Sudan University of Science & Technology

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Efficiency Evaluation of MODIS Data Products In Monitoring and Mapping The Wild land Fire

(Case study: Dinder National Park)

تقويم كفاءة منتجات بيانات مودس في رصد ورسم خريطة حرائق الاراضي البرية

(حالة الدراسة: محمية الدندر القومية)

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Prepared by:

Dalia Omer Saeed Hsbalkhalig

Supervisor:

Dr. Mohamed Elamin Ahmed Babiker

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بسم الله الرحمن الرحيم

الآيـــة

{قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا}

(صدق الله العظيم)

سورةالكهف

الأية (109)

Dedication

Thisdissertationisdedicatedtomyfatherandmymother, to allmyteachers, and tomybrotherswhohavesupportedme, andtomyfriends.

Abstract

El Dinder National Park (DNP) is one of the oldest parks in Africa. It was established in 1935. DNP is included in the UNSCO list of biosphere reserves since 1987. Fire in DNP starting in early as mid-September. During the dryness seasons in DNP, the number of forest fires increase rapidly and there is need to develop, with high efficiency, fire prevention strategies, in order to avoid the loss of natural resources. As any other natural disaster, there for, this research used analysis of the remote sensing data time-series of multispectral satellite imagery of Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data to generate a historical back ground of wild land fire regime. Burned area were detected for the years 2013-2014-2015 based on direct method of visual and digital interpretation ofburned scars area, to locate and map areas that have been burnt in past events (burnt scars), burned areas identifiable on imagery by bare ground and dark charcoal/ash appearance.The static result shows the maximum area burnt in the park in year 2013 (1342.63Km^2) and the minimum area burnt in year 2013 (1.34 Km^2).The study revealed several important facts regarding the fires, which generally begin in September and continue until November and reach the highest extent . This month,modissensor has also proved highly efficient in detecting and mapping fires .The study reveals that most of the fires were in the eastern, northern, southern and central parts of the country of the study area .The least exposed areas were in the western part of the study area.

مستخلص

حديقة الدندر العامة واحدة من أقدم المتنزهات فى أفريقيا، وهى أسست فى العام 1935 ، حديقة الدندر العامة ضمنت فى قائمة الينسكو لمحميات المحيط الحيوى منذ العام 1987، الحرائق فى حديقة الدندرالعامة تبداء فمنتصف شهر سبتمبر. أثناء الفصل الجاف،عدد حرائق الغابات يتزايد بتسارع وحديقة الدندر العامة تحتاج للتطوير أستراتيجيات مكافحة النيران بالكفاءة العالية ،وذلك لتفادى خسارة الموارد الطبيعية مثل أى كارثة طبيعية أخرى،لذلك،هذا البحث أستخدم تحليل سلسلة زمنيه لبيانات الأستشعارعن بعد من الصور الفضائية متعددة الأطياف من صور فضائية للطيف الراديومترى متوسط الطيف (موديس) لإنشاء خلفية تاريخية للحرائق البرية، المناطق المحروقة أكتشفت لعام 2015-2014-2013 مستندة على طريقة مباشرة من التفسير البصرى والرقمى للمناطق المحروقة ، لمواقع وتخريط الحرائق التى حرقت فى أحداث سابقة، المناطق المحروقة تتميز على الخريطة عبر الأرض الخالية وظهور الفحم والرماد الداكن ،النتائج الأحصائية أظهرت أعظم مساحة مناطق محروقة فى الحديقة فى العام 2013 ($1342.63km^2$) وأقل مساحة منطقة حرقت فى العام 2013 ($1.34km^2$) .كشفت الدراسة العديد من الحقائق الهامة فيما يخص الحرائق التى تبدأ عموما فى سبتمبر و تستمر حتى شهر نوفمبر و تبلغ أعلى مدى لها فى هذا الشهر, كما ان المستشعر موديز اثبت كفاءة عالية فى اكتشاف وتخريط الحرائق, حيث ان الدراسة تكشف لنا ان معظم الحرائق كانت فى الجزء الشرقى و الشمالي والجنوبى والوسط من منطقة الدراسة ' وأقل مناطق تعرضت للحرائق كانت فى الجزء الغربي من منطقة الدراسة .

Acknowledgement

I would like to express my thanks to all my friends and colleagues who have given me much help full advice and engorgement during this study.I thankvery much my supervisor Dr. Mohamed Elamin Ahmed Babike

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Abbreviations

ASTER Advanced Space borne Thermal Emission and Reflection Radiometer

AVHRR Advanced Very High Resolution Radiometer

BAI Burnt Area Index

BAIM Burnt Area Index for MODIS

DNP Dinder National Park

DBR DinderBiosphere reserve

ENVI Environmental For Visualize Image

ENSO E1 Nino Southern Oscillation

EVI Enhanced Vegetation Index

FNC Forest National Corporation

GIS Geographic Information System

MODIS Moderate Resolution Imaging Spectroradiometer

NASA National Aeronautics and Space Administration

NBR Normalized Burnt Ratio

NDVI Normalized Difference Vegetation Index

NIR Near Infrared

NOAA National Oceanic and Atmospheric Administration

RS REMOTE SENSING

SPOT Satellite pour l'observation de la Terre

SWIR Short Wave Infrared Index

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Forest fires are a very common problem that has significant impacts on terrestrial, aquatic, and atmospheric systems throughout the globe . Every year the world faces extreme wild fires which affect millions of hectares of forest leading to adverse effects on biodiversity, ecosystem functioning and landscape stability. Forest fires are mostly classified as crown fires, surface fires and ground fires on the basis of intensity (Narendran, 2001)

According to United Nations study, the total forest area of the world in 1900 was nearly 7000000000 ha and by 1975, it was reduced to 2890000000ha.Severe forest fires have occurred in many countries in Asia, Africa, Europe, North America, South America and Australia. Many of the forest fires that occurred during the years 1997 and 1998 have been linked to a drier climate and have been attributed to events such as ENSO (Narendran, 2001).

Remote sensing presents the only viable source of timely and consistent data for burned area assessment and spatially explicit fire impact analyses. The importance of burned area mapping is reflected in the numerous algorithms and approaches developed for this application in many parts of the world.

Observations received from coarse resolution instruments (e.g. SPOT-VEGETATION, AVHRR, MODIS, and ASTER) are of particular importance because they provide daily observations and monitoring of fire activity (temporal

availability), spatially it has large coverage area, and it's available free of cost via the internet (Loboda andCsiszar, 2005). Here we provide an evaluation of some fire products from MODIS as MODIS products for mapping the burned area.

1.2 Research Problem

Wild land fire causes major problemsof the human lives as well as property, and also led to decrease or losses of natural resources. Therefore, its observation and monitoring on large scale basis is very important for a large country like Sudan.
The frequent occurrence of drought helped the fires spread and the lack of adequate protection and advanced methods of fire-fighting.

1.3 Research objectives

The overall aim of this research is monitoring and mapping Wildland fire in

ElDinder National Park in Sudan, using remote sensing and geographic information system.

The specific objectives of this research are including the following:

Documentation of wild land fire by monitoring and mapping in DNP and

Using MODIS product for mapping burned areas.

1.4 Previous studies

(Ana FernándezTorralbo and Pablo Mazuelas Benito, in the year 2012)used Landsat and MODIS images for burned areas mapping in Galicia, Spain. The objective of this study was the evaluation of multi-scale remotely sensed images and various mapping methods for the identification and estimation of burned areas. The area of the study was situated in Galicia, a region of Spain punished year after year by important wildfires. By employing 7 images before, during and after the occurrence of forest fires, and working with different methods it was possible the collection of several products and results.

The satellite imageries used were Landsat TM5 and MODIS, and the methods carried out were mainly spectral indices such as Normalized Burnt Ratio (NBR), Short Wave Infrared Index (SWIR), Burnt Area Index (BAI), and Burnt Area Index for MODIS (BAIM) and supervised classifications. Based on a wide literature review there were selected as suitable techniques for assess, localize and quantify burned areas. The work was separated in two sections, being differenced monotemporal and multitemporal analyses, depending on the images involved in each part.

As a final products were obtained with precision the total burned area, the perimeter, the localization and the burn severity of the regions affected by wildfires. The data obtained could be used to create a database of burned areas, or based in the repetitive patterns, as useful information in order to prevent future forest fires.

“(MohanedElTijani Mohamed ELMardi, 2009) studieddinder biosphere reserve the research studied and assess the history of wild land fire regime in Al

DinderBiosphere Reserve (DBR). Most the study incidences of that the fires, which start in October, are on North East side of the park, most possible because the North Eastern side has lower precipitation and it becomes the drier side a situation that initiates fire. In the November fire moves to the center of the park and finally in December, when most of the grasses become dry, the fire spreads on the remaining parts of Dinder Biosphere reserve".

1.5 Dissertation Layout

This dissertation falls in five Chapters .the first chapter forms the introduction to the thesis and discuss the research problem and the main objectives of the study.

In chapter two aliterature reviewcontains brief portrayal of remote sensing , Geographic Information Systems (GIS) and wildfire is which are discussed in details .

Chapter three outlines the methodology used , study area and data acquisition in details.

Chapter four mainly represents the results of the study in addition to analysis of significant fire wild in the study betweenthe year 2013 and 2015.AlostheResults and Analysis are represented.

Chapter Five contains the main conclusions and recommendations of the study.Based on the results obtained in this study for future researches.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Wildfire is the term used for an uncontrolled fire fuelled by natural vegetation. In Australia wildfires are called bush fires and in North America they are called brush fires. They often start in rural, wilderness areas but migrate to rural-urban fringes, affecting buildings, animals and people.

2.2 General information about wildfires

2.In general, wildfires are caused by a mixture of factors such as high temperatures, drought conditions following a period of vegetation growth and a trigger which can be natural such as lightning or human influenced such as arson. El Nino is thought to have an effect on the occurrence of wildfire cases. Due to El Nino tropical countries on the western pacific experience a higher risk due to the enhanced dry season. In September 1997 Malaysia and Indonesia were affected by major wildfires, there were bush fires in Australia in late 1997 and early 1998 and forest fires in Borneo during April 1998, all of which are thought to be due to the prevailing El Nino.(Natural Disasters Association)

2.3Remote sensing

Remote sensing is the acquisition of information about an object without making physical.Provided remote sensing techniques many of the features that made the technology of which alternative for many applications mention of these features include:

The broad coverage resulting from the high-rise

There are no contraindications natural or political prevent access to the targeted area and collect data

Sensing data for help after the fire management in three stages

- Before the fire - we can see the vegetation and moisture content caseFor plant
- During fires identify active fires on the surface of the Earth
- After the fire help evaluate the burned areas.

