examine the LULC changes; dates were selected taking into account the availability and quality of Landsat data as well as the weather. From the standpoint of spatial composition, the data for Landsats 5 and 8 revealed a little consistency problem. These problems were fixed in the pre-classification stage of the study and have also been effectively handled by a few earlier research. We chose the visible bands—red, green, and blue—for the purpose of classifying land uses. Landsat 5 classified bands 2, 3, and 4. From the USGS earth explorer website (https://glovis.usgs.gov) utilizing Path/Row 150/37 for the Islamabad/Rawalpindi catchment region, landsat photos were collected for the years 1990, 1995, 2000, 2005, 2010, 2015, and 2020. The datasets were included to ArcGIS to produce LULC maps. At several phases of the investigation, the ArcGIS pro software suite was employed. Sighted during different seasons of the year, the satellite's photos all had a 30-meter spatial resolution. Once the Landsat picture was verified by date, the resultant photos were cropped to extract the research area.

Table 1. *Specifics about the Landsat photos that were utilised to research the region.*

Year	Landsat Scene ID	Path	Date Acquired	Resolution (m)	Row	Earth-Sun Distance
1990	LT05_L1TP_150037_19950709_20200913_02_T1	150	09 Jul 1990	30	37	1.0132773
1995	LT05_L1TP_150037_20001129_20200906_02_T1	150	16 Jul 1996	30	37	0.9878930
2000	LT05_L1TP_150037_20020103_20200905_02_T1	150	23 Jul 2000	30	37	1.0034227
2005	LT05_L1TP_150037_20101227_20200823_02_T1	150	27 Jun 2005	30	37	0.9834906
2010	LT05_L1TP_150037_20101227_20200823_02_T1	150	2 Aug 2010	30	37	1.0128080
2015	LT05_L1TP_150037_20020103_20200908_02_T1	150	23 Jul 2015	30	37	0.9902608
2020	LT05_L1TP_150037_20101222_20200812_02_T1	150	15 Jul 2020	30	37	0.9834906

3.2.1 CLASSIFICATION

False colour composites and normalized differences water and vegetation indices were generated to get excellent classification precision. The artificial colour composite that was used for better visualization was a combination of green, near-infrared (NIR), and red bands (R). For each picture, NDVI, or normalised difference vegetation index, and NDWI, or normalised difference water index, were also generated. NDVI has been successfully used in the last years for a variety of applications in vegetation coverage estimate.

False colour photos assisted in the identification and display of various land features, while NDVI and NDWI were applied to differentiate the water and vegetal surfaces in the research region, respectively. Because spectral variability in certain cover categories has been successfully addressed by the supervised classification approach, Landsat pictures were digitally classified using it. Multiple recent studies have shown that supervised classification yields superior results compared to unstructured classification. By applying a per-pixel signature to the same digital number (DN) of various landscape characteristics, four classes were created from the analysis of all the satellite photographs. The stated classifications included water bodies, flora, barren terrain, and built-up areas (BUAs).

Drawing polygons around the typical sites for each of the predefined LULC categories allowed for the selection of training samples. A suitable spectral signature is one that makes little difference between the to be mapped land coverings. Every class has more than 100 spectral signatures, therefore a selection of over 400 training points was made from each of the four classes. Afterwards, signature files were generated, which represent a specific class or cluster. The base map, which provides the geographical context of the research region, was added subsequent to the creation of the signature files.

Table 2. *The system of categorization for land cover and use (LULC).*

Class	**Description**
Water bodies	Lakes, ponds, reservoirs, rivers, and open waters.
Built-up Areas	A combination of human-influenced barren regions and bare soil patches.
Vegetation	Fields of crops and long, uninterrupted forests, some of which can reach 50 metres in height; these forests include mangroves, plantations, and natural areas as well as land for agriculture.
Barren Lands	Exposed soil regions and uninhabited, arid regions of land.

Following the maximum-likelihood classification method was used for the supervised categorization of the Landsat photos. The user can choose pixel values associated to various classes using this categorization technique. The supervised classification results together with better resolution photos demonstrate the research area's categorization. Afterwards, the kappa coefficient was computed to evaluate the categorised map accuracy. A measurement of the general coherence between the categorised pictures and reference data is the kappa coefficient. The kappa coefficient was computed using the multi-separate variables approach in order to assess the classification map accuracy. Its source was the confusion matrix connecting the cited data and categorization map.

