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Investigation of Fire Regime Using MODIS Sensor Imagery

Case study: Eastern Part of South Kordofan State

التحقق من نظـام الحـرائق باسـتخدام صـور المتحسس مـوديـز

دراسـة حالــة : الجزء الشرقى من ولاية جنوب كردفان

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DEDICATION

To The Moon and Sun of my life Mother& father

To the flower of my life my wife

To my sweetest kids

To the Soul of my beloved grandfather hamza

Mogahid

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ABSTRACT

South Kordofan State is rich in its natural resources mainly vegetation cover, the area characterized by dense forests, rich pasture and arable land, as well as the occurrence of wildfire in the dry season, There is no suitable information available on when, and where, how often and how much wildfires, large areas of forests and pastures are subject to wildfires in the dry season. The objective of study is to investigate the fire regime (extend, seasonality and frequency of wildfires) using remote sensing and GIS techniques through MODIS data. The study was conducted in Eastern part of South Kordofan State for season (2000-2001) to (2013-2014) in order to investigate the fire regime through burned area map using a collection of 32 images per each dry season)448 images for fourteen seasons(which were processed to extract the burned area. Envi 4.7 and Arc Map10.0software were used for image processing and maps production. The study showed that the largest area burned was in season (2012-2013) then season (2003-2004) and the lowest area burned was in season (2013 - 2014) and then season (2000-2001).In order to generate a fire frequency map each three successive number of times burn have been put into a Categories .The study revealed important results about fire regime such as the fire season which is generally start in the mid of September and continue up to the beginning of May with peak in November and MODIS 8 day surface reflectance 250 m spatial resolution images are showed high efficiency in burned area mapping .The frequency map revealed that the higher fire frequency is located in Eastern, western and Southern parts of study area. The positive and negative impacts of wild land fire on flora and fauna needs more detailed studies.

Key Words: Fire regime, remote sensing, fire mapping

مستخلص باللغة العربية

ولاية جنوب كردفان غنية بمواردها الطبيعية وغطائها النباتى حيث تتميز بغابتها الكثيفة ومراعيها الغنية واراضيها الخصبة بالاضافة الى حدوث الحرائق فى موسم الجفاف.الا انة لاتوجد معلومات حول كيفية واماكن ومواسم حدوث الحرائق، كما ان هنالك مساحات شاسعة من الغابات والمراعى معرضة لخطر الحرائق . ولذلك فإن الهدف من هذه الدراسة هو دراسة نظام الحرائق (المساحة و الموسمية و التكرار) باستخدام الاستشعارعن بعد ونظم المعلومات الجغرافية من خلال بيانات ومعلومات المستشعر الصناعى (MODIS) وقد اجريت هذة الدراسة فى الجزء الشرقى لولاية جنوب كردفان للمواسم (2001-2000) الى (2014-2013) للتحرى من نظام الحرائق بالمنطقة ، تم تنزيل عدد 32صورة لكل موسم خلال فترة الجفاف (448 صورةلأربعة عشرموسم) وتمت معالجة صور كل المواسم لمعرفة الحرائق . وتم ذلك باستخدام البرامج Envi 4.7 و Arc Map10. لمعالجة الصور التى تم الحصول عليها من (MODIS). من خلال الدراسة اتضح لنا ان أعلى مساحة تمت بها الحرائق فى موسم (2013-2012) ويلية موسم (2004-2003) وادنى مساحة تمت بها الحرائق كانت فى موسم (2014 - 2013) يلية موسم (2001 - 2000). للحصول على خريطة التكرارتم جمع كل ثلاثة مواسم حرائق متتالية ووضعها فى فئة واحدة وتم جمع كل هذة الفئات لعمل خريطة واحدة تسمى خريطة الحرائق . كشفت الدراسة العديد من الحقائق الهامة فيما يخص نظام الحرائق التى تبدأ عموما فى منتصف سبتمبر و تستمر حتى بدايات شهر مايو و تبلغ أعلى مدى لها فى شهر نوفمبر كما ان المستشعر موديز اثبت كفاءة عالية فى اكتشاف وتخريط الحرائق . من خلال خريطة التكرار تكشف لنا ان معظم الحرائق كانت فى الجزء الشرقى و الغربى والجنوبى من منطقة الدراسة وفى شكل هلال وأقل مناطق تعرضت للحرائق كانت فى الجزء الشمالى والاوسط من منطقة الدراسة . الا ان محاسن ومساوىء الحرائق على الانسان والحيوان والغطاء النباتى لم يتم معرفتها.

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ACRONMES & ABBREVIATION

ENVI	Environmental For Visualize Image
FAO	Food and Agriculture Organization
MODIS	Moderate Resolution Imaging Spectroradiometer
GIS	Geographic Information System
NASA	National Aeronautics and Space Administration
FNC	Forests National Corporation
NDVI	Normalized Difference Vegetation Index
EVI	Enhanced Vegetation Index
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration
AVHRR	Advanced Very High Resolution Radiometer
CAD	Computer Aid Design
RPA	Range and Pastures Administration

CHAPTERONE

1. INTRODUCTION

South Kordofan is Located in the rich savannah area with a rainfall more than600mm.(Daldoumand Adam 2012).The area characterized by dense forests, rich pasture and arable land, as well as the occurrence of wildfire in the dry season. The livelihoods of the local inhabitants depend mainly on the cattle breeding and move out in search of pasture, grass and water. They practice rain-fed agriculture in the rainy season where they plant corn and millet for their daily living and there are few large schemes. More than 80% of the state population depends on subsistence rain-fed farming and Grazing there cattle's in range land. Southern kordofan contains rich biodiversity resources, some of which are highly threatened due to the wildfires in the dry seasons which negatively affect the environment. Large areas of forests and pastures are subjected to wildfires in the dry season, which lead to their destruction and hence negatively affect the local population and increase their poverty. Wildfires also change the plant composition and structure of the forests and the pasture and usually the undesired species replace the desired ones. Dominance of fire resistant species and usually of low nutrition value is the justifiable product of repeated annual burning. Wildfires burn the available seeds on the soil and reduce the seed bank, which eliminate or extremely hinder the natural regeneration in the pasture and forests) Bashir and Kamal. 2010) and (Idris, 2015).

All of these factors create a competition between the local population on scarce resources and narrow land, which leads to conflicts between them.

Total of 4million tons of wood are annually removed for various purposes from the natural and managed forests of Sudan, fire is responsible of the destruction of 250,000 ton. Most of the fire in the savannah region is surface fires spreading through the tall grasses in the open stands with very high flames. Surface fires are much greater threat to natural regeneration (FNC. 2008).

Fire has important role to play in nature, land management, the cleaning of agricultural schemes is carried out by fires and the remaining ashes increase the fertility of the soil, which helps to increase the production of food crops. Maintaining fire dependent ecosystems and providing an important fire control and effective land use tool on the one hand, while on the other hand, causing deforestation, forest degradation, emission of greenhouse gases destruction of livelihoods, loss of biodiversity and infrastructure. In recent year there is increasing of effect, extent, and riskiness of uncontrolled burning globally that has led to calls for international environmental policy concerning fire (FAO. 2007).

1.2 Research Problem

South Kordofan State is located in fire prone environment there is no information available on when, where and how much fire burn, in other words the fire regime is not investigated (i. e. the fire seasonality, extend, intensity and recurrence). Large areas of forests and pastures are subject to wildfires in the dry season which lead to their destruction and hence negatively affect the local population and increase their poverty.Such information is needed for the establishment of integrated fire management plan and to investigate the related fire impacts on flora and fauna.

As a result of no sufficient awareness among politicians and decision makers, there is no functioning specialized wildfire management organization, there is a limited annual program to establish fire lines, but usually faced with shortage of budget availability. There is no awareness among the local population with the risk of wildfire and its devastating effect on the local and global environment.

1.3 Research Objectives

1.3.1 General Objectives

This study is oriented towards using remote sensing and GIS techniques via MODIS data to generate wildfire background history and produce maps of burned areas in Eastern part of South Kordofan State from the fire season of the years (2000-2001) till the fire season of the years (2013-2014(.In order to contribute in improving fire management through the knowledge of the fire regime (fire extend, intensity, seasonality and recurrences).

1.3.2 Specific Objectives

1- Investigating fire regime (wildfire extend, frequency and fire season) in Eastern part of South Kordofan State
2- To quantify and map the spatial distribution of the burned areas in the study area for each fire season during the period of the study.
3- To produce fire frequency map.

1.4 Research Question

1- How much areas burned annually in the south kordofan state?
2- How many times fire repeated in deferent part of the area of study during the period of study?
3- When fires season starts and ends in the area of study?

1.5. Justification

1.5. 1 Research Justifications

1- The area is composed of different ethnic groups who rely on agriculture and rangelands for their livestock grazing
2- The area is fire prone due to the existence of long grasses and long dry season.
3- There is lack of reliable records on fire behavior, its spatial distribution and the fire regime is not adequately investigated.
4- To contribute in generating integrated fire management plans

CHAPTER TWO

2.LITERTURE REVIEW

2.1 Remote Sensing

Is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites or by the other words we can say remote sensing is the founding of information about an object without making physical contact with the object. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation), information transfer is accomplished via electromagnetic radiation (EMR).EMR is a form of energy that detects its presence by the observable effects it produces and this occurs when it orientated to the targets, a signal is first emitted from aircraft or satellites (Paul.2010).

Satellite remote sensing can be traced to the early days of the space age (Both Russian and American programs) and actually began as a double approach to imaging surfaces using several types of sensors from spacecraft. A primary use of remote sensing data is in classifying the myriad features in a view (usually presented as an image) into meaningful categories or classes. The image then becomes a topical map. There are several regions of the electromagnetic spectrum which are useful for remote sensing. The process involves an interaction between radiation and the targets of interest (Kadygrov.2006).

2.2 Remote Sensing System Components

A complete remote sensing system composes of seven components the first one is Energy Source or lighting, the second is Radiation and the Atmosphere it refers to the interaction of atmosphere with the energy, the third one is interaction with the target this interaction depends on the properties of both the target and the radiation. The fourth component is the Sensor which Record the back reflected or Scattered of Energy from the target, the fifth component is the process of transmission, reception, and processing where the data are processed into an image (hardcopy and/or digital). The component number six is Interpretation and Analysis by which we means that the processed image is explained, visually and/or digitally or electronically to extract information about the target and the seven component is Application which means to benefit from the information we have been able to extract from the imagery about the target in order to better understand it, detect some new information, or assist in solving a particular problem (Campbell. 1987).

2.3 Remote sensing satellites

Huge numbers of Remote sensing satellite are in used now days to accelerate the development in space technology which is adopted by many countries. The oldest group of sensors is trios Series (1960-1965) (Adolphet al., 1981) which is referred to The television and infrared observation satellites, National Oceanic and Atmospheric Administration satellites NOAA is an example for the first operational remote sensing satellite system, other sensors like Advanced Very High Resolution Radiometer (AVHRR) is an example of resolution satellite, one of the important satellite group is the

Land sat series which are used mainly for land area observation (Jensonand John R. 2007).

2.4Moderate Resolution Imaging Spectrodiometer MODIS SENSOR

The Moderate-resolution Imaging Spectroradiameter (MODIS) is a payload scientific tool launched into Earth orbit by NASA and launch of the TERRA (EOS AM-1) satellite on December 18, 1999 with the successful launch of AQUA (EOS PM-1) from Vandenberg Air Force Base, CA, on May 4, 2002, a second MODIS sensor was put into orbit for studying the Earth's water cycle and our environment.

TERRA and AQUA (both with a 705km orbit) have a sun-synchronous, near polar, circular orbit. AQUA cross the equator daily at 1:30 p.m. as it heads north (ascending mode) in contrast to TERRA, which crosses the equator at 10:30 a.m. daily (descending mode). With this formation it is expected that AQUA's afternoon observations combined with TERRA's morning observations will provide important information into the daily of global precipitation and ocean circulation (Pravin et al., 2015).

2.5 Use of remote sensing in forestry

There are many forestry applications that remote sensing can be used for. Some of these applications include terrain analysis, forest management, cultivation, updating of existing forest inventories, the delineation of burned areas, and mapping of cleared areas.

Remote sensing images can detect signs of damage of forests by fire, insects or disease. Air photos can also provide information about range and wildlife habitat management, in outdoor recreation surveys and in estimating the

volumes of the standing trees. Individual tree species will be identifiable through shape, size, pattern, shadow, tone and texture. Measurements include tree height or stand height, tree crown diameter, and density of stocking and stand area.

One major use of MODIS data is for detection and mapping of wild land fires at global level. The United States Forest Service's Remote Sensing Applications Center analyzes MODIS imagery on a continuous basis to provide information for the management and suppression of wildfires. With the launch of the Moderate Resolution Imaging Spectroradiometer (MODIS) in December 1999, a new period in spectral satellite remote sensing began. MODIS makes possible continuous monitoring of the environment by measuring atmospheric gases effect and dust density, and mapping the surface of clouds, land and sea in a variety of spectral ranges from the blue to the thermal infra-red (John .2008 and Abdulrahman.2010).

2.6 Vegetation Indices

Vegetation indices are widely used to describe different between features in satellite image such as vegetation, soil and water in one hand, while in the other hand it could be used to generate information about vegetation characteristics. Vegetation indices obtained from satellite image data have become one of the primary information sources for monitoring vegetation conditions and mapping land cover change. Most vegetation indices (VI) combine information contained in two spectral bands: red and near-infrared. These indices are established in order to minimize the effect of external factors on spectral data and to derive canopy characteristics such as leaf area index (LAI) and part of absorbed photosynthetic active radiation (Thomas.et al., 1995).

2.6.1Normalized Deference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adapted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not. NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). The bigger the difference therefore between the near-infrared and the red reflectance, the more vegetation there has to be. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands. The result of this formula is called the Normalized Difference Vegetation Index (NDVI). Illustrated mathematically with the following formula NDVI = (NIR — R)/ (NIR + R)Calculations of NDVI for a given pixel always result in a number that ranges from minus one to plus one; however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves (Wim and Alfredo .1999).

2.7 Geographic Information Systems (GIS)

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. Provide extremely useful tools for environmental and natural resources management. They are widely recognized as supporting tools for the planning, monitoring, and management of the appropriate utilization of resources at the country, regional and global levels (Kenneth and Margaret. 1995).