MODIS is a key instrument aboard the Terra (originally known as EOS AM-1) and Aqua (originally known as EOS PM-1) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.

MOD13Q1: MODIS/Terra Vegetation Indices 16-Day L3 Global 250 m SIN Grid V006

The MOD13Q1 Version 6 product provides a Vegetation Index (VI) value at a per pixel basis. There are two primary vegetation layers. The first is the Normalized Difference Vegetation Index (NDVI) which is referred to as the continuity index to the existing National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer (NOAA-AVHRR) derived of NDVI. The second

vegetation layer is the Enhanced Vegetation Index (EVI), which has improved sensitivity over high biomass regions.

The NDVI quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).

NDVI always ranges from -1 to +1. But there isn't a distinct boundary for each type of land cover.

The NDVI is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily, from a space platform, and assess whether the target being observed contains live green vegetation or not ..

2.4Geographic Information System

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. GIS (more commonly GIScience) sometimes refers to geographic information science (GIScience), the science underlying geographic concepts, applications, and systems.

GIS can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business. For that reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization.

GIS can relate unrelated information by using location as the key index variable. Locations or extents in the Earth space–time may be recorded as dates/times of occurrence, and x, y, and z coordinates representing, longitude, latitude, and

elevation, respectively. All Earth-based spatial–temporal location and extent references should be relatable to one another and ultimately to a "real" physical location or extent. This key characteristic of GIS has begun to open new avenues of scientific inquiry.

2.5 Fire Forest in Sudan

The fire season starts after the end of the rainy season when the grasses become dry and that in months of September and the risks increase with increase of herbs and rising temperatures is reduced atmospheric humidity with Northeast dry winds (Bayoumi,2001 and Mahgoub , 2000) .

Fires increase desertification and the loss of a lot of fertile agricultural land and lead to the loss of gum Arabic yields at Gum Arabic belt equivalent to 50% as well as the impact of fires on 70% of pasture land and cause the loss of hard currency. Combating fires is useful to help in increasing the national income. Possible cultivation of tree species that are resistant to fires in areas that are exposed to fires (Maxi. 2014).

It is noted that there are no special fire management units and follow up and document of forest fires is not exist, even in the (FNC) where no sufficient information for researchers or decision makers, there is a limited annual program to establish fire lines, but usually faced with shortage of budget availability.

CHAPTER THREE

DATA AND METHODS

3.1 Data Acquired and Sources

different types of data and materials were used for the purpose of research work and analysis using remote sensing and geographic information system (GIS) Table (3.1) shows remote sensing data (MODIS product) and sources.

Table (3.1) Remote Sensing Data (MODIS Product) and Sources

Sensor types	Date	product	Resolutions in meter	Bands	Source
MODIS Products	8September-8October-17November 2013 8September-8October-17November 2014 8September-8October-17November 2015	MOD13Q1	250 meter	Band 1 Band 2 Band 3	National Center of Researches

The analysis is performed on the basis of 9 MODIS images (MOD13Q1, surface reflectance,250m spatial resolution), sensed in the period 1/9-30/11 2013 ,2014 and

2015 to cover the whole summer fire season. Beside these data we used information about fire events that occurred in the 2013 , 2014 and 2015 .

3.2 study area

3.2.1 locationand extent of the study area

The study area of this research is Dinder National Park in the southern eastern Sudan The Park is located between latitude 12° N and 13°N and longitude 34°E and 35°E. Covering an area of 10197 km², figure (3.1) represent the map and location of study area.

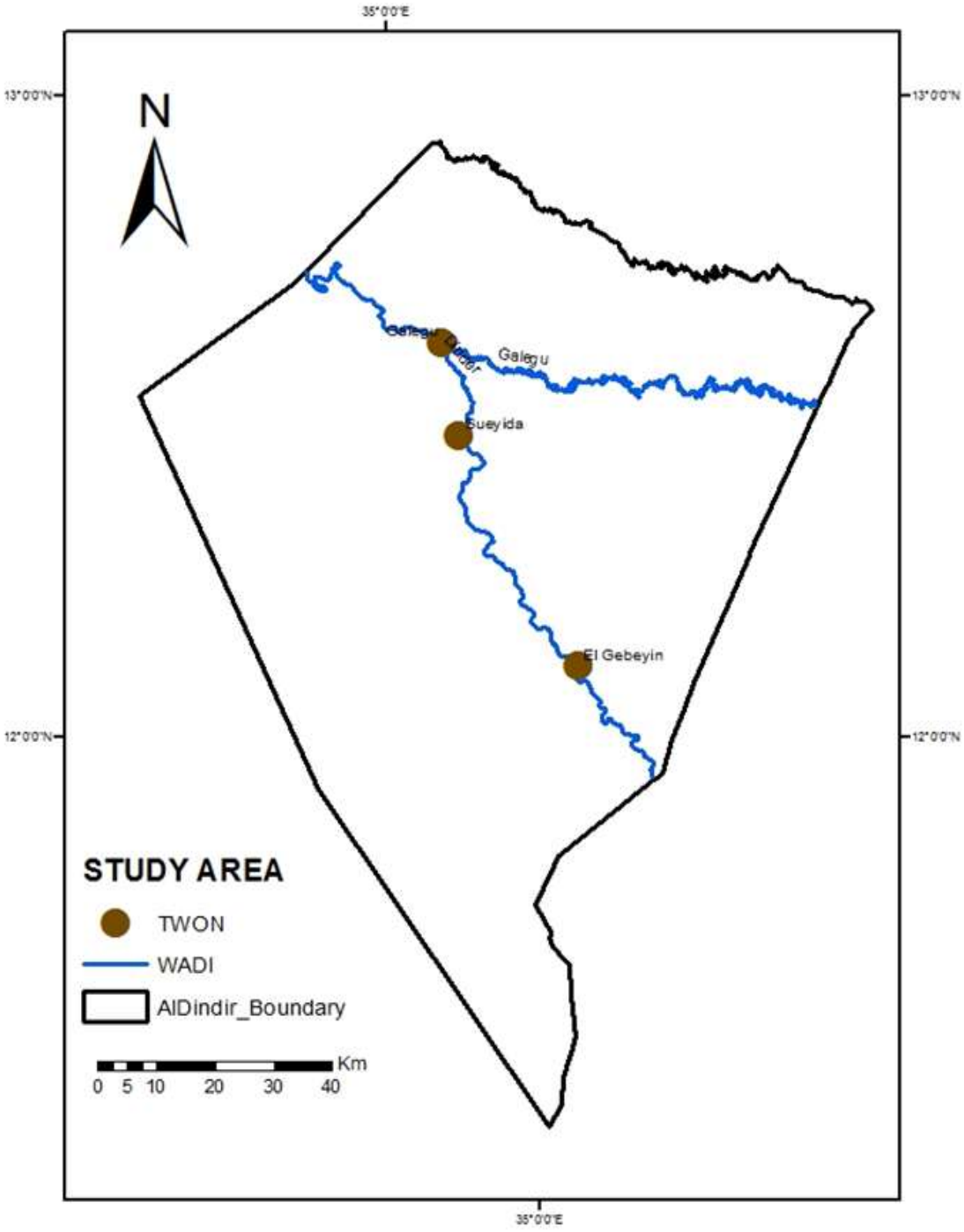

Figure (3.1) the study area

3.2.2 Climatic information

The climatic conditions of DNP in general, can be summarized as cool and dry in winter and wet and warm in summer. The wet season starts in May and ends in November, during which the area receives an annual rainfall ranging 600-1000 mm. The annual mean relative humidity varies between 35-45% but higher value of 79% was recorded during the peak of the rains in August (Dai, 1982) (e.g., rainfall, temperature etc).

3.2.3 Soils type information

According to Holsworth (1968) and Dasman (1972) have described two types of soils in DNP the vertisols and entisols The former which are the most extensive in the park are dark, heavy clays and soils often known as the black cotton soil they crack deeply during the early dry season. The entices dominate the eastern limits of the park towards the foothills of the Ethiopian.

3.2.4 Land use / cover information

Holsworth (1968) and Hakim et al. (1978) described the vegetation of the DNP to three ecosystems:

- Wooded grass land: is woodland or wood grassland, dominated by species of Acacia seal Balkanizes aegyptiaca this ecosystem occurs extensively on deep cracking clay soils .
- Revering ecosystem: Revering ecosystem occurs in the banks of Dinder and Rahad River. The forest is multi-layered vegetation, dominated by Hyphened thebaica (Doom), Acacia nilotica (sunt), Zizphusspina Christi (Siddir).
- Maya ecosystem: Mayas are wetland (Meadows) found along the flooded plains of rivers. They have been formed due to the meandering characters of the channel and nature of flows of their waters.

3.3 Software used

In general, different types of software were used for this stady**:**

3.3.1 ENVI

ENVI (which is an acronym for "Environment for Visualizing Images") is a software application currently marketed by ITT Visual Information Solutions used to process and analyzes geospatial imagery.

3.3.2 Arc GIS

ArcGIS is a suite consisting of a group of geographic information system (GIS) software products produced by Esri Arc map software 10.4
Used to layout and clip image.

3.3.3 Other Systems

Microsoft office Excel 2007. Microsoft Windows 7
wereuseds to create graphs.

3.4 Methodology

The research methodology includes the use of Remote Sensing (RS) and Geographical Information System (GIS) to assess fire regime in Al Dinder National Park. The methodology was based on analysis of the remote sensing data time-series of multispectral satellite imagery of NASA archive by MODIS data.The data has been used to map fire scars (burned areas identifiable on imagery by bare ground and dark charcoal/ash appearance). The image data consists of multiple bands collected in the visible and infrared spectral wavelengths that were used for classification and discriminative purposes. The image processing technique that was used to classify fire scars in each individual MODIS scene. This is classification consists of the following general steps:

I. Acquisition of MODIS satellite images product 8 days resolution 250m during the fire season from MODIS.
II. Subset the study area from the images .
III. Calculate NDVI by using band ratio between the red (band 1) and infrared (band 2).
IV. Extract ranges of burned area (pixels values) and save it to produced Classified Images.
V. Generate the region of interest and Built Mask to extract burned area from the noise
VI. Calculate total burned area.