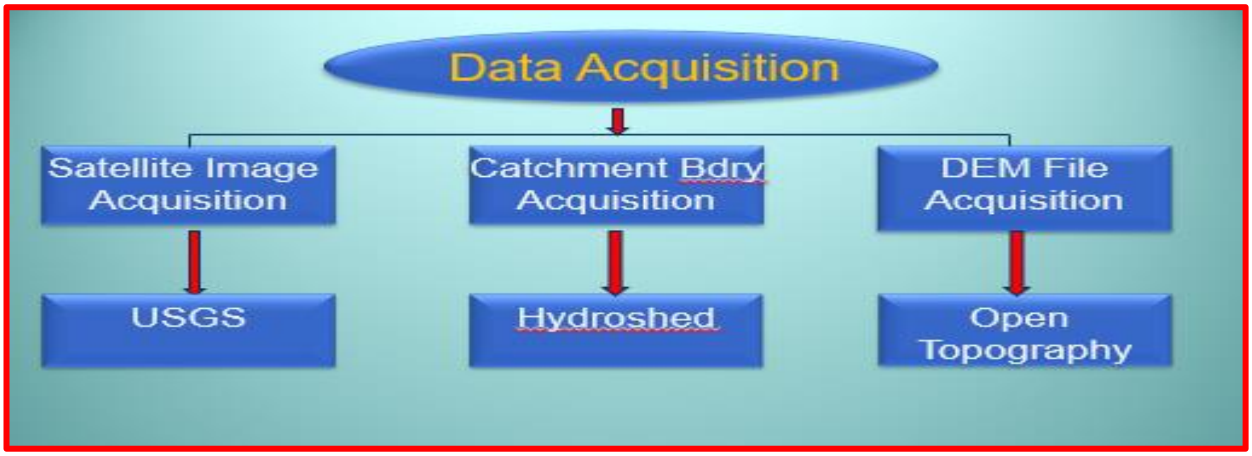


Figure 2: *Data Acquisition*

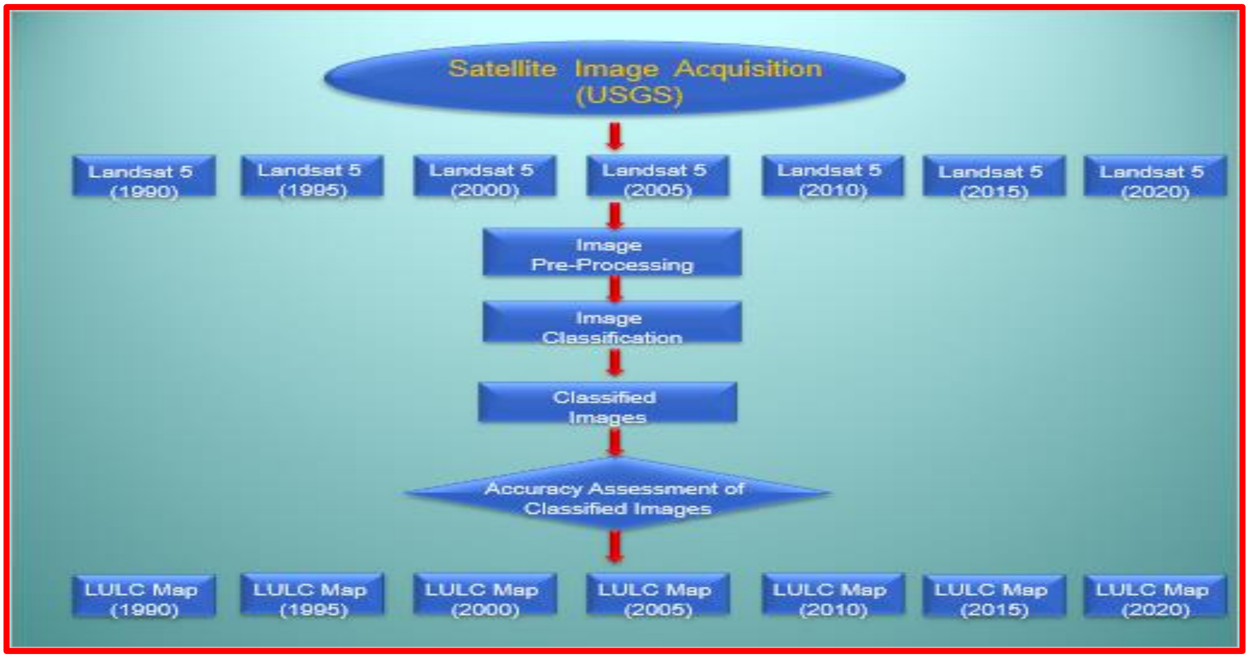


Figure 3*: Satellite Image Acquisition (USGS)*

3.2.2 CHANGE DETECTION

Identifying the differences in land use patterns of various classes (i.e., water bodies, barren and urban areas, agricultural lands, and thick forests) throughout different time periods is thought to be mostly accomplished by change detection. This approach is essentially able to detect changes in data from different sources and time periods. Finding the difference in the area covered by various land use classes between the five periods of 1990 to 2020 with a five-year interval between each was the method used to determine change detection. The "attribute table" was produced following analysis of the land use categorization in order to calculate the area covered by various land use classifications.

3.2.3 ARTIFICIAL NEURAL NETWORK CELLULAR AUTOMATA MODELING

Several models built on simulations have been created within the past 20 years and are used to model changes in land cover worldwide. In this work, free source QGIS software was utilised to simulate and assess the LULC trends of the Islamabad/Rawalpindi River basin up to 2020 using a mix of CA and ANN. The Markov chain method is the foundation of the QGIS CA feature; that is, it depends on the current state of land use instead of the past. Combining geographic input factors with past and present land use maps, this model produces the output data in the form of tables and maps. MOLUSCE trains the model with methods based on such data. ANN methods are more accurate than other techniques, hence the LULC transition potential model was trained using them. ANNs have been widely used in remote sensing for appropriate LULC modelling and categorization in recent decades. Similar neurons to those in human brains make up an ANN, which utilises them to identify data trends. The type of artificial neural network that is employed the most frequently is the multilayer perceptron (MLP). The MLP-ANN preprocesses the provided data from land use groupings, such as agricultural fields, aquatic bodies, barren and urban zones, by dummy coding of different categories into a set of independent variables like 0 and 1.