2.8 Wild land fires

The fire is the first enemy of the forests because of the loss that it causes in economics, environment, and natural resources. Forest is the lung of world gives us oxygen and takes out carbon which decreases the temperature in the atmosphere. Fire is a common natural phenomenon closely related to forest hydrology in forest ecosystem. The influence of fire on water is indirectly manifested in that the post fire changes of vegetation, ground cover, soil and environment affect water cycle, water quality and aquatic lives. The fires effect depends upon fire severity and frequency. Many factors contribute to the threat of wildfire damages and two major factors are the decline in forest and rangeland health and the expansion of residential areas into wildland over the past century, aggressive wildfire, as well as past grazing and logging practices, have altered many ecosystems, especially those where light, surface fires were frequent. Many areas now have unnaturally high fuel loads like dead trees and a historically unnatural mix of plant species (Yao. 2003) and (Ross and Kelsi 2012).

2.8.1Types of wild land fires

The underground surface crown spread wildfire varies based on the flammable material present and its vertical arrangement. For example, Flammable materials which are in high areas are more prone to ignition of the low-lying areas. Fire can be transmitted from one place to another if have then finds flammable materials. Overall, fire types can be generally characterized by their fuels as for ground fires are fed by underground roots and other buried organic matter. This fuel type is especially prone to ignition because the fire find flammable materials while it creeping in surface orientation fueled by low-lying vegetation such as leaf and timber litter, debris, grass, and low-lying shrubbery. Fires ranging in levels of fire flames consume material between low-level vegetation and tree canopies and Crown, or aerial fires which burn suspended material at the canopy level, such as tall trees (Vicki and Todd Mielke. 2006).

2.8.2 Fire regime

The fire regime includes the extent, seasonality, frequency, intensity, and spatial distribution of fires. The integrated fire management plan cannot be prepared and the ecological effects of the fire on fauna and flora could not identify without good knowledge of fire regime. Satellite images could detect changes in land surface due to the fire occurrence. Such changes include removal of vegetation cover and burned material deposit. The detectable changes are then used for mapping burned areas. Fire regime is an important foundation for understanding and describing effects of changing climate on fires pattern and characterizing their combined impacts on vegetation. The concept of fires provides an integrated way of classifying impacts of these diversity spatial and temporal patterns of fire and impacts

of fire at an ecosystem. The dry season after the end of the rainy season is the season of forest fires in the area of savannah and almost from the beginning in the mid of September to the beginning of May. Fire frequency is the average number of fires or regularly occurring fire events per unit time in designated area (Evan. and Rob.2000).

2.8.3 Wildfire Prevention

Wildfire prevention refers to the preemptive methods of reducing the risk of fires as well as lessening its severity and spread. Effective prevention techniques allow supervising agencies to manage air quality, maintain ecological balances, protect resources, and to limit the effects of future uncontrolled fires. Wildfire prevention programs around the world may employ techniques such as wild land fire use and prescribed or controlled burns. Wild land fire use refers to any fire of natural causes that is monitored but allowed to burn. Controlled burns are fires ignited by government agencies under less dangerous weather conditions (Ram and Raj 2010).

2.9 Wildland fire and Climate change

In the year 2000, (FAO) estimated 350 million hectares of forests and woodlands were destroyed by fire in all over the world (FAO 2006). Although historical data is lacking, recent evidence suggests that climate change is resulting from intensity and extent of forest fires. Fires lead to the increase of carbon, which contributes to increase global warming which lead to increase acid rain with a negative impact on agricultural and food crops and increase the temperature However, people remain the biggest cause of uncontrolled vegetation fires, and future prevention and preparedness strategies will undoubtedly need to prioritize awareness campaigns and education (Alison.2007).

2.10 Wildfire effect in Ecosystems and Livelihoods

Fires lead to change the composition of the ecosystem because they eliminate large amount of forest trees species and destroy the Wildlife and convert the lives of birds and insects and wildlife and change the composition of the soil. Wildfire leads to forestry damage and has negative results like erosion of the soil and shrinking of spaces of arable land and that forests keeps the groundwater because it works by its roots of trees to purify the water before it reaches the fountains (Jose.2005) as well as fires eliminate seeds stock in the forests land which hinder the natural regeneration of the forest and thus lead to desertification and sand creeping and mud loss of fertile land so that fires lead to change the composition of the soil (Smith. 2000 and Nicosia.2006).

2.11 Burned Area mapping

Forest trees and grass of fires is located in the forest turned to coal ash, as a natural product of these fires as well as change the structure of the tree. Use MODIS satellite sensor for mapping of these fires areas takes advantage of these spectral, temporal, and structural changes. It detects the approximate date of burning at 500 m by locating the occurrence of rapid changes in daily surface reflectance time series data (George.2009).System for remote sensing of high capacity to detect and follow the changes that occur on the surface of the earth requires effective and automated change detection techniques. The majority of change detection techniques rely on experiential derived stage to differentiate changes, considered a noise. These processes include reflectance computing, projecting and observe all burned area mapping variables. It is of useful importance in mapping fires to see how

fire extended and change agent affecting in ecosystem structure (Mutlu.et al., 2010).

2.12 Fire Situation 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,

2.12.1Impacts of wildfires

fires increase the poverty of citizens and many of them lose their food crops that have been harvested after the planting season which is stored in stores and the outbreak of fires burn the production which creates a famine in the villages As well as fire destroy homes of citizens because they are made of straw and wood, leaving them in the open and vulnerable to displacement (McMichael and Campbell. 2003).

All or some of these may occur risks like Soil erosion due to burning of the grasses and scraps of trees and humus and for that we must Changing species composition of the forest toward the fire resistant species in fires prone to fires area , for example Ziziphusspinachristi and Acacia seyal. To provide an environment free of the causes of fires as well as the cause of fires in the events of disorders and the migration of animals from the forest, which take forests its home (Goldammer. 1991).

There is no unit or department specializing in fires management but (FNC) and range and pasture authority make annual activates like opened fire lines and these lines themselves do not open in the right way because the fire lines must be two meters wide and be clean of weeds or burning material but often stop these activities because of the lack of budget, and due to the war between the Sudanese's army and the rebel movements in areas of the Nuba mountains causes of fires cut forests in order to clean the land of the inhibitions that holed the enemy. The war makes it difficult for officials to reach those insecurity areas in order to do forestry activities and applications. In Sudan there are no annual plans to fight fires but traditional methods of fire-fighting effort and traditional tools are used to fight fires. Forest Act of 1986 prohibits any citizen to ignite the fire inside the forest, for cooking or carryout any human activity or ignite fire near the forest and obliged any citizen to assist in extinguishing the fire (Bayoumi. 2001).

2.12.2 Public policy concerning fires

The forest policy of 1986 emphasizes the protection of forests against fire. The forest law of 1989 prohibits trespassing of people and their animals into reserved forests and prohibits the carrying of ignited material into the forests, making fires for cooking or other purposes in or near forests and

obliges people to help extinguish forest fires. Reduction of fires will definitely conserve the natural resources of the country and will improve the growth of many tree species. Fire management needs are complicated because of different environmental conditions and the need for different management techniques. The very large size of the country, the various local factors and weather conditions, the trend toward repeated intense droughts and desertification, the increase in population and domestic animals, the displacement of rural people to cities, the expansion of unplanned rain-fed cultivation, the poverty of the people and the lack of knowledge of decision makers related to forest conservation are all major problems and hindrance. Sudan needs extension capability to teach people how to protect their lands. Research is needed to find safer methods to prepare land for agriculture or forest plantations. Above all, trained personnel and supporting equipment are needed for transport, detecting and fighting forest fires（Goldammer. 1991).

There are no documented events of fires that occur in Sudan also there is no a monitoring program or integrated extension campaigns to educate citizens and raise awareness among them in the fight against fires. In colonial times and up to the end of the 1960s the Native Administration, under the supervision of the Range and Pasture Department and in close collaboration with the Forestry Department, maintained a firebreaks network extending north-south over North Kordofan and North Darfur to protect grazing lands and gum gardens. Usually two four-meter-wide lines are cleaned and spaced parallel to each other and separated by an 80 m wide to be burned early just before the grass fully drought. This pattern is repeated systematically over the semi-arid lands. Early warning, detection and monitoring systems are not available. No volunteer fire fighters are available but people and

communities are obliged by the forest law to report and help fight wildfires (Bayoumi.2001).

CHAPTER THREE

3. STUDY AREA

3.1. Location

South kordofan state is one of sixteen states of the Sudan. Located between the latitudes (9° to 13° N) and longitudes (27° to 33° E) with an area of (141 096 km²). Population are Nuba tribes and Arab groups who is arrived to South Kordofan through migration from West Africa in search of rich pasture, South kordofan is rich with human resources, agriculture, arable land, livestock, forestry and minerals of iron, gold, phosphorus, cement, petroleum and there are traces of natural gas and a tourist resources and rich folklore (Suliman et al., 2014).

Nuba Mountains are divided into four sections, namely the northern mountains and located in the Dilling locality and southern mountains are located in the Kadugli locality and the eastern mountains, which known as old Tagaly Islamic Kingdom which united in the sixteenth century and now consists of three localities, the Rashad locality and Abu Jubaiha locality and Talodi locality and fourth section of the Nuba Mountains is Arab which located in the Lagawa locality.

An estimated population of approximately 1,100,000 people (2000).Kaduqli is the capital of the state. It is centered on the Nuba Hills.

South Kordofan state is situated in Southern Sudan on the border to South Sudan country. The state also borders north and West kordofan states and White Nile state.

South Kordofan is suffering from the civil war carried out by the Public Movement in the areas of the Nuba Mountains, which led to the displacement of citizens and displace them from their villages and towns, as well as led to the loss of pasture and water sources and agriculture land, affecting negatively to the lives of citizens (facebook-history of Nuba mountains page, 2013).

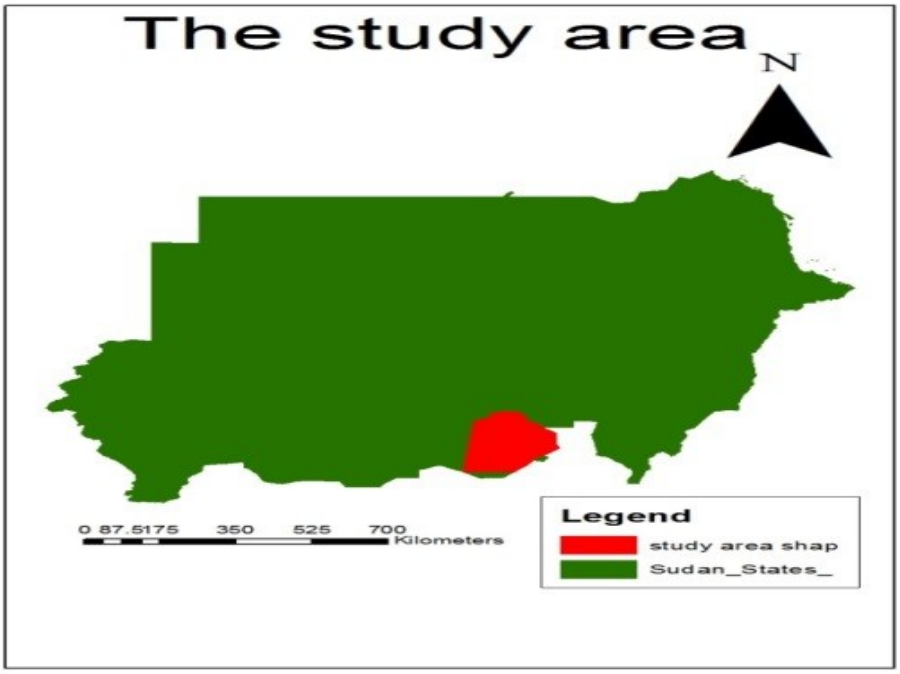


Figure (3.1) study area location map

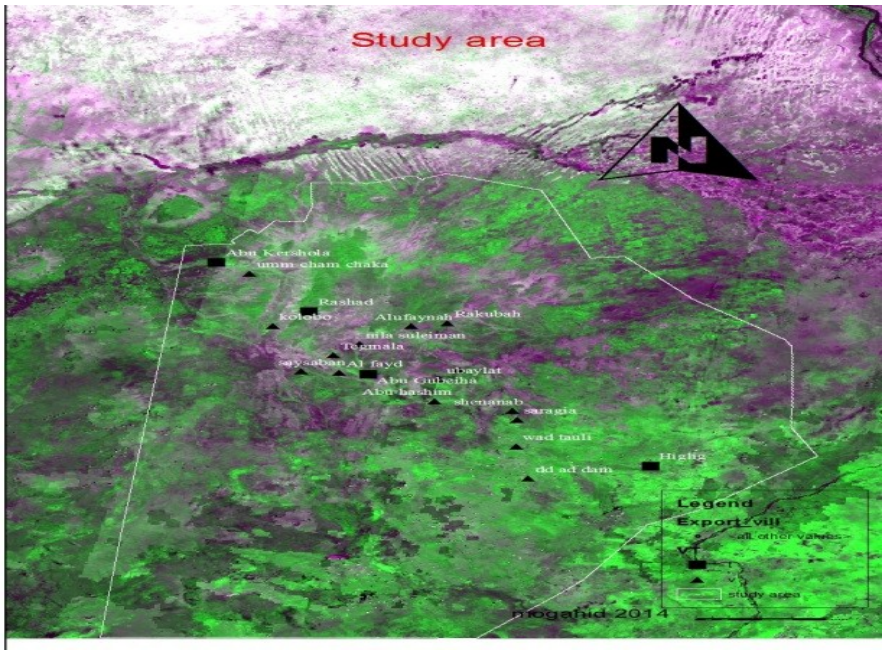


Figure (3.2) study area location map

3.2 Agriculture

South kordofan states is a home of the cotton of short staple, which was contributing in the national economics throw providing the hard currency (Cottons Nuba Mountains), Before civil war and destroy fields of cotton production, livehood of the local people depend on income from livestock and Handicrafts. But also South kordofan is the best area for the cultivation of crops such as maize, sesame, cowpea and others. But cultivation takes place in a small scale and large agricultural projects do not exist. The hunger season is normally broken by early harvesting of small-scale maize plots (Ahmed.25-9-2013.Sahafa daily newspaper).

3.3 Soils

Soils suitable for the cultivation of the basic food staples of the Nuba Mountains are limited. They are divided broadly by local people into the fertile clay soils of the plains, the sandy/clay pediment soils found at the foot of the mountains (known as gardud) and the rocky soils found in the mountains (karkar). As a result the land has to be left fallow after a few years to recover and many plot cleared under a ‘shifting agriculture’ regime. Clay soils need to be left fallow for at least the same length of time for which they have been cultivated, and sandy soils need three times as long under fallow as under crop. Small plots of rocky mountain soils are cultivated every year but this is only possible due to the application of household waste and manure. It is therefore the clay soil on which most of cultivation takes place (Simon. 2003).

