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Detection and Monitoring of Forest Fires in Dinder National Park, Sudan During 2010 - 2014 Using Remote Sensing Technology

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Abstract

This study aims to monitoring forest fire in Dinder National Park (DNP), Sudan, which is considered one of the richest biodiversity spots in the country. Being a typical savanna ecosystem, DNP is embedded in a highly fire-prone environment. The overall objectives of the study is to monitoring forest fire in DNP during 2010 - 2014, also to determine the burned areas by using application of remote sensing and GIS. As such, GIS layers (e.g. fire occurrences) were collected from NASA database and the climate data were collected from the global weather archive. The results showed that the fire occurred in 219.6, 419.6, 454.5, 372.4 and 375.1 ha, for 2010, 2011, 2012, 2013 and 2014, respectively (total area of DNP is about 1841.2 ha). During these four years, year 2012 witnessed a burning of about of 25% of the park area. Common causes of these forest fires in DNP include honey collection, farming and nomadic activities. We conclude that DNP authorities should focus on awareness-raising and extension programs to local communities to reduce the causes of these fire events but also to involve them in the management plan. Finally, this research provided insights about 5-years of fire patterns in DNP that can potentially be developed to a full wildfire database which can have substantial management implications in the future.

Keywords

Forest Fire, Remote Sensing, Dinder National Park

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1. Introduction

1.1. Definition of the Forest

Tropical forests are considered vital ecosystems that provide essential goods and services. Beside provision of foods, building woods, fuels, and livelihoods, tropical savanna woodlands, for example, serve as refuge and habitat for many wildlife populations and unique place for many ecological processes. Forest concepts and definitions influence how we assess and interpret forest transitions the change over time in the balance between forest loss and forest gain within a geographic region where both loss and gain are defined in terms of tree canopy cover [1]. This objective requires that forest be defined for the purpose of managing yield related characteristics over large spaces (many stands of timber) and long time periods (more than one rotation) in order to assess the amount of wood that could be harvested [2].

Use of different definitions leads to vastly different estimates of national and global forest cover [3]. For example, the estimate of global forest area increased by 300 million ha (approximately 10%) between 1990 and 2000 simply because

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the FAO's Forest Resources Assessment (FRA) changed its global definition of forest, reducing the minimum height from 7 to 5 m, reducing the minimum area from 1.0 to 0.5 hectares (ha) and reducing minimum crown cover from 20 to 10% [4]. In many cases, forest assessments do not distinguish between land covered by natural and planted forests [5]. Thus, if natural forests are cleared and replaced with plantations, no net loss of forest cover is reported [6]. Furthermore, tree harvesting from managed plantations is not distinguished from clearance from natural forest [7].

1.2. Forest Fire

Wildfires are common ecological phenomenon that frequently occurs in dry land tropics. For instance in Sudan, areas such as Dinder National Park (DNP) a savanna-dominated ecosystem, bush fires are a natural phenomenon occurs during dry season. Despite the ecological roles that fires play in the ecosystems but it obviously destroys everything in the forests including the resident wildlife communities. Thus, animals flee to look for safe refuge [8]. Nearly 62% of all post-fire forest area showed a non significant to Enhanced Vegetation Index EVI re-growth trend from 2000 to 2010. The trends of large post-fire forest regrowth and could be impacting the resilience of post-fire forest ecosystems [9]. Common causes of these forest fires in DNP include honey collection, farming and nomadic activities. However, the long-standing challenge for forest mangers is to control forest fires and reduce its devastating effects. To achieve this goal, usually forest mangers strive to get accurate and cost-effective information about fire events such as historical occurrences, extent, severity, causes, as well as re-current interval.

1.3. Remote Sensing Application

Currently, remote sensing becomes a quick and cheap technique for detecting and monitoring forest fires on a large scale. It has been used for a long period for fire detection in national parks. The use of Moderate Resolution Imaging Radio Spectrometer (MODIS) for fire detection has recently preceded AVHRR and a large number of fire products are being developed. MODIS based forest fire detection and monitoring system can solve the problem of real-time forest fire monitoring. The system facilitates data acquisition, processing, reporting and feedback on the fire location information in an automated manner [8]. The MODIS instrument is on board NASA's Earth Observing System (EOS) Terra (EOS AM) and Aqua (EOS PM) satellites. The orbit of the Terra satellite goes from north to south across the equator in the morning and Aqua passes south to north over the equator in the afternoon resulting in global coverage every 1 to 2 days [13].

