Sudan J. Des. Res. Vol. 12 (1) :15-30, 2020

Evaluation and Modelling of Disturbances and Threats in Wad Al-Bashir Tropical Dry Forest, Elgadaref State, Sudan*

Nasradeen Gadallah[1,2], Abdelnasir Hano [1 ,2]and Omer Musa[1]

Faculty of Forestry, University of Khartoum, Khartoum, Sudan

Abstract: Tropical dry forests of Sudan provide multiple goods and services that are critical to sustaining societies and ecosystems; however, several emerging risks pose serious implications on their survival. Thus, this study aimed to assess, map and model the severity of anthropogenic, biotic and abiotic forest disturbances and threats in Wad Al-Bashir Forest (WAF), so as to restrict their impacts and hence combat and mitigate the adverse effects of drought and desertification. The ground-based-survey was used to gather the relevant data using a systematic sampling technique (800*800 m) where 54 circular sample plots were visited using a GPS device. In each sample plot, the effects of humans, pests, diseases, fire and wind have been recorded.Data gathered for this work, were ranked based on three criteria: threats presence, intensity and insistence; and subsequently analyzed through the interpolation tool in ArcMap software (Version 10.4.1) and eventually depicted on maps according to their adverse impacts as:severe, slight, mild and none, respectively. The results showed many forest disturbances and threats that varied in magnitude and spatial distribution. The rampant anthropogenic disturbances were farming activities followed by illegal tree cutting and uncontrolled grazing. The common biotic disturbances were invasive species (*Acacia nubica*), climbers and pests (*Sinoxylon senegalensis*)

* Part of thesis submitted by the author to the University of Khartoum, for the partial fulfillment of M.Sc. degree.

[1]Department of Forest Conservation and Protection, Faculty of Forestry, University of Khartoum, Khartoum, Sudan

[2]Desrtification and Desert Cultivation Studies Institute, University of Khartoum, Khartoum, Sudan

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

respectively. The most existing abiotic threats were: wind and fires sequentially. Conclusively, forest disturbances and threats exist inWAFwith different types and magnitude in spite of the continued forest authorities' efforts, which calls for extra conservation efforts. Thus, protecting this forest is crucial as human demand for forest products and services increases. This study, recommends a more sophisticated representation of forest disturbances and threats in the Sudan forested areas that considers their spatial, temporal and severity variabilities for long-term forest monitoring system.

Keywords: Tropical Dry Forest, Biotic Disturbances, Abiotic Threats, Sudan

INTRODUCTION

Forest ecosystems are important components of terrestrial ecosystems (Hu and Hu, 2020). The total area of global forest ecosystems is 3.99 billion hectares, accounting for 30.6% of the total landed area which represents the largest carbon stock in the global terrestrial ecosystem where approximately 45% of the carbon is being stored (FAO, 2015). Consequently, the conservation of forest vitality and biodiversity is vital for humankind as it provides enormous goods such as biological resources and ecosystem services(Ahmad and Goparaju, 2017). Forests estates cover about 58 % and 10.3% of Sudan's landed area in 1958 and 2015 respectively (FAO, 2015; Gadallah, 2019). Lately, the tropical dry forests of Sudan are facing many disturbances and threats such as deforestation, degradation and forest fires, which are responsible for deteriorating their conditions (Atta El Moula, 1985; Glover, 2005; Elsiddig *et al.*, 2007; Gadallah, 2018). As stated byHu and Hu (2020) the deterioration could occur in different forms and intensities, including natural disturbances such as wildfires, pests or human disturbances like trees harvesting and buildingconstruction.

According to Murphy and Lugo (1986), dry tropical and subtropical forests take place in areas where the mean annual biotemperature is higher than 17°C, mean annual rainfall is between 250-2000 mm, and the annual ratio of potential evapotranspiration to precipitation is higher than one. These factors are vital to the ecosystem structure and functions. The variability of Sudan's dry tropical forest ecosystems, coupled with the

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

scarcity of the environmental data available, allows only rough generalizations regarding their disturbances and threats types. Thus, the assessment and monitoring of these disturbances and threats represent a key point for environmental policy and for the management of environmental resources especially in the sub-Saharan African countries like Sudan (Hosonuma *et al.*, 2012; Paudel *et al.*, 2014; Joshi *et al.*, 2015; Bau, 2016; Tegegne *et al.*, 2016).