3.4 Vegetation

The characteristic of natural vegetation type on the northern clay plains is Acacia – Balanytes savannah woodland associated with thorny bushes and annual tall and short grass. Annual grass fires and grazing are among the many factors that contribute to the disturbance of the vegetal development of this area. However, the clearance of the land for cultivation and fuel wood production are the dominant factors in the destruction, approximately 37.000 acres annually. Acacia tree is predominate in the forests of South Kordofan State, especially in the clay soil and utilized in coal and firewood for domestic purposes in addition to the tree, Almhogueny utilized in the manufacture of furniture, as well as acacia tree, which is used as a tanning and eat by human and animals and Hashap tree which produces gum Arabic .There are also other types of tree such as abanos, aradeab and aerd (Harrison and Jackson. 1958).

3.5 Livestock Production

Livestock Production in South Kordofan sector plays a major role in the Sudanese economy, which contributes 20% of production and 23.1% of the total income of the country's foreign exchange and contributes with 40% of the agricultural sector and over 25% of the total export earnings of Sudan, estimated at 800 million dollars annually which is concentrated in the state of South Kordofan, and they are small in size and their types is characterized resistant to the tsetse fly and now known as cows of Nuba Mountains (abdela.alsahafa daily newspaper16-10-2011).

3.6 Demographics

The population according to the census in 1993 was about 1,003,560 rose to 1,151,330 in the census of 2002 rose to 2.500,000 in census of 2008, about

17.4% of them live in urban areas, 79.3% in rural and 3.3% are nomads. If we look at the population pyramid, we find that the distribution of sample follows the normal pattern by 16.8% for the age group (0-40) of the total population. Considered the state of South Kordofan include many kinds of terrains and include inside a lot of different tribes and ethnic groups(Abdel Raouf.2008).

3.7 Income and poverty situation

Southern Kordofan state is suffering from civil war in Nuba Mountains that impacted negatively on the lives of citizens and raise poverty to advanced rates. The national War made Population lose their homes, their livestock, and their limited sources of income and live in camps and all producers have turned to consumers. Southern Kordofan state is suffering from lack of basic infrastructures which can be helping in establishment of development projects and that make improving of living conditions of the population is possible, and the process of political stability in the state.

Population suffering in the state to access the safe drinking water, most of them is dependent on water reservoirs that are stored after the autumn (Niveen.1998).

CHAPTER FOUR

4. MATERIAL AND METHODS

4.1. Materials

The following materials were used:

4.1.1 MODIS images

32 MODIS images were ordered from the web site (http://reverb.echo.nasa.gov/reverb/) for each season (from 15th Sep to 5th May, the next year). With the following specifications: 250 m spatial resolution, 8 days product 2300km swath. Free downloaded of images and shape file was done used as study area.

4.1.2 Software

4.1.2.1 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.

4.1.2.2 Arc GIS

ArcGIS is a suite consisting of a group of geographic information system (GIS) software products produced by Esri Arc map software 10.0

4.1.2.3 Other System

Microsoft office word 2010. Microsoft Windows 8

4.1.2.4 Hardware

Computer laptop, Cor i3, 6G MB of RAM, Windows 8

4.2 Methods

4.2.1Methodology of burned area mapping

In this study remote sensing and GIS techniques are used through MODIS data to document fire history and produce maps of burned areas in Eastern part of South Kordofan State for season (2000-2001) to (2013-2014)

The methodology applied is based on analysis of Images acquired by MODIS sensor to map the burned areas. A collective of 32 images per each season is processed (448 images for thirteen seasons) and analyzed to extract the burned area. The following steps were carried out:

1. Study Area Subset:

Shape file for the study area was prepared using Arc GIS 10.0 software, Shape file imported by ENVI as ENVI vector file (EVF) then exported to region of interest, which used to subset the image (subset via region of interest). The resulted subset image was used as template for subsetting the rest of the images.

2. NDVI Calculation:

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

(float (b2)-float(b1))/(float(b2)+float(b1))

Where

b1=Band1 (Red band)

b2=Band2 (Near infrared band)

NDVI is based on the reflection characteristics of vegetation which is gives increase 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 green chlorophyll gives the NDVI the privilege to detect the burned area as pixels can be classified into ranges of burned scares area that takes the lowest NDVI value.

3. Change Detection

In order to detect the burned areas within 8 days each earlier NDVI image was subtracted from the previous one and the results were saved in change detection images for further processing.

A color density slice was created by identifying the pixel of the lowest NDVI value and the one with the highest value within each change detection images then the created color image was saved as class image.

4. Region of Interest Generation and Mask Building:

The region of interest was draw around the real burned areas in order to mask out the noise which look similar to burned one. Unburned areas that have values similar to that of the burned areas were removed (masked out) and a new image free of noise is created.

5. Removal of multiple burned area mapping

The multiple burned area mapping that usually occurred at the margin was removed using the ENVI functions (b1 gt 0) which assign DN equal to one for all pixels having DN greater than zero.

6. Monthly Burned Area Image Generation:

The monthly burned area image for each season was generated by summing all burned areas detected between all successive images in the same month.

The total burned area image was generated by summing all burned areas detected between all successive images in the same season. This was done for each season.

The resulting monthly and total burned area images were converted from raster to vector (shapefile) to be used in ARCGIS software 10.0 to calculate all burned area polygons and to be used to generate the final burned area maps.

7. Generating burned area frequency map

In order to create a fire frequency map the. Burned area of all season are summed in one image. The DN of this image represents the number of times burned.

CHAPTER FIVE

5.RESULTS AND DISCUSSIONS

5.1. Delineation of Burned Areas

The results obtained in burned area mapping are combination of visual and digital interpretations in order to identify the burned areas scars from MODIS image. The burned areas in the original images appear with black tones. The result described in the study enable to identify more preciously the exact burned areas in each image from which the total burned areas maps are produced identified by the starting and ends date with the total burned area for each season as shown in table (5 – 1) below.

Table (5-1) shows the starting and ends date with the total burned area for each season.

Season	Start Date	End Date	Burned Area feddan
2000-2001	13.Sep.	8. May.	13,411
2001-2002	5.Sep.	30.Apr.	13,736
2002-2003	7Sep.	5.May.	15528
2003-2004	13.Sep.	8.May.	20943
2004-2005	8.Sep.	6.May.	19,770
2005-2006	12.Sep.	1.May.	17,238
2006-2007	5.Sep.	8May.	16600
2007-2008	12.Sep.	7.May.	18,291
2008-2009	9.Sep.	30.Apr.	15,771
2009-2010	10.Sep.	2.May.	19,219
2010-2011	13.Sep.	3.May.	16,849
2011-2012	5.Sep.	8.May.	16,003
2012-2013	6.Sep.	6.May.	24,092
2013-2014	8 .Sep.	1.May.	11,878

One feddan equal 0,4167hectar

Table (5-2) shown the Monthly burned areas in feddan

season	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2000-2001	167	1711	4655	2001	1342	978	968	1589
2001-2002	159	1097	5945	2139	1273	1239	911	973
2002-2003	471	1073	4686	2958	2027	1627	1311	1375
2003-2004	230	3738	8246	2222	1556	2023	1589	1339
2004-2005	138	1830	6140	2939	1625	2903	3060	1135
2005-2006	192	1147	6590	2932	1568	2558	1316	935
2006-2007	209	2118	6671	3008	1273	1589	1299	433
2007-2008	142	783	5119	3838	2703	1618	1794	2294
2008-2009	302	1354	3355	2808	1889	1823	1918	2322
2009-2010	147	2829	4426	2622	2920	1523	2384	2368
2010-2011	164	390	4633	4195	2801	1711	1675	1280
2011-2012	190	1220	6228	3110	1777	1304	1251	923
2012-2013	185	2839	14401	3277	1451	759	833	347
2013-2014	166	525	3451	3548	1911	1304	1028	349
total	2862	22654	84546	41597	26116	22959	21337	17662

One feddan equal 0, 4167hectare

5.1.1 Fire Season

The study revealed various important results about fire regime in the study area such as the fire season which is generally start in the mid of September and continue up to the end in April or the beginning of May with peak in the burned areas in November this is attributed to the fact that most of the grass in the area become drier at this time of the year.

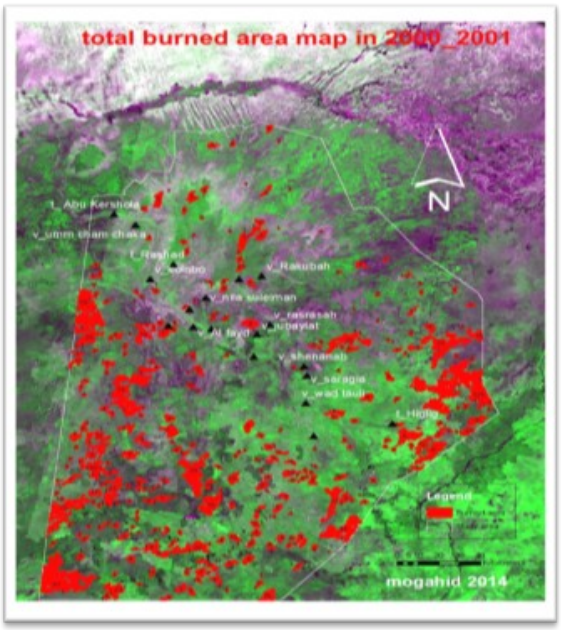
The study shows that the largest area burned was in season (2012-2013) and then season (2003-2004) and the lowest area burned was in season (2000 - 2001) and then season (2008-2009).This may be attributed to the amount of the rain fall in each specific season, which concur positively with the amount of the grasses the main type of fuel wild land fire consume

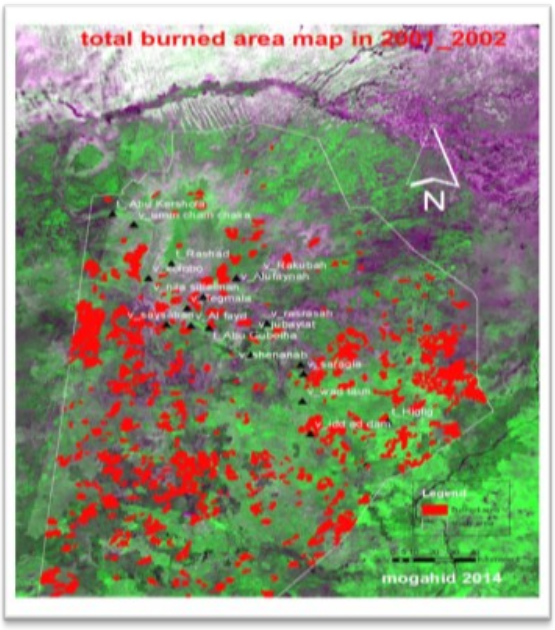
A climate factor poses an additional threat for the forest ecosystems wildfires. The forecasted increase in temperature and further arid climate is leading to more frequent wildfires, which are additionally affecting to the forests (UNDP.2013).

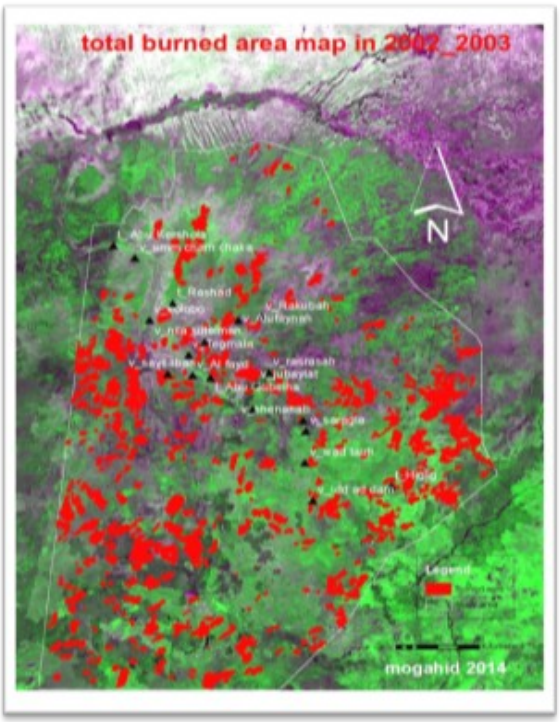
5.1.2 Causes of fires

The fire season start in about month later just after the ends of the rainy season i.e. in the mid of September where the grass start to go drier and continue up to beginning of May in this period two main activity charcoal production and clearing the lands for agriculture are the main causes behind fires outbreak .