The study created the transition potential model for learning graph stabilization using a momentum of 0.050 and a learning rate of 0.100. In addition, the problem of overfitting in the model was mitigated by using 500 iterations. ANN-CA simulation was used to model the changes in land utilization. The condition of the new cell in CA was determined by changes in the adjacent cells and the status of an existing cell. The transition potential model, a raster of spatial parameters, and LULC classes are examples of raster data that are selected by the ANN-CA simulation through the use of an ANN algorithm. The simulation identifies potential changes for every class and generates a raster of the most likely transitions. The simulation alters each pixel's class after examining a certain number of pixels in order to make the transitions that have the highest confidence match the most likely ones. The simulation was ran many times to get forecast maps for 2030, 2040, and 2050.

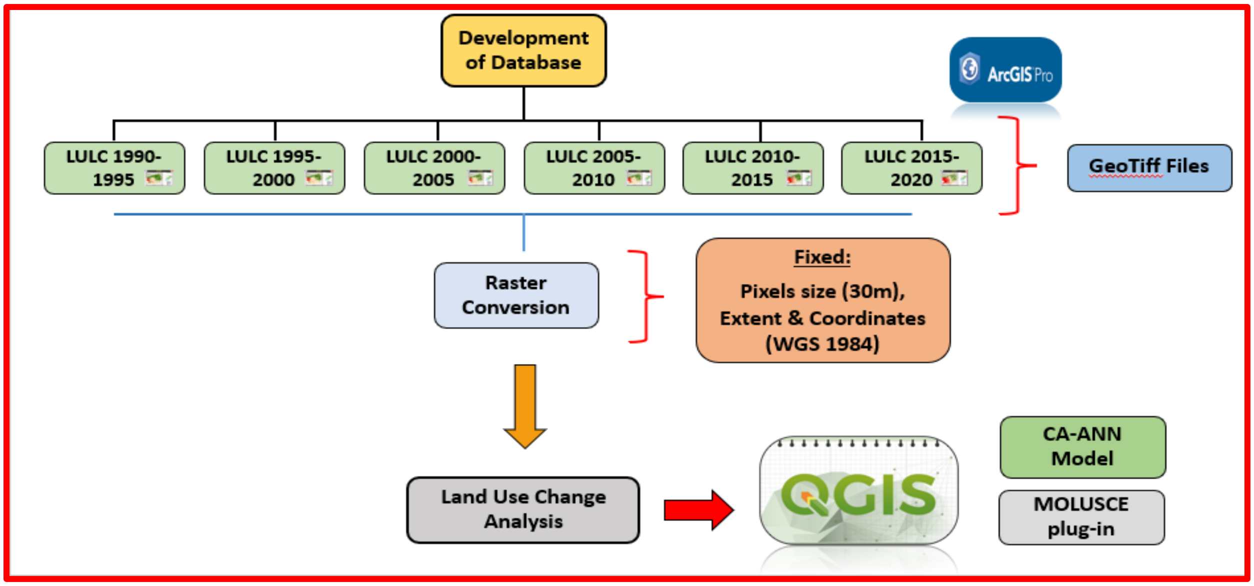


***Figure 4:** Development of Database*

The ANN-CA simulation, which enables for the verification, comparison, and validation of the obtained results, was followed by validation. Validation was done by comparing reference data with simulated results. It is said that there is a clear difference between calibration and validation procedures, which are important aspects in verifying a simulation model. Input data for the projected maps of 2030, 2040, and 2050 was classed maps from 1990 to 2020 (5 year increments). The level of agreement between the pixels of the two maps was evaluated by comparing the projected map of 2030, 2040, and 2050 with the observed categorised map of 2020. Calculated was the total kappa coefficient, which range of values is 0 to 1. The validation of the simulation model was shown by the good value of the kappa coefficient and the high degree of agreement. The foundation of the future projected maps from 2030 to 2050 was this verified simulation model.

4. CHAPTER 4 - RESULTS AND DISCUSSIONS

4.1 Land Use Change and Accuracy Assessment

The LULC types of four main land cover classes—water bodies, buildup areas, vegetation, and bare lands—are shown spatially between 1990 and 2020. These statistics show the situation of land usage in the basin of Islamabad and Rawalpindi. First, Landsat photos were uploaded into an image analysis programme to determine the band composition. Afterwards, the fingerprints of every spectral class were recognised using Landsat pictures. Classes with identical spectral signatures were combined for supervised classification. In this way, the land cover classes may be automatically allocated to every pixel in a picture. Applications of training sets created from Landsat pictures were made to the maximum-likelihood classifier.