Reliable and functioning methods for forest disturbance and forest degradation assessment and mapping have become progressively vital for sustainable forest management (Hirschmugl *et al.*, 2017). In this regard, the current progress in science and technology (i.e. remote sensing and Geographical Information System (GIS) provided an opportunity to track and monitor the changes taking place on the Earth's surface including Sudan (Ahmad and Goparaju, 2017; Gadallah, 2018; Hu and Hu, 2020). Moreover, the analysis of ground-based-surveyed-data in GIS is also reported to provide insight into the various driving factors that lead to the loss of biodiversity in the threatened tropical dry forests.While the conventional approach of remote sensing for land use/land cover change detection was used widely to compare and detect the differences between two or more remotely sensed images. This study takes the ground-based data for evaluating and modeling the intensity and distribution of the forest threats and disturbances in WAF as one of the Sudan's forested areas.

Sudan's forest estates are considered among the most important features to its environment, where they form with other varying intensities of plant cover, the base for the terrestrial ecosystems of the country (FAO, 2010). These forests support agriculture through ameliorating an otherwise harsh climate, combat soil erosion, conserve water, contribute to carbon sequestration as well as playing a vital role in the economy and welfare ofpeople; through providing a wide range of benefits (Elsiddig *et al.*, 2007). Yet, these resources have been threatened by many factors and information regarding these threats, status' changes and nature of these changes is required for scientific, management and policymaking purposes. Understanding the nature of forests' disturbances and threats is an important step to ensure an accurate and up-to-date state of forests over time and space to predict their present and future dynamics (Hermosilla *et*

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

al., 2019). Hence, this study attempted to gather relevant information on the anthropogenic, biotic, abiotic tropical dry forests' disturbances and threats as well as their spatial distribution and extent rate using a ground-based-surveyed inWAF. Understanding their spatial distribution and dynamic changes in this forest is of great importance for the ecological security and communities' livelihood sustainability.

MATERIALS AND METHODS

Study Area:

This area has been selected due to its geographical position in Sudan's dry regions category (class two i. e. moderately desertified), that is characterized by a fairly good vegetation cover but, currently, these areas witness a serious degradation (NDDC/UNDP, 2006). Wad Al-Bashir Forest lies in the southwestern part of Elgadaref State of Sudan (Figure 1) between Al-Hawata and Al-Mafaza areas, at the longitude of 3436▪ 36▪ ″E - 3430▪ 37▪ ″E and latitude 9▪ 30▪ 13″N -13▪ 3319▪ ″N, with an area of 3,468 hectares. This forest is located in the semi-arid zone, with summer rains and warm winter, unimodal rainfall pattern that ranges from 400 to 800 mm (Glover, 2005). The temperature is very high in summer and mild in winter, the average daily maximum temperature ranges from 25° to 40° C.Furthermore, and as reported by Harison and Jackson (1958), this area is located in the zone of low rainfall woodland savanna on clay, near the transition between low-rainfall woodland savanna on clay: *Acacia mellifera* thorn land and *Acacia seyal-Balanites* a*egyptiaca* woodland.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

