DSTUDY THE IMPACT OF RECENT DEVELOPMENT ACTIVITIES ON GREENING THE ENVIRONMENT OF ISLAMABAD

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Certificate

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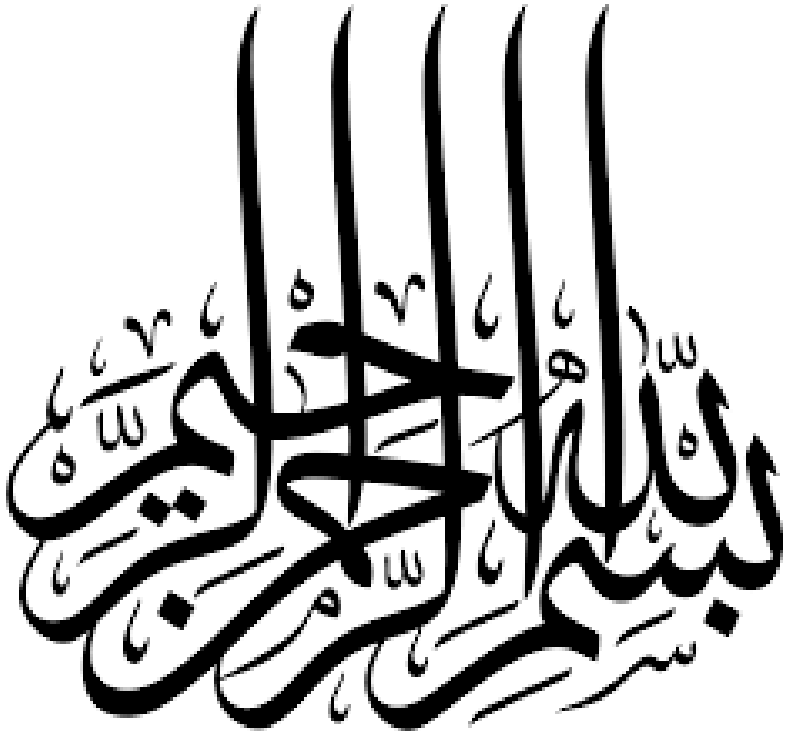
To my father **QALAM KHAN** who's been a rock of stability throughout my life

&

my mother **KHUSH BEGUM,** whose loving spirit sustains me still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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
CDA	Capital Development Authority
EIA	Environmental Impact Assessment
GIS	Geographic Information System
ICT	Islamabad Capital Territory
IEE	Initial Environmental Examination
LS	Lime Stone
LUCL	Land Use/Land Cover
MHNP	Margallah Hills National Park
MLC	Maximum Likelihood Classifier
NDVI	Normalized Difference Vegetation Index
NTFP	Non Timber Forest Products
PM	Particulate Matter
PMD	Pakistan Meteorological Department
RS	Remote Sensing
SWM	Solid Waste Management
UNEP	United Nations Environmental program
WHO	World Health Organization
WWF	World Wide Fund for Nature

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ABSTRACT

Islamabad was built in 1960 as a capital of Pakistan. It is a city famous for its beauty, greenery, and beautiful trees. The total area of Islamabad is 906 km^2. With increasing population, a lot of development projects have been initiated within the city, which had a huge impact on the vegetation. Awareness of urban vegetation, environmental quality and knowledge is really important for conservation of natural resource, management and improvement of ecosystem of urban resources. The impact of these development activities on vegetation was assessed for the last twenty years within Islamabad using remote sensing techniques. For this purpose, satellite images of Landsat were acquired for 1992, 2000, and 2013. Supervised classification and NDVI analysis were done to calculate the area under vegetation and other classes of all the images. Analysis of these satellite images revealed that vegetation was very dense in the past, but with the passage of time the vegetation loss became significantly prominent.

Vegetated area estimated for 1992, 2002, and 2013 shows that the total area under vegetation is 58, 50, and 34 % respectively of the total area of Islamabad. The overall rate of vegetation loss between 1992 to 2013 was 10.02 km^2 (per year) which is 1.09 %. Furthermore sector wise analysis was done to find out the most vulnerable area with respect to vegetation loss. The included H-10, G-13, G-5, and D-13. Residential sectors (G-13 and D-13) were found to be at high risk as compared to educational sectors (H-10 and H-12) and diplomatic enclave (G-5). Although, some initiatives are being introduced to control vegetation area, but they do not match the pace of vegetation loss. Necessary measures need to be taken to maintain and improve vegetation to the desired level.

CHAPTER ONE

INTRODUCTION

1.1 Background

The spatial expansion of settlements of human is known as inevitable and natural process which results in conversion of barren land to settlements having different physical structures (Cohen, 2004). When the Spatio-temporal growth is being done against the approved plans, then it creates unexpected and violated built up areas by spilling the protected lands which further give threats to the naturally available resources and misleads the spatial growth. This issue is gaining importance as far as the population is increasing and land has become scarcer. Land Use Land Cover (LULC) affects settlements due to which it has gained importance as it has many environmental and social-economical consequences.

In developing countries about 70 percent of urban inhabitant's life in settlements which are irregular and one can easily observe the severe violation of upcoming development activities mostly in developing countries (Lasserve and Clerc, 1996). The unauthorized expansion is mainly in particular places or within a specific region/country. The planners and geographers have given focus to the spatial, temporal trends of expansion because of its many environmental and social-economical consequences. The most current and accurate information about the unauthorized expansion is necessary to introduce strategies for planning, to identify alternatives and for the evaluation of the implementation.

The evolution of Islamabad's Greenway concept dates back in the 1960's when new strategies were adopted to increase the beauty of roads and quality of landscape in Islamabad. Islamabad with its large green spaces and parks is one of the fastest growing cities. The rapid urbanization of Islamabad has resulted in removal of green areas i.e green belts and agricultural land. Green area in any built up area is randomly spread.

Primarily they are not fro the aspect of ecology. This research aimed to present a comprehensive information about the vegetation of Islamabad. The results of this research can be used for sustainable planning and management of the Islamabad while this city is rapidly transformed into a metropolitan city with no green spaces.

1.2 Urban Development & Role of Vegetation

As a component of the environment and climate, vegetation plays an important role in the terrestrial biosphere (Foley *et al*., 2000) and terrestrial biosphere is affected greatly by global warming (IPCC, 2007). For assessing the agricultural and natural land production, the status of vegetation is mainly used (Cai & Sharma, 2010; Sims *et al*., 2008; Yu *et al*., 2009). The browning or declining of vegetation is an indication of degradation of land (Metternicht *et al*., 2010; Wessels *et al*., 2007; Zika & Erb, 2009). Vegetative productivity is always correlated with Normalized Difference Vegetation Index (Tucker, 1979) and for browning or greening the NDVI trends are used as a representative (Alcaraz-Segura *et al*., 2010; Bai *et al*., 2008). The vegetative productivity is affected by different factors like management system and climate change so it is really complicated to determine the exact cause and effects (Evans & Geerken, 2004; Lupo *et al*., 2001; Wessels *et al*., 2007).

For the conservation of natural resources, and quality of urban environment the understanding and deep knowledge vegetation and environmental quality of urban environment is crucial (Pysek, 1995). The relationship between environment and vegetation environment shows various underlying factors resulting in different patterns of vegetation patterns of urban ecosystems (Zeleny, 2008; Pausas & Austin, 2001). The pool of species and environmental factors greatly affects the richness of the vegetation species in an urban ecosystem (Leps,2004) although because of limited knowledge of natural vegetation benefits these factors are always ignored by the city planners and policy makers and planners.

Environment variables are counted as indirect, direct and resource gradients. Factors like soil properties which directly effect vegetation are direct variables (Tyler,

2003). Geometry and area are the most significant factors affecting the richness of species (Sanders, 2002). Although topographical variables and altitude never directly affect vegetation, but based on their association with direct variables they are considered important. Factors which are utilized by plants such as nutrients or light are resource variables. Site age and patch area are greatly related to the diversity of species in some instances (Hermy & Corneils, 2000). Limited space for growing is also associated with decreased tree growth for specific urban sites (Rhoades & Stipes, 1999) and imbalance in nutrients (Dyer & Mader, 1986). Growth rate of the tree is also affected by biotic factors like competition with other species in urban ecosystems (Close *et al*.,1996; Rhoades & Stipes, 1999). In urban ecosystems, chemical and physical properties of soil strongly influence the number of species (Fostad & Peterson, 1997). In Tropical countries and Asia, there are very few studies on structures of urban landscape in relation with communities of vegetation (Alvey, 2006).

Like most of the developing countries, Pakistan is facing environmental degradation due to rapid urbanization, industrialization and population growth (Qadir *et al*., 2008). On the correlation of land use types and urban vegetation types not much research has been done in Pakistan. Unfortunately, among decision makers and the general public, there is very low concern about this issue in the general public and policy makers. With increasing projects the and clearing of land for these projects, the structure of Islamabad has been largely changed in past years.

1.3 Geographical Information System and Remote Sensing Technologies

The best tool for researchers is remote sensing (RS) and geographical information system (GIS) gives spectral data from any satellite without physical contact with the object of digital type which is later transformed into a visual image. This visual image known as imagery is the most reliable data in several contexts of the earth's surface like land use, biodiversity and topography, etc. GIS is the most recent technology for geographers for displaying, checking, storing, collecting, retrieving, integrating, and analyzing. It provides the users different components like software, computer system,

spatial data and analysis procedures. The emerging technique from GIS and RS is NDVI, which is used to check the spatio-temporal change in the vegetation cover for small regions on the surface of the earth (Luther *et al.*, 2006), and condition (Rossini *et al.*, 2006; Wulder *et al.*, 2006). Apart from checking the change in vegetation it can also quantify the photosynthetic capacity of the forest. The value of NDVI remains from -1 and +1. NDVI less than zero represent non-vegetation areas and 0-1 value always means wide variation in vegetation.

In both mapping and measuring areas of forests LANDSAT imagery is very effective and it can be used globally for the measurements of carbon storage changes in forests. Species, stand boundaries, density, height, extent of dying timber and dead and site quality are the characteristics used for the mapping of forests.

1.4 Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index which is a numerical indicator which utilizes visible and near infrared bands to calculate the live green vegetation in the targeted area. It has a wide variety of applications in the studies of vegetation and to estimate the yield of crops, carrying capacity of rangeland and pasture performance. The NDVI is sometimes related directly to the other ground parameters like photosynthetic activity of plants, the percentage of ground cover, leaf index, surface water and biomass amount.

The lush green vegetation always absorbs the major portion of the visible light which falls on it and then reflects most of the segment of near-infrared light. Sparse or unhealthy vegetation reflects less near-infra red light and more the visible light. While the barren soil reflects both infrared and red portions of the electromagnetic spectrum (Holme *et al.*, 1987). As we know about the plant behavior against electromagnetic spectrum so we can easily derive the information of NDVI by putting focus on satellite bands responsive to information of vegetation (red and near-infrared). The larger the difference between red and near-infrared reflectance, the more is the vegetation. The

logarithm of NDVI subtracts the values of red reflectance from values of near-infrared and then divides it by sum of red and near-infrared bands.

This allows us to deal with this fact that any two identical portions of vegetation can have different values, e.g. under a cloudy sky and in bright sunshine. Larger values will always be with the bright pixels which mean the large absolute difference between bands which can be avoided easily by dividing with the sum of the reflectance. In theory values of NDVI are always represented as ratio ranging from -1 to 1 but in practical the negative values always represents the water bodies and values around or near to Zero represent barren soil and the values over 0.6 means there is dense vegetation. In this research values greater than 0.3 are taken in the category of vegetation.

The healthy plants always absorb the solar radiation to utilize it as an energy source for photosynthesis. The NDVI is measured from near infrared and visible light which has been reflected by the vegetation. Leaf cells reflect and transmit the solar radiation in the region of near-infrared spectral, while the strong absorption of solar radiation by plants will overheat them causing damage of plant tissues. (Gates, 1980) Snow and cloud cover are bright in the red and other visible wavelengths but dark in the near-infrared.

NDVI of dense green vegetation will have positive value for example 0.3-0.8 and the snow fields will have a negative value. Water bodies like lakes, oceans, rivers and lakes will possess the reflectance in both the spectral bands resulting in positive or slightly negative values. The near infrared spectral reflectance of barren soils is always larger and therefore small positive NDVI values i:e. 0.1-0 represents the barren areas of rock snow. The relatively moderate ratio of this NDVI always represents the shrub and grassland like 0.2-0.3, while the values larger than this indicates temperate and tropical rainforests like from 0.6 to 0.8.