The general procedures adopted in this study are summarized in the flowchart displayed in Figure (3.2).

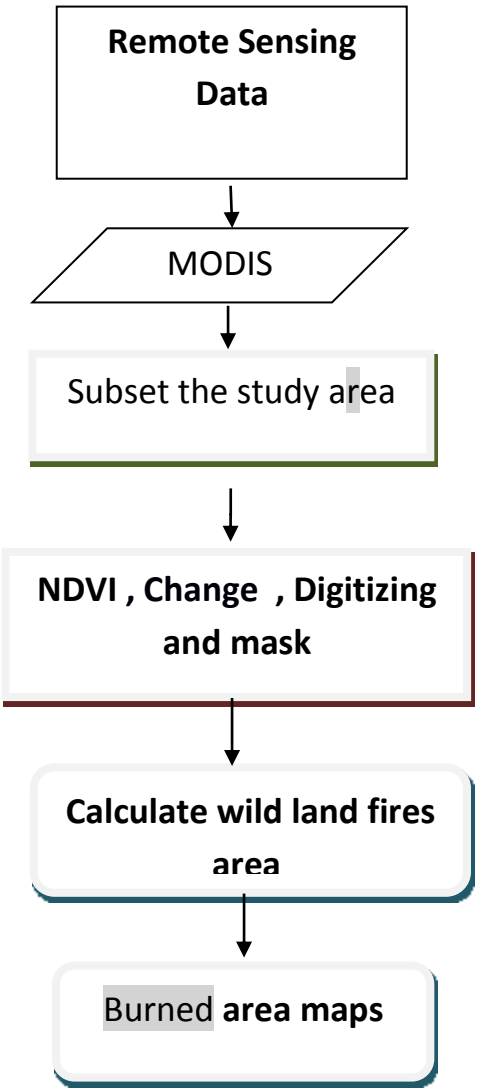

Figure (3.2) Flowchart of the Research Methodology.

3.4.1 Study Area Subset

Shape file for the study area was prepared using Arc GIS 10.4 software, shape file imported by ENVI as ENVI vector file (EVF) then exported toregion of interest, which used to subset the image (subset via region ofinterest). The resulted subset image was used as template for subletting therest of the images, Figure (3.3) represents Subset of the Study Area.

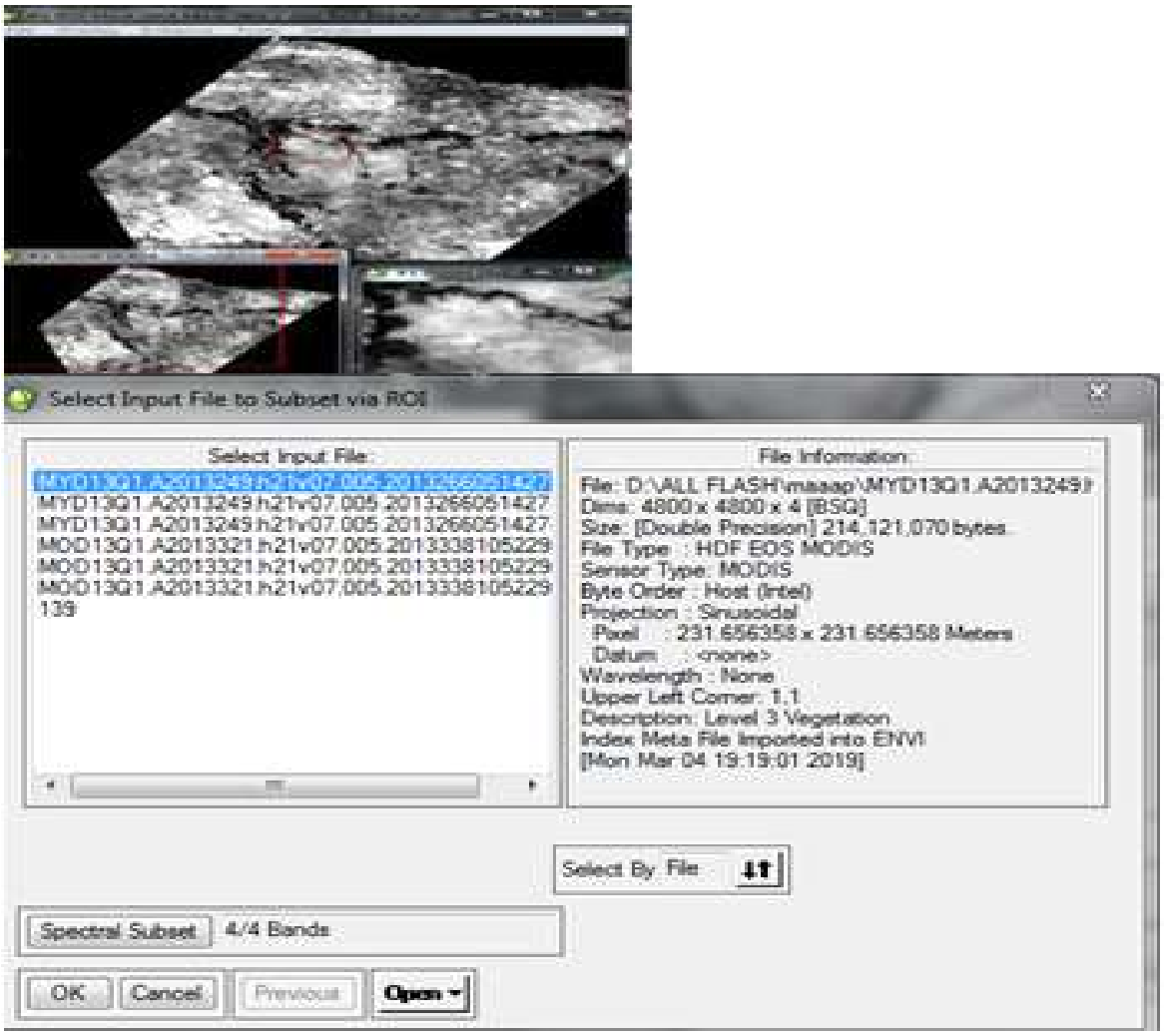

Figure (3.3) Subset of the Study Area.

3.4.2 NDVI Calculation

With ENVI band math the Normalized Difference Vegetation Index NDVI was calculated for all images and this was done by applying NDVI formula:

(float (b2)-float(b1))/(float(b2)+float(b1))……..(3.1)

Where,

b1=Band1 (Red band)

b2=Band2 (Near infrared band)

NDVI is based on the reflection characteristics of vegetation which is givesincrease in reflection from red over infrared for the healthy vegetation due to the presences of green chlorophyll and the internal construction of plants,the fact that burned vegetation looks black due to the absence of greenchlorophyll gives the NDVI the privilege to detect the burned area as pixelscan be classified into ranges of burned scares area that takes the lowest NDVI value. Figure(3.4) represents NDVI.

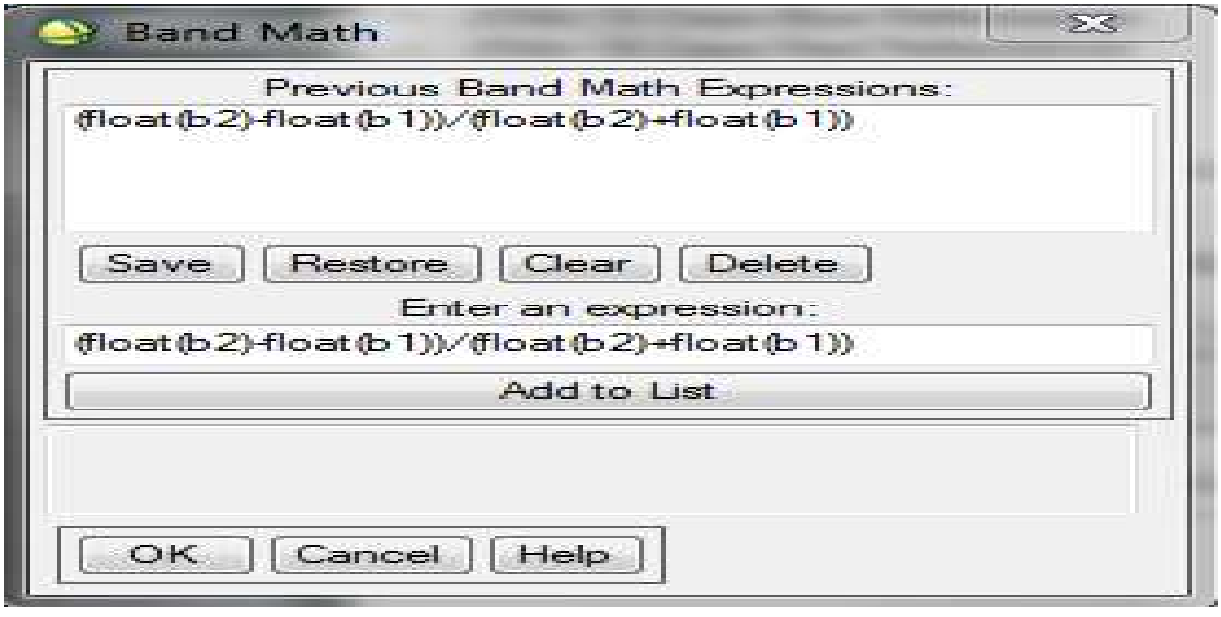

Figure (3.4) NDVI.