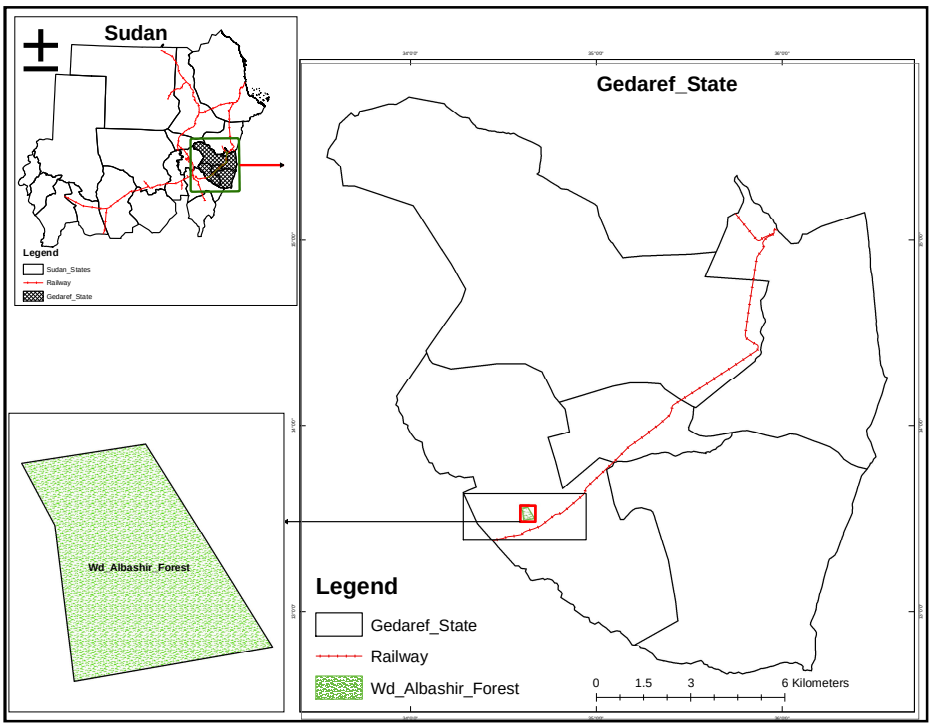

Figure 1:Wad Al-Bashir ForestinElgadaref State, Sudan
Source: Author under construction

Data Collection

A ground-based-survey technique was adopted for gathering the biotic and abiotic forest disturbances and threats. Map Source and ArcMap (Version 10.4.1) softwarewere used to create the geo-samples that have been subsequently visited through the GPS device. Thus, this survey was accomplished using systematic sampling technique, where the distance between the survey lines is 800 m and also between the sample plots (i. e. 800*800 m). The sample plot was designed as a circular form with a 100 m radius = 31,400 m^2 constituting about 5% of the study area as depicted in Figure 2. At each sample plot; detrimental factors (i.e., pests, diseases or their symptoms, sign of trees cutting, sign of fire destruction, sign of grazing (stunted trees), agriculture activities, effects of winds ...etc.) along with the types and numbers of attacked tree species have been recorded. Additionally, trees regeneration and the dominant tree species were also recorded. This method was able to assess and depict WAF's conditions

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

including its abiotic and biotic disturbances rigorously during the period of 11-17 December 2017.