1.5 Environmental Challenges to Islamabad and their Impact

The study area of this research is the Islamabad Capital Territory. The total area of Islamabad is 906 kilometer square (km^2). During 1960's the Islamabad was built as a replacement of Karachi as the capital of Pakistan. The master plan of Islamabad was drawn by Greek architects, which was in the shape of a triangle with grid system and apex towards the hills of Margalla. It was built to give pollution free atmosphere, healthy climate, lush greenery and plenty of water. Islamabad is the most carefully planned modern city. It has large houses with wide tree-lined streets and elegant public places.

All of these sectors have public park and separate shopping areas. There are total five parks in Islamabad named as Jasmine and Rose Garden, Chattar Bagh, Fatima Jinnah Park, Shakar Padiyan and Japanese Park. There is a green belt in every sector, which play a role of the oxygen generators. Due to developmental activities and accelerated urbanization in the recent years, sewage wastes are being continuously dumped and discharged improperly, which ultimately affects the soil environment adversely (Chen *et al*., 2005).

Environmental degradation is the major problem for many governments in the world is. In developing countries this issue is acute due to ineffective monitoring mechanism and improper law enforcement as weak rules and regulations have led to serious environmental degradation in the form of air, degradation of native vegetation, soil, scarring of the land surface and water pollution. Being as the capital of Pakistan it embarks upon rapid economic expansion and many environmental issues through demographic changes and economic development which has lead to many environmental issues such as habitat destruction, water contamination and loss of vegetation. Therefore, there is an urgent need to design new strategies to manage the resources effectively. There is no major emphasis in our literature focusing the assessment based on remote sensing for the environmental change detection within the vicinity of Islamabad. This study explores the applications of remote sensing with importance on the environmental impacts of new development activities in Islamabad.

The beauty of Islamabad is now being tarnished now a days and it is no more different from various rush cities of Pakistan having major problems like traffic congestion, which becomes worst, especially in the morning and evening rush hours, which results in creating peak hour traffic jams, jamming the roads, and waste of time that. To increase the vegetation of Islamabad paper mulberry introduced in late 1972 which has created a pollen problem in Islamabad. Paper Mulberry is not the native plant. To document the impact of invasive species on Pakistan's biodiversity very limited work has been done. 700-4500 species of vascular plants are indigenous and alien. Some of them for example a dominant invasive weed in Peshawar University campus and Islamabad, *Parthenium hysterophorus* and *Broussonetia* are highly allergens *(*Khalid, 2000) but CDA planted it just because of the reason that it grows quickly because birds carry its seeds and increases its spread. Today, the Paper Mulberry is causing pollen allergy problems.

These sources of pollution in Islamabad are listed below:

1.5.1 Vehicular Emission

There are about 1lac and fifty thousand vehicles in Islamabad. There are lots of buses owned by a private institution and government, which are driven by diesel and vans for public transport are mostly found emitting visible smoke. The trespassing of GT road huge traffic being diverted via Kashmir Highway to Islamabad is the most serious issue. About 3lac ninety thousand vehicles daily pass through Kashmir Highway, out of which half is the diesel driven trucks, which adds around 400 tons of particulate matter (PM) in the atmosphere each year. The rapid urbanization of the area is the major reason behind the increased pollution level and hence, few protective measures have been proposed (A. Khalique *et al*., 2005). NO2 as a major component of air pollution is harmful for human health and it aggravate asthma and other pulmonary diseases (Zafar *et al.,* 2012).

1.5.2 Industry

Industrial Estate Islamabad knowns as IEI was founded in 1963. More than 200 industrial units are present in this area which spread over 625 acres of land (Malik *et al*., 2010). According to CDA bylaws, no polluting industry was allowed in Islamabad. Despite of this law steel furnace, galvanizing, marble cutting/grinding units, steel melting, were built which highly contributes to pollution. Between residential and industrial areas of I-10 and 1-9 sectors a buffer zone was provided which was alter converted into a commercial area.

There are eight steel furnaces in the industrial area emitting more than one ton of PM each day. The particle level has drastically increased due to the presence of 04 cement units in Islamabad with no facility of wastewater treatment.

There is not a single area designated for industrial waste dumping and therefore, one can see heaps of waste in front of all industrial units. The waste water drains are dumped in the natural drains leading to a single main drain known as Nallah Lye. Metals which are discharged from these industries include Pb, Zn, Cu, Co, Ni, Cr, and Cd etc. (Nazir *et al.*, 2011).

1.5.3 Brick Kilns

Brick-kilns deteriorating air quality of Islamabad and Rawalpindi by emitting poisonous smoke. There are around ninety brick kilns around the Islamabad, which emits high levels of black soot, poly aromatic hydrocarbons etc. which further worsen the air quality. Around 38,000 metric tons of coal is burned in Rawalpindi and Islamabad monthly for the production of bricks. Emission of sulfurous smoke had become one of the strong factors in deteriorating the air quality of Islamabad (Siddique *et al*., 2012).

1.5.4 Burning of Solid Waste

Capital Development Authority in 2002 conducted a study which says that the solid waste generation rate in Islamabad is 0.662-kg per capita per day, which means 563 metric tons per day and ultimately 194,394 tons per year. Solid waste is not being

adequately collected for disposal due to lack of manpower and especially financial resources, shortage of waste lifting machinery and improper management (Pak-EPA, Guidelines for Solid Waste Management, 2005).

1.5.5 Untreated Domestic Effluent Discharge to Rain Water Streams

There are around twenty six large and small rain water channels in the city, passing through the residential sectors and two main streams of Islamabad.

Leakage of municipal sewers and domestic waste is being dumped in these streams which increase the load of pollution resulting in stinking of streams during low rainy season. This makes them the breeding places of flies and mosquitoes. Taking the assistance of Korean Volunteers, Pak-EPA conducted a study of these streams to analyze the water quality and results showed extreme contamination due to mizing of waste water in steams. (Mashiatullah *et al*., 2010).

1.5.6 Revision of Master Plan and Unlawful Spatial Expansion

The original Master Plan of Islamabad was discarded in the late 1970s. After that CDA with the help of UNDP and UNCHR started revision of the Master Plan which had become an official document. In the mid 1980s with the assistance of UNDP and through in-house expertise of CDA experts another systematic revision was started (Botka, 1995).

Islamabad Capital Territory Zoning Regulation (ICT) 1992 came as the most vital change of this revision. Urban areas of ICT were separated into five different zones under this Zoning Regulations:

Zone 1 comprises of some future gridiron and existing sectors for education, housing, administrative area and commercial (Blue Area).

Zone 2 constitutes periphery of Islamabad.

Zone 3 comprises of Margallah Hills National Park.

Zone 4 includes Islamabad Park and rural areas.

Zone 5 constitutes southern Islamabad.

These zones were visibly marked on the master plan of Islamabad without any physical boundary of Zone 5 to be separated from the urban areas of Rawalpindi. The original plan had marked clearly to build Soan Highway, which will segregate these two areas, but both revisions are still about the Soan Highway status.

To develop urban areas different institutional and planning arrangement was set up in twin cities. A lot of problems were caused by this disintegration like the most notable housing and urban transport. There was increased economic growth of twin cities for the last two decades due to building private housing schemes, but the twin cities could not catch the speed of rapid urban development. Hence, this type of analysis is a high need to figure out the status of vegetation after of rapid urbanization and development.

Islamabad's rural part is countered with the problems of unforeseen expansion on the vicinity of agricultural land, ultimately degrading naturally existing environment and disturbing the designed capital territory.

Spatial expansion is occurring in severe violation of Islamabad's master plan in which Zone four was reserved for the rural area and for holding recreational facilities and national institutions, with no deterioration in the natural environment (Doxiadis, 1960). The external expansion of the villages is not tolerable in the master plan. The soil studies prove that the land is sensitive to soil erosion. The removal of vegetation can result in washing away of land (Capital Development Authority 1973). But ongoing expansion and construction are destructive for the naturally occurring resources and planned growth of the area.

1.6 Development Projects in Islamabad

Ideally and primarily, the changes (to a master plan) should only happen over an extended time when it is gravely necessitated, but the Capital Development Authority

(CDA) has so far made major changes in the city's master plan. The federal capital is not what it was visualized by a Greek architect firm, Doxiadis Associates, in 1960. In 1964 first change was made in master plan by locating Quaid-e-Azam University to its current location from the National Park area southeast of Rawal Lake.

The metro bus project, a new parade avenue and the Centaurs Mall all made it to the city's landscape only after making changes to the original master plan. Similarly, a new road for running parallel to the Islamabad Highway starting from Faizabad Interchange to the Lok Virsa signal was approved after making another change to the original master plan, while several trees had to cut to level the land for the parade avenue. Private sector housing societies were allowed to work in Islamabad, for which initial requirement of land was 2,000 canals which was reduced to 1,600, to 1,000 canals and now 6,00 canals are sufficient to start a private housing society in the capital.

The area, where Convention Centre, Serena Hotel and the under-construction Grand Hyatt Hotel, was reserved as a green belt in the original plan. The changes were made in 1995 to allow construction on the green area.

Environmentalists say that the city managers' lack of wisdom and gullibility has engulfed many green zones allowing the growing industries to pollute the areas designated for trees. In 1973 sectors E-10, E-9, and E-8 were designated for the armed forces residential and official facilities although they were designated for government residential and public facilities.

In 1985 near the Margalla Hills National Park, FECTO cement plant was approved while violating the master plan. PIMS was shifted to the present location in 1974. Similarly, E-11 was to be developed and acquired as a housing sector for low-income employees but in 1964 the CDA was stopped from acquiring the land due to the the location of Golra shrine. Now many private developers have launched housing schemes in the location allegedly on grabbing land.

In 1974, H-10 and H-12 sectors were allocated to private and public educational institutes, Sector H-9 was converted into an orchard while the upper half of H-8 was designated for construction of buildings of different institutions. Similarly, I-16 I-15, I-14 sectors were planned for industrial units and their accommodations, but in 1991 all the them were converted into residential areas. Originally, the present Lok Versa was located in an area near Tarlai Kalan, but it was shifted to the present location in 1975 (Maria & Imran, 2006).

1.7 Vegetation Condition in Islamabad

Evolved from its roots back in 1960's Greenway concept of Islamabad has been introduced to beautify the roads of Federal Capital to improve the landscape quality. Characterized by park areas and large green spaces the city is amongst the fastest growing urban settlement (Dogar, 1985). According to Modalities and Procesdures Framed under I.C.T (Zoning) Regulations-1992, the planning standards may change depending upon the desire of residential density to be achieved by the scheme sponsors. But the percentages of land use must remain within the following limits:

1. Residential not more than 55 percent.

2. Open/ Parks/Green Spaces not less than 8 percent.

The rapid urbanization of the city has swallowed areas of agricultural land resulting in the shrinkage of green spaces. Uneven distribution of green spaces in the built up area is the serious concerns as this way they are not kept primarily for the ecological aspect. This study aimed to provide a detailed composition of vegetation in urban green spaces of Islamabad specifically to assess the area of green spaces in Islamabad and provide information about the impact of development activities on the greenery of Islamabad. In the era of rapid transformation of unnatural land in to an urban land, the results of this study will be very helpful for further planning and management of the area.

Steps taken by CDA for the construction of new roads by refurbishing the already existing roads is although good, but it should not have been done at the cost of the vegetation removal, it must have been replaced by new vegetation in other location after removal from its original place**.**

1.8 Legal Adherence of Development Projects

The increasing development projects have resulted in increased residential apartments, buildings, housing schemes, industrial units and educational institutions which is somehow good, but the impact of these development projects has forced the CDA to make changes in Islamabad master plan and to make up gradation in physical infrastructure. The EIA of every development project should include all the elements and it should be considered why approving those projects (Maria & Imran, 2006).

A well planned EIA reflects many elements of good governance like sufficient information flow, transparency, responsibility, accountability, and stakeholder participation (Kakonge, 1998). To achieve good environmental governance in the context of EIA regulation, across the board application of EIA and high degree of transparency to all the public or private sector projects can be helpful.

According to a variety of studies in most of the developing countries EIA systems can be characterized by lack of transparency, non regulatory nature of EIA requirements, and public participation in the EIA process (Ahmad and Wood, 2002). The main causes of theses weaknesses have been identified as lack of power by enforcement agencies flawed legislation, lack of monitoring equipment and capacity including human resources (Parikh and Khan, 2002).