1.4. Problem Statement and Justification

Many recent reports indicated that forest fire is notably decreasing the natural resources and threat people live. In addition to environmental, sanitary and biological risks, near the study area is thought to be severely affected. The impacts of wildfires are not limited to the respective areas or regions but affect ecosystems and livelihoods of people on a larger scale. In this research, we have been focused on forest fire in DNP, during 2010 - 2014 to assess its extent and distribution.

Forest fires can have strong influences on natural resources, human health, weather and climate. Post-fire forest re-growth has increasingly drawn interest from the climate change and global warming research communities. Previous studies have focused mainly on variations in recovery rates of biogeochemical cycling, carbon sequestration, and Satellite observed photosynthetic [10-12].

1.5. Objectives

The objectives of this research are to assessment and monitoring the forest fires in DNP area, from 2010 to 2014 and determine burned areas in each year use application of Remote Sensing (RS), Geographical Information System (GIS). Monitoring and management of forest fires is very important due to its economic and social impacts. It is important for national park mangers to have real time or near real time detection of active fires for early warning and for aids in fire fighting and management. Satellite remote sensing is documented to provide a useful means of detecting regional and local fires.

2. Material and Methods

2.1. Study Area

DNP is a national park and biosphere reserve in eastern Sudan, and is connected to Ethiopia's Alattash National Park. It established in 1935 to conserve its essential habitat and large number and a wide variety of wildlife. Dinder lies approximately 400 kilometers southeast of Khartoum, on either side of Dinder River bounded to the north by Rahad River. The town of Dinder (100 kilometers northwest) acts as a gateway for tourists wishing to enter the Park. DNP was established as a park in 1935 following the London Convention of 1933 and designated in 1979 as a member of the World Network of Biosphere Reserves.

The park is located between longitude 34 °C to 35 °C, and latitude 13 °C to 12 °C, covering an area of 3975 km^2. Two seasonal rivers water the park representing the dominant topographic feature of this area, namely Dinder and Rahad. Both the rivers descend from Abyssinian massif and flow directly westward and cross the plains in Sudan to join the

Blue Nile. The rainfall average 800 to 1000 mm annually, lasting from June the end of October with occasional showers in may. The northeast boundary of the park has the least amount of rainfall, which gradually increases towards the southeastern part.