After classification came the accuracy evaluation of the categorised photos. LULC map accuracy was assessed after the stratified samples were created using Google Earth pictures. For the purpose of measuring accuracy, a confusion matrix was constructed between testing samples and categorised pictures. That is an easy approach to assess how often a pixel misidentifies class. On the categorised maps, 189, 202, and 177 random points were chosen for the generation of the confusion matrix table for the years 1990, 1995, 2000, 2005, 2010, 2015, and 2020, in that order (Table 3).

Images from Google Earth were contrasted with these arbitrary locations, which represented different types of land usage. The user's and producer's adjusted values were represented by these haphazard places. The dataset table became a confusion matrix when the user's corrected values in each class were compared to the overall producer's values. The kappa values of the classified images are considered satisfactory by Anderson's classification method if they reach the minimum accuracy requirement of 0.85. Iteratively increasing the size of the training sample was attempted in an effort to boost accuracy until the kappa coefficient attained the desired level of above 0.85. As Table shows, the total accuracy of categorised photos for the years 2000, 2010, and 2020 were 0.86, 0.90, and 0.91, in that order. The table also specifies, for every image, the accuracy of each class.

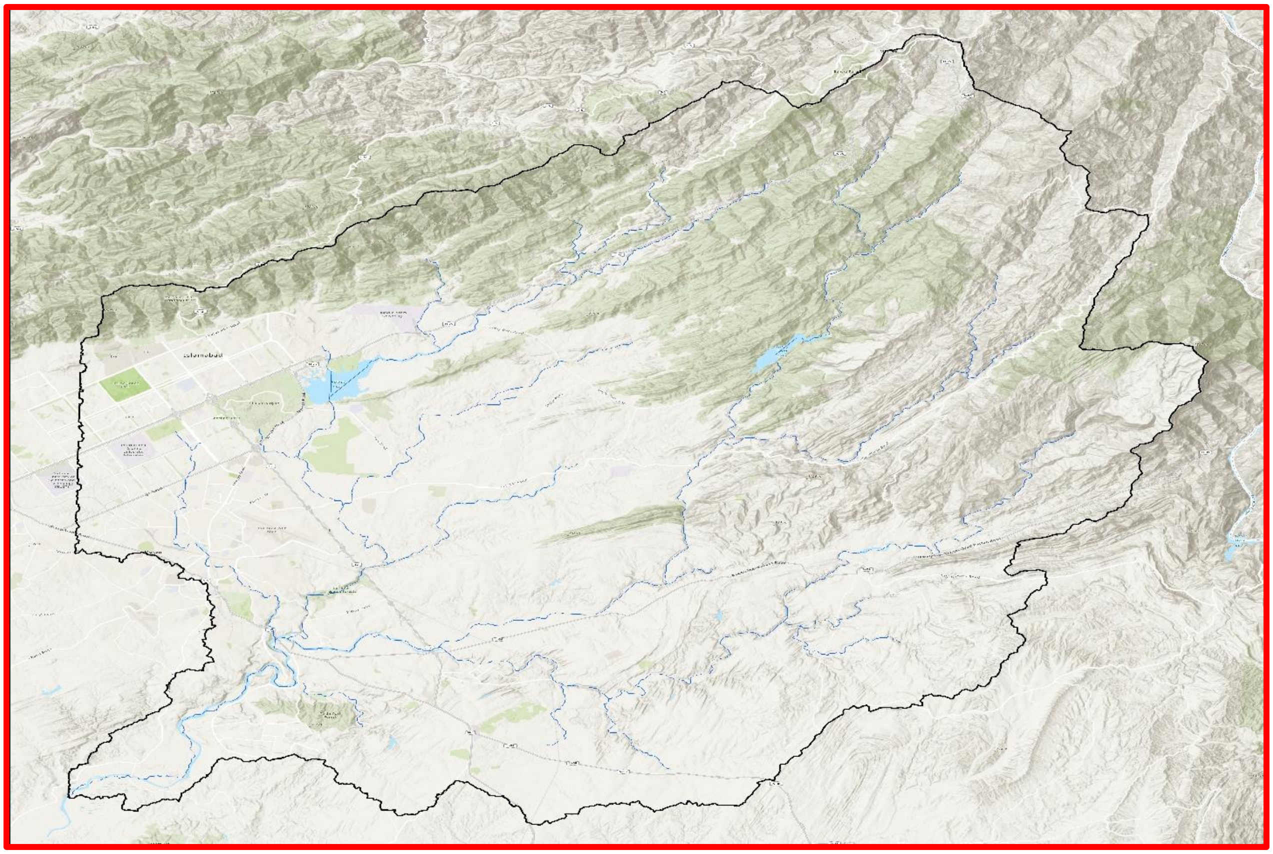


Figure 5: *Google Earth Images GEI*

Compared to this, the diverse environmental features made the accuracy of the agricultural and barren classes somewhat low. The accuracy evaluation for every picture shows that the spatial resolution limitations of the Landsat photos make it challenging to identify agricultural fields and regions with less forests with great accuracy. In arid places, the presence of farmlands and waterbodies raises the amount of mixed pixels. Accompanying data and visual interpretation of photographs were employed for suitable mapping of agricultural and desolate areas. The confusion matrix shows the improvement in classification accuracy for the categorised photos between 2010 and 2020. Accuracy increased because supporting data was easily accessible for the categorization. The linkage of many data sources—that is, the data from Google Earth and Landsat images—also increased the accuracy for the classification of agricultural and barren area. The next research on LULC alterations will have a strong basis thanks to these results. In the Islamabad/Rawalpindi Basin basin, the main causes of the rise in urban and barren areas were the quick development of urban areas, the rise in agricultural production that eventually deteriorated forest, and the fluctuation in the yearly rainfall. Deeper comprehension of how these events were altering the hydrological process of the Islamabad/Rawalpindi basin depends on such LULC change study.