Despite guidelines, regulations sound legal basis in Pakistan, EIA practice and environmental institution's hierarchy, particularly in case of public sector development projects with few exceptions, has been generally weak. (GoP, 1997a; GoP, 1997b). There have been many cases where projects were implemented without EIA or EIA was done at

the stage of construction. NGOs, public sector organizations and environment professionals are playing significant role in supporting EIA Besides.

1. 9 Hypothesis

From the overall scenario a hypothesis was developed as "Development activities are posing a great threat to the vegetation of Islamabad".

1.10 Objectives

The research was carried out to achieve the following objectives:

- To quantify the spatial/temporal vegetation change over the last 20 years.
- To Perform the sector wise vegetation analysis to figure out the most vulnerable areas with respect to vegetation loss

CHAPTER TWO

LITERATURE REVIEW

This chapter is structured to highlight the general background of analysis of natural vegetation and its importance in the environment. It also provides the review of supervised classification, Normalized Difference Vegetation Index and studies being done on vegetation using remote sensing technologies in Pakistan.

2.1 Background

Undertaken shortly after the formation of the new state, to serve as the capital city Islamabad is one of the examples of modern urban planning of Pakistan. Greek architect firm, Doxiadis Associates, in 1960 prepared the master plan of Islamabad by integrating the city of Rawalpindi as a twin city and considering Islamabad as a part of a large metropolitan area. In spite of increased economic growth of twin cities, they could not catch the speed of rapid urban development. Hence, this type of analysis is a high need to figure out the status of vegetation after of rapid urbanization and development

To detect the global coverage greening trends NDVI data which is available from 1981, vegetation indices and remote sensing is widely used around the globe (Agone and Bhamare, 2012). Vegetation serves as the basic foundation of all the living beings so it has high importance in any environment. Classification of vegetation through remote sensing technologies is precious as it can calculate the distribution of vegetation and analyze the influence of various factors like elevation above sea level, moisture, length of growing season, latitude, temperature regimes, solar radiation, drainage conditions, soil type, slope and topographic aspect, air pollutants and prevailing winds.

2.2 Urbanization

The destruction of the naturally existing ecosystem, conversion of barren land into settlements and exploitation of lawns, gardens, parks is caused by urbanization. Most of the environmental issues results from the sharpening and continuation of existing issues which have not received attention politically. Many important issues are neglected in various countries among these issues the critical ones are freshwater scarcity, pollution, climate changes, population growth, and deforestation. The complexities of these issues have increased and now it has become very important to address these problems. We all know that all these environmental problems are interconnected but there is a lack of information. One of the issues is to integrate water and land use planning for the provision of water and food security.

The increase in demand of land for settlements and population increase has caused the degradation of already existing plantation and inadequate planting sites. This has badly affected the human health quality and ecological environment. The urban sprawl has caused the natural greenery loss and destruction of open green spaces over the past several decades. (Benedict, 2000).

The cities are dynamic and complex entities which have a heterogeneous mixture of semi natural, remnant natural and newly created or modified habitats. The cultural and natural realms verify the mixture of indigenous and introduced plantation of urban areas (Rowntree, 1988).

2.3 City Expansion and Environmental Change

The most important reason of several environmental issues is the rapid increase in human population. Each year ninety million babies are born which implies that by 2050 the global population will be around ten billion. In developing countries, there is increased population growth therefore they are in charge of ninety per cent of the current population. According to as estimate by 2025 eighty four per cent of the people in the world will be accommodated by the developing regions.

The population growth of Islamabad is also increasing at higher rate resulting in construction of wide roads and new houses which is highly destructive to the environment and green image of Islamabad. Without giving attention to the environment and vegetation many schemes of development are being implemented in Islamabad and these development projects belong to the public sectors and private. There is inadequate coherence between development agencies and environmental regulatory institutions. Most of the projects come to the surface when construction work is started due to information gap.

2.4 Reasons of Urbanization in Pakistan

The studies have found that the natural population increase of Pakistan is a great source of urban population increase, which is being followed by the internal migration. (Arif and Ibrahim 1998). Which is true in all provinces of Pakistan, but the condition is totally different while separately considering the major cities. From 1981 to 1998 around fifty eight percent of the total population increase in Islamabad was due to internal in-migration and around thirty eight percent of population increase in Karachi is due to in-migration and in Lahore around twenty six percent of population increase was due to internal migration during same time period. In the last few decades cities of Pakistan like Islamabad have witnessed a rapid increase in urbanization and other massive changes.

2.5 Benefits and Problems of Urbanization

In building the market economy the major role is played by the cities and policies that affect them. Rawalpindi, Lahore and Faisalabad from Punjab; Hyderabad and Karachi from Sindh; Quetta from Baluchistan and Peshawar from the NWFP are the most developed districts of the Pakistan **(**Pasha *et al*., 1990). These districts are also the extremely urbanized cities of the Pakistan. Even other developed provinces like Punjab and Sindh have a relatively large under developed compartment. *(*Pasha and Hassan 1982*)*. This is an indication that the development in these provinces is just because of development being done in their cities like, Faisalabad, Lahore, Rawalpindi, Hyderabad, and Karachi.

Rapid urbanization can be overwhelming, leading to the abundance of squatter areas and slums as well as damaging environment. The expansive houses in the formal sector of Pakistan have given birth to settlements which are informal called as slums or *katchi abadis*, which are increasing in size and number along with the time. The 1/3rd of the urban population is residing in 2,184 slums and 2,460 (Pakistan Economic Survey, 2010-11). These areas are stuffed with the un hygienic conditions like limited access to water, no proper sanitary facility, social and social services which results in the spread of diseases like cholera and tuberculosis.

2.6 Impact of Urbanization on Green Spaces

Degradation of urban green spaces is always linked to the urbanization due to which there is an information gap of limited consideration to other significant factors which removes urban green spaces in various ways. Using Islamabad as a study area in which now a days rapid deterioration of greenery is occurring, this research sought to fill the gap by exploring many other important factors along with urbanization which are in charge of the removal of green spaces. In Islamabad apart from the urbanization as the key factor, negligence in the enforcement of development laws and controls, low priority for the lush green spaces, problem of ownership of green space lands, difficult attitudes of the general public, inappropriate coordination and improper culture of maintenance among the associated bodies on green lush spaces plays important role in the degradation of urban green spaces. This research therefore concludes that for Islamabad should have sustained and preserved urban green space, proper city development plans and broad public policy which can take all the factors mentioned in the research in addition to urbanization into consideration.

2.7 Remote Sensing Tools for Analysis of Vegetation

The use of Remote Sensing/GIS applications to study vegetation dynamics and its effects on the environment is on the rise in Nigeria. According to the NRC which stands for Natural Resources Canada (2008) RS is the art and science of acquiring spatial, spectral and temporal values regarding the area, phenomenon or objects without having a

contact with that area, phenomenon or objects phenomenon under examination. Studies involving the use of this technique have been used to assess and monitor changes in biodiversity. For acquiring information, remotely sensed data is a proven source about detailed classification of vegetation (Luther *et al.*, 2006).

Vegetation's spectral characteristics changes with the wavelength. According to a research by Samvedan in 2007 chlorophyll in leaves robustly absorbs solar radiations in red and blue wavelengths, but it reflects green wavelength and therefore the internal composition of healthy leaves plays a role of a diffuse reflector of the near-infrared wavelengths. For most of objects reflectance changes with the wavelength just because of the reality that at certain wavelengths energy is absorbed/scattered to different degrees and these variations are obvious when reflectance is plotted versus wavelength for different types of materials (Delegido *et al.*, 2011). The biometrical properties of vegetation in different wavelengths of the electromagnetic spectrum can be analyzed as well used for modeling and simulation of biophysical processes (Jarocinska and Zagajewski, 2009). Vegetation has distinctive spectral characteristics as was observed by Gates (1980), who noted that vegetation leaf reflects and transmit incident radiation in a manner that is unique characteristics of pigment cell containing water solution. Generally, the spectral reflectance curve for green vegetation over the wavelength range 0.4 um - 2.6 um (Belward and Valenzuela, 1991).

In the Aberdares Reported cases of deforestation due to the value of this forest resource have drawn considerable concern. Aberdares is a water catchment area for many streams and rivers, traversing a large part of Kenya, providing fresh water to millions Kenyans and 3 million residents of Nairobi. To analyze the extent of deforestation, a project was carried out between 1987 and 2000 within a period of 13 years. Source of data was Landsat TM images. Using IDRISI software, Landsat images were processed and analyzed by carrying out post classification change detection. Unsupervised classification was done on all images and then areas from resulting classes were compared for change detection. The analysis reflected a major decline in forest cover

during the time period of the study. To determine change in biomass, as a support technique NDVI was also employed (Ochego, 2003).

For the mapping of land cover change and monitoring of vegetation conditions, one of the primary sources of information is the vegetation indices which are derived from satellite imagery data. For humans and other species, vegetation also represents a significant natural resource, quantifying the extent and types of vegetation and is important to issues regarding land cover change and resource management (Townshend 1992). Vegetation indices are mathematical combinations of various bands (Jensen, 1983). They are used to detect the change in vegetation and monitor landscapes of terrestrial by using satellite sensors which were first developed in 1970's and are very successful in the assessment of foliage, cover and vegetation condition etc.

2.8 Vegetation Indices

The Normalized Difference Vegetation Index is one of the most widely used indices are for vegetation analysis and globally utilized for the study of biophysical properties of canopies of vegetation. In the classification of global, regional, continental land cover, the application of multi-temporal data sets in recent work has been observed, which illustrate the dynamics of vegetation by studying their phenological changes throughout the duration of a year (Verhoef *et al*., 1996).

The main function of spectral vegetation index is to increase the information contained in spectral reflected data, by extracting the changes in the characteristics of vegetation (e.g. Vegetation cover, LAI) and to minimize atmospheric, soil etc. (Moulin, 1999). Spectral vegetation index compose of a convenient and simple approach to take out information from data because they are easy to use, which facilitates the analysis and processing of large data (Govaerts *et al*., 1999; Myneni *et al*., 1995). Significant progress has been achieved to understand the nature and proper interpretation of vegetation indices (Myneni *et al*., 1995; Pinty *et al*., 1993) and theoretical frameworks have been proposed and optimized for sensors to support indices development (Gobron *et al*., 2000; Verstraete *et al*., 1996).

The range of vegetation indices application varies from global levels to leaf level (Boegh *et al*., 2002; Xiao *et al*., 2002). However, most of the vegetation indices are not robust as they are species specific. Hence, when they are applied on various species having different leaf structures and canopy are not robust..

In future there will be many new development activities in Islamabad. With completion of new projects, not only the natural resources of Islamabad will be impacted, but the pollution load will further enhance. Research is needed in this regard to assess the impact of these projects on the environment of the capital of Pakistan.

2.9 Supervised Classification

Whether the classification of images is used as a final product or as one of many analytical procedures used for extracting information from any image, the selection of the suitable classification technique to considered always have good impact on the results (Gabrya and Petrakieva, 2004).

In the identification of desired features the indices are known as important tools by combining of two or more than two spectral bands. For the comparison of vegetation/greenery from different images NDVI can be used a standard method as it is the indicator of greeness and biomass. To get best results from supervised classification the maximum likelihood classifier (MLC) should be used. For the calculation of non vegetative and vegetative cover the supervised classification has been proven best. Prior knowledge of the land cover of the area under study is really important for doing supervised classification, making it more instinctive procedure mapping the land-cover change**s**. The calibration pixels in supervised classification are selected and the associated statistics are generated for all the classes (Bahadur, 2009).

Literature shows that use of supervised classification with maximum likelihood classifier is very accurate and fruitful (Landgrebe, 2002). The quality of a supervised classification is related to the quality of selected training sites. Supervised classification whenever is applied, it follows these steps.

1. Defining training sites.

2. Signatures extraction.

3. Image classification.

Usually two or three training sites are completed with digitized features. To get the best results more training sites are selected and hence, assures true interpretation of the results and accurate classification. After digitizing training site, signatures are created and ultimately the methods of classification are applied (Palaniswami, Upadhyay, and Maheswarappa 2006). Image classification is an important part of the remote sensing data. The performance of the classifiers depends upon the data (Richards, 1999).

2.10 Studies being Conducted in Pakistan

2.10.1 Causes of Vegetation Removal

Use of natural vegetation and its impact on the socioeconomic well-being of the local communities has been highlighted by various social and biological scientists in the world.

. The local inhabitants living around Margallah hill National Park are dependent on different plants for different socio-economic requirements such as fodder, food, health care, and shelter. Different herbs are used for medicinal purpose by the local inhabitants (Shinwari and Khan 1997).