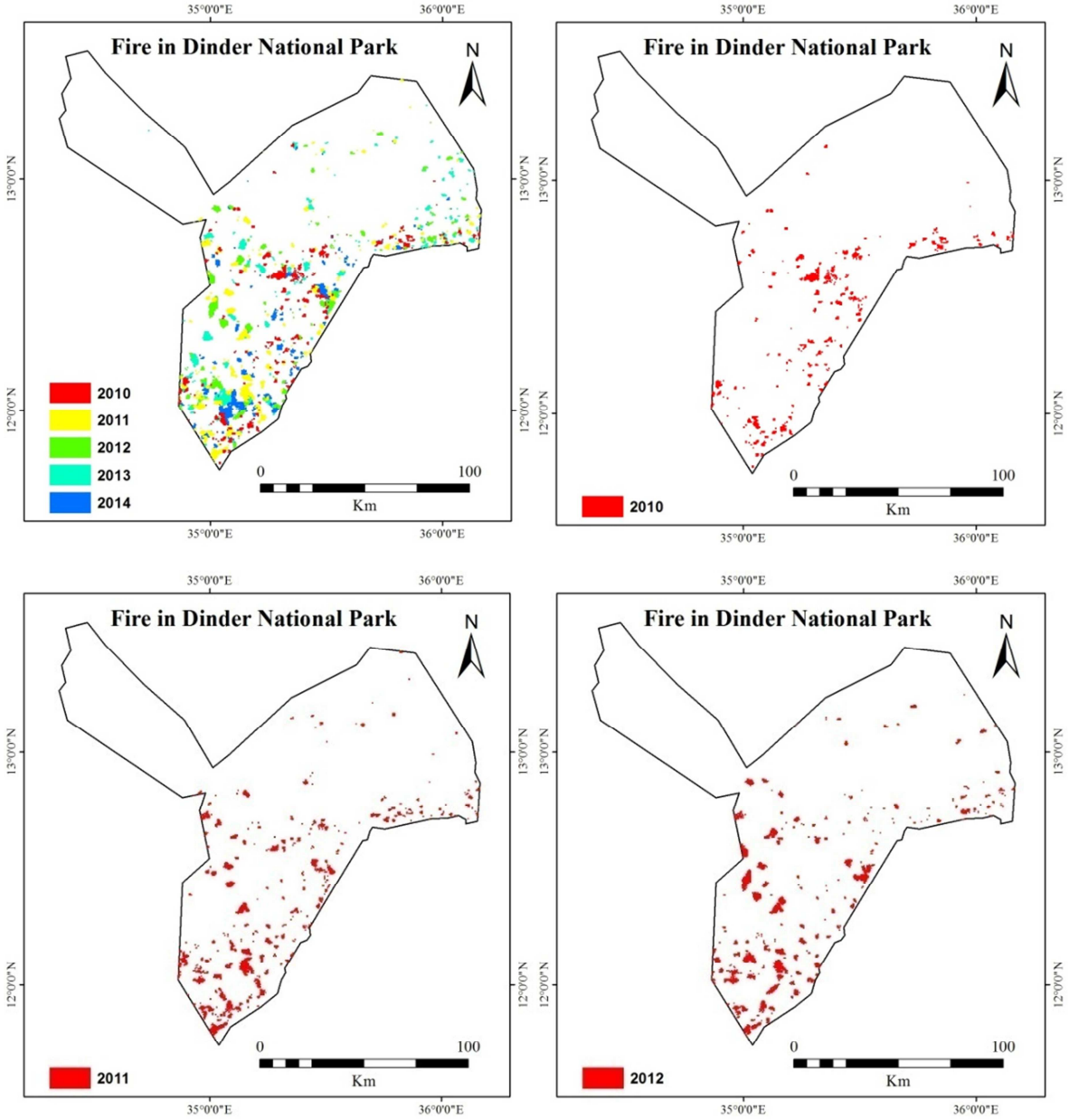
During the rainy season, the maximum temperatures are about 30 °C and the minimum around 20 °C. As the rains decline, the maximum rises. At the start of the cool dry weather in December, the daily maximum temperature average about 30 °C. By February and March the temperature average about 38 °C. In April and May the temperature, reach a maximum of 44 °C imposing extreme conditions of heat and desiccation on vegetation, which are relived only by the onset of the rainy season.

2.2. Material Methods

In this study, the vector shape file of fires is collected from NASA website to mapping the forest fires in DNP for 2010 to 2014 by using the ArcGIS software v 10.2. Documentation of spatial distribution and burned areas within the DNP for period of 2010 to 2014 was conducted.

3. Result and Discussions

As shown in Figure 1, most of forest fires in DNP during the five years is detected in the southeastern part that has a very dense vegetation cover. According to our ground survey and the verifications by images from Google map, also, this part of DNP has high amount of rainfall, thus not surprisingly, dense vegetation cover and subsequently occurrence of fires become frequent process in that side.