Year	1995	2000	2005	2010	2015	2020	2030	2040	2050
Vegetation	592.2	584.04	549.13	488.62	452.9	411.5	359.4	308.5	298.4
Barren Land	1032.6	998.68	980.65	943.03	813.4	667.1	580.89	491.86	385.6
BUAs	147.2	189.93	242.65	341.92	507.5	695.2	834.4	974.5	1090.8
Water	14.5	13.96	14.1	12.9	12.67	12.5	12	11.89	11.9

Table 3 : 1995-2050 Data Predictive Calculations

A strong foundation for comparing the influencing elements to the dynamics of the region basin may be provided by the integration of remotely sensed images with GIS. The results of the study indicate that the land usage in Islamabad/Rawalpindi Basin has altered within the past 20 years. Dense woods, for example, have drastically declined as key basin components. Comparatively speaking, more changes and increases have occurred in barren land than in any other land use category. The amount of impermeable surfaces has increased as a result of the conversion of the vast number of light woods into development zones brought about by the growth in urban and desolate area. Main causes of the fast urbanisation were population increase and industrial expansion.

In 2010 there was a little positive growth in the class of water bodies, which may be explained by the increase in water bodies, like reservoirs that serve as retention ponds during flood season. Rainfall and barren land increases were major factors in the basin's hydrological system shifting. Several research indicate that higher rates of runoff caused by precipitation over freshly constructed places lead to the problem of floods in the low-lying area. In addition, a lot of rain can raise the amount of stagnant water in cities with inadequate drainage and retention systems. Changes in land use, temperature, and soil infiltration rate are some of the factors that affect the catchment area basin and may seriously impair the hydrological process of the river basin.