Most of the population in Pakistan depends upon the resources of plant for fodder and fuel wood. The major risk to the shrubs and trees in the mountains is the fuel shortage. Among the total population of Pakistan, for fuel and timber 70% of the people are still depending on the wood. Tribal people in Pakistan still use fuel wood as an energy source for cooking their meals at home. 565 million cubic meters of fuel wood are consumed and continuously increasing with around 80% of the households using wood as fuel, 10% using animal dung, 4% using kerosene oil and less than 4% using electricity as an energy source (Shinwari *et al.*, 2002).

Around 4.8 percent of the total area of Pakistan is covered by natural vegetation and it contributes to 80% of income of people living in severe poverty. For the income of the household 34% of the locals are dependent on Non Timber Forest Products (NTFP) and 17 species of mushroom are used for food. Honey, wild fruits, spices and nuts are main food products taken from natural vegetation. Silk cocoons, eggs, ivory skin, different birds and animals products are provided by natural vegetation (Latif *et al.,* 2005).

2.10.2 Vegetation Condition in Pakistan Using Remote Sensing

Human interruption has affected natural and artificially grown vegetation patterns in Islamabad. Therefore, It is essential to take into account trends like land abandonment, human influence, and land use for the conservation and maintenance of vegetation (Ali and Malik 2010).

Limestone (LS) is an important component of cement manufacturing, which is widely used in the construction of infrastructure such as buildings and roads. The MHNP contains a large amount of LS reserve and its extraction is causing harmful environmental impacts on surrounding areas. From 1992-2009, LS exploitation area has been increased from 0.35% to 5.72% and vegetation of MHNP has been decreased from 23.46% to 12.12%. This study was conducted by using remotely sensed data (Iqbal *et al.,* 2013).

A study was conducted to examine the zoning management of MHNP using GIS and RS technologies. The natural recovery zone is an area where ecological recovery is necessary and that has been destroyed or degraded. The land use pattern is a major factor behind the degradation of this area. The study concludes that 6700 hectares area needs to be recovered and this zone covers 34.36 percent of the total area of the park (Zafar *et al.,* 2011).

By using remote sensing technologies (Ahmad, 2012) monitored the total vegetation area in Sargodha district. Vegetation cover maps were generated from NDVI analysis and supervised classification and then they were compared. Comparison of NDVI and Supervised Classification showed that the vegetation cover is dense at the periphery and mouth of lower areas of Chaj Doab and the vegetation is worst at the bottom of the Doab.

2.10.3 Importance of Vegetation Analysis of Islamabad

The master plan is typically a planning framework for the core systems that shapes the city's physical, social, environmental and economic future. The original Master Plan of Islamabad, was never enforced, which covers the urban areas of Rawalpindi. The root cause behind this weak enforcement is the lack of institutional development. In 1960, CDA was established under Federal Government to guide implementation and planning of the capital. But CDA authority was limited to the urban area. Absence of proper planning, imbalance resource allocation and the administrative fragmentation of Rawalpindi and Islamabad are the major obstacles to implement the original Master Plan of Islamabad (Maria and Imran, 2006)

CHAPTER THREE

MATERIALS AND METHODS

NDVI Analysis and Supervised Classification were carried out on all images using ERDAS IMAGINE and ArcGIS softwares from the Institute of Geographical Information Systems (IGIS), National University of Sciences and Technology (NUST), Islamabad, Pakistan to study the impact of development activities on the natural vegetation of Islamabad. The details of all kinds of TECHNIQUES are provided in this chapter.

3.1 The Study Area: Islamabad

The study area selected for this research is Islamabad, which is located at 33.43°N 73.04°E with an elevation of 1,770 ft. Islamabad and Rawalpindi are located as twin cities as there is no precise boundary between them. The total area of the city of Islamabad is approximately 906 km^2. There are undulating plain in the southern portion of this city and it is drained by River Kurang, on this Rawal Dam is also located.

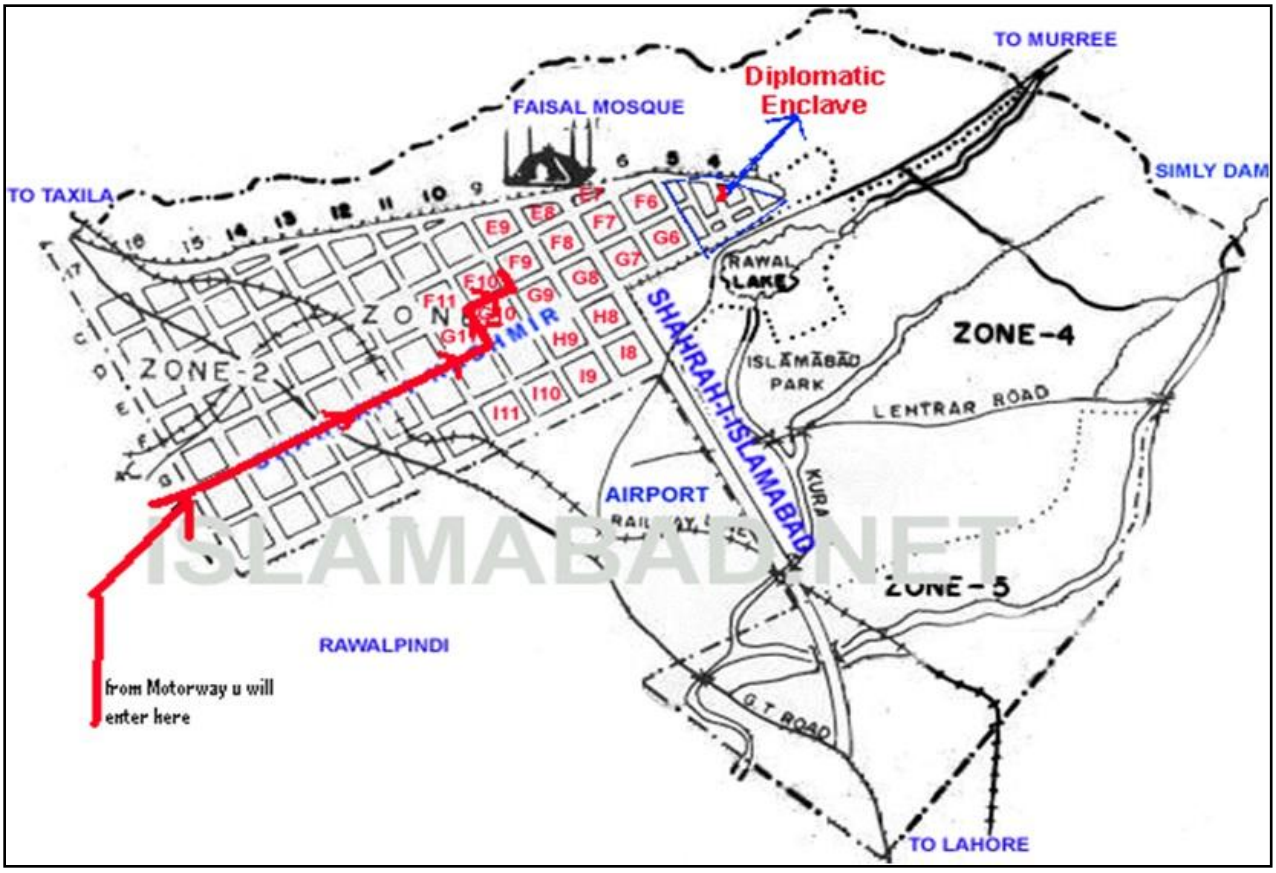

Figure 4.1 Map of Study Area

3.2 Datasets Used

Three Landsat images having resolution 30 m and three bands red, green and near infrared were taken from WWF-Pakistan. The images were of different dates 1992, 2000, and 2013 with the vector layers of the whole Islamabad having 30 by 30 resoultion.

3.3 Softwares Used

Following are the softwares used in this research

1. Erdas Imagine
2. ArcGIS

3.4 Methodology

The estimation of vegetation cover has been done by two different methods. The whole methodology is composed of six stages:

1. Mosaicing.
2. Clipping images with vector layer.
3. Visual interpretation of vegetation cover.
4. Estimation of NDVI.
5. Supervised classification.
6. Analysis of the results.

By using ERDAS IMAGINE 9.1 and ArcGIS 9.2, input data were processed and analyzed. Mosaicing was done on all the images and the vector layer of the Islamabad was used to clip and subset the image. Pre-processing along with geo-rectification was also done on all images to reduce or remove the errors in the satellite images. A typical Landsat scene covers a large area. At times, it makes sense to cut out a subset of this larger image to simplify your analysis and focus on the portion of the scene that is of primary interest. Enhancement techniques were applied to increase the brightness values to increas the visually contrast.

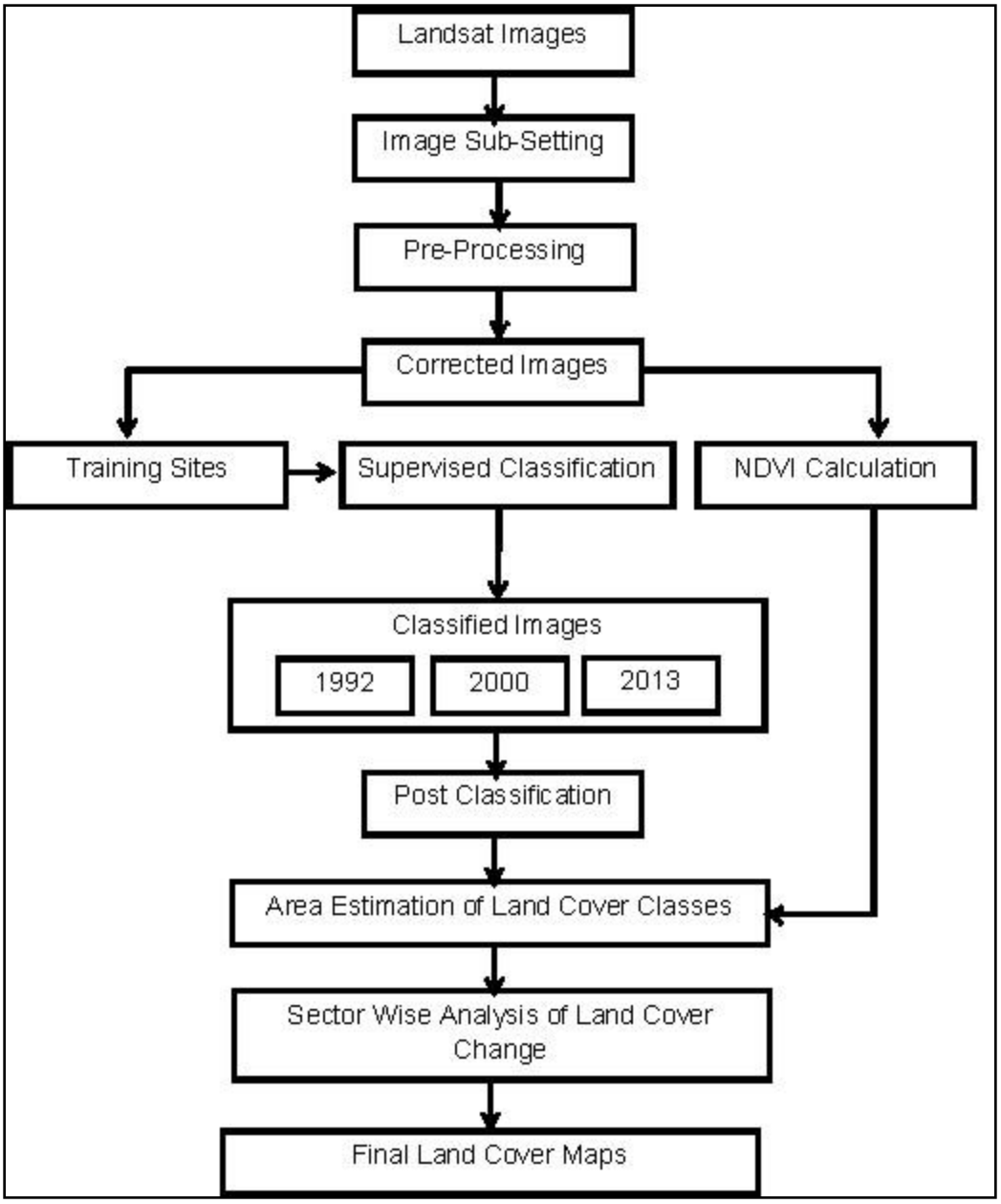

Figure 3.1 Methodology Flow Chart

3.3 Normalized Difference Vegetation Index Analysis

Indices are a unit typically designed by combining 2 or a lot of spectral bands and are wide acknowledged as powerful tools in distinguishing options of interest. Several studies describe a large variety of band combination/indices developed for vegetation, crop and land use assessment. NDVI provides an even technique for examination of the vegetation greenness from completely different satellite pictures. NDVI will be utilized as an associate indicator of relative biomass and greenness (Boone *et al*., 2000). The NDVI could be a specific measure of chlorophyl abundance and energy absorption; it's utilized to calculate the vegetation condition (Tucker et al., 1985), phonology and coverage. NDVI was used to delineate the vegetative area which was developed by Rouse *et al* (1974).