3.4.3 Presentation Areas of Fire

A color density slice was created by identifying the pixel of the lowestNDVI value and the one with the highest value within each change detectionimages then the created color image was saved as class image. Figure (3.5)represents Areas of Fire

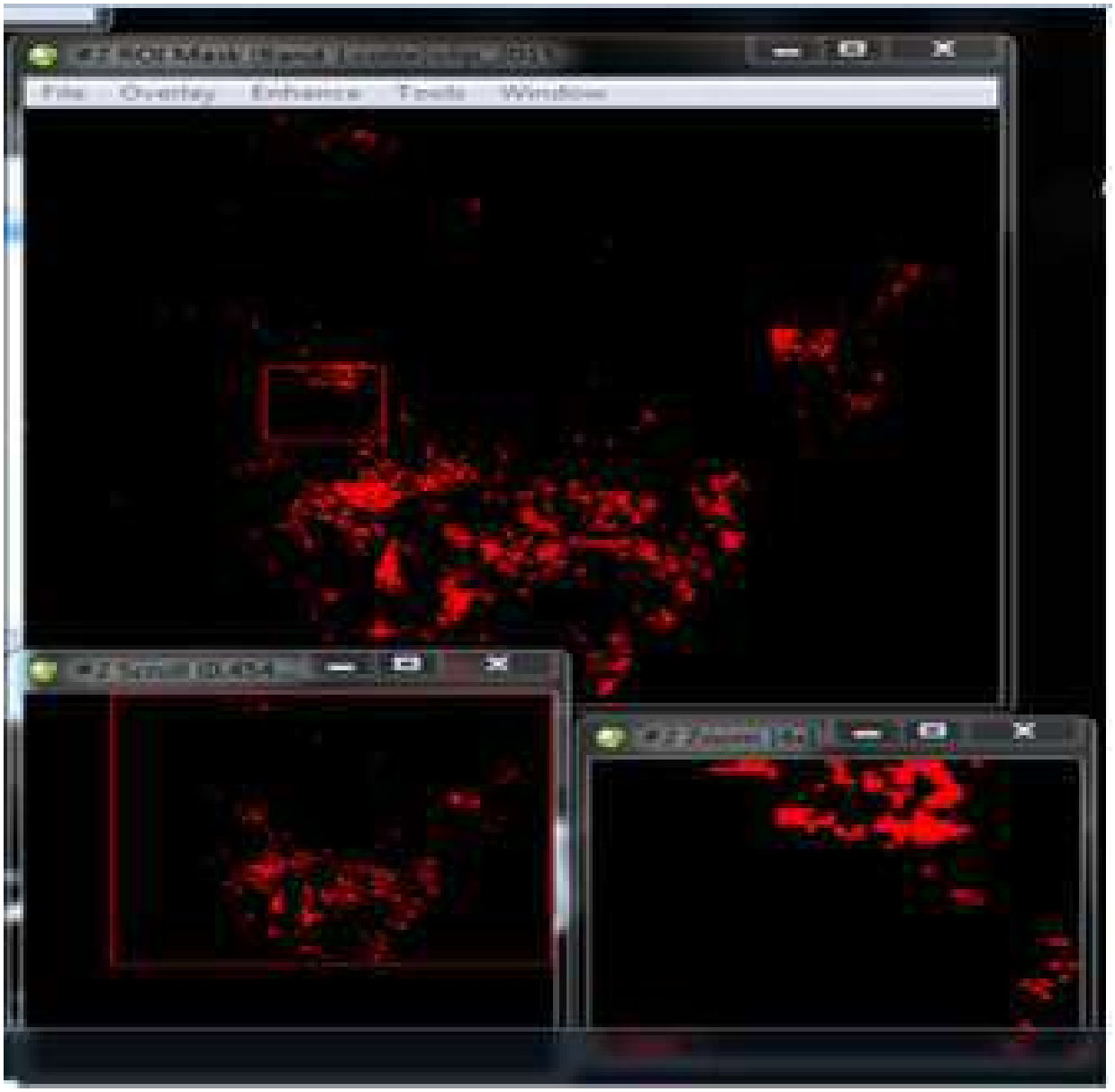

Figure (3.5) Areas of fire.

3.4.4 Identification of burned areas

The region of interest was drawn around the real burned areas in order tomask out the noise which look similar to burned one. Unburned areas thathave values similar to that of the burned areas were removed (masked out)and a new image free of noise is created. Figure (3.6) represents identification of burned areas.

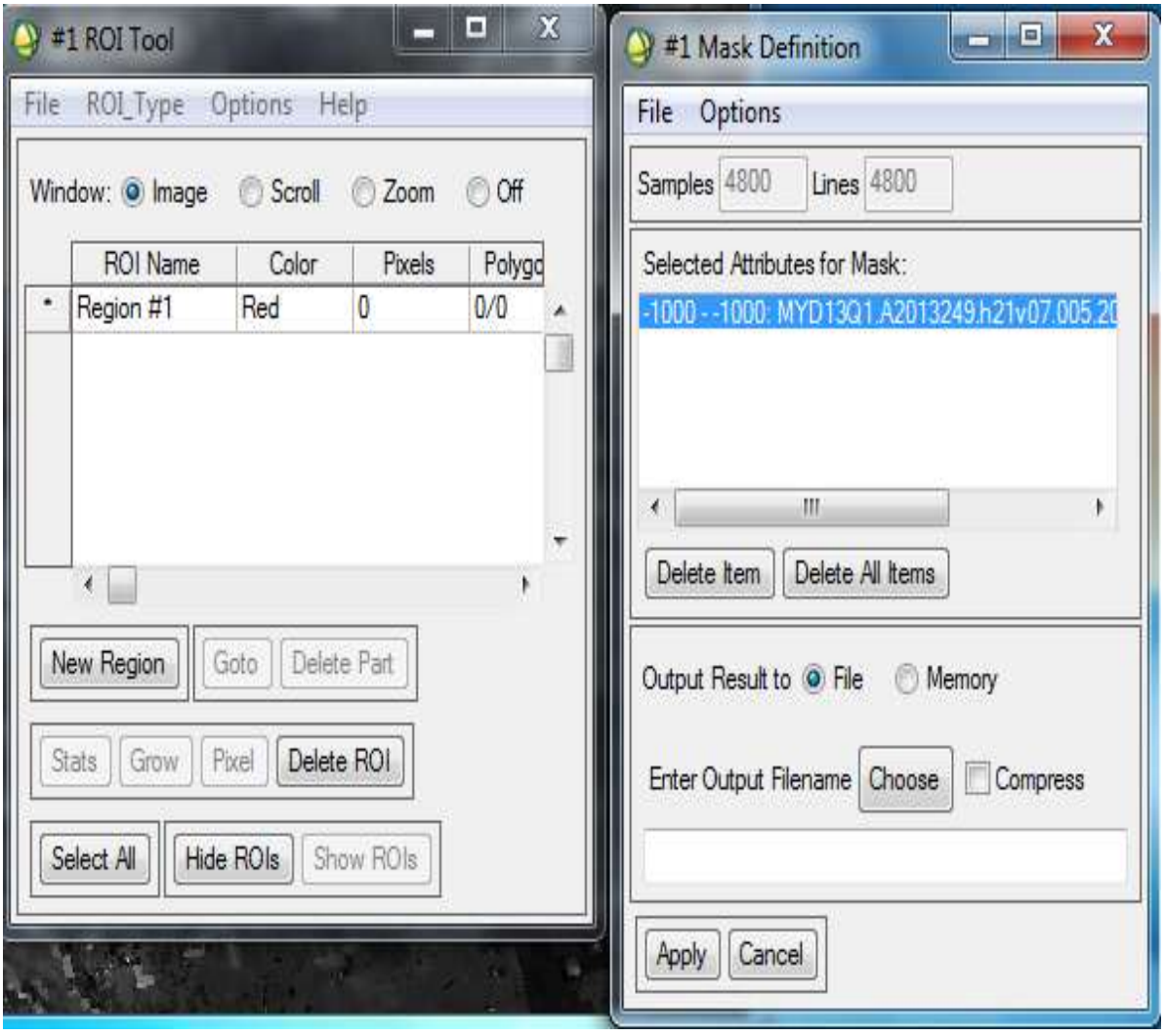

Figure (3.6) Identification of burned areas.

3.4.5 Calculation of burned area

To calculate burned spaces, the path is followed :

Vector parameter dialog →option→ report area of EVF.

The resulting monthly burned area images were converted fromraster to vector (shapefile) to be used in ARCGIS software 10.4 to calculateall burned areas polygons and to be used to generate the final burned areamap. Figure (3.7) represents calculation of burned area.

Figure (3.7) Calculation of burned area.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 RESULTS

The main objective of this study directed towords monitoring and mapping wildland fire in Eldinder National Park in sudan using remote sensing techniques and geographic information systems .

A study of the results of the region showed the presence of the were fires in the region in the northe part.Reason for this may be the presence of projects agricultural.

The study began in 2013, 2014 and 2015, which is considered to be the period of roots and ethnicities that constitute the study area.

Satellite MODIS were used to investigate fire elsewhere in the region without accessible which gave us alot of money and effort and time.

The study area has been under extreme wild fire which affect forest land.The study can be categorized according to the time series 2013,2014 and 2015.

4.1.1 2013 Firewalid

Figure (4.1), (4.2) and (4.3) represents the burned area in September, October and November 2013.