wildfire differs from other fires by its extensive size, the speed at which it can spread out and its potential to change direction unexpectedly, Wildfires are characterized in terms of the cause of ignition, their physical properties such as speed of propagation, the combustible material present, and the effect of weather on the fire (Wikipedia. 2010)


total burned area map in 2000_2001
N
Legend
mogahid 2014


total burned area map in 2001_2002
N
Legend
mogahid 2014


total burned area map in 2002_2003
N
Legend
mogahid 2014

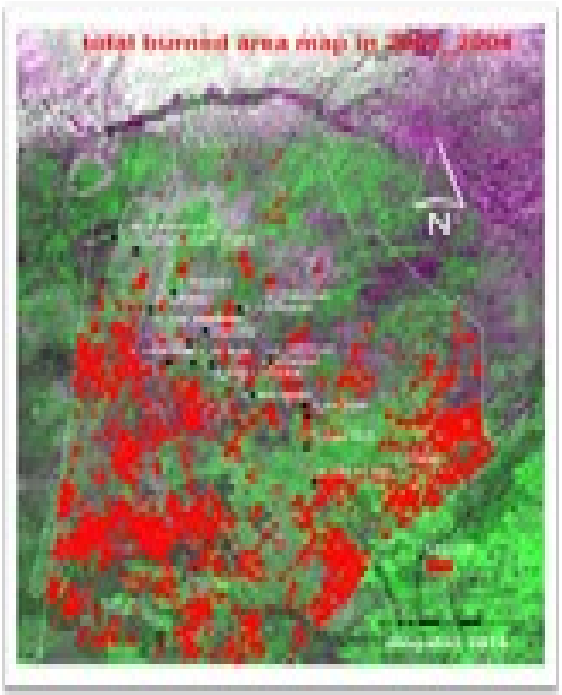
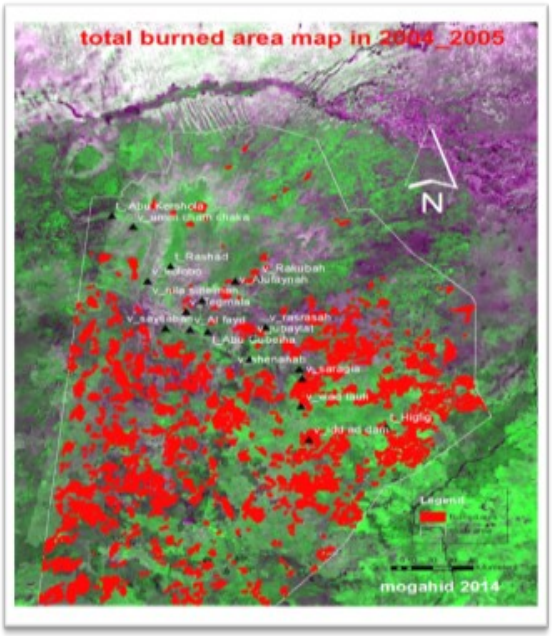
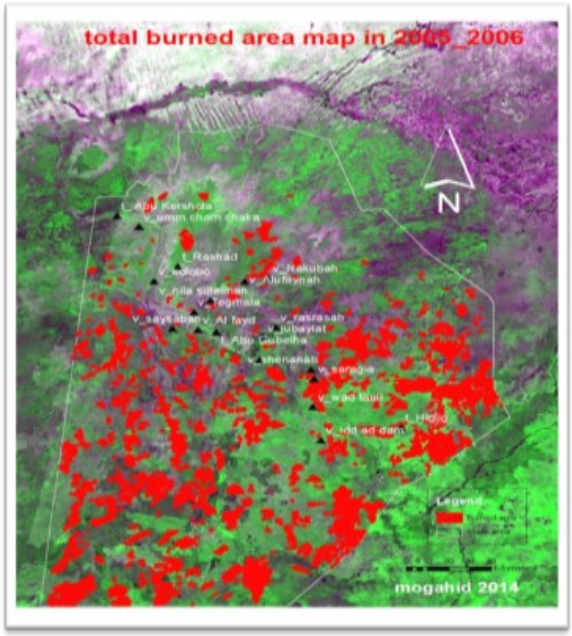

total burned area map in 2003_2004
N

Figure (5-3) Maps of total burned area seasons 2000-2001, 2001-2002, 2002-2003 and 2003-2004


total burned area map in 2004_2005
N
Legend
mogahid 2014


total burned area map in 2005_2006
N
Legend
mogahid 2014

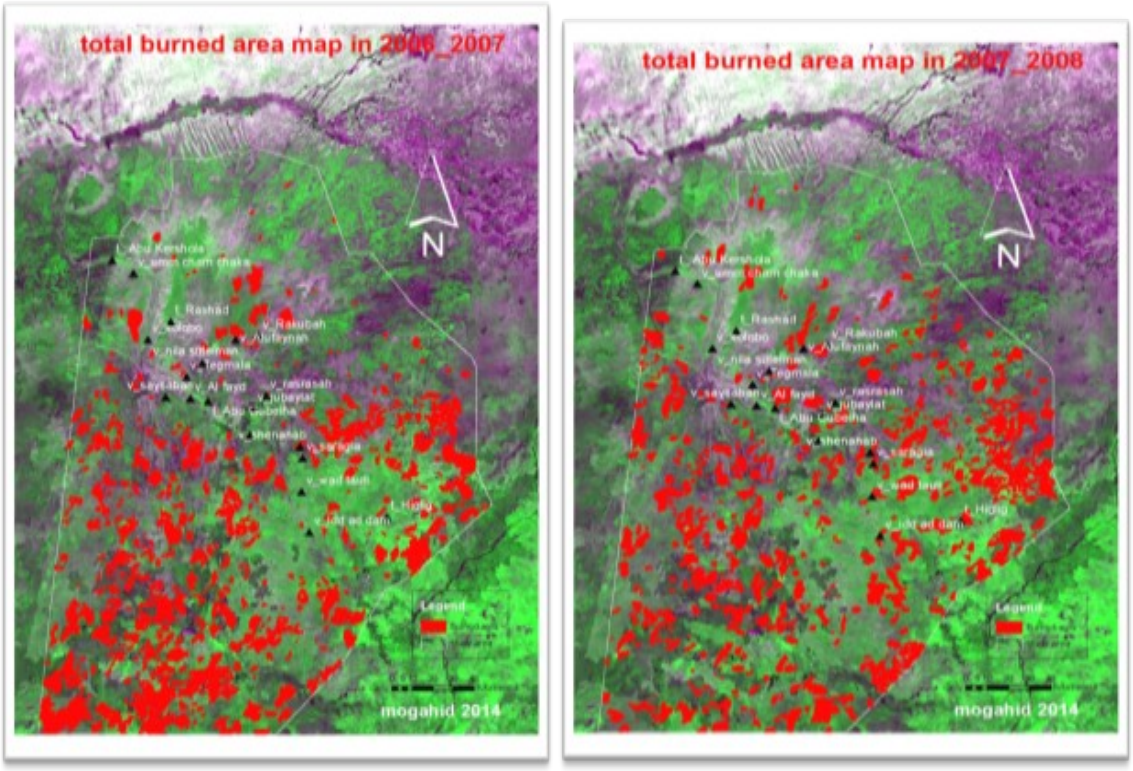
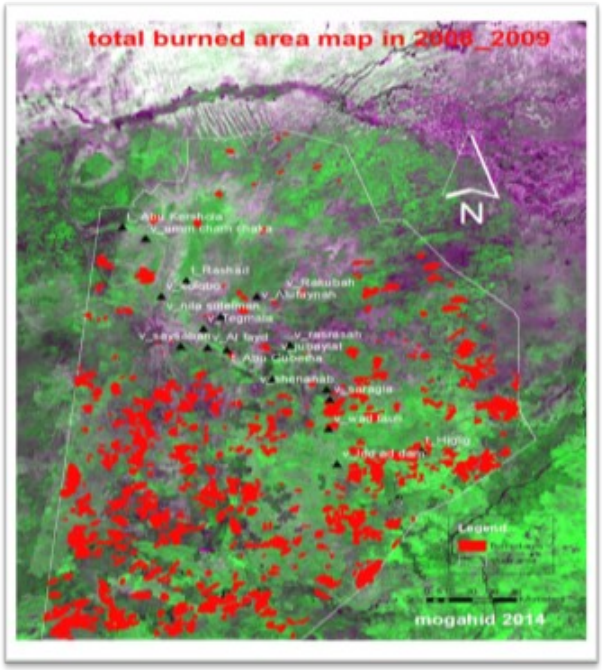
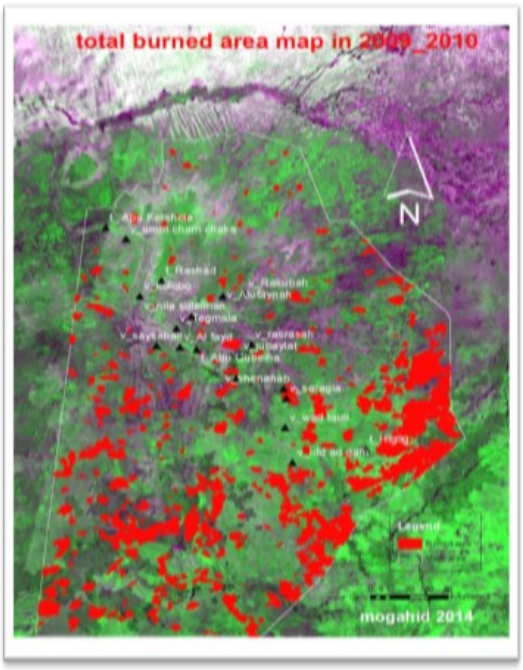
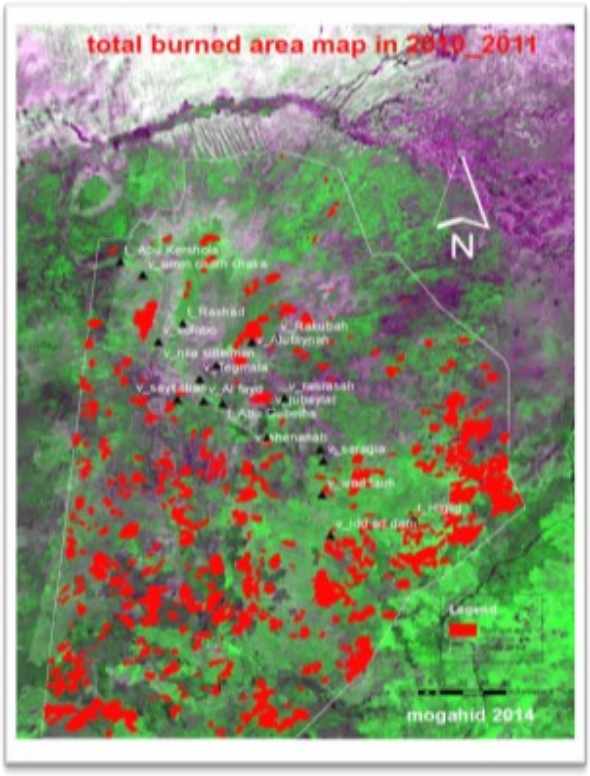


Figure (5-4) Maps of total burned area seasons 2004-2005, 2005-2006, 2006-2007 and 2007-2008


total burned area map in 2008_2009
N
Legend
mogahid 2014


total burned area map in 2009_2010
N
Legend
mogahid 2014


total burned area map in 2010_2011
N
Legend
mogahid 2014

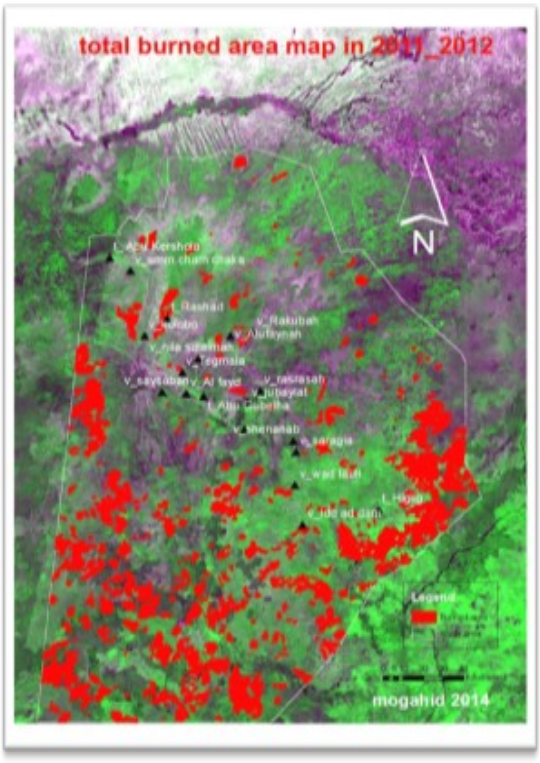

total burned area map in 2011_2012
N
Legend
mogahid 2014

Figure (5-5) Maps of total burned area seasons 2008-2009, 2009-2010, 2010-2011 and 2011-2012

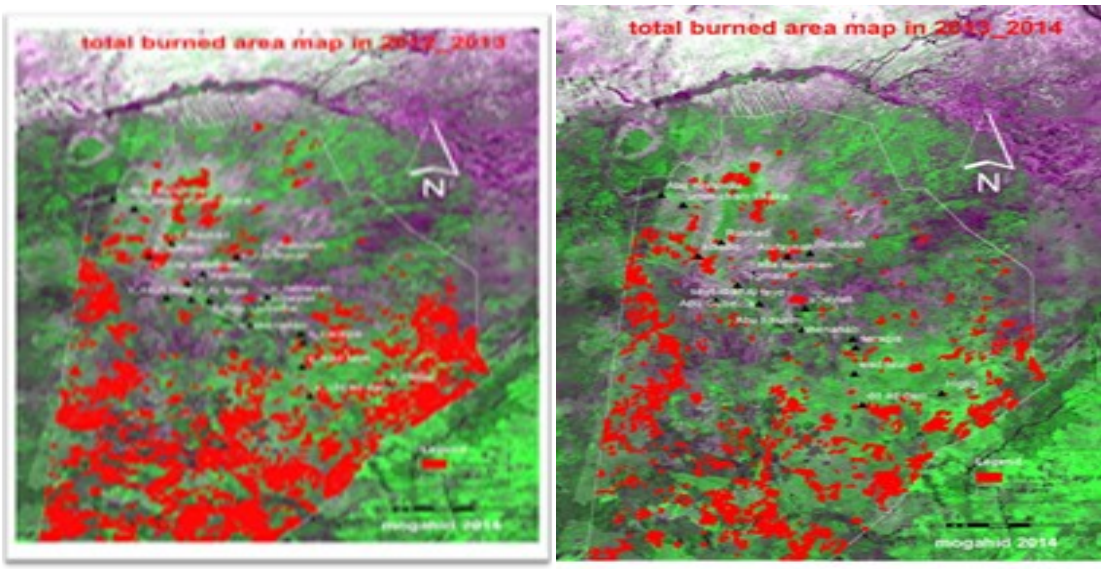


Figure (5-6) Maps of total burned area seasons 2012-2013_2013 and 2013-2014

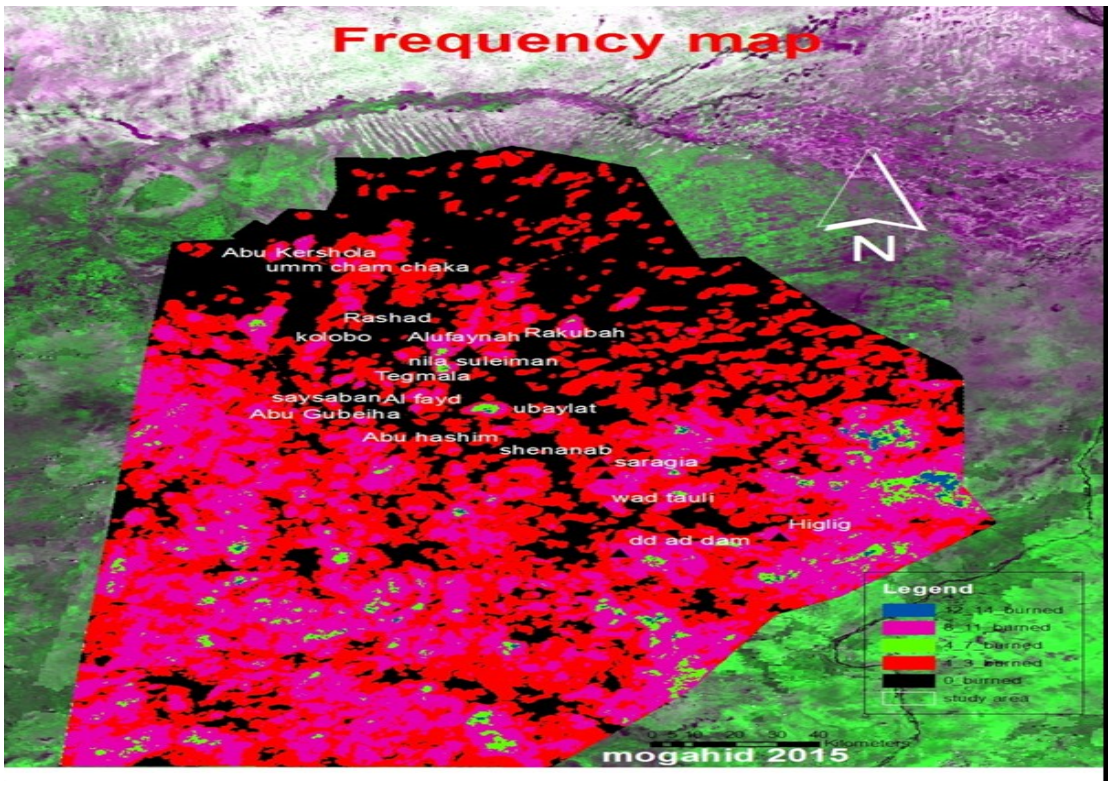


Figure (5-7) Frequency map

5.1.3 Result Validation

The map of season (2013_2014) which produced using MODIS image was compared with LAND SAT8 2013 map for the same season and this mean that MODIS could fairly be used for fires mapping with a high accuracy, a clear matching between the two satellites mapping was found.