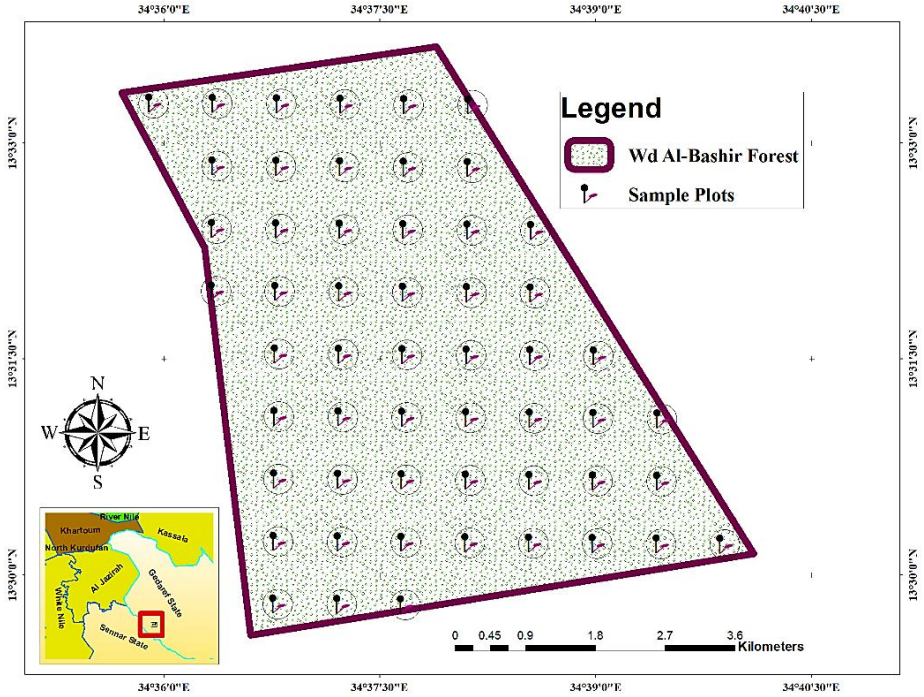

Figure 2: Systematic circular sample plots (800*800m) in WAF

Data Analysis

Data concerning the current conditions, disturbances and threats inWAF that affected its trees' health, have been subjected to analysis. Each threat was then ranked based on three criteria: a) threats presence, b) Intensity (the impact of the threat on the trees; will it destroy the entire sample or part of it), c) Insistence (the reoccurrence of the threat; will the threat occur in the near or far years in the future). Accordingly, the disturbances and threats were coded and given grades (0, 5 or 10) and subsequently analyzed through the tool of interpolation in Arc-Map software for which maps have been produced. For instance, if the number of trees affected by illegal cutting at a particular sample were more than five trees; this was coded under 10, and 5 when the number less than five, and samples that have not experienced any disturbance or threat were given zero.

In some instances; such as insects' infestations effect, disease damage, fire destructions, climbers and wind effects, whose occurrence was quite

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

rare, these were given 10 even if the affected trees are less than five. Subsequently, these values were shown in figures and maps indicating places that have been influenced by specific risk or illegal acts, along with the severity of their effects as:severe, slight, mild and none, respectively.

RESULTS AND DISCUSSION

In this study, sites that presented several disturbances and threats across WAF, were mapped, reported and analyzed with reference to the disturbance agents, their distribution and severity because agents vary in their types and effects among locations. For instance, Silayo and Macrice (2016) have categorized the types of forests disturbances and threats as discrete forces that cause significant changes in the forests' structure and composition through either natural events such as fire, flood, wind, or biological agents like insects, disease, or by human-caused events such as trees' logging. Hence, this study identified three categories of forest disturbances and threats i.e. anthropogenic disturbances, abiotic threats as well as biotic disturbances, and each of these disturbances and threats was ranked according to its impact degree as severe, slight, mild and none.

Spatial Distribution and Severity of Anthropogenic Disturbances

The nearness and accessibility to the forests and their goods and services are of particular importance to human well-being in rural and urban areas specially if their livelihood mostly depend on forests (Gadallah *et al.*, 2019; Referowska-Chodak, 2019). Thus, the results of this study found communities around WAF depend largely on wood and non-wood forest products for their energy, buildings and food purposes. However, many human-related-activities are observed as forest disturbances that affected and were distributed in many sites across the forest with different types and impacts severities (see Figure 3). Accordingly, their effects were ranked as severe, slight, mild and none respectively.

It is commonly known that the high frequency of such disturbances or threats is an indicator of their impacts; however, in some instances, small but frequent disturbances can create huge effects (Sierota *et al.*, 2019). The greatest disturbances in terms of severity and distribution in WAFarea were farming activities, illegal tree cutting and uncontrolled

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

grazing, respectively (see Figure 3). Therefore, the effects of these disturbances will increase rapidly if the human population increases, which leads to high pressure on the available forest resources.