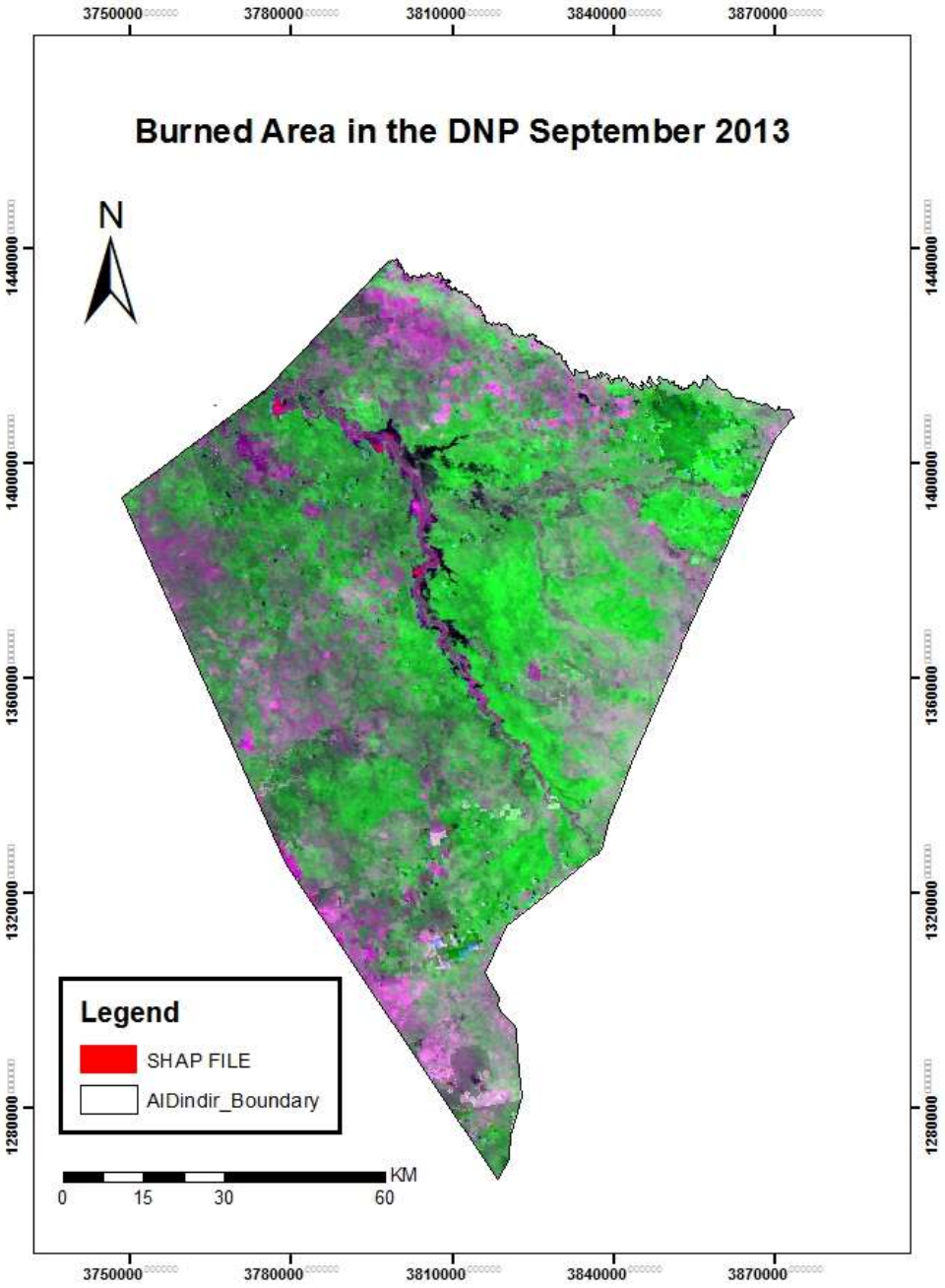

Figure (4.1): Burned Area MODIS 8-day Product September 2013

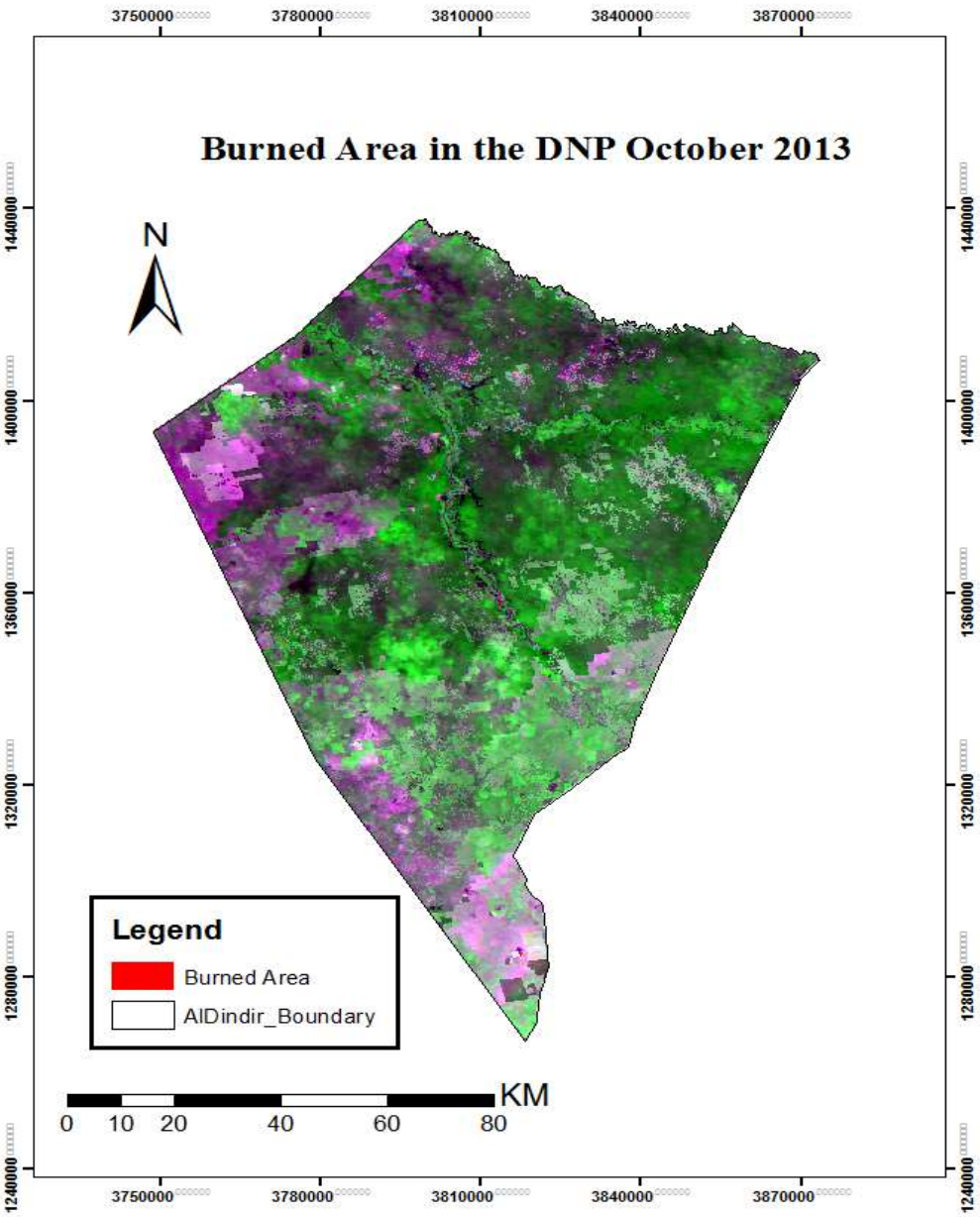

Figure (4.2): Burned Area MODIS 8-day Product October 2013

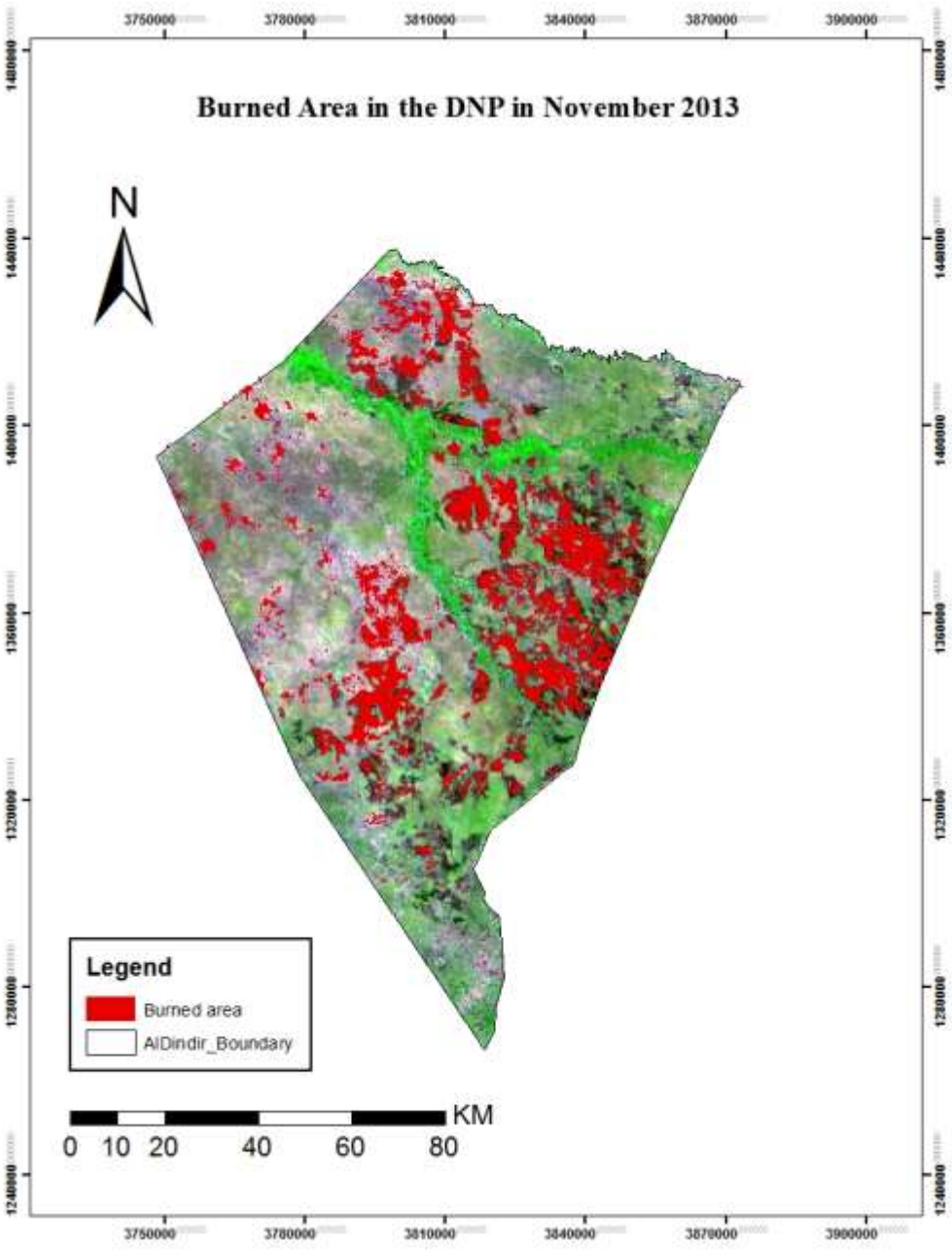

Figure (4.3): Burned Area MODIS 8-day Product November 2013

4.1.2 2014 Firewalid

Figure (4.4), (4.5) and (4.6) represents the burned area in September, October and November 2014.