5.1.4 Fire Frequency

In order to generate a fire frequency map each three successive number of times burn have been put into a Categories for example area burned one time, two times and three times altogether added to 1-3 burned category and

so on. The unburned area or zero time burned Categorized as zero burned area.

It is clear from the frequency map that the higher frequency burned area is located in Eastern, western and Southern parts of study area In the shape of a crescent and least frequency burned area is located in the northern parts of the study area associated with the existent of cultivated land while the medium frequency burned area dominated in the middle part of the study area.

The table (5-3) below shows you the percentage of frequency burned area from the study area.

Category	Burned area feddan	%
0	0	36.18
1-3	42,675	40,2
4-7	74,551	18.5
8-11	70.13	3.01
12-14	51.973	0.11

One feddan equal 0,4167hectar

CHAPTER SIX

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

- Wild fires largely extend in most parts of the study area.
- The fire season starts normally in mid of September and lasted towards the ends of May.
- The severe burned area is spread outside the cultivated because the farmers usually protect their farms from being burned.
- MODIS 8day surface reflectance 250 m spatial resolution images show high efficiency in burned area mapping.

6.2 Recommendations

The following recommendations could be of high value in the future studies

- More investigation is needed to determine the various causes of wild fire
- The social impacts of wildland fire needs to be investigated
- The positive and negative impacts of wildland fire on flora and fauna needs more detailed studies
- More investigations is needed for non-burned areas having the same change detection value as the burned areas
- more investigation is needed to check the possibility of using LAND SAT 8 images in burned area mapping

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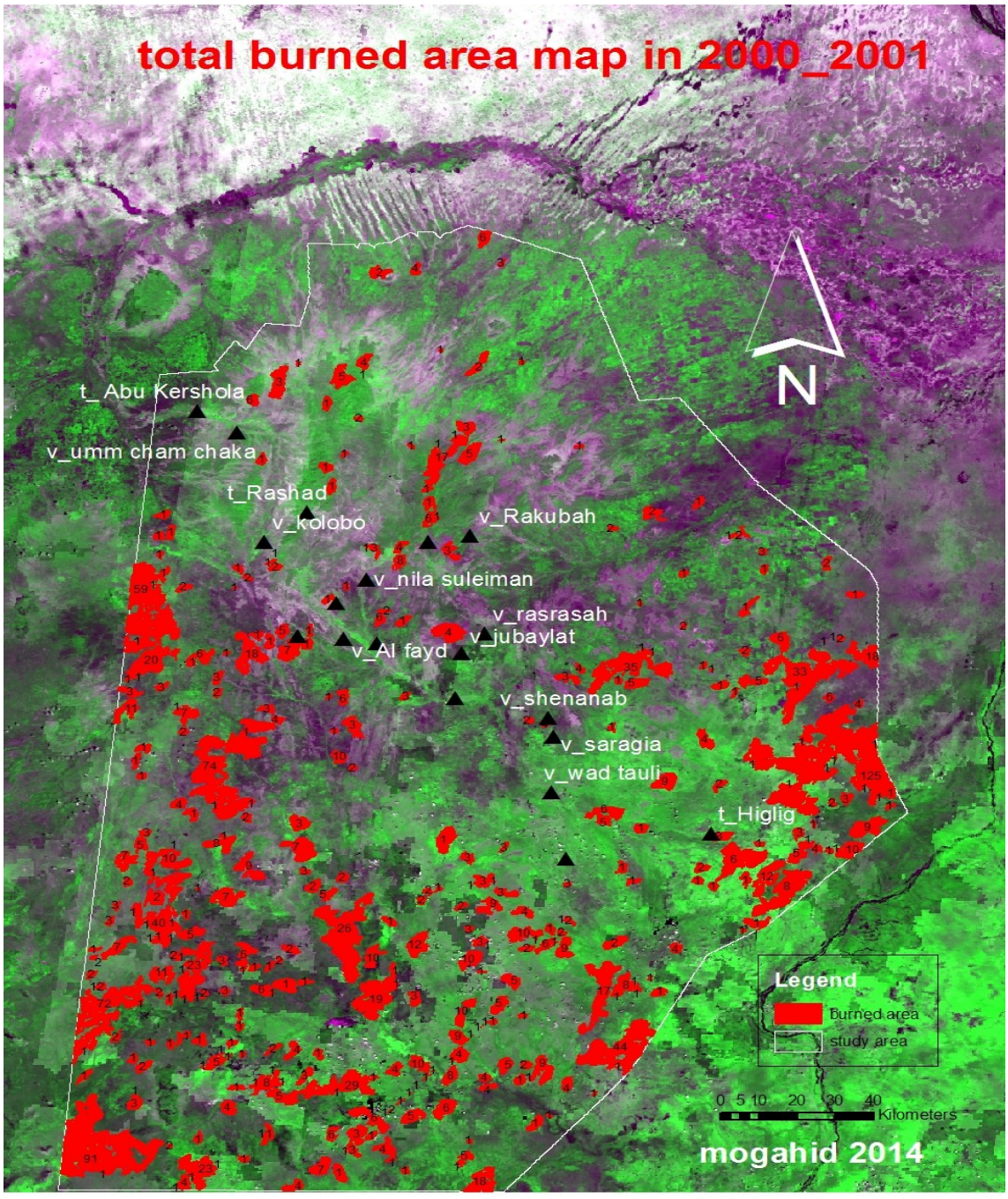
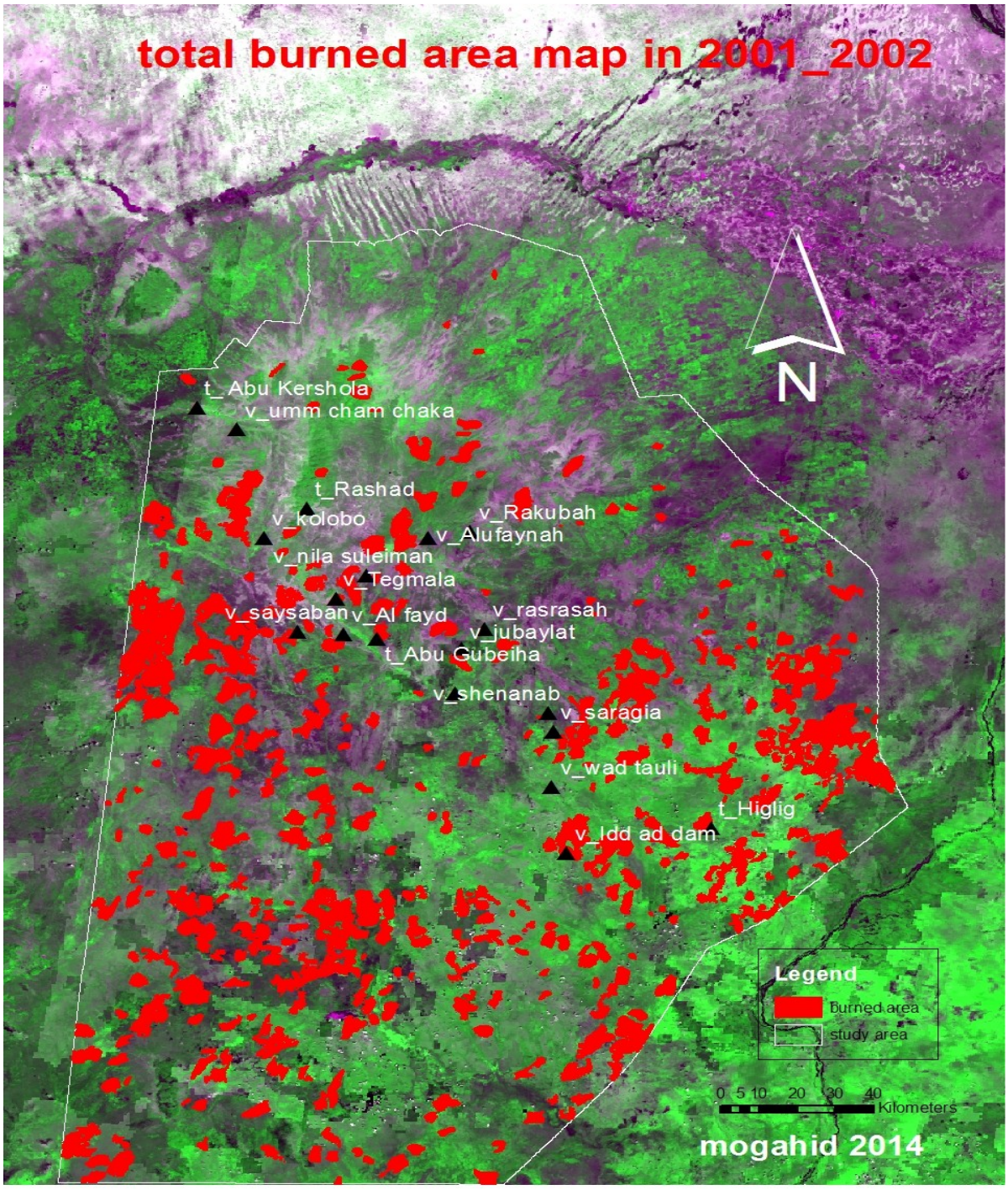
8. APPENDEIXES

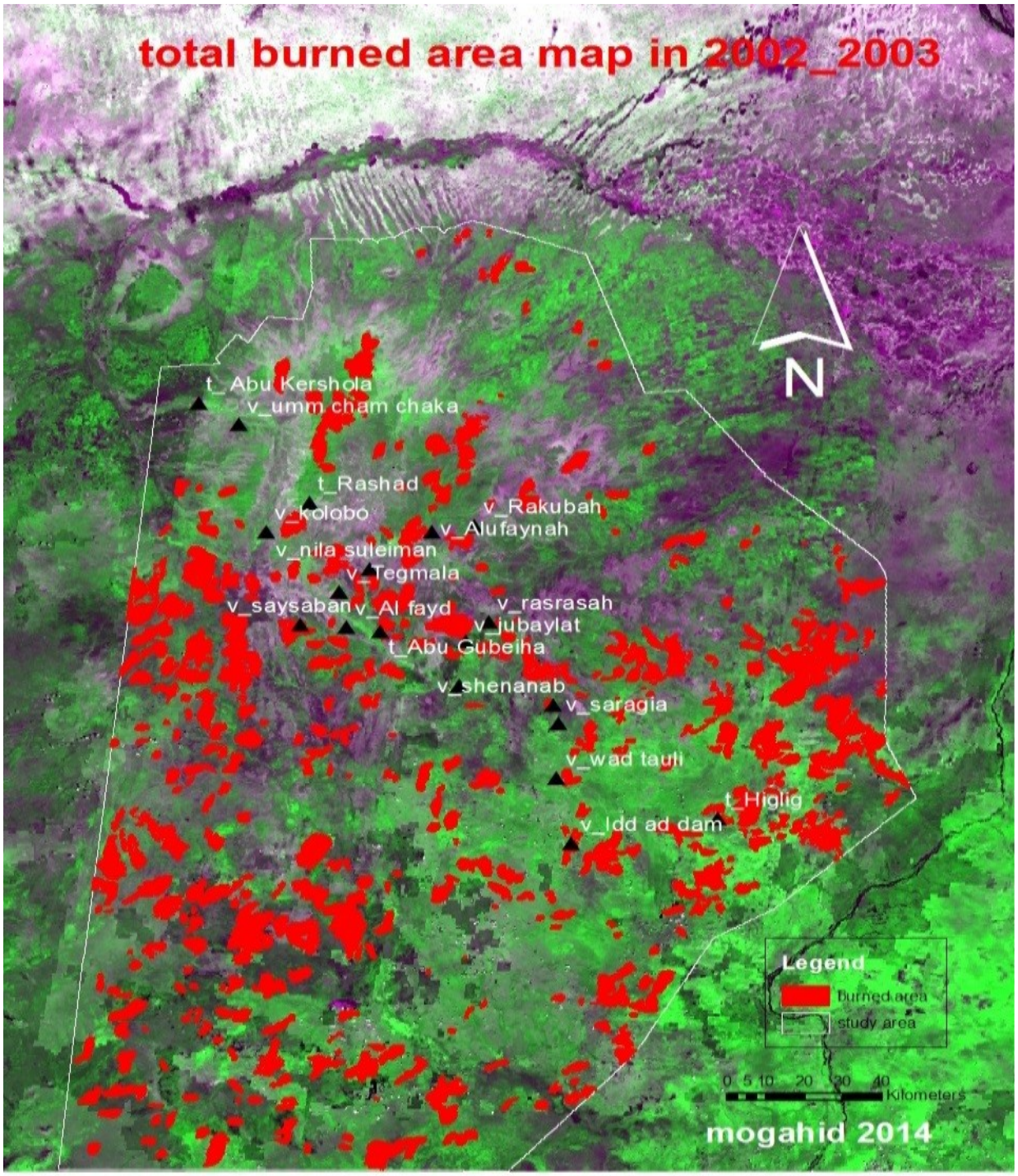
Appendix (1) Map of total burned area season 2000-2001 From Modis Sensor