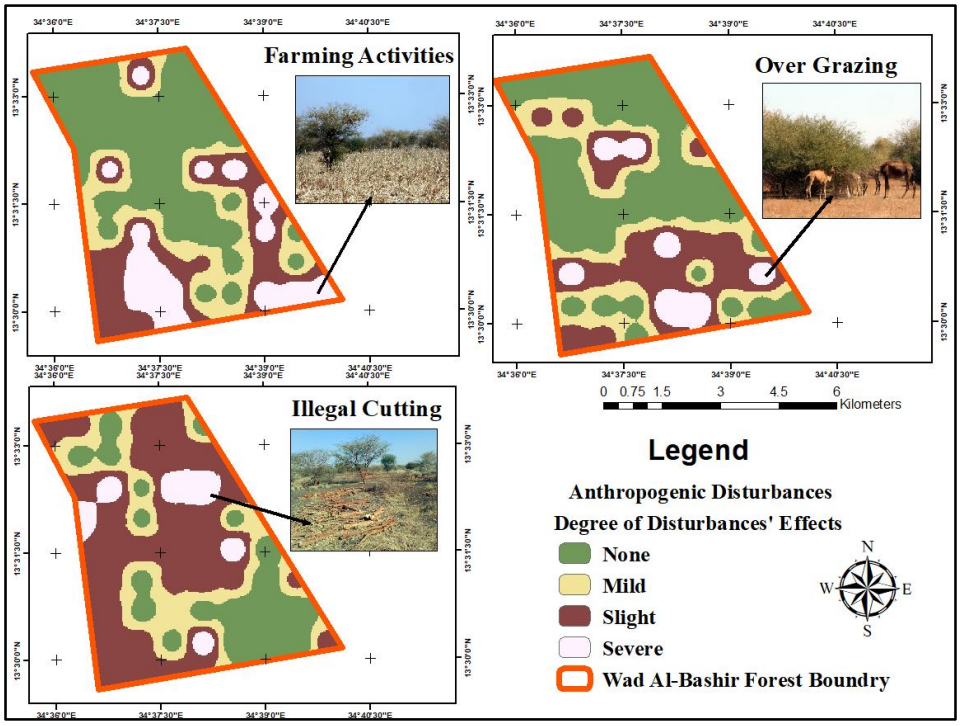

Figure 3: Distribution and severity of the anthropogenic disturbances

Accordingly, the farming activities inside WAF have caused serious deterioration of forest cover as well as its tree health. Likewise, the presence of domestic animals in WAF was found to be derived by agriculture schemes expansion on the account of rangelands. Moreover, illegal tree logging was also rampant by these communities so as to meet their needs for energy, building materials as well as other livelihood aspects.

Generally, these communities were found to favor some species more than others when they are cutting. *Acacia seyal* was preferred for most purposes including energy and other traditional uses by women. Similarly, animals have preferences when they are feeding; in terms of tree species, ages and heights. For instance, camels favor *Acacia senegal*

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

trees at small age or when the small branches sprout, while goats prefer the seeds and buds which both prohibit trees' regrowth and regeneration and subsequently will result in land use/land cover changes. The land-use change by these activities poses a serious threat to forestland throughout the country as well as creating problems such as deforestation, fragmentation, habitat destruction, environmental deterioration and inappropriate forest management as reported in plethora of literature (Joshi *et al.,* 2015; Tegegne *et al.,* 2016; Ahmad and Goparaju, 2017;Gadallah, 2018).

Spatial Distribution of the Forest Biotic Disturbances

The second category of the forest disturbances focused on the biotic disturbances that include: insects, invasive plants, pathogens and climbers that alter forest structure and the capability of the forests to deliver ecosystem services (Kautz *et al.*, 2017). Therefore, the distribution and severity of the rampant disturbances in the study area were reported and depicted in Figure 4, where the effects of invasive species such as *Acacia nubica*, climbers and pests (*Sinoxylon senegalensis*) were clearly presented.

Furthermore, the effects and distribution of biotic disturbances was reported to be influenced by forest types and surrounding conditions including the competition and trees diversity. In this regard, Randhir and Erol (2013) have considered these biotic disturbances as threats that have different sets of interventions, probability of occurrence and magnitude of damage. Moreover, the local movement of people and animals have facilitated the introduction of some exotic species such as *Acacia nubica* which might replace the dominant species if nothing has been done to manage it.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