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

Where NIR is the near infrared reflectance and RED is visible-red reflectance having wavelength 0.78 to 0.89 and 0.61 to 0.68 ìm, severally. The general accuracy of NDVI was proved up to ninety eight per cent during a case study in state, China (Jiang et al., 2008). NDVI was typically used to calculate the density of vegetation (Purevdorj et al., 1998). The NDVI values tentatively vary between -1 to +1, the values near +1 denotes the dense vegetation condition. Higher index values are related to higher levels of healthy vegetation, whereas index values near zero or less than zero shows less vegetation or non-vegetated area.

3.4 Analysis of Supervised Classification

In almost all studies, classifiers have demonstrated superior to conventional classifiers (e.g. Maximum Likelihood) with overall accurateness of 10 to 20 percent. The success of classifiers in calculating land cover and land changes can be attributed to numerous factors. These classifiers are not controlled by statistical assumptions. Hence, they are best for analyzing (Gopal and Woodcock, 1996; Abuelgasim *et al*., 1999; Rogan *et al*., 2001).

The maximum likelihood classifier of supervised classification has been proved to give best results for calculating vegetation and non-vegetation cover (IDNP, 2002). Venkatratnam, (1983) reported that maximum likelihood of supervised classification has 90 percent accuracy.

Ahmed and Andrianasolo (1997) classified Landsat TM and SPOT XS images by supervised classification in Bahawalpur and Bahawalnagar of Pakistan. The results showed that supervised classification is best for classification of vegetative and non-vegetative areas.

In this study, by applying Maximum Likelihood Classifier the training samples for the supervised classification were utilized to classify the satellite image. Around six training sites for each class were taken and then using a maximum likelihood algorithm the **s**upervised classification was done. Then the image was classified into different classes on the basis of spectral response. After that classes were being merged according to the type of class.

3.5 Analysis of Sectors

In this research after calculating the vegetation index of Islamabad by NDVI and supervised classification further sectoral analysis has been done to find out the sectors at risk of losing vegetation at an alarming rate. The National capital is split into several completely different sectors, each known by a letter of the English alphabet and a number, with each sector covering an area of roughly 2km x 2km.

Each sector is additional divided into four sub-sectors. The sectors presently in use are lettered from D to I. The E sectors are numbered from E-6 to E-12. Several foreigners and diplomatic personnel are living in this sector.

The F sectors are numbered F-5-F-12. F-5 is a very important sector for the software package business, as each of the two software package technology parks are here. The whole sector of F-9 is devoted to the Muhammadan Jinnah Park. The Centaur complex are the key landmarks of F-8.

The G sectors are numbered G-5 through G-14. Some necessary landmarks here are the Convention Center, SS-CARE and Serena hotel in G-5, the Lal mosque in G-6, the Karachi Company shopping area in G-9 and also the PIMS Hospital in G-8.

The H sectors are numbered H-7 through H-12. Shifa International Hospitals are placed in sector H-8/4. Sectors H-8, H-9, H-10 and H-11 contain the campuses of variety of prime universities and Institutes of the country, together with Institute of Cost and Management, COMSATS, Allama Iqbal university, and Beacon House faculty in sector H-8 of national capital; the National University of contemporary Languages (NUML) and International school of Islamabad in sector H-9; the International Islamic University in sector H-10 Islamabad; the National University of computer and emerging Sciences (FAST-NUCES) in sector H-10 Islamabad; and also the National University of Sciences and Technology (NUST) in H-12 Islamabad.

The I sectors are numbered I-8 to I-10. Except I-8, these sectors are primarily put aside as a part of the industrial zone.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Overall Condition of Vegetation and Settlement

NDVI Analysis and supervised Classification were done on all images and the images were then compared with google imagery to validate the results. During pre-processing and geo-rectification errors were eliminated or reduced to get the most accurate results. Different sectors were selected to further study the change in vegetation within the different areas of Islamabad where the vegetation loss was evident. The selected sectors were: H-10, G-13, G-5 and D13. In all the maps of 1992, 2000 and 2013 the RS data was used to generate maps of vegetation cover generated by supervised classification

4.1.1 NDVI Analysis

NDVI was calculated to analyze the change of vegetation area in the study area and two classes of vegetation and non-vegetation cover were made. As shown in Table 4.1, the values of NDVI shows that almost 21 per cent vegetation area has been removed as the vegetation cover in 1992 is 56 percent of the total area and in 2013 it is 35 percent of the total area of Islamabad. NDVI is a very helpful method for classification of vegetation cover. In a study conducted in Inner Mongolia, China Jingwei *et al.* (2008) confirmed that the overall accuracy of NDVI was 98%.

Table 4.1 Results of NDVI Analysis

Year	No of Pixels	Area of one Pixel	Total Area under under Vegetation	Total Area of Islamabad ($km^{2)}$	Percentage
1992	572834	0.0009	515.5	906	56
2000	493117	0.0009	443.8	906	48
2013	356979	0.0009	321.2	906	35

4.1.2 Results of Supervised Classification

The RS data was used to generate maps of vegetation and non vegetation cover by two methods, i.e., NDVI and supervised classification. The study of vegetation cover developed from the Landsat demonstrates a clear area of vegetation in Islamabad. The spatial analysis of the vegetation covers clearly indicate that the biomass become poor with the passage of time.

In Table 4.2 the loss of vegetation and settlement increase is given. Vegetated area which is estimated at September 1992 was 529.12 km^2, 58% of the total area of Islamabad. While in 2000 it was 455.43 km^2 around 50% of the total area and in 2013 the area under vegetation has been rapidly decreased to 308.67 km^2, which means it is 34% of the total area of Islamabad. From 1992-2000 settlement was increased from 15% to 18% and in 2013 it has reached to 23%. The rate of vegetation loss from 1992 to 2013 was 10.02 km^2 per year that is 1.09 % of the total area of Islamabad per annum. From 1992 to 2013 total of 226.21 km^2 of vegetation has been removed up till now.

Table 4.2 Change in Vegetation and Settlements during 1992-2013

	Area (km^2) 1992-2000	**Area (km^2) 2000-20013**
Vegetation	-73.69	-146.76
Settlement	+24.13	+41.84

4.2 Land Cover Classification

Land cover classification of Landsat images was performed using MLC of supervised classification to categorize vegetation cover. The results showed the area covered by non vegetation and vegetation cover. The land use categories of interest in my research are Vegetation, Settlement, Water, and other lands.

In the Figure 4.2 the map of 1992 is clearly showing a larger area under vegetation because in 1992 as Islamabad was constructed as a forward capital in 1960 and it was not highly developed during 1992 which is the main reason behind more greenery during this time period.

In the Figure 4.3 the supervised classified map of year 2000 is showing removal of vegetation which is mainly due to the constructions of new buildings and sectors in Islamabad ultimately increasing the built up area at the cost of greenery. The area, where Convention Centre, Serena Hotel and the under-construction Grand Hyatt Hotel stand today, was designated as green belt in the original master plan. The changes were made in 1995 to allow construction on the green area.

While Figure 4.4 shows a huge loss of vegetation because until now many mega projects have been initiated. The metro bus project, a new parade avenue and the Centaurs Mall all made it to the city's landscape only after making changes to the original master plan. Similarly, a new road for running parallel to the Islamabad Highway starting from Faizabad Interchange to the Lok Virsa signal was approved after making another change to the original master plan, while several trees had to cut to level the land for the parade avenue.

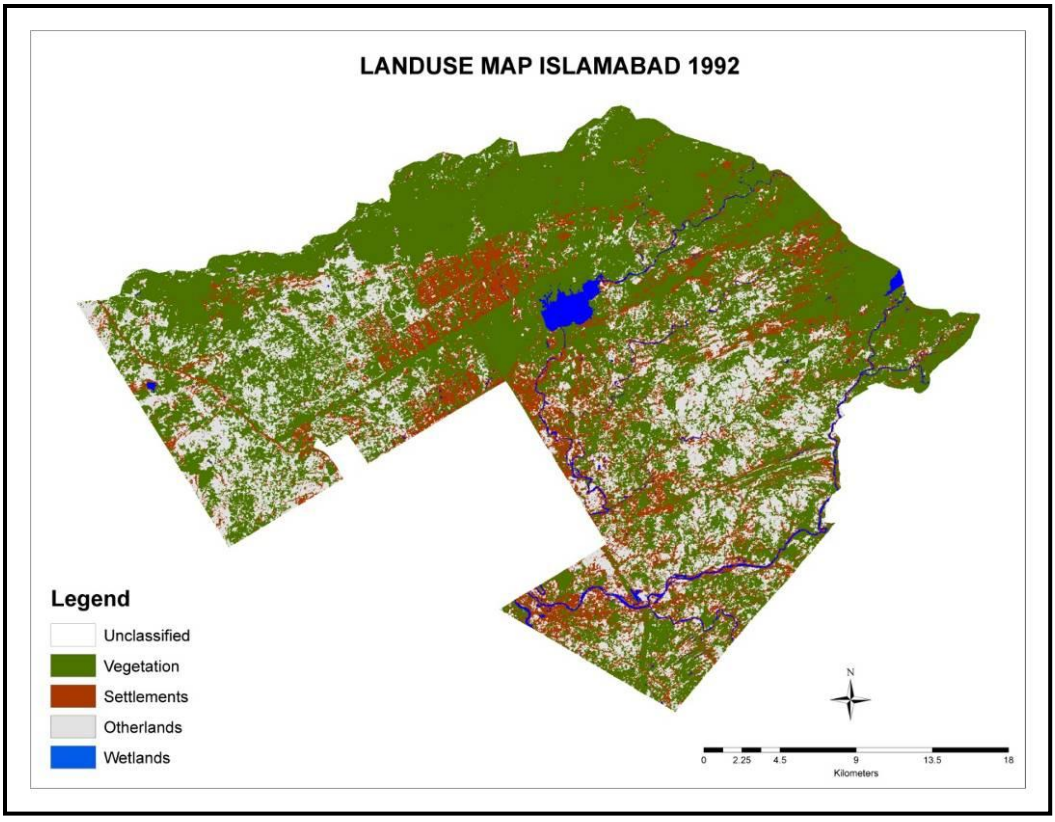

Figure 4.2 Map Showing Various Classes of Year 1992.

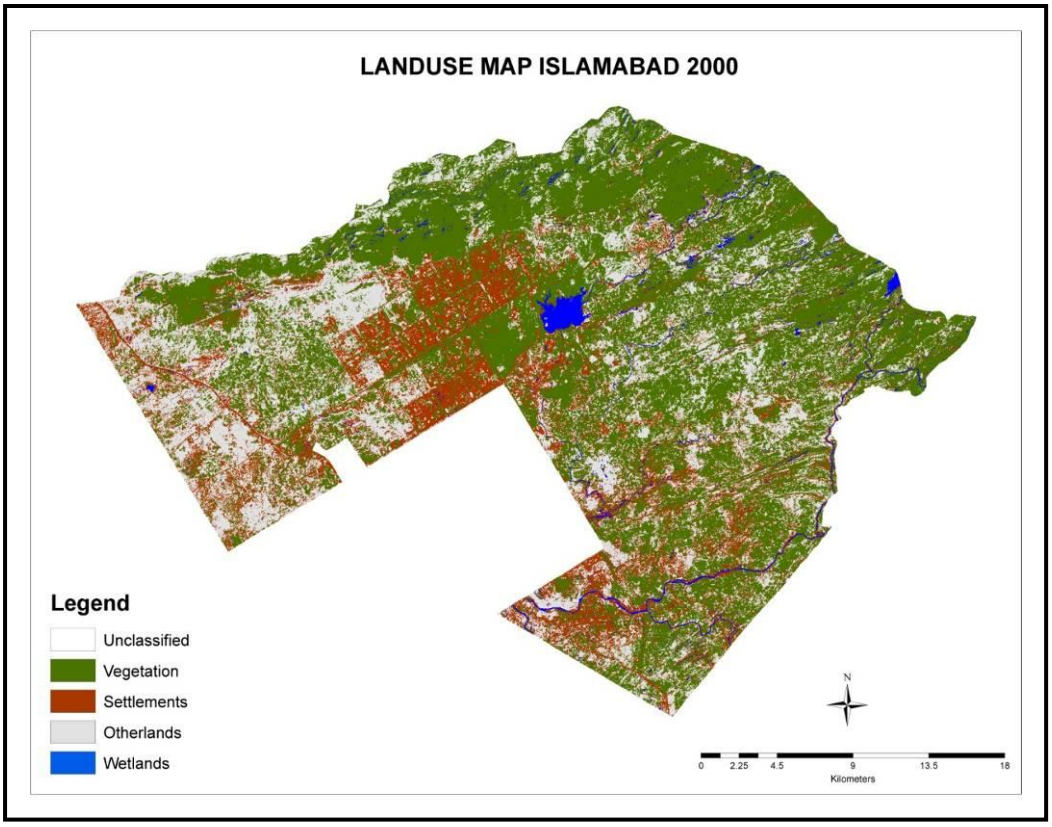

Figure 4.3 Map Showing Various Classes of Year 2000.