***Figure 6**: area wise comparison*

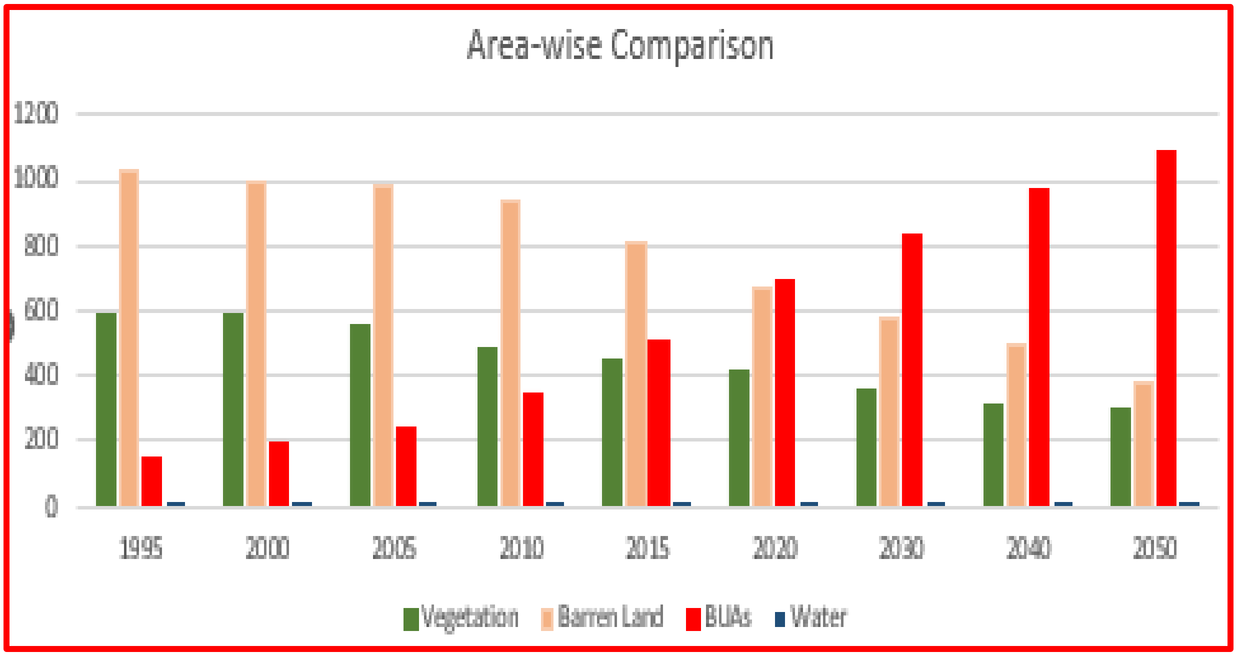


***Figure** 7: area wise comparison*

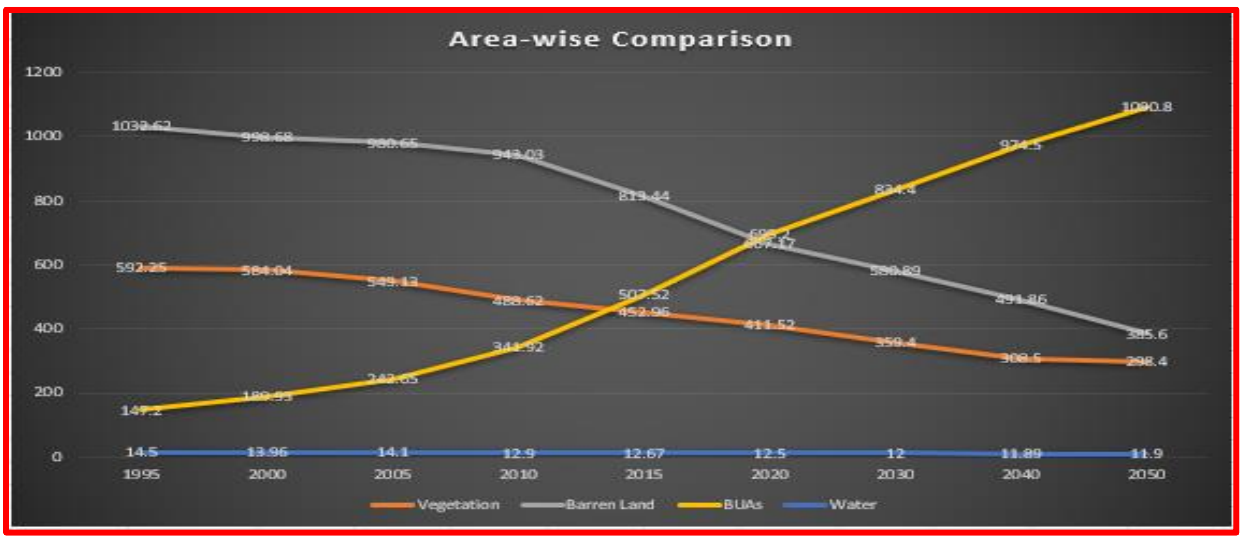
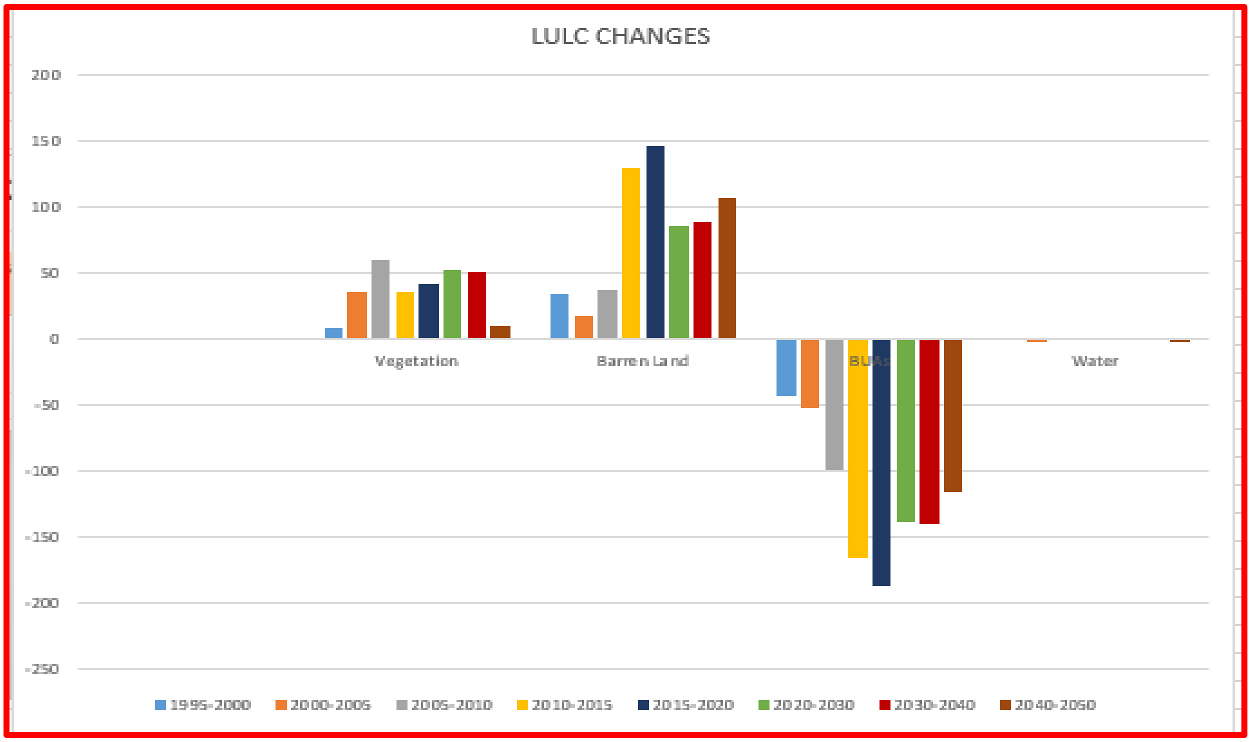