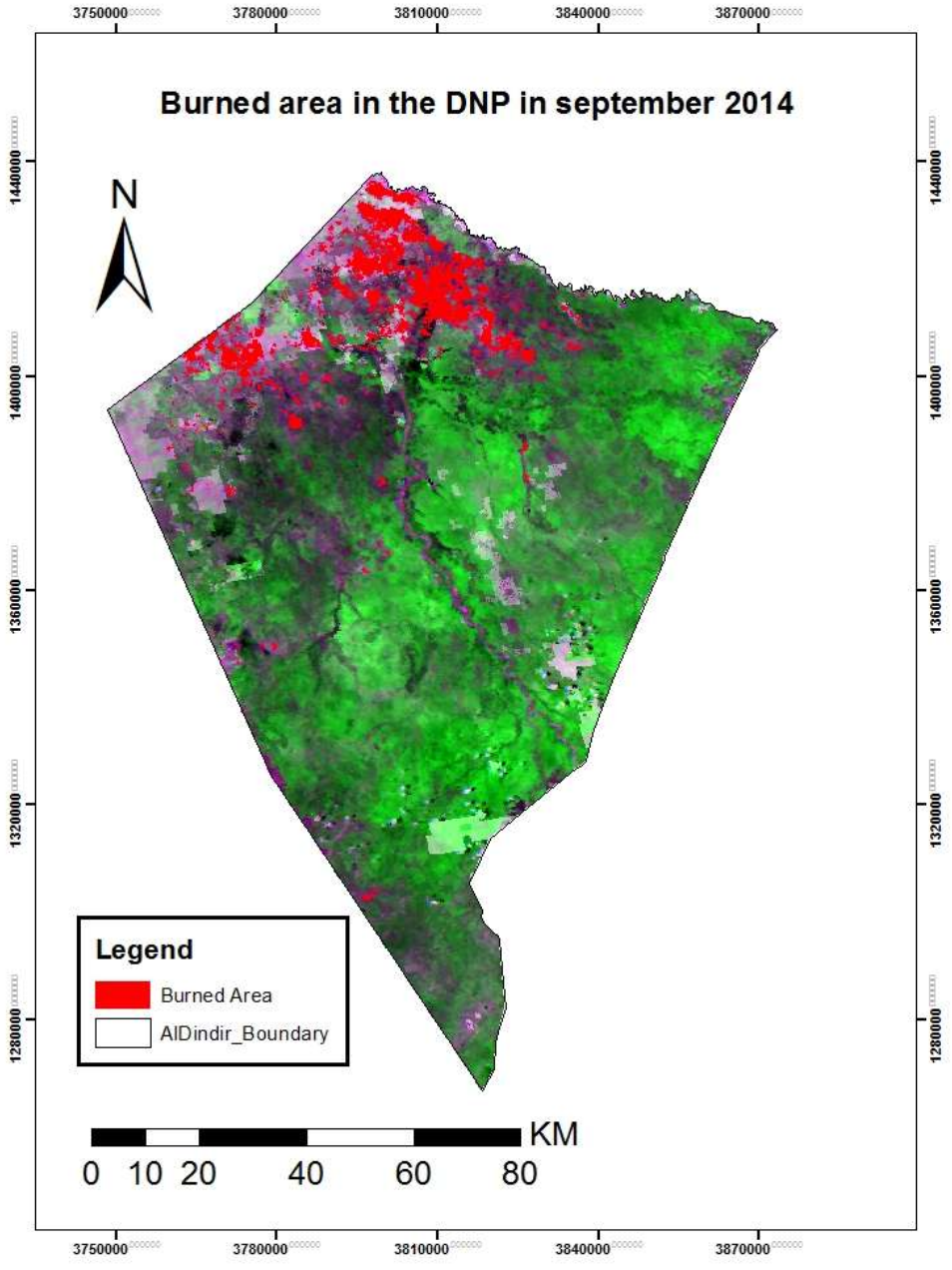

Figure (4.4): Burned Area MODIS 8-day Product September 2014

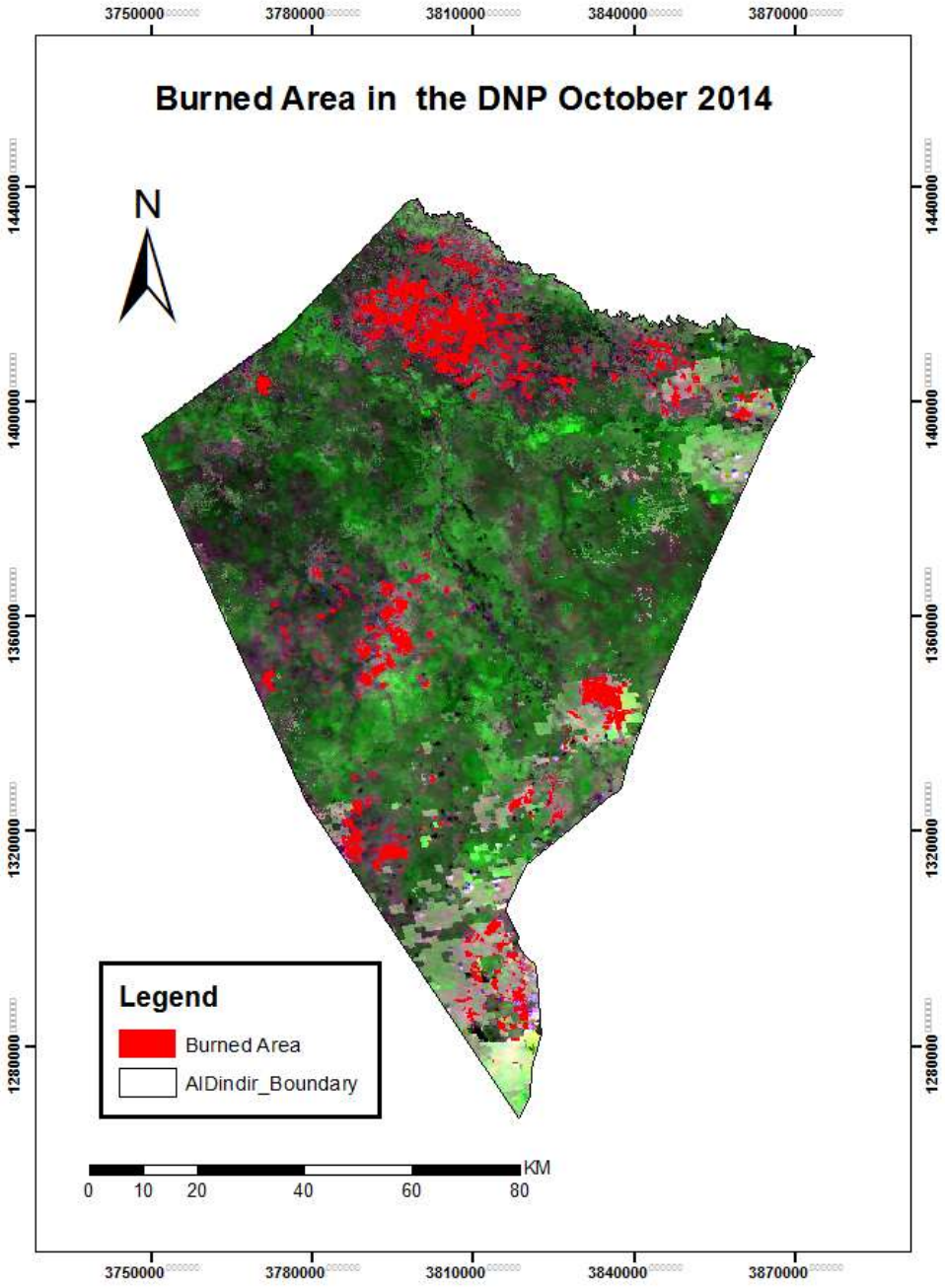

Figure (4.5): Burned Area MODIS 8-day Product October 2014

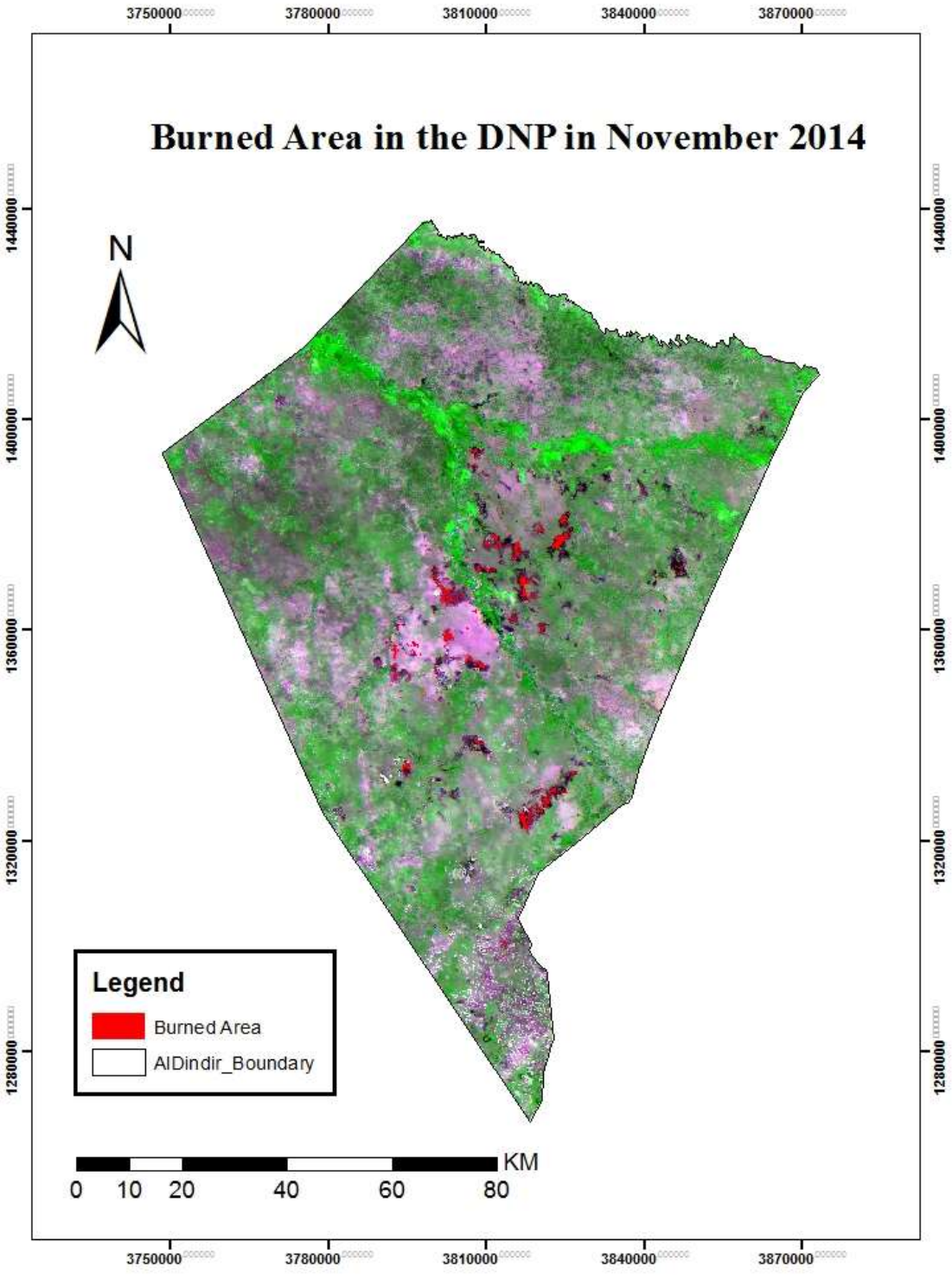

Figure (4.6): Burned Area MODIS 8-day Product November 2014

4.1.3 2015 Firewalid

Figure (4.7),(4.8) and (4.9) represents the burned area in September,October and November 2015.