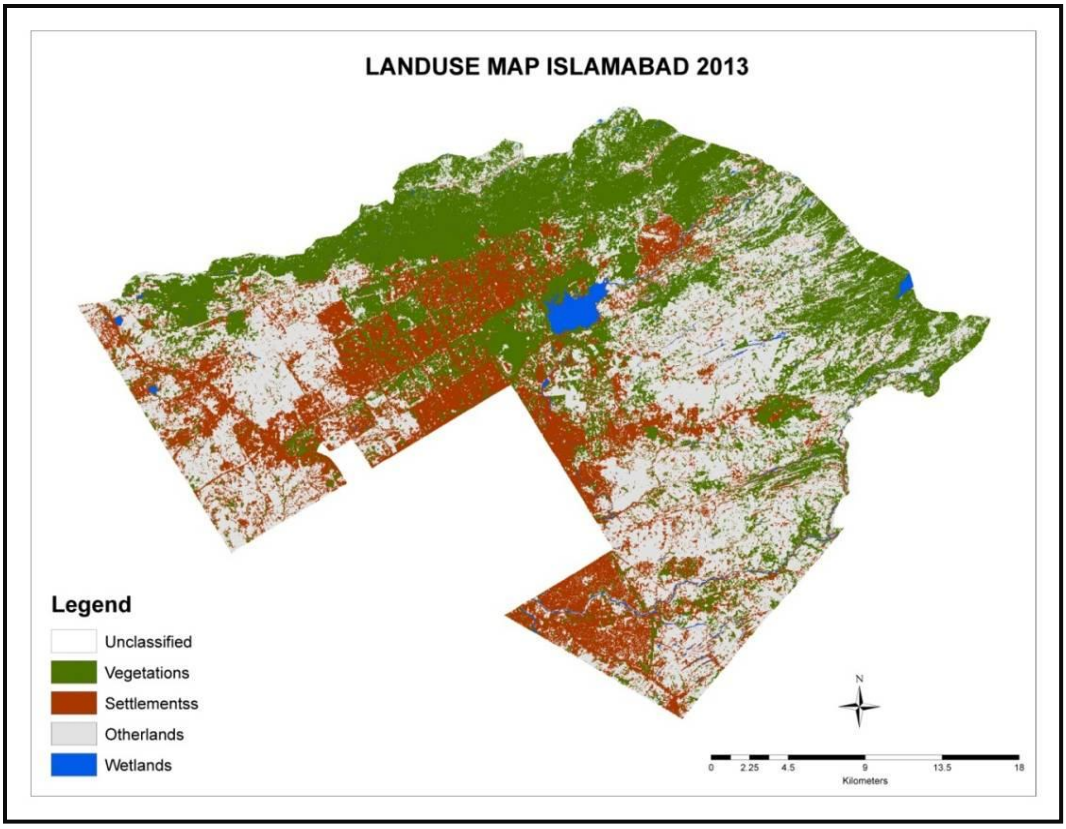

Figure 4.4 Map Showing Various Classes of Year 2013.

4.3 Vegetation Cover

One cannot estimate and monitor the change in area under vegetation effectively for past years without applying the remote sensing technologies. The change in vegetation covered area facilitates us to unearth the impacts of decreasing and increasing trends on the environment. Assessment done in this research gives us a reliable warning of the changes in the vegetation cover during the time period of 1992 to 2013 in Islamabad. Vegetated area estimated for 1992, 2002, and 2013 shows that total vegetation is 58, 50, and 34 % of the total area. The overall rate of vegetation loss from 1992 to 2013 was 10.02 km^2 per year that is 1.09 % of the total area of Islamabad per annum.

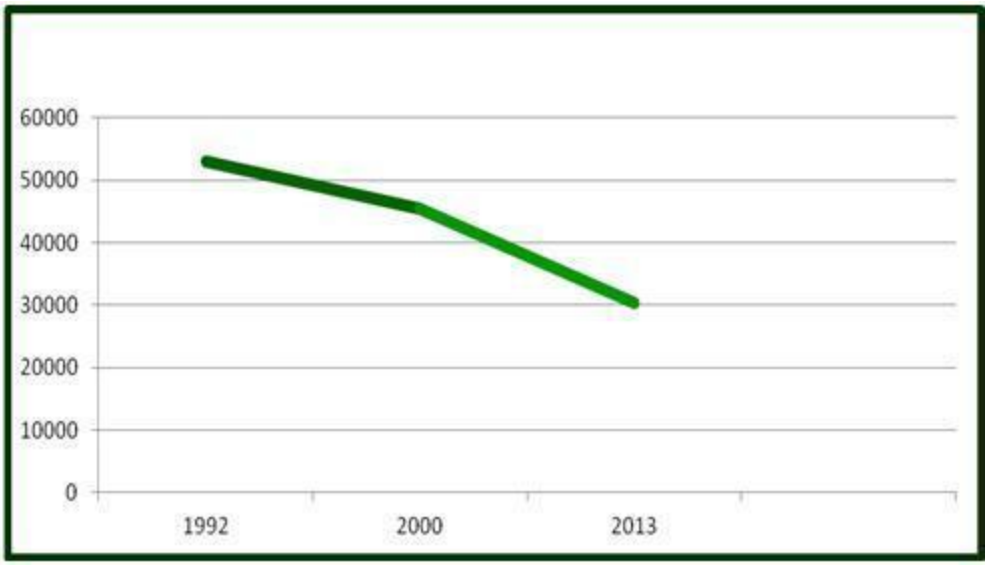

Figure 4.5 Graph Showing Change in Vegetation Cover over the Past Year.

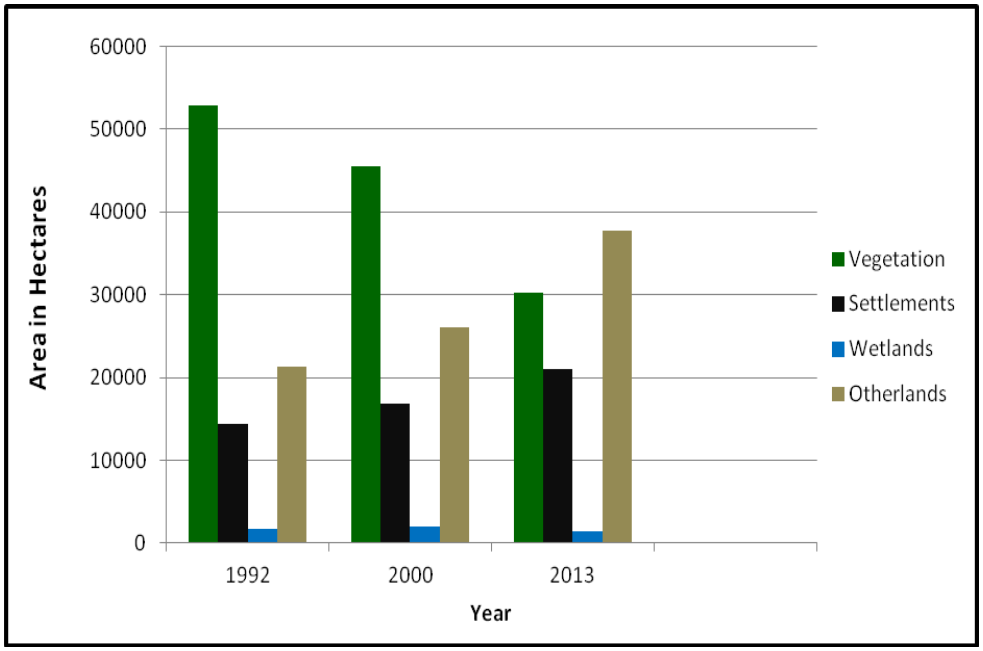

Figure 4.6 Graph showing the trend of different classes from Supervised classification.

Table 4.3 Area under various classes of Land Cover during 1992-2013.

Classes	**Area in Km^2**		
	1992	**2000**	**2013**
Vegetation	529.13	455.50	302.91
Settlements	143.92	168.06	209.90
Water Bodies	17.35	19.94	13.53
Other lands	213.40	260.26	377.03

4.4 Sector Wise Analysis

Different sectors were selected to further study the change in vegetation within the different areas of Islamabad where the vegetation loss was evident. The selected sectors were:, H-10, G-13, G-5 and D-13. Residential sectors (G-13 and D-13) were found to be at high risk as compared to the educational sector and diplomatic enclave .

4.4.1 Sector H-12

In Figure 4.8 the vegetation removal is continuous with respect to time because in H-12 the National University of Science and Technology is located Previously NUST was located in Rawalpindi but in In 2008, the headquarters of NUST were shifted to the newly constructed campus in H-12 Islamabad. This is the reason of huge vegetation change in this sector.

4.4.2 Sector H-10

The H-10 sector has The International Islamic University and the National University of Computer and Emerging Sciences (FAST-NUCES). In Figure 4.9 The supervised classified image of 1992 shows that there was enough vegetation in 1992 around 1.62 km^2, but then in 2000 the vegetation has been decreased to 0.57 km^2. In the year 2013 again vegetation has been increased from 0.57 km^2 to 1.40 $km^{2.}$ The vegetation increase is due to the fact that this sector contains the institutions and re vegetation has been done by the management of International Islamic Univeristy and FAST-NUCES .

4.4.3 Sector G-13

Sector G-13 is a newly developed sector so in the Figure 4.10 the supervised classified image we can is clearly showing a huge vegetation loss from 1.96 km^2 in 1992 to 0.05 km^2 in 2013. This is due to new development activities being done in this sector affecting the natural vegetation at an alarming rate.