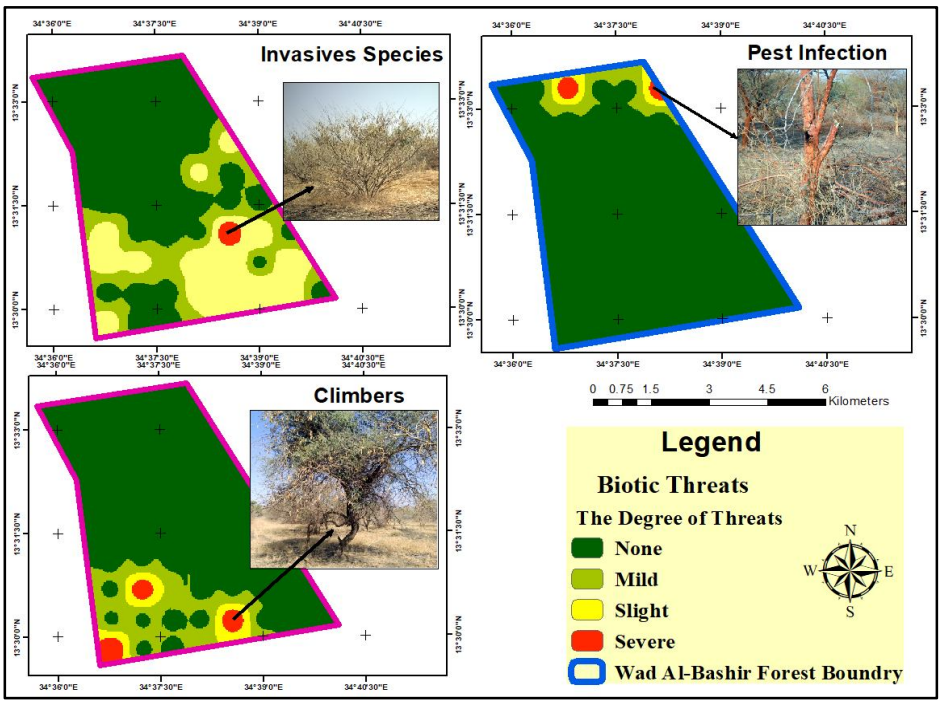

Figure 4: Spatial distribution and severity of biotic disturbances

Distribution of Forest Abiotic Threats and their Effects

The result of this study depicted the most common two abiotic threats in the study area, which were wind and fires. Other threats such as high and low temperature have not been considered in this study. However, the local and global changes in the climate are reported to have influences on the occurrence, season, frequency, duration, extent, and intensity of the forest disturbances and threats (Randhir and Erol, 2013).

Although, the effect and distribution of the two threats was not significant,the wind effect was visible in the old trees, while fire threat was infrequent in term of distribution and occurrence. However, the impact of forest fire is reported as severely eroding forest biodiversity and ecosystem services even if in small scale (Seidl *et al.*, 2017).Therefore, precautionary efforts are needed to halt and hinder any forest fire incidences.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