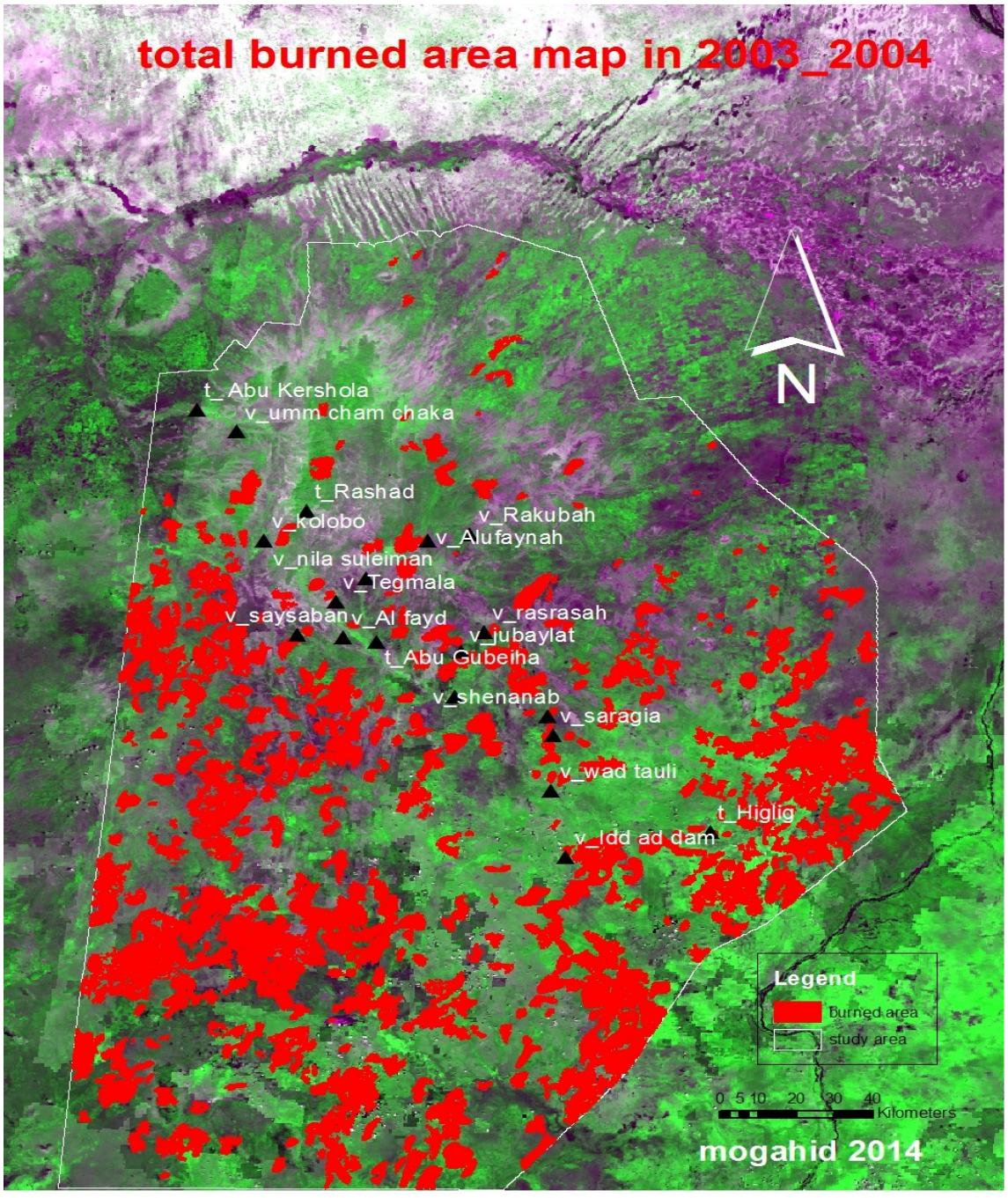
Appendix (2) Map of total burned area season 2001-2002 From Modis Sensor



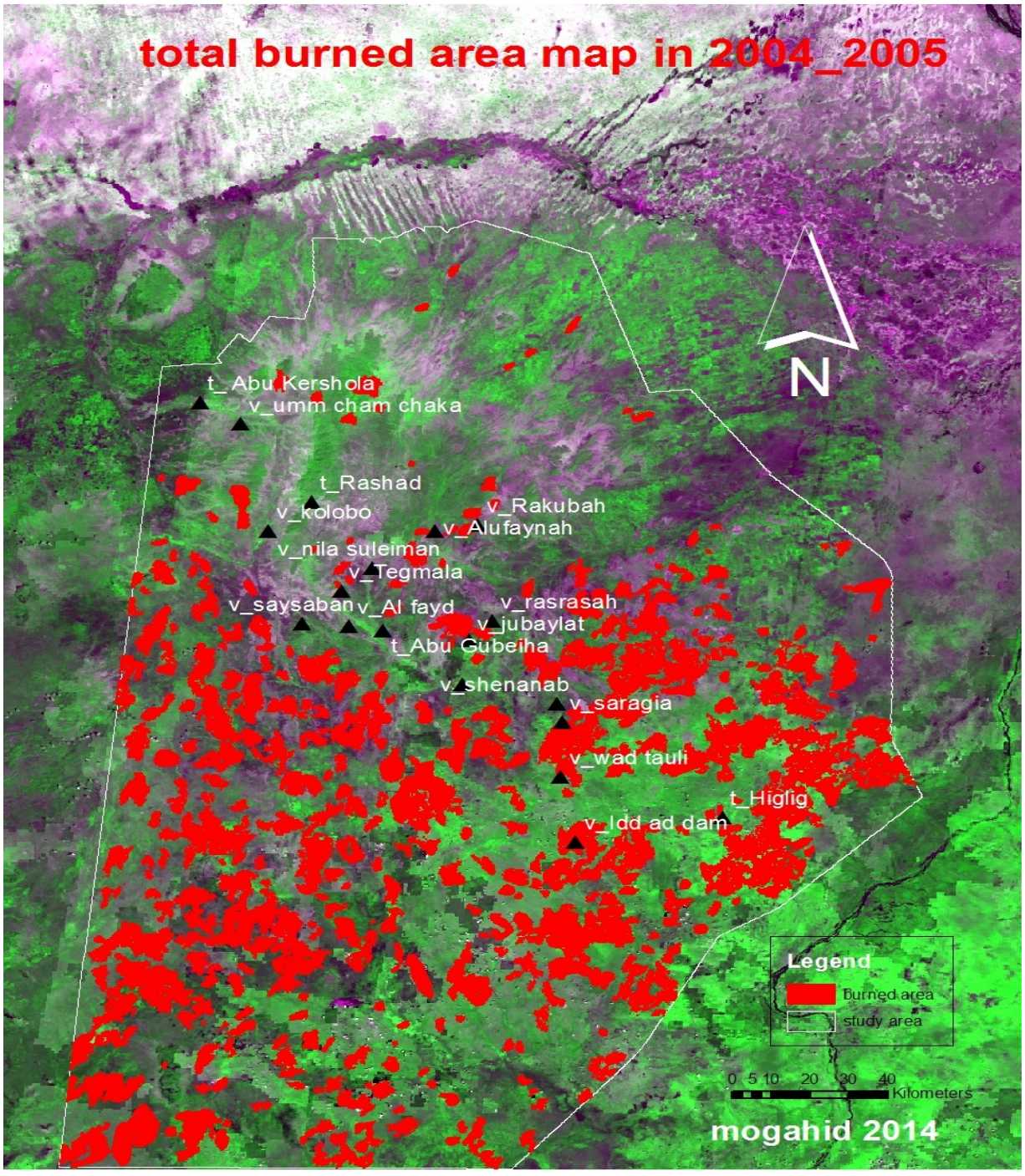
Appendix (3) Map of total burned area season 2002-2003 From Modis Sensor



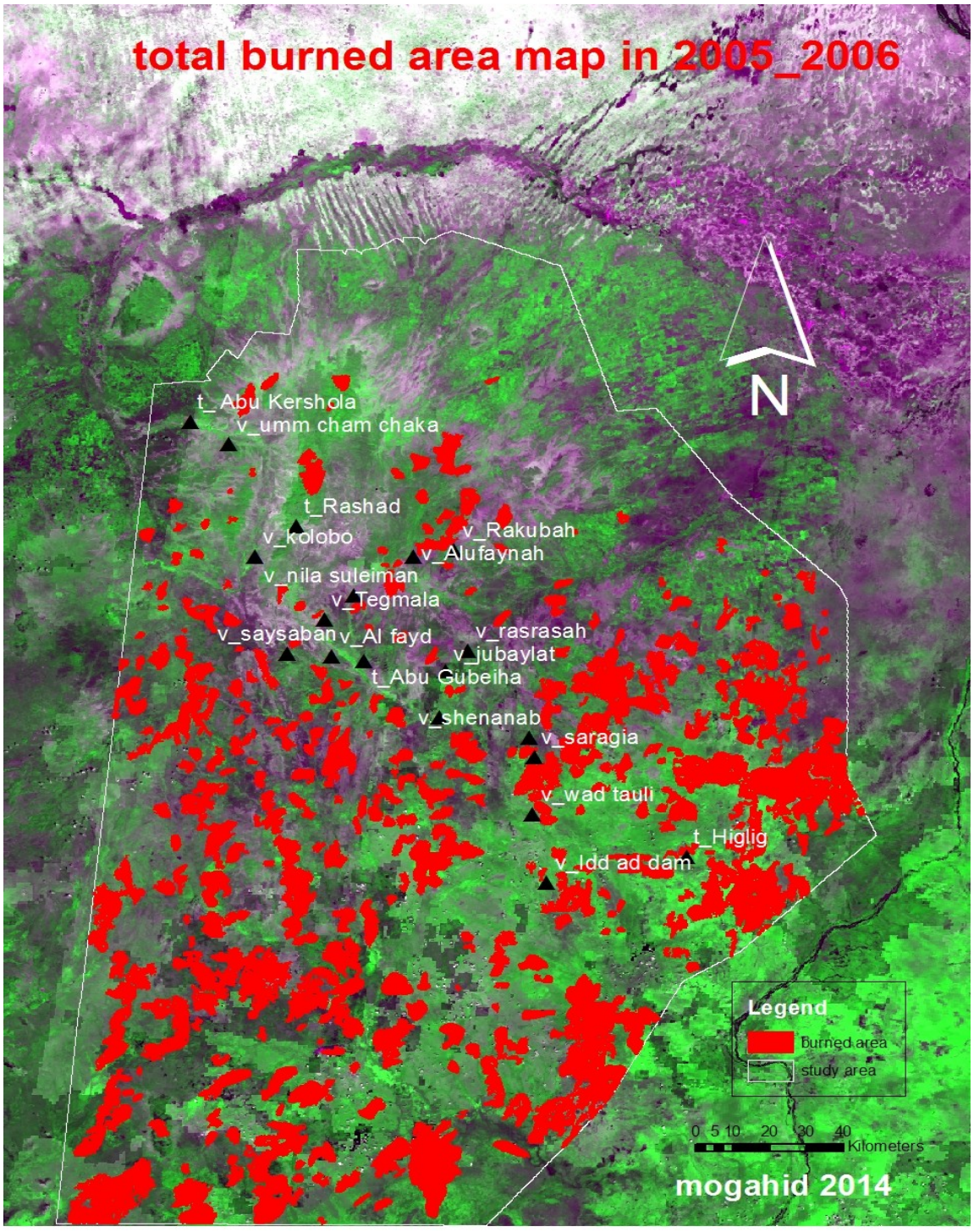
Appendix(4) Map of total burned area season 2003-2004 From Modis Sensor



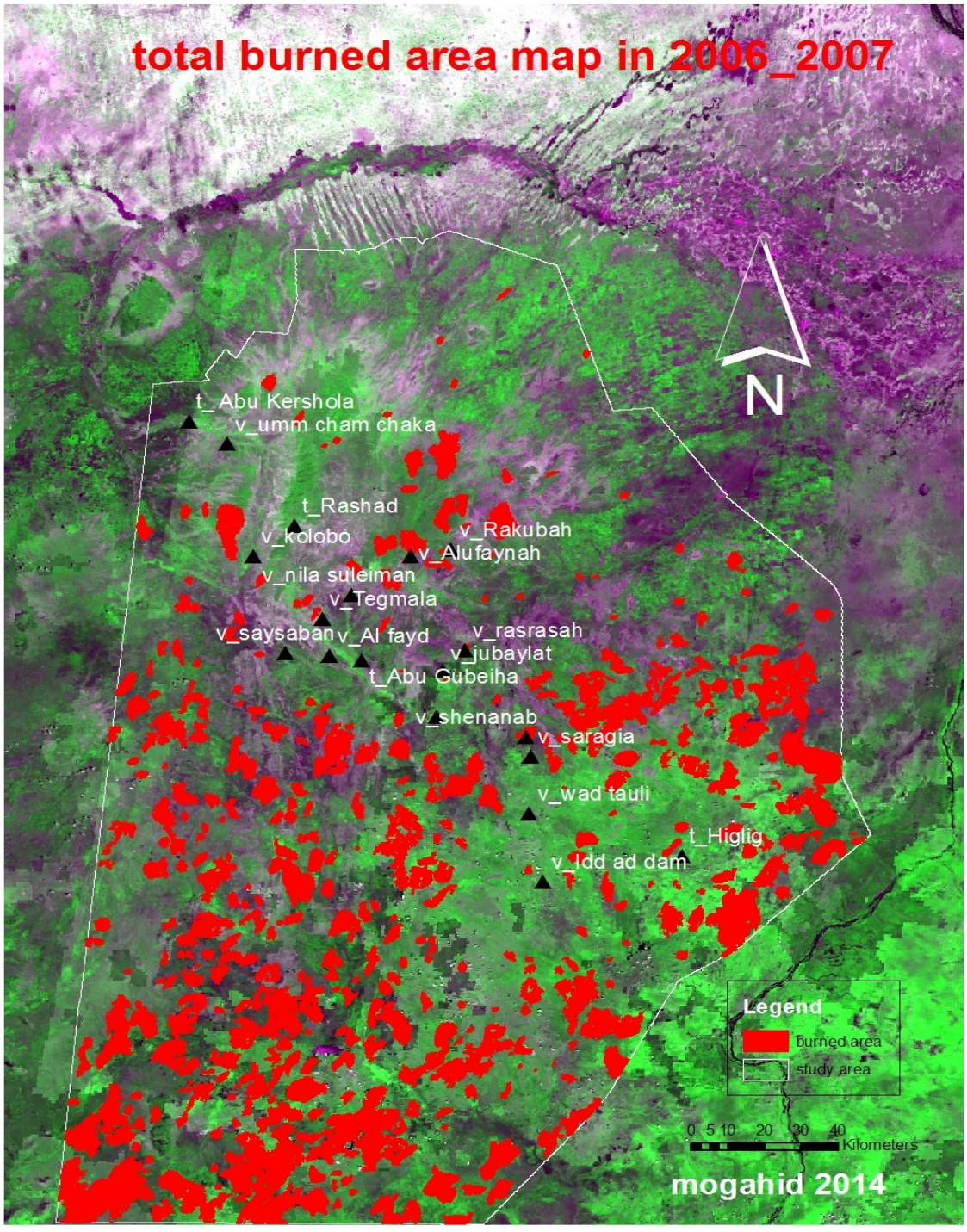
Appendix (5) Map of total burned area season 2004-2005 From Modis Sensor