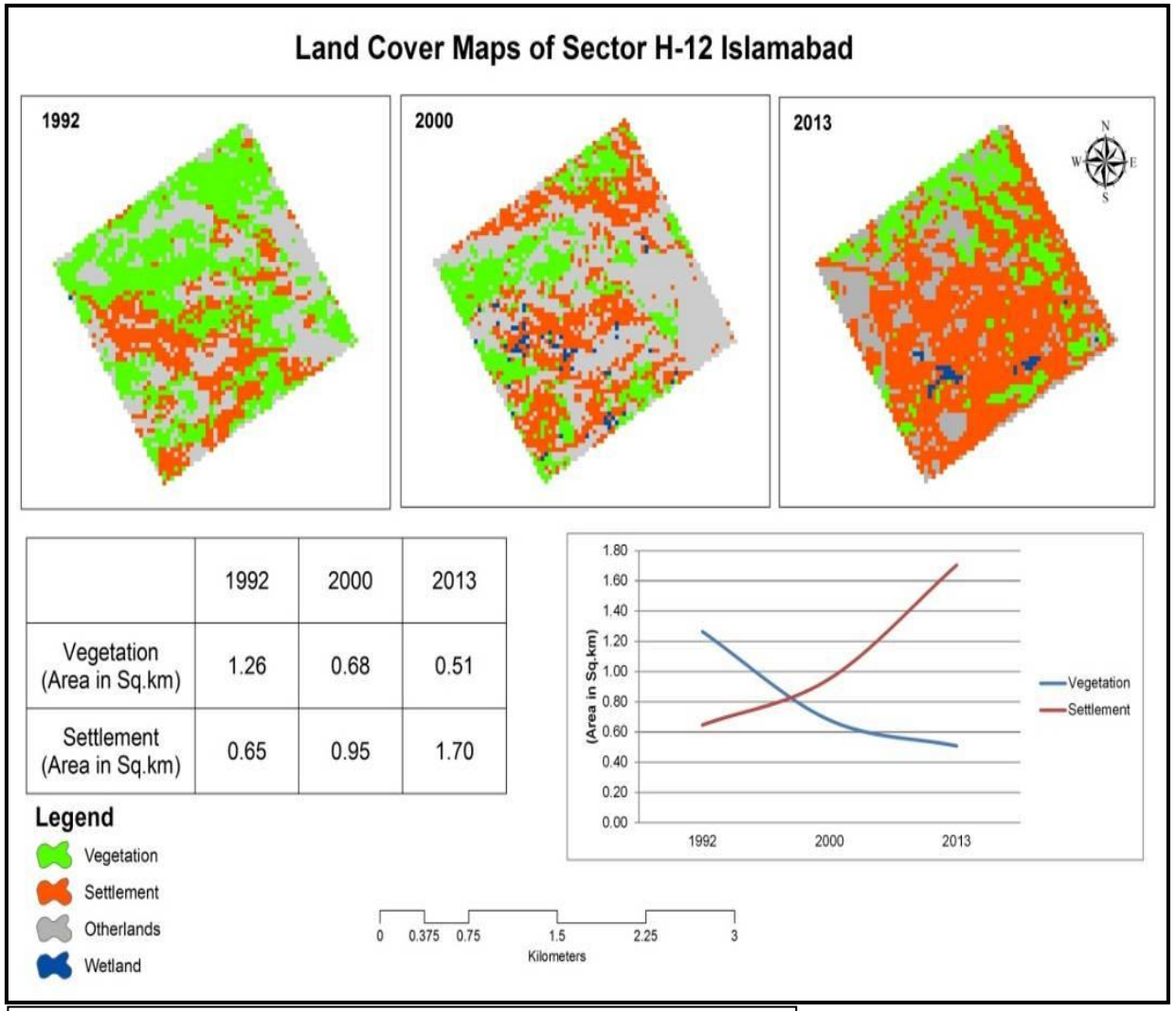

Figure 4.8 Map Showing the Vegetation Change in H-12.

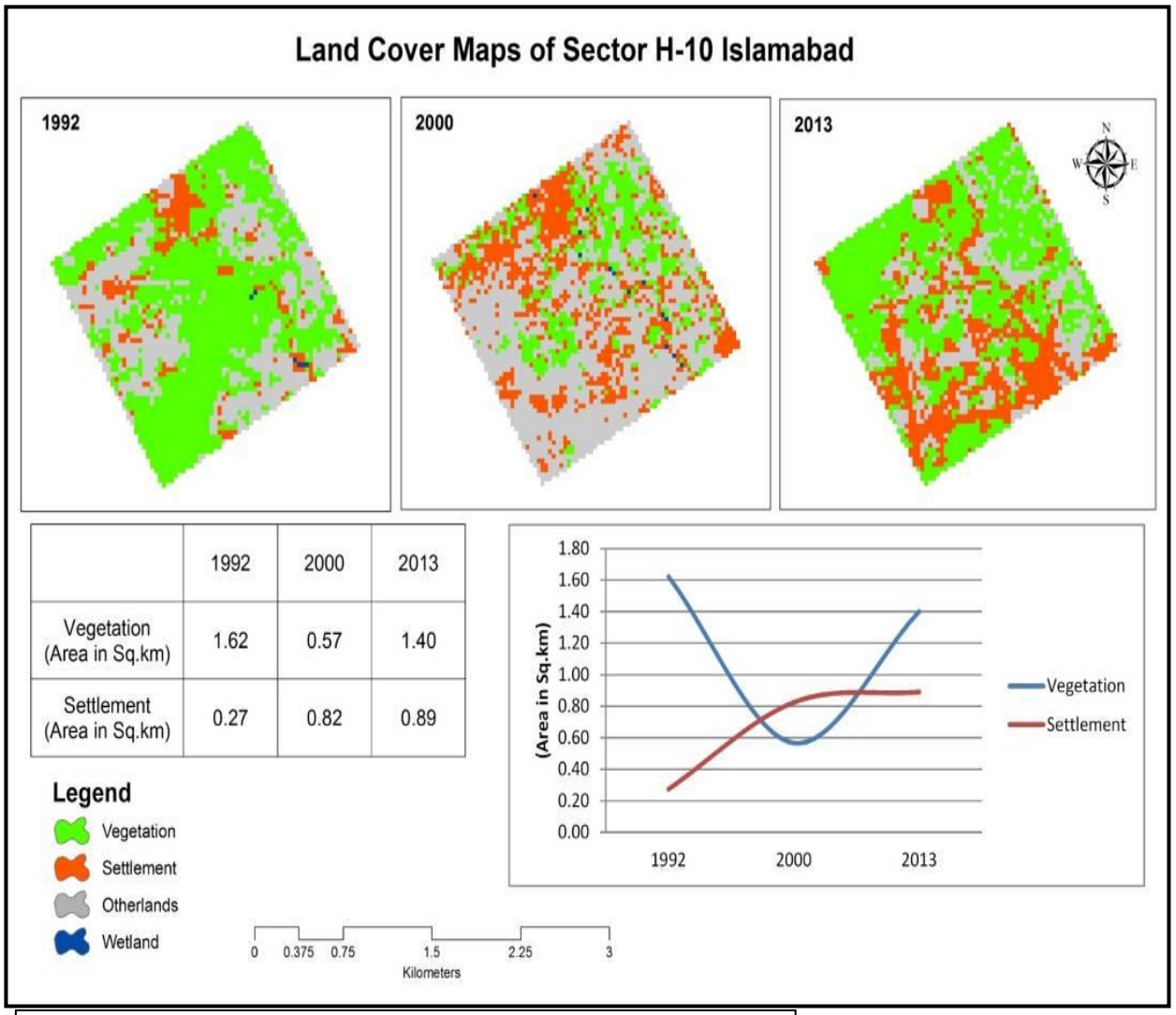

Figure 4.9 Map Showing the Vegetation. Change in H-10.

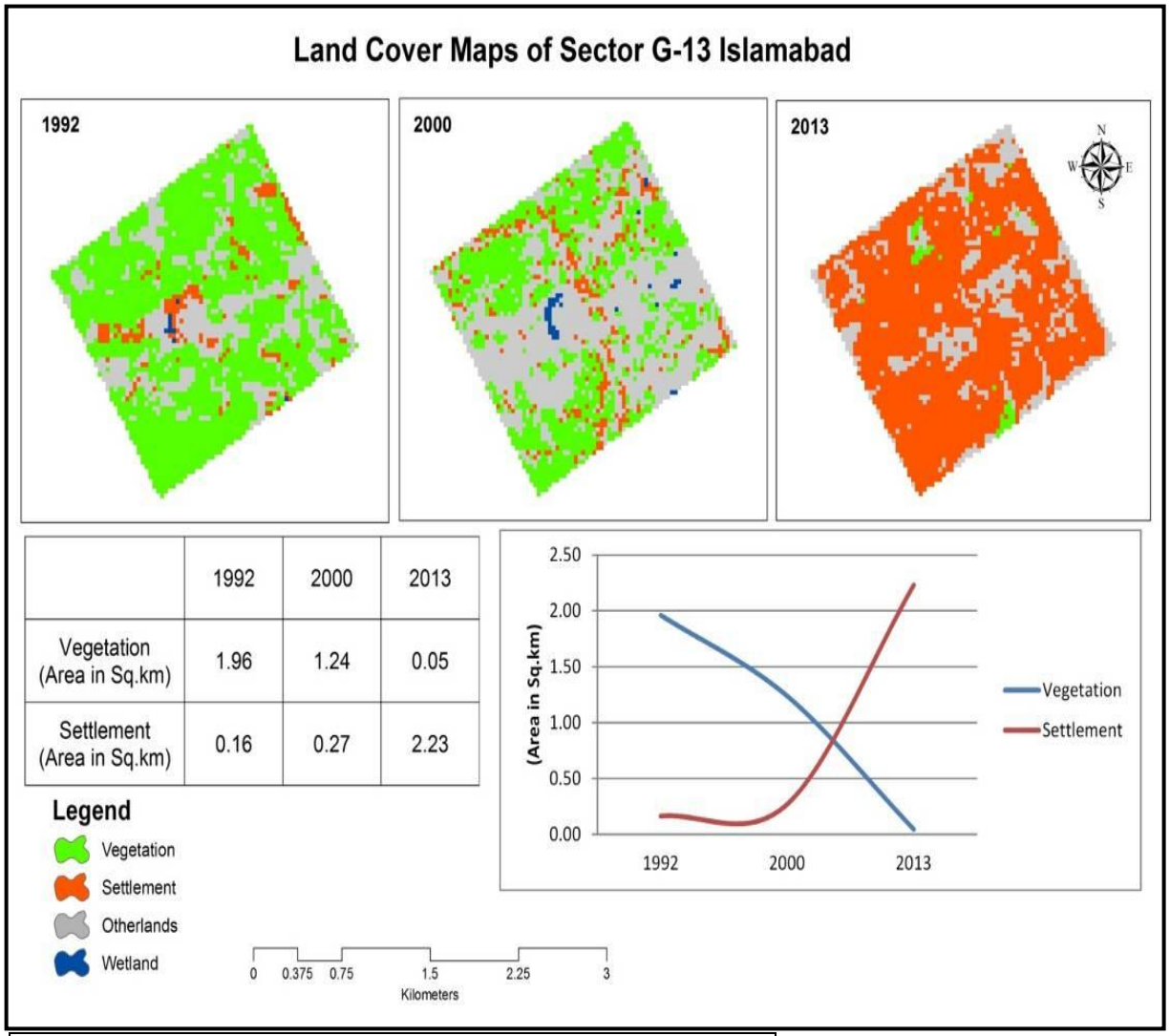

Figure 4.10 Map Showing Change in Vegetation of G-13.

4.4.4 Sector G-5

Vegetation loss in the Secteriate area of G-5 is not high as vegetation in 1992 is 1.40 km^2 and 1.24 km^2 in 2013 as seen in Figure 4.11 and Figure 4.12. While in diplomatic enclave the vegetation loss is very high. This is due to the fact that in the area of Pakistan secretariat there are so many government institutions operating so they have maintained the ration of vegetation within that area while in diplomatic enclave the high vegetation loss is because later all the embassies were shifted out of the red zone and they are located now in diplomatic enclave that's why the vegetation is continuously decreasing in this area as many new embassies were also built and while doing all this lot of green vegetation was removed .

4.4.5 Sector D-13

In the Supervised classified image of D-13 the vegetation has been decreased from 0.99 km^2 in 1992 to 0.06 km^2 in 2013. Previously, there was no development in D-13 but it has been developed as a new sector so the image clearly shows the decrease in vegetation while the rapid increase in the settlement area. The image of 2013 shows a high area under other lands which shows that more settlements are under construction that's why the area under other lands (barren soil) is very high in 2013.