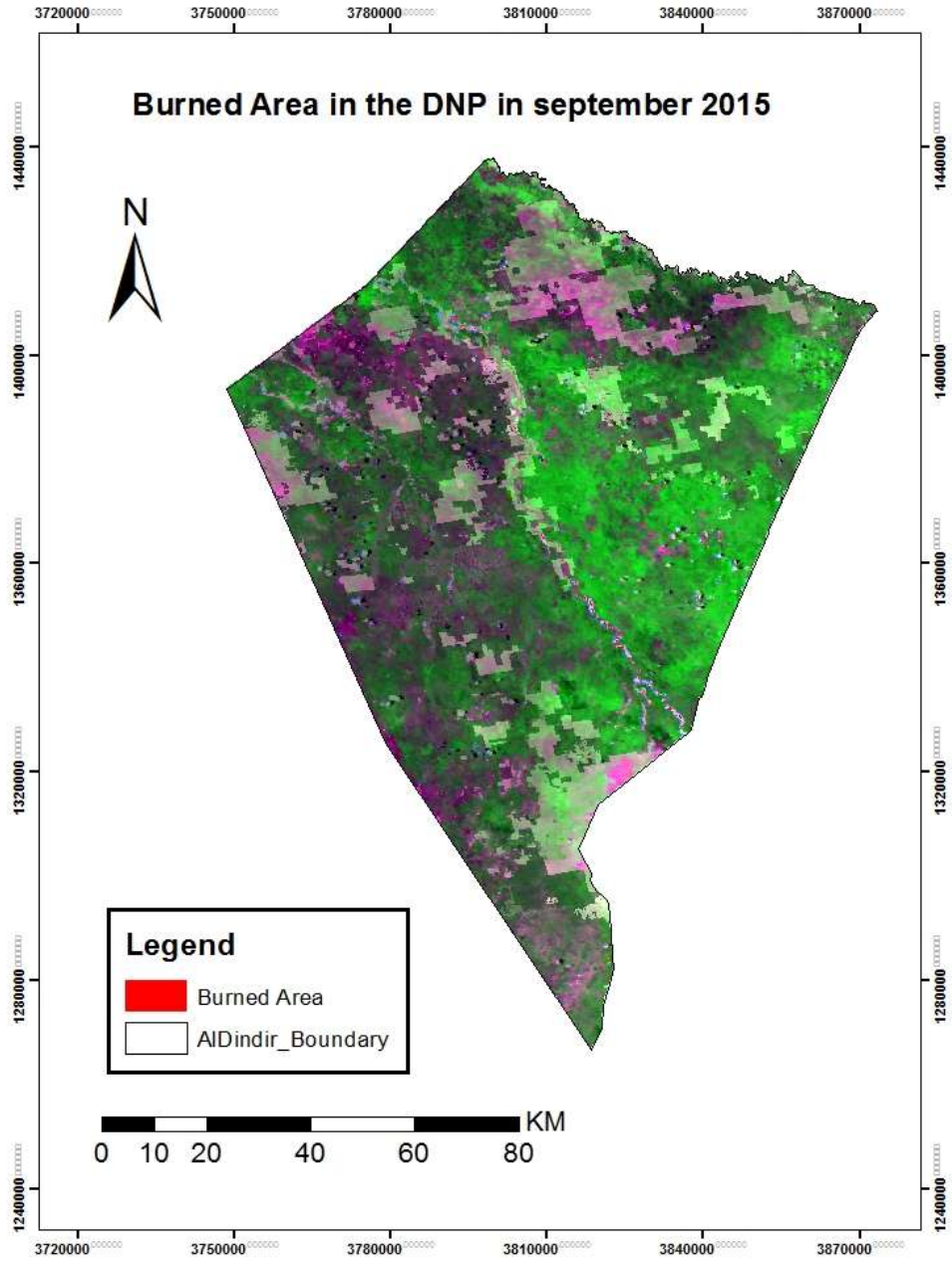

Figure (4.7): Burned Area MODIS 8-day Product September 2015

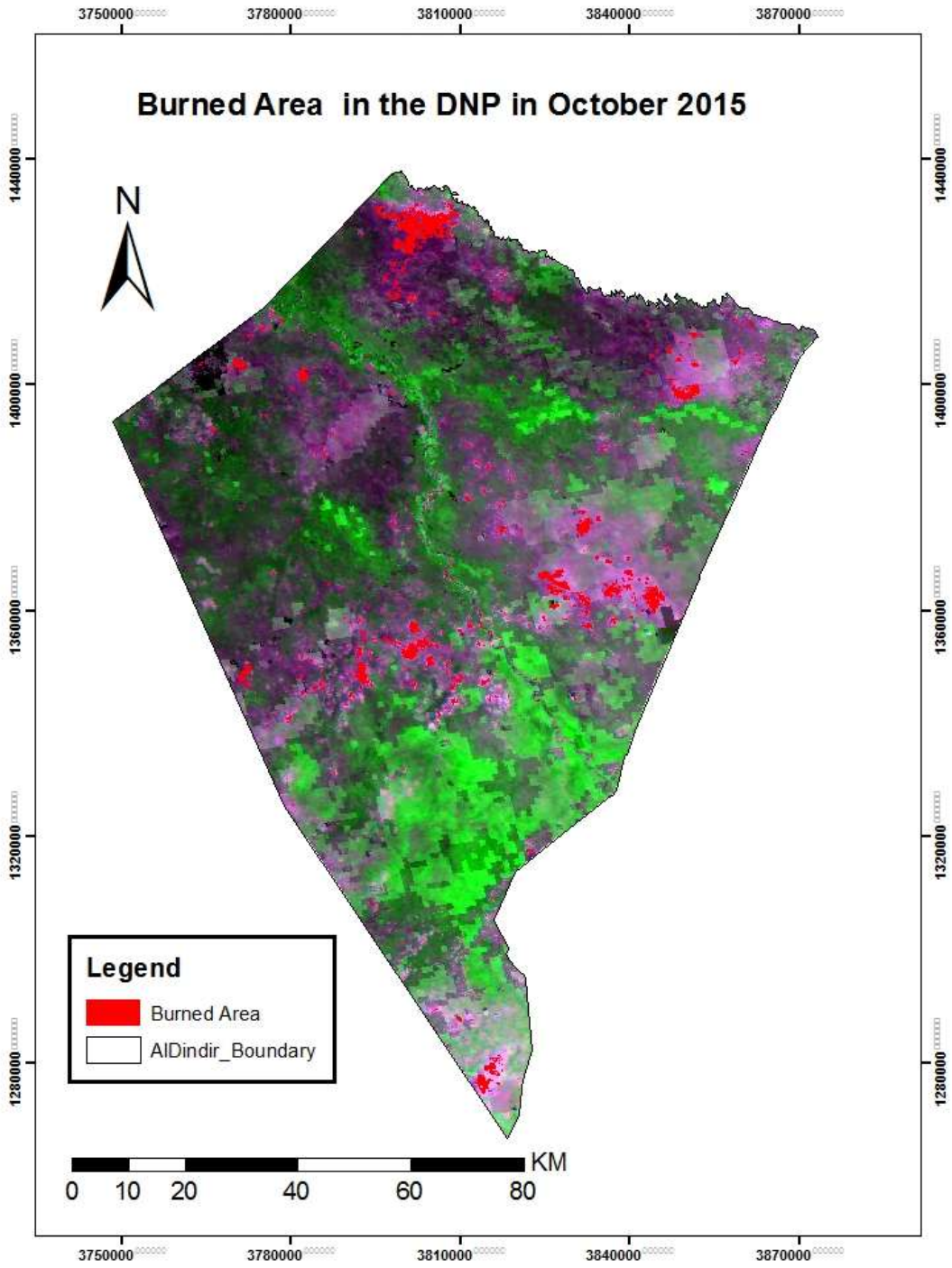

Figure (4.8): Burned Area MODIS 8-day Product October 2015

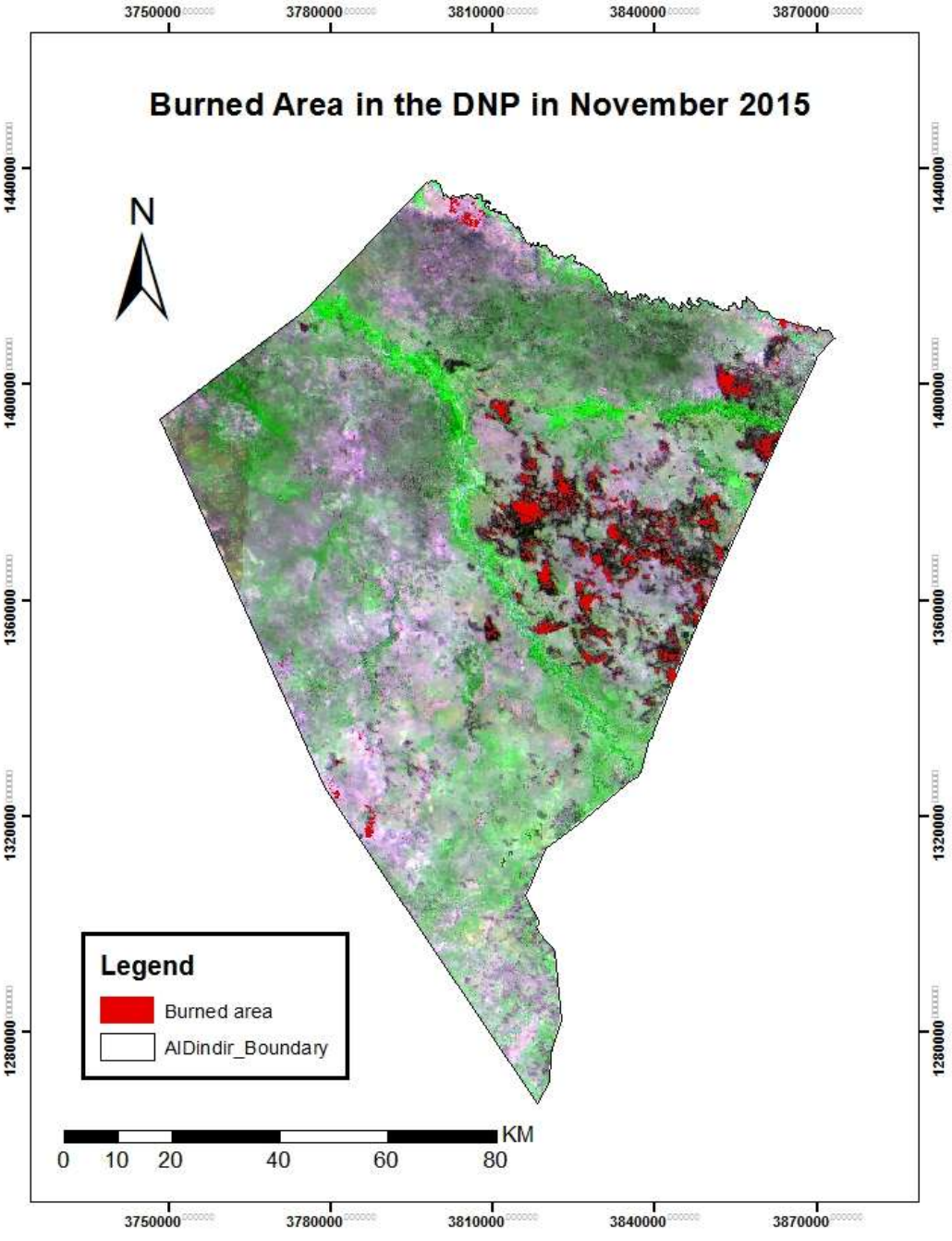

Figure (4.9): Burned Area MODIS 8-day Product November 2015

Table (4.1) shows burned area in thestady area at differen years 2013,2014 and 2015(september,october and november).

Table(4.1) Burned Area in MODIS Product

Months	Total area (Km^2)	Burned area (Km^2) 2013	Burned Area (Km^2) 2014	Burned area (km^2) 2015
SEPTEMBER	10197	4.94	450.25	3.65
OCTOBER	10197	1.34	566.48	212.62
NOVEMBER	10197	1342.63	50.44	181.60

4.2 Analysis of Results

In the year 2013, the highest area of fire was found in November, the largest area of fire by studying the area, as the fires spread in the northern, eastern, western and central parts.

In the year 2014, the highest fire area in the month of October. The fires spread more in the northern parts and fewer areas in the southern and intermediate penalty.

And in the year 2015 the highest burned area was found in the month of October. The fires spread more widely in the eastern parts.

The rate of expansion and the dynamic of change of fire vary in sequence. The annual rate of fire for each year can be shows by graphs in figures(4.10),(4.11)and(4.12).

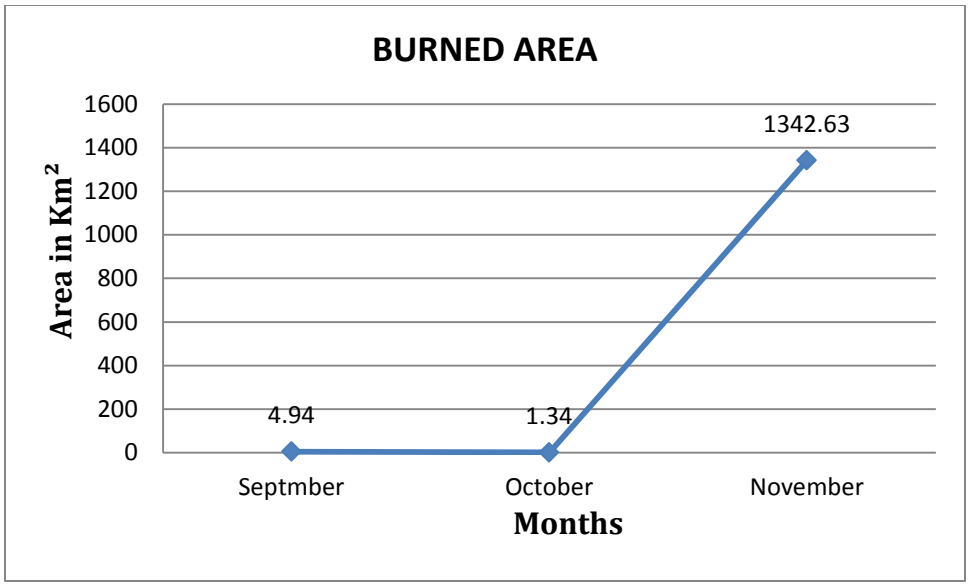