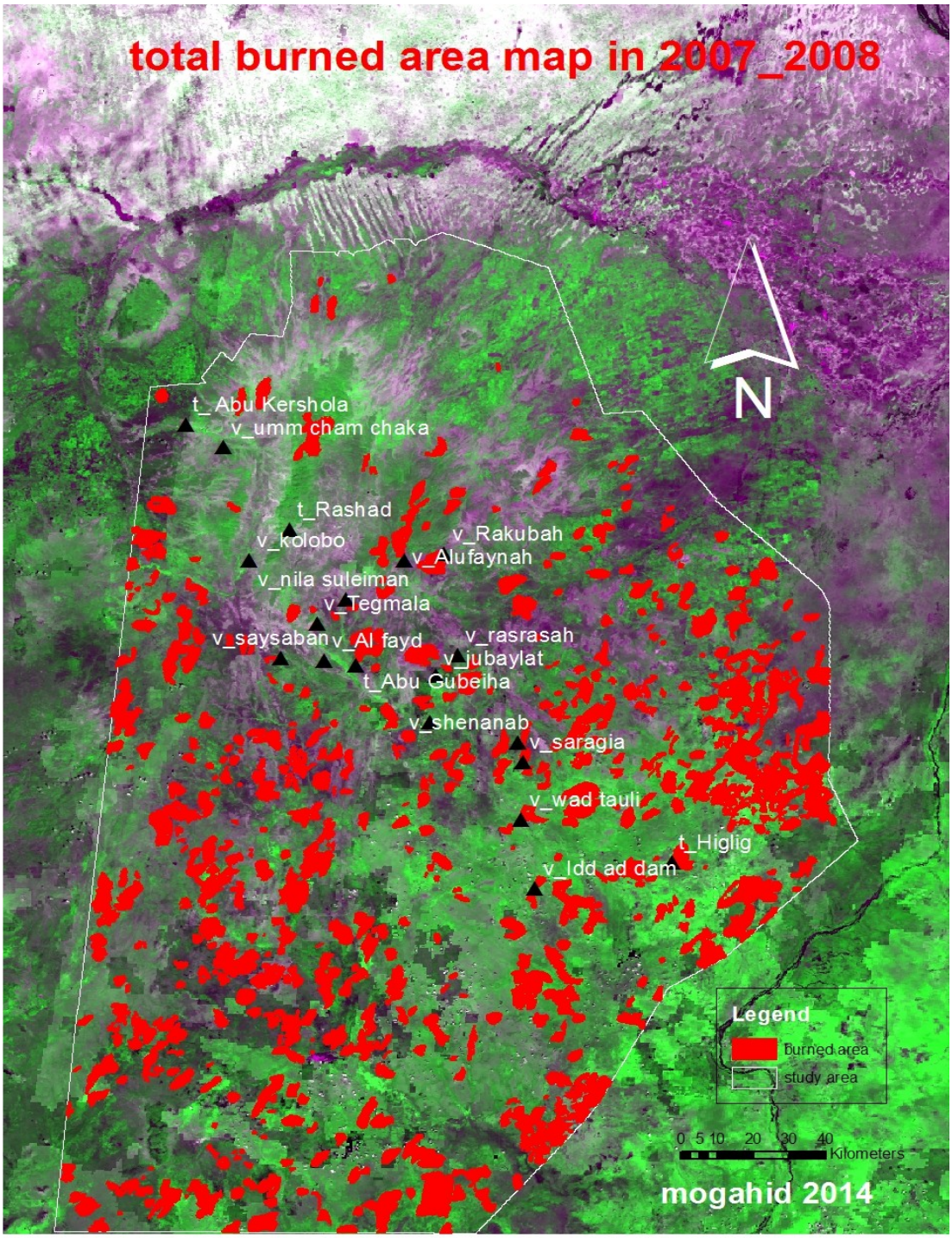
Appendix (6) Map of total burned area season 2005-2006 From Modis Sensor



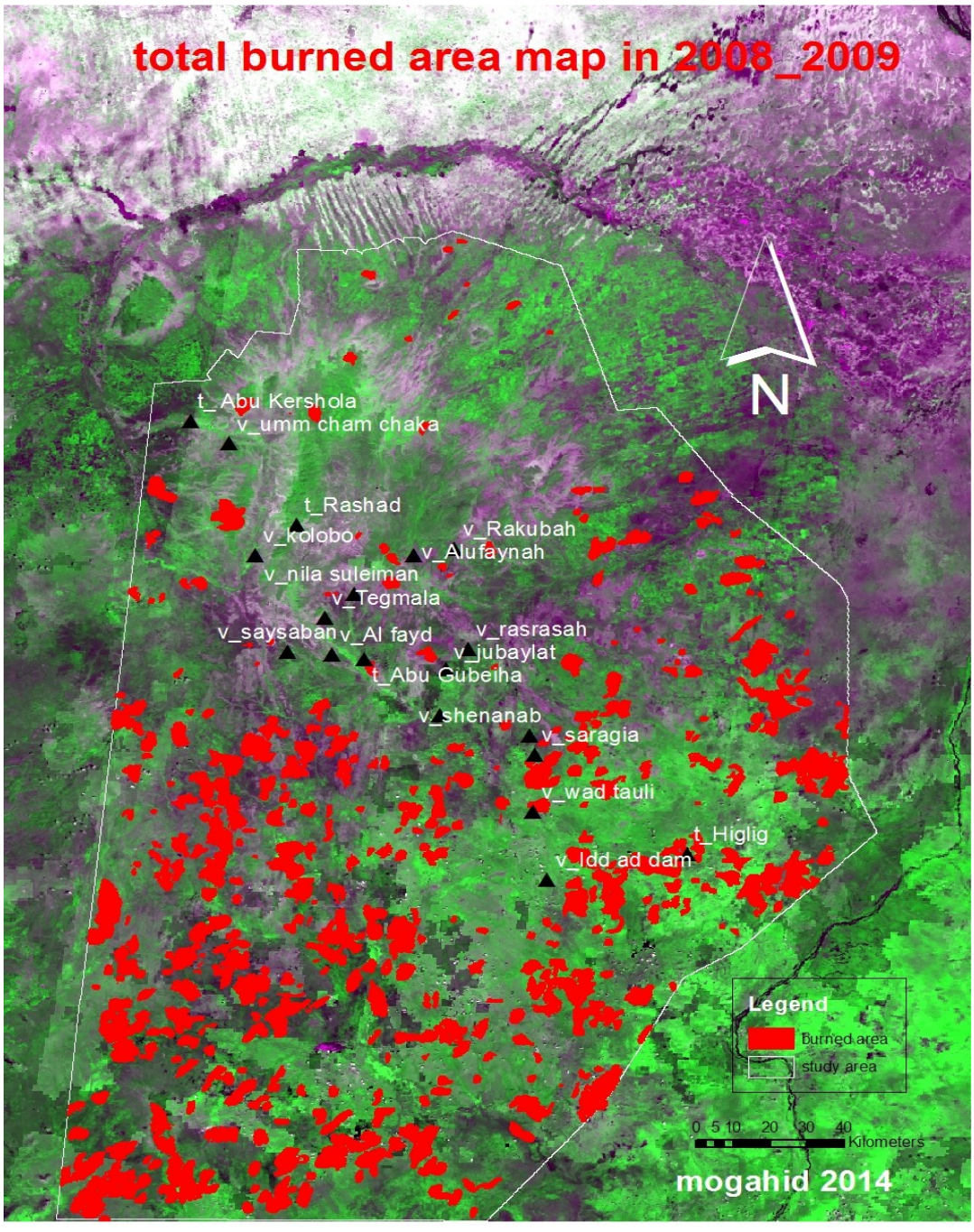
Appendix (7) Map of total burned area season 2006-2007 From Modis Sensor



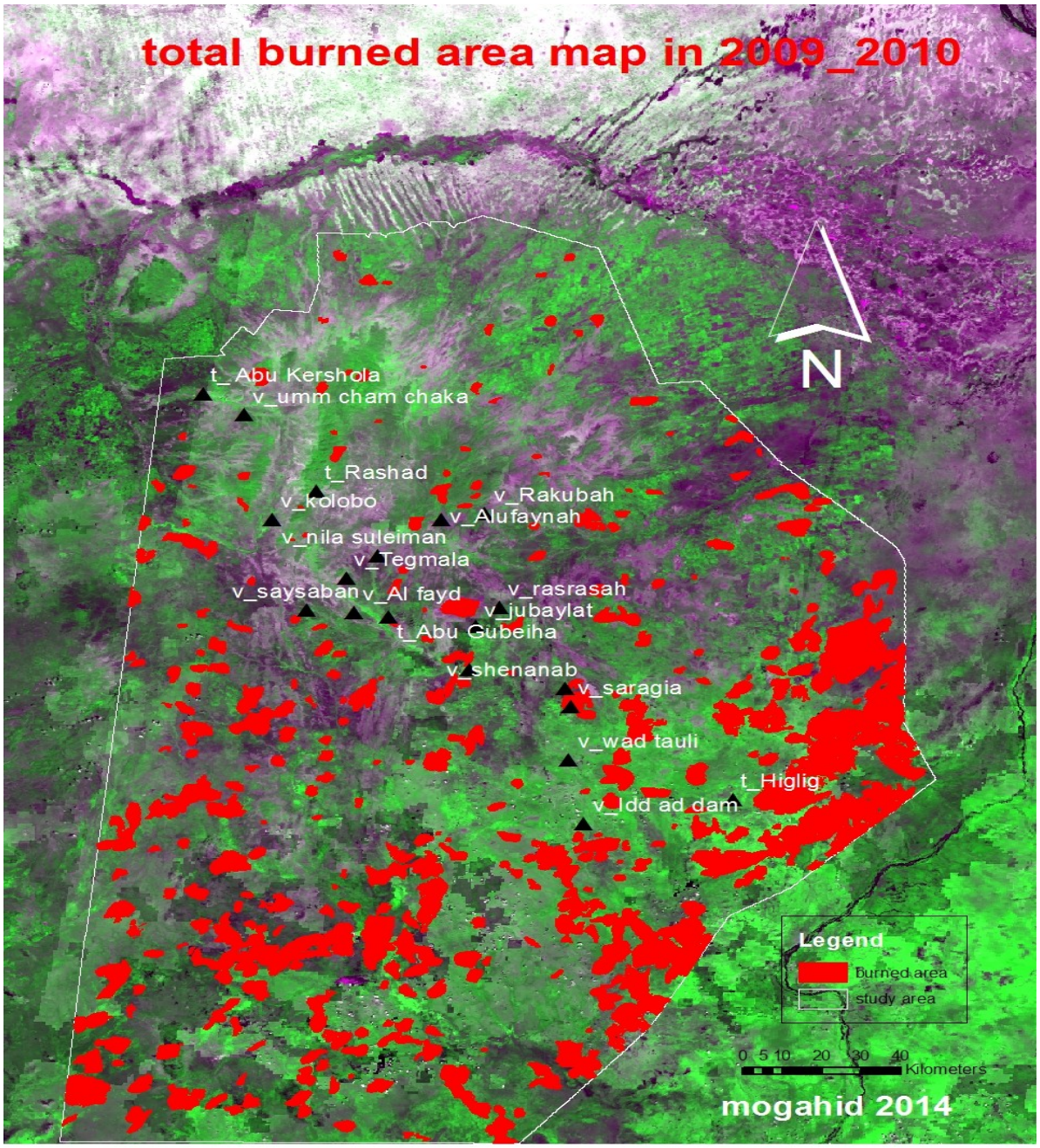
Appendix (8) Map of total burned area season 2007-2008 From Modis Sensor