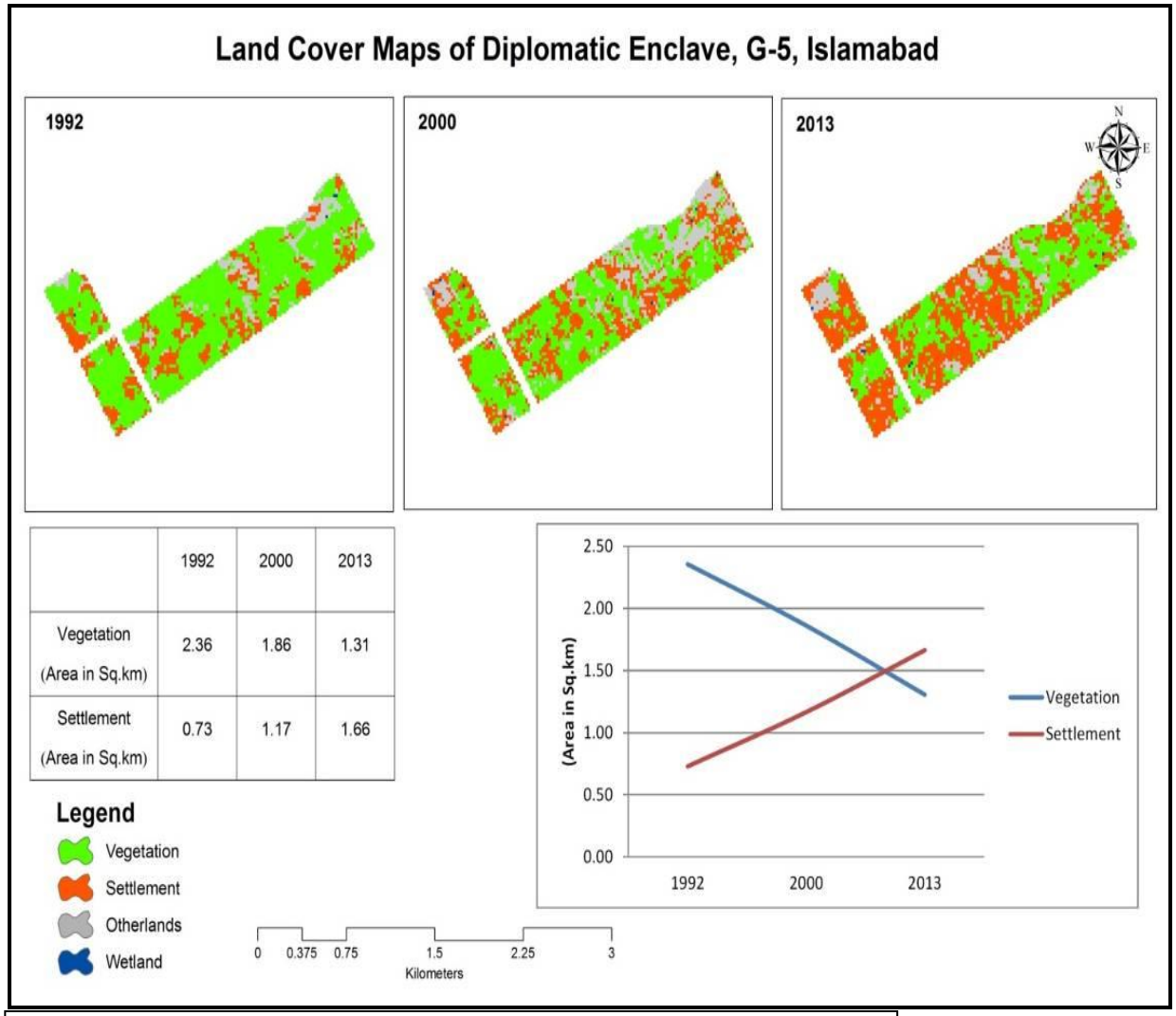

Figure 4.11 Map showing Vegetation Change in Diplomatic Enclave.

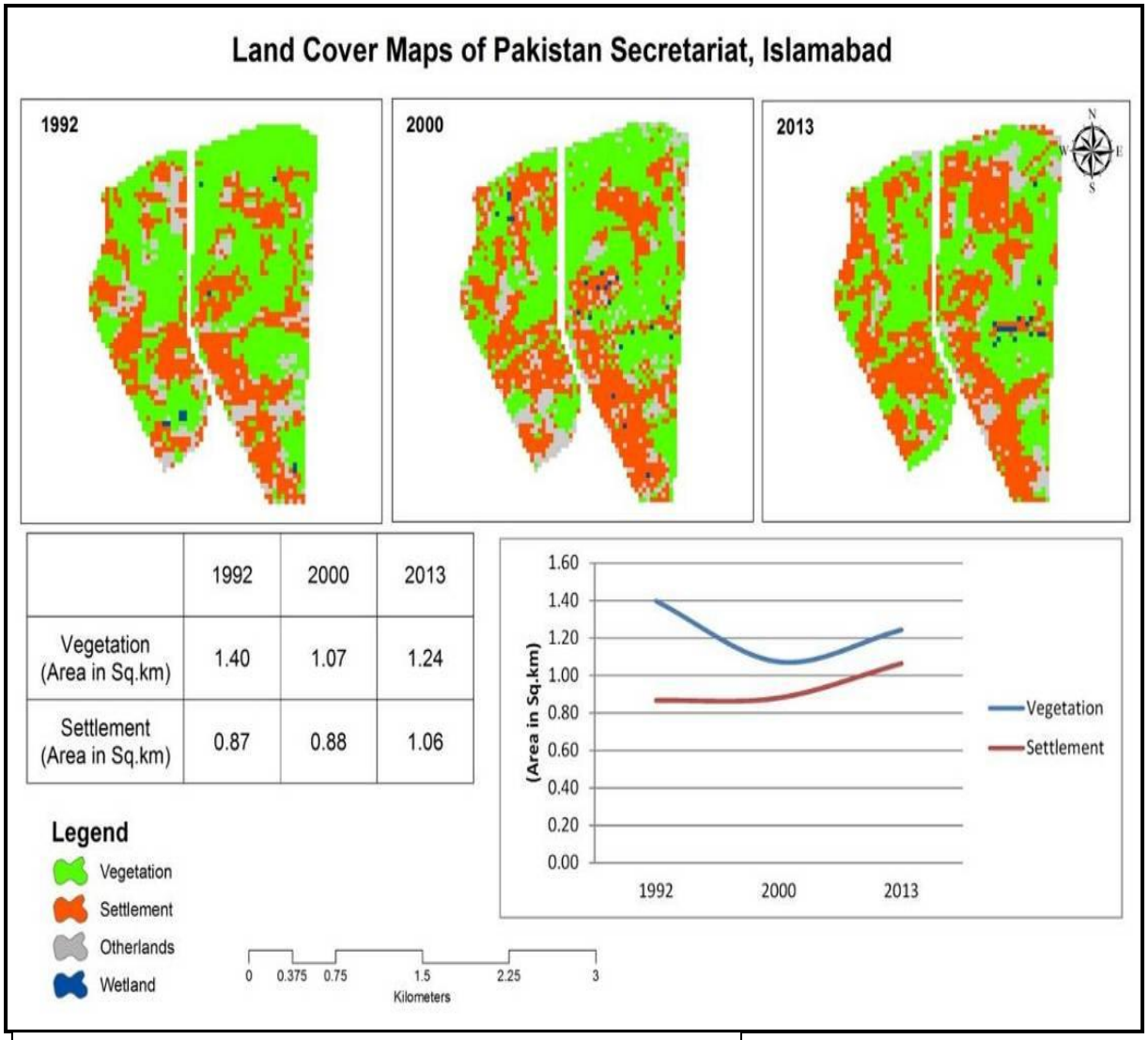

Figure 4.12 Map Showing Vegetation Change in Pakistan

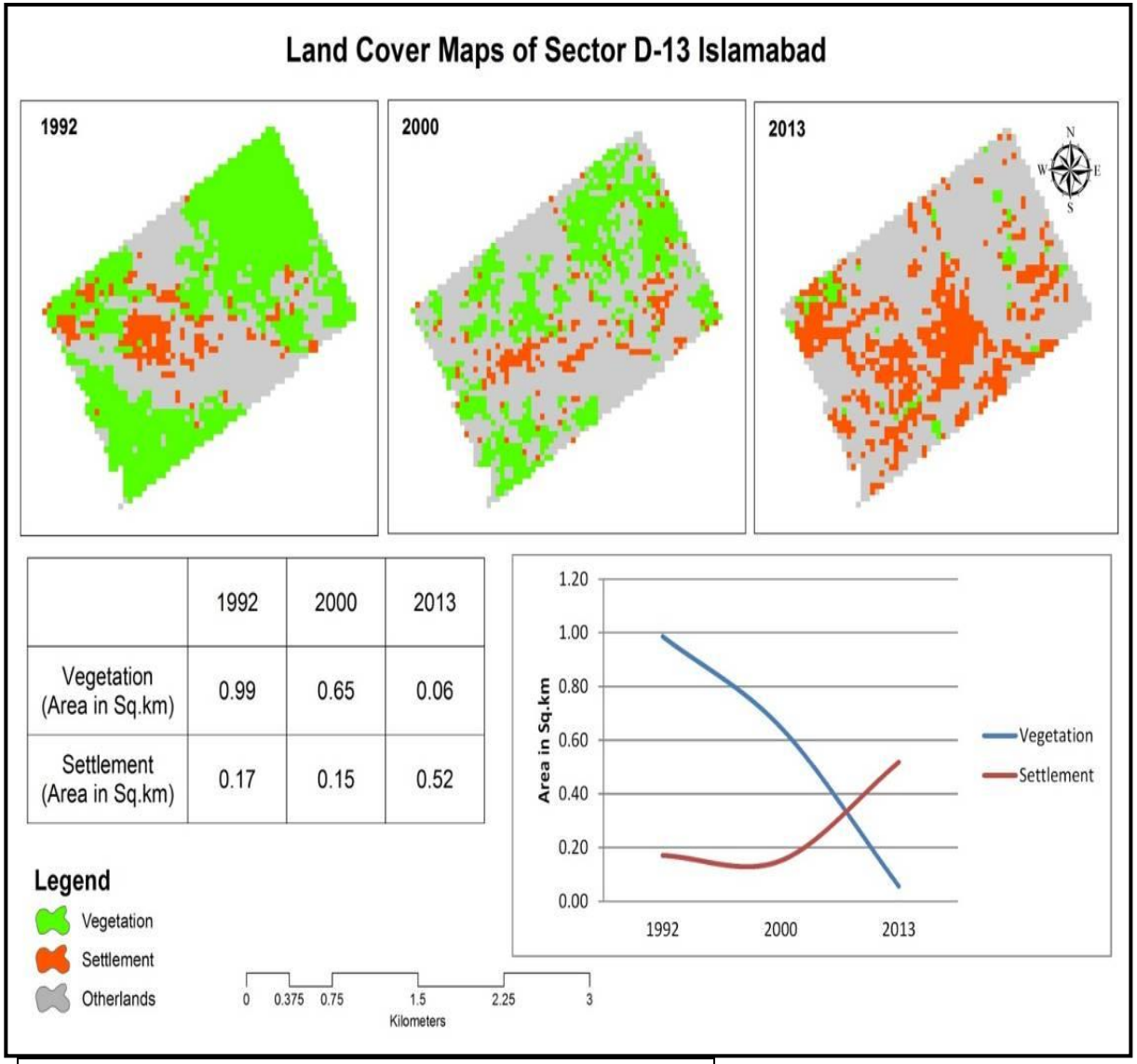

Figure 4.13 Map Showing Vegetation Change in D-13.

The population of Islamabad is increasing rapidly with the passage of time, which is the major reason behind the destruction of green areas. In a bid to cope with the burden of more people, the city planners are forced to build new sectors, some of them on green belts and park areas of the city. The green belts are not only important for the aesthetics of the city, they also serve as places of respite for the common man. CDA had been violating city bylaws by converting open spaces, greenbelts and parks into residential plots.There should be effective monitoring of all development activities to ensure sustainable development within Islamabad.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Using the remote sensing techniques allow analyzing spatial condition of vegetation and these analyses can be used for automated vegetation monitoring. This study confirms reports of vegetation degradation within Islamabad. The results of the study are very important for the governmental organizations, non governmental organizations and the general public to respond faster and address the problem. The problem here is not only to do with the Islamabad vegetation alone, but also all other cities of the country. Otherwise, the lives of present and future generations are at stake. By adopting the recommended measures, and others which may be appropriate to the current situation in our green area are likely to improve**.**

The study has explored the utility and potentials of remote sensing techniques for vegetation cover monitoring in Islamabad. The results showed that the vegetation is in worst condition. Although, some efforts are being made to control vegetation area, the efforts does not match the pace of vegetation loss. Necessary measures need to be taken to maintain and improve vegetation to the desired level.

- From 1992-2000 total area of 73.63 km^2 of vegetation was removed in Islamabad.
- From 2000 to 2013 total area of 152.59 km^2 of vegetation was lost in Islamabad.
- Residential sectors are losing vegetation at a very alarming rate as compared to the other sectors.
- The annual rate of vegetation removal is increasing (0.9% to 1.3% in 1992- 2013)
- The annual rate of settlement is increasing (2.7% to 3.22% from 1992-2013)
- The flora of Islamabad is under a constant threat.

5.2 Recommendations

The development and management of cities need greater consideration. The first thing is for the governments to identify the seriousness of the urban issues. The second step is to get right context to create a suitable policy of development which means economic growth requiring a favorable climate for the public and private investment. After that, it is essential to structure the improvement program which requires thorough examination of all the development activities in urban areas. There is also a need to adopt a program for the control of population growth and urban expansion at a rapid rate.

Few of the recommendations are:

1. It is necessary to engage the local community in planning stage for sustainable urban development.
2. Strong awareness movement is needed to aware people of Islamabad regarding naturally existing resources and engages them in managing the resources
3. This study can be successfully used for monitoring the growth of cities/removal of vegetation and it can be applied for other cities of Pakistan
4. For further research high resolution data can be used like 20m or 10m.
5. Remote sensing data should be used as input for analysis and decision supporting system.
6. This type research can be used as a support for the Sustainable development.

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