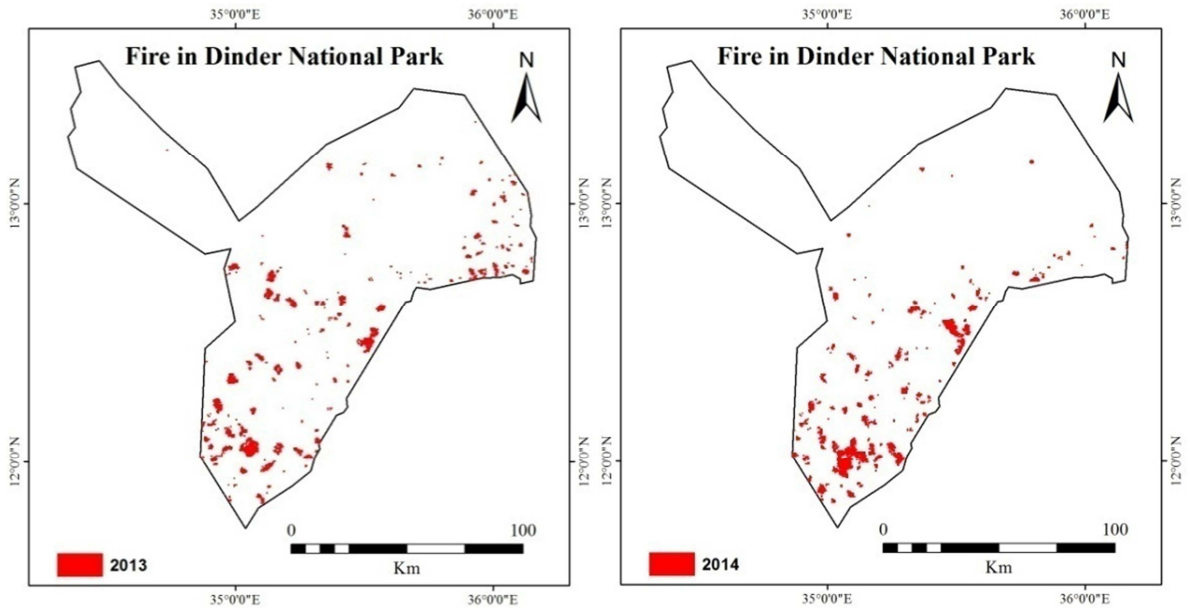


Figure 1. The distribution of forest fire in DNP from 2010 to 2014.

Our analysis revealed that fires occurred in all five years of the study period (i.e. 2010 - 2014) with different intensities and spread. From records of fire spread in these five years, burned areas in year 2010 was the smallest in the period representing only 11% of DNP area. On the other hand, year 2012 was the largest as it covered almost 25% of the park area. The frequency of occurrence of and areas covered by of forest fires in DNP are presented in Table 1 as burned area/ha. Also from personal communications we knew that mobility of nomadic tribes is a primary cause of these forest fires in DNP as from different activities such as honey collection following smoke method and food cooking.

Table 1. The total areas and percents covered by fires in DNP during 2010 to 2014.

Year	Area (hectare)	Area%
2010	219.6	11.9
2011	419.6	22.8
2012	454.5	24.7
2013	372.4	20.2
2014	375.1	20.4
Total	1841.2	100

4. Conclusion and Recommendation

The study concluded that DNP is a fire-prone area and subject to annually severe wildfire with an increasing trend that primarily caused by human activities. This situation can have adverse consequences on biodiversity in the park and can potentially contribute to the decline of many wildlife populations. The study recommends developing an integrated fire management plan with emphasis on the participation of local people. We also suggest provision of specialized training courses for DNP's rangers, forestry staff and local people on wildfire management activities and supporting them with the needed tools to enable them to perform their work safely and easily. We also emphasize the important role of extension awareness-raising in eliminating or reducing occurrence of wildfire and the necessity of attracting participation of local people in fire fighting. Finally we urge authorities to prepare a written fire management plan that suits the situation of the DNP, which contains fire detection, prevention, pre-suppression, and suppression plans.

Integrate the role of the local people participation into the fire management plan is also much needed intervention at the moment. They are the main wildfire causer and at the same time, they are the best potential fire fighters. Forest National Corp should devote an annual budget for fire lines cleaning before the beginning of October, in order to finish the work early before the grasses fully dried. This would give a chance to implement early burning (prescribed burning) to safely reduce the amount of the fuel. The incentives paid for the fire lines cleaning piecework should be reasonably enough to attract laborers for work. Also DNP should encourage local communities to follow a new and fire-free method for honey production (e.g. boxes) and the protective clothes to reduce or eliminate wildfires that occur due to honey collection with traditional methods.

Organizing the processes of agricultural land cleaning, that near the forests and involve the local leaders in this matter. Process of road construction should continue to facilitate quick access in case of wildfire occurrences. Supplying the park with well-distributed water pumps and trains some people to use and maintain them effectively. Develop a wildfire database system to keep statistics of wildfire

occurrence and causes in order to help in future planning. Lastly, this research recommended using the remote sensing and GIS techniques to monitoring future fire occurrences and extent in DNP.

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