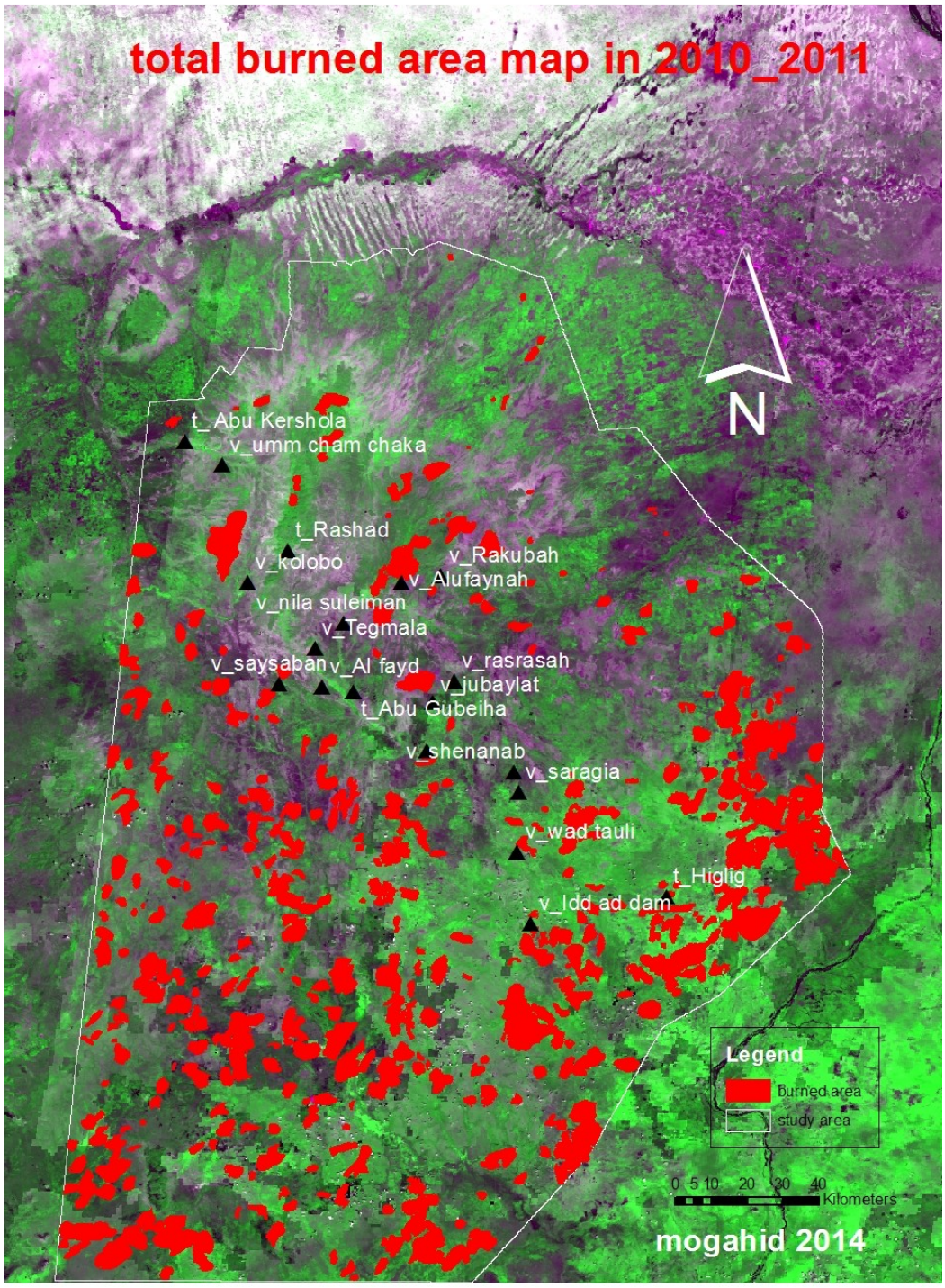
Appendix(9) Map of total burned area season 2008-2009 From Modis Sensor



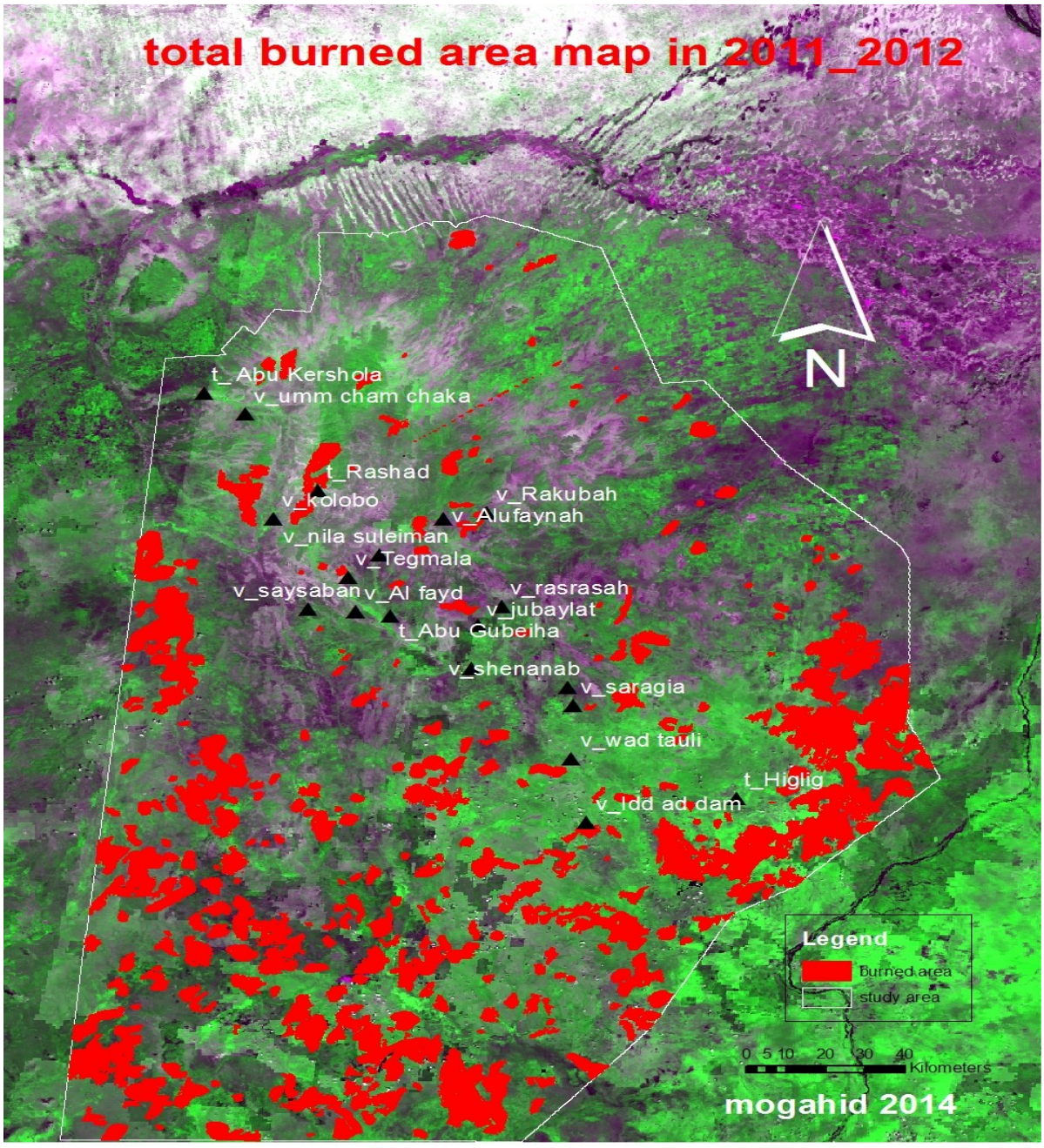
Appendix (10) Map of total burned area season 2009-2010 From Modis Sensor



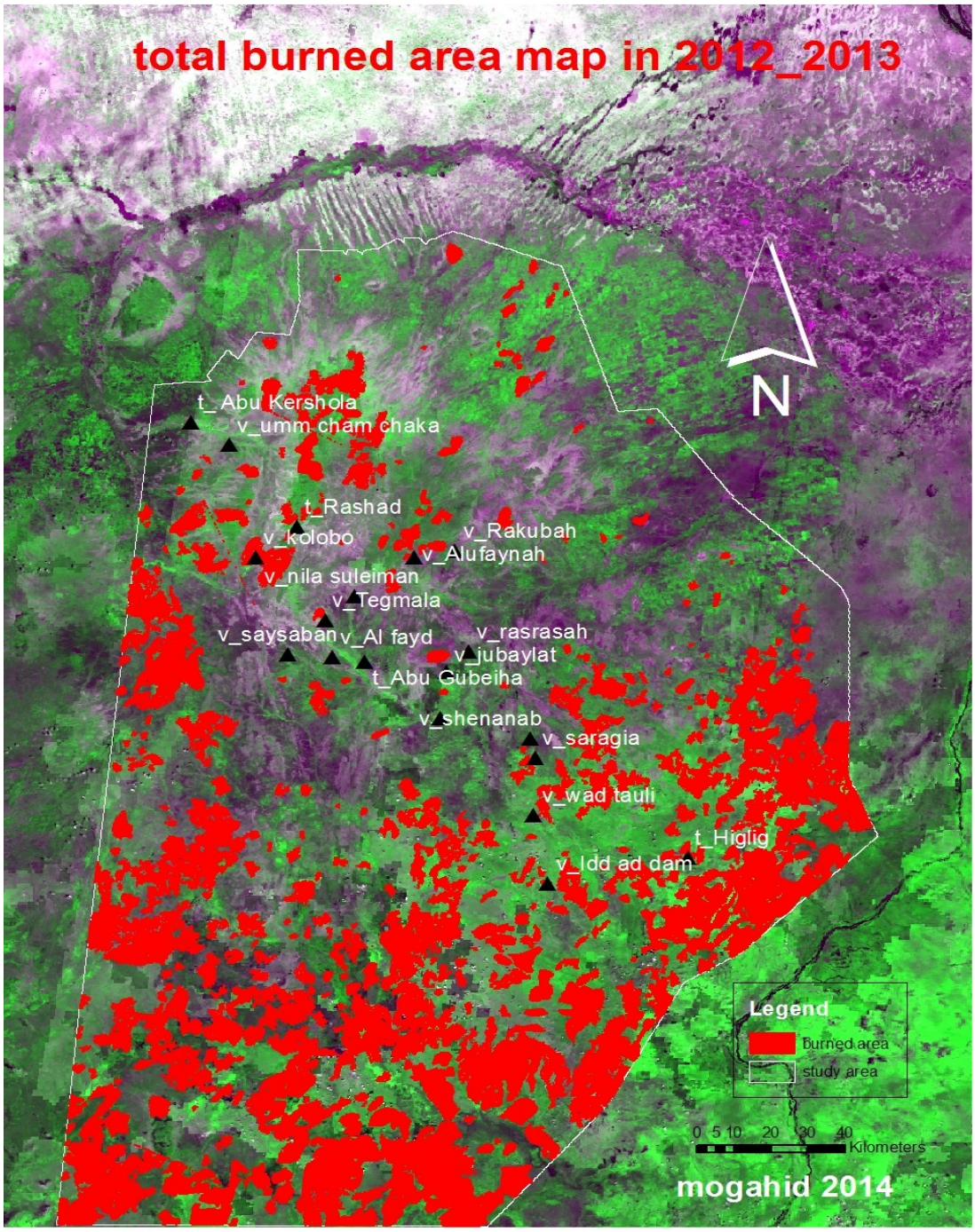
Appendix (11) Map of total burned area season 2010-2011 From Modis Sensor



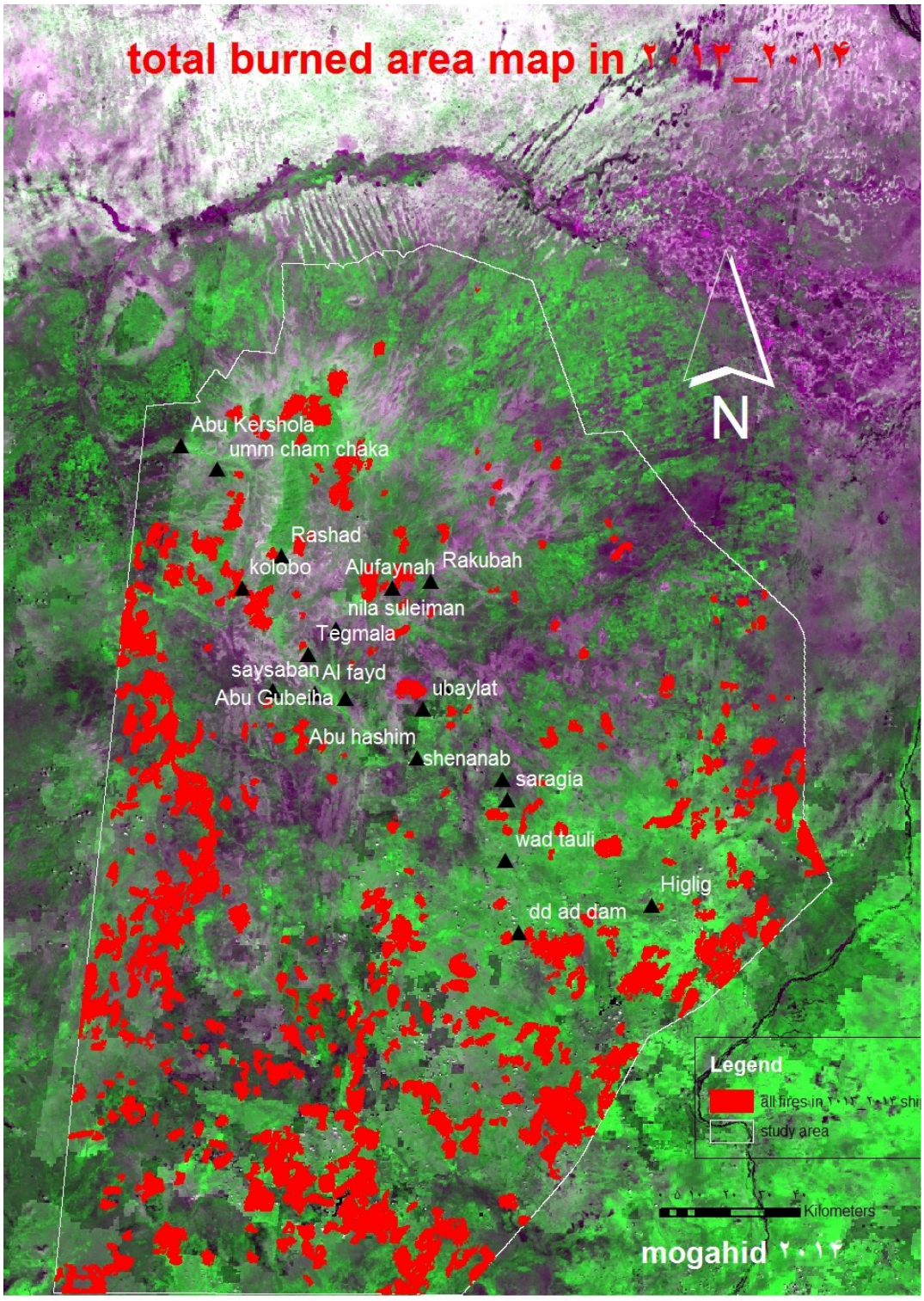
Appendix (12) Map of total burned area season 2011-2012 From Modis Sensor



Appendix (13) Map of total burned area season 2012-2013 From Modis Sensor



Appendix (14) Map of total burned area season 2013-2014 From Modis Sensor



Appendix (15) Fire Frequency mapFrom Modis Sensor