Figure (4.10) Shows the fire levels in year 2013.

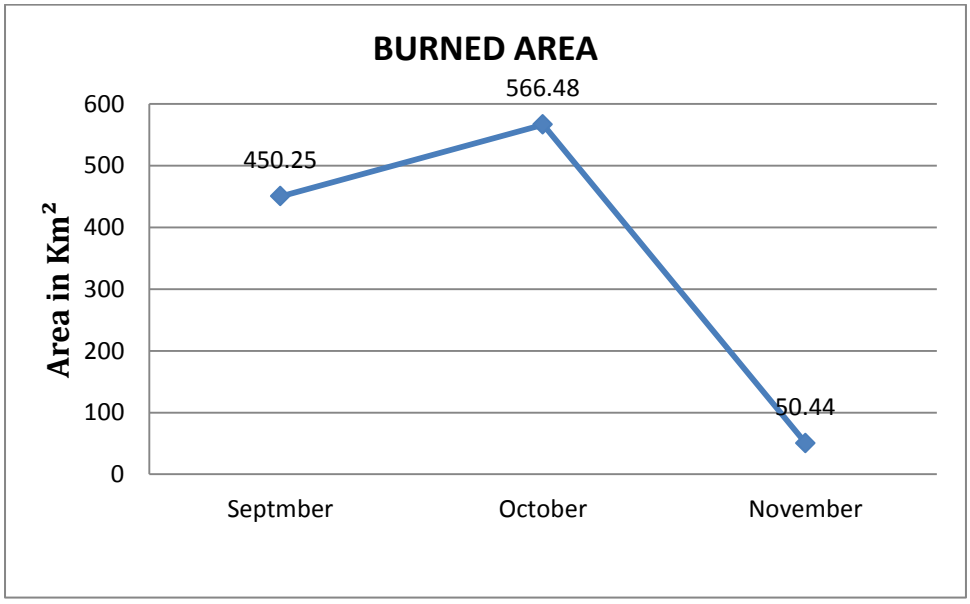

Figure (4.11) Shows the fire levels in year 2014.

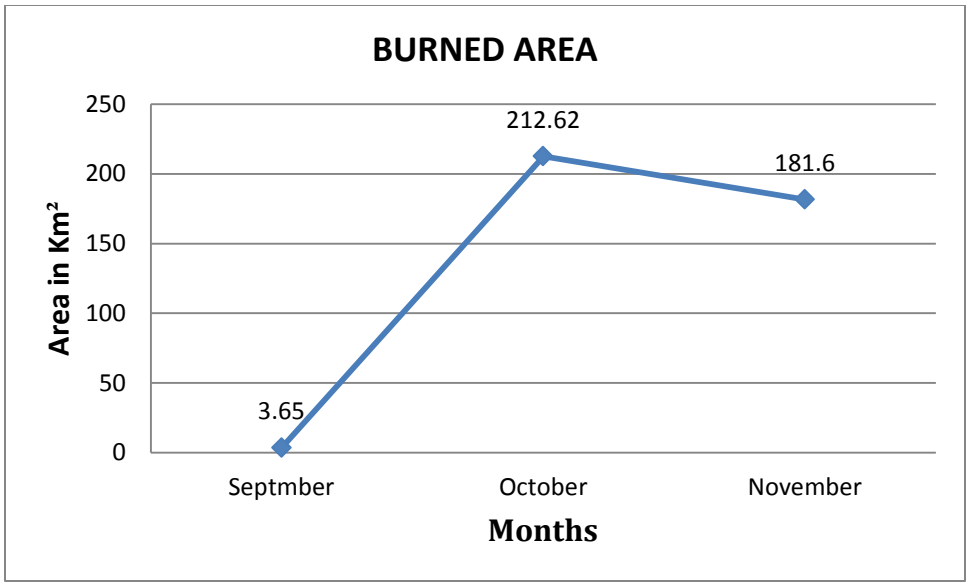

Figure (4.12) Shows the fire levels in year 2015

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

3.5 CONCLUSIONS

The main conclusion obtained from the results and analysis of thisstudy can be expressed as follows:

- Wild fires largely extend in most parts of the study area.
- Wildland fire in the DNP occurs annually on large scale.
- Using NDVI values is a direct method for locating and mapping areas that were burnt in the past events (burnt scars).
- MODIS 8day surface reflectance 250 m spatial resolution images

show high efficiency in burned area mapping.

3.6 RECOMMENDATIONS

Regarding to the finding of this study of determining and mapping wild fire in the DNP, the following recommendations are mude for future studies

- It is recommended that the visual interpretation is complemented with other techniques such as the analysis of NDVI values which is a direct method to locate and map areas that were burnt in past events (burnt scars).
- Undertake studies to determine and analyze the causes of the wildland fire in the DNP.
- Develop and implement integrated fire management plan for the DNP.

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