***Figure 8:** LULC Changes*



4.1.1 TRANSITION POTENTIAL MODELING USING ANN

LULC variations between 2000 and 2010 were identified by training the transition potential model with an ANN. The LULC transition matrix, an input for the ANN to determine the transition probability, was constructed using the changes in the area of various classes. Momentum was set to 0.050 and the ANN was ran with a learning rate of 0.09 and a maximum iteration of 100. The best inputs to train the ANN were determined to be these ones. The 2020 prediction map was simulated by ANN-CA using geographic parameters and the transition potential model (McFeeters, 2013).

4.1.2 VALIDATION OF ANN-CA SIMULATION

The percent of accuracy and kappa coefficient statistically confirmed the simulation findings. The QGIS instructions were used to compute the kappa coefficient. In earlier works on land use prediction utilising ANN-CA simulation, the same validation technique has been effectively applied. We got the validation parameters from the 2020 categorised and simulated reference maps. These maps' comparison yielded the percentage of accuracy and kappa coefficient. The kappa coefficient proved to be 0.826. Figure 8 is a graph showing the comparison and correlation between the project maps of 2030, 2040, and 2050 and the reference maps. The validation graph shows that the two maps' data points are in agreement, which means that the forecast was accurate, as opposed to a deviation from the reference line, which shows that the land cover was wrongly simulated.

The simulation's few mistakes can be ascribed to misidentification of land use patterns and misreading of spatial factors (e.g., maps of slope, elevation, and network of roadways). Previous research (Mohamed, 2017) had revealed comparable patterns during the validation of simulated maps. We used several iterations of the verified simulation findings of 2020 to get the projected maps of 2030, 2040, and 2050. The simulation was 90.4% right. When compared to the real LULC maps of 2030, 2040, and 2050, the percentage of accuracy indicates that there would be a 90.4% possibility of correctness in anticipated results of these simulations. It further shows that the future land use pattern for the Islamabad/Rawalpindi Basin basin will be similar to the maps displayed in Figure assuming the present LULC changes follow the same trajectory.

4.1.3 PREDICTION MAPS OF YEAR 2030, 2040, AND 2050

According to the results of the ANN-CA simulation, which are presented in Figure 8, the areas of agricultural and barren lands in the Islamabad/Rawalpindi Basin basin would drastically decline in the years before 2030, 2040, and 2050. Dense forests will, however, decline between 2030 and 2050 because of the anticipated rise in the rates of deforestation and the development of forests into urban areas. Comparably, as commercial, residential, and industrial sectors are predicted to grow, urban lands will also rise between 2030 and 2050.

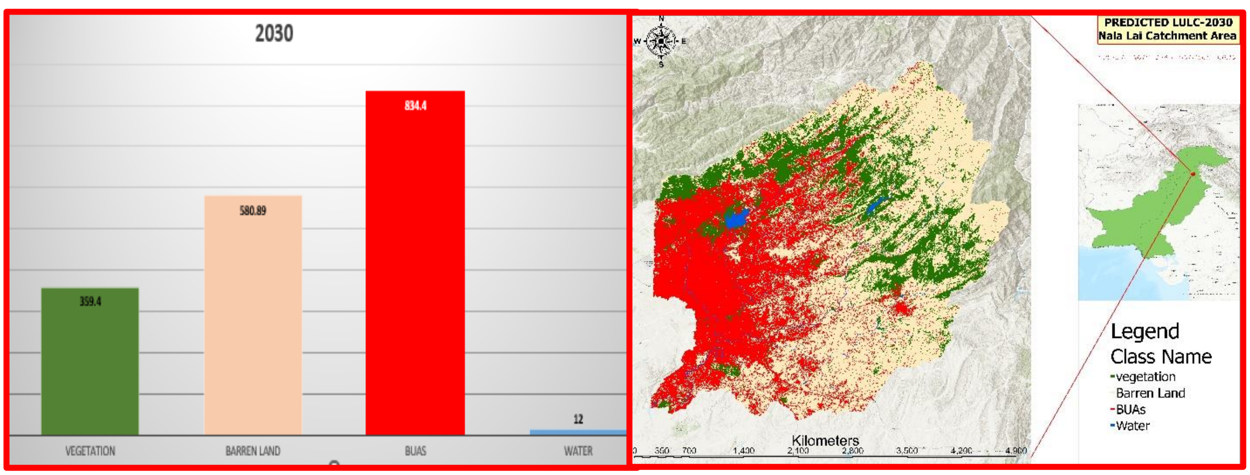


Figure 9: *Year 2030*

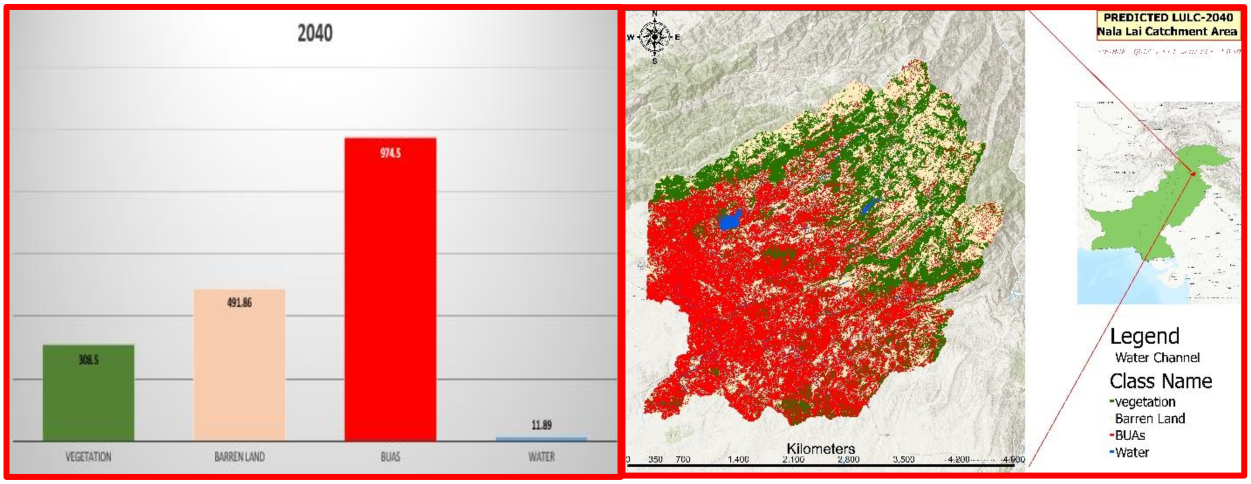


Figure 10: *Year 2040*

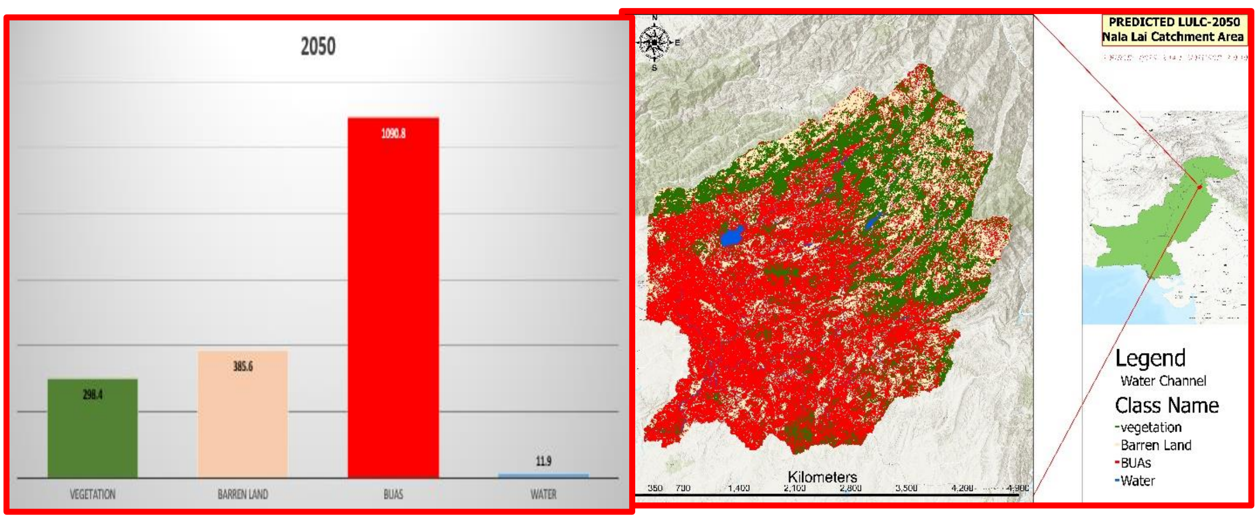


Figure 11: *Year 2050*

5. CHAPTER 5 – CONCLUSION

5.1 CONCLUSION

This study successfully introduces an ANN-CA application for tracking and predicting LULC changes and geographical distribution patterns. The increase in LULC changes and future predictions of the Islamabad/Rawalpindi basin were investigated using multi-temporal data spanning from 1990 to 2020. The LULC changes maps, which were classified for the years 2000, 2010, and 2020, demonstrated the primary changes in the research region. In addition, decadal trends in each LULC class were tracked by computing areas of those classes. The findings demonstrate a rapid expansion of urban areas in the Islamabad/Rawalpindi basin from 2000 to 2020.

Decades of land use and land cover (LULC) surveys in the Islamabad/Rawalpindi basin revealed a steep drop in the dense forest. The thick woods in the Islamabad/Rawalpindi basin were converted into a built-up zone after being first designated as non-agricultural areas. One of the best and most effective ways to mimic complex LULC changes is what the research called an ANN-CA simulation model. This model may be used for other places with similar levels of complexity. In the decades leading up to 2050, the ANN-CA model predicts that commercial, industrial, and residential urban areas would expand many times their current sizes. Politicians and regional authorities may find this study's findings on LULC changes and predictions useful for developing sustainable urban planning and improving living conditions.

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