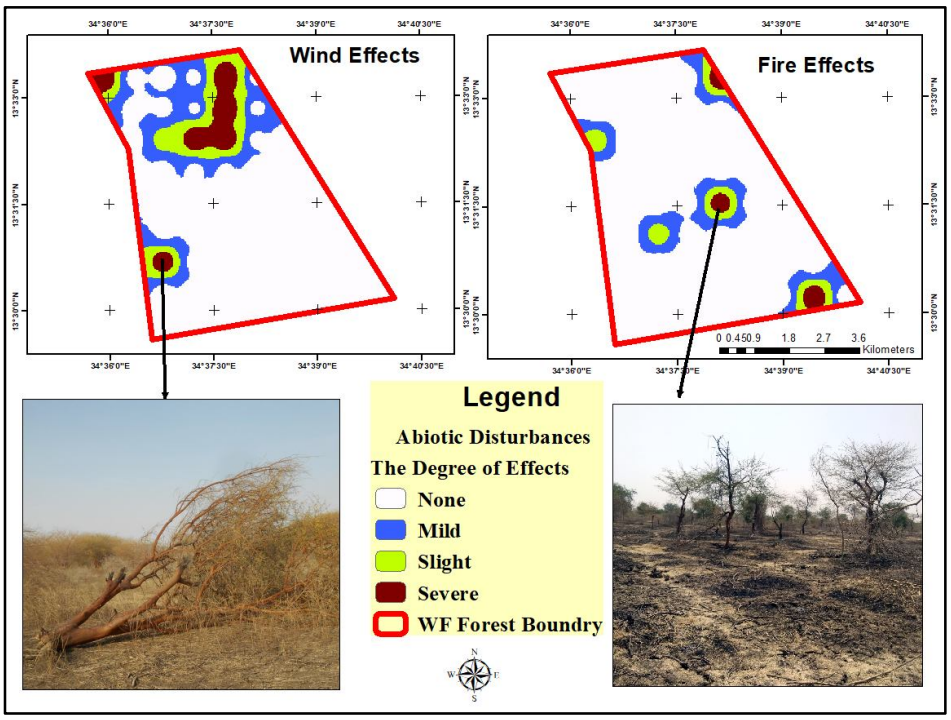

Figure 5: Distribution and effects of abiotic threats

CONCLUSIONS AND RECOMMENDATION

Tropical dry forests of Sudan are critical parts of its terrestrial ecosystemsand human life. Although there are multiple ecosystem services provided by these forests, several emerging disturbances and threats call for a rehabilitated approach to manage them. Thus, the results of this study explored the existing forest disturbances and threats as well as their potential extent and distribution in WAF, which will help in developing forest management policies and strategies. Therefore,disturbances and threats observed in the study area were varied in magnitude and spatial distribution. The rampant anthropogenic disturbances were farming activities followed by illegal tree cutting and uncontrolled grazing. The common biotic disturbances were invasive species (i.e.*Acacia nubica*), climbers and pest (e. g *Sinoxylon senegalensis*), respectively, and the existing abiotic threats were winds and fires effects.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

The status of forest disturbances and threats in spite of the Forest National Corporation (FNC) efforts, calls for extra efforts for sustaining WAF. Thus, protecting the forest systems is imperative as human demand for forest products and services increase.The management of forest disturbances and threats along with reforestation activities will potentially reduce the negative trend of the forest degradation. For future research, this study recommends a more sophisticated representation of forest disturbances and threats in Sudan's tropical dry forest that considers the spaetial and temporal variability and distribution on a long term basis, and an improved forest monitoring system to provide accessible, precise and consistent data on forest disturbances and threats occurrence and severity.

Acknowledgment
Many thanks are given to the staff of Desertification and Desert Cultivation Studies Institute - University of Khartoum as well as colleagues that participated directly or indirectly in the data collection and analysis process. Thanks are to for the contributions of Sudan National Forest Corporation personnel in Khartoum and Elgadaref States. Special thanks are due to the financial support provided by the Ministry of Higher Education and Scientific Research.

REFERENCES

Ahmad, F., and Goparaju, L. 2017. Assessment of Threats to Forest Ecosystems Using Geospatial Technology in Jharkhand State of India. Current World Environment 12: 355-365.

Atta El Moula, M.E. 1985. *On the Problem of Resource Management in the Sudan*. Environmental Monograph Series (no 4). Khartoum. Sudan.

Bau, D.E. 2016. *Deforestation and forest degradation in southern Burkina Faso: Understanding the drivers of change and options for revegetation.* A Ph.D.Thesis, University of Helsinki, Finland.

Elsiddig, E.N.A., Mohammed, A.G., and Magid, T. A. 2007. *Sudan forestry sector review.* Khartoum, Sudan.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

FAO, 2015. *Global Forest Resources Assessment* 2015 - Desk reference. Food and Agriculture Organization of United Nations. Rome. Italy

FAO, 2010. *Global Forest Resources* - Sudan Report. Food and Agriculture Organization of United Nations. Rome. Italy

Gadallah, N.A. 2018. *Assessment of Sudan Forest Management Policies and Practices In Relation To Deforestation and Forest Degradation Drivers in Tozi and Wad Al-Bashir Forests*. M.Sc. Dissertation, Pan African University, Nigeria.

Gadallah, N. A., Adewole, N.A. and Ajayi, D.D. 2019. Potential of agroforestry as forest landscape restoration tool to solve forest cover loss cum food security in Sennar and Gedaref States, Sudan. International Journal of Development and Sustainability 8: 199-210.

Glover, E.K. 2005. *Tropical Dryland Rehabilitation: Case Study on Participatory Forest Management in Elgadaref , Sudan*. A Ph.D.Thesis, University of Helsinki, Finland.

Harison and Jackson, 1958. *Ecological Classification of Vegetation*. The Sudan Agricultural Publications Committee, Khartoum, Sudan.

Hermosilla, T., Wulder, M.A., White, J.C., and Coops, N.C. 2019. Prevalence of multiple forest disturbances and impact on vegetation regrowth from interannual Landsat time series (1985–2015). Remote Sensing of Environment 233: 111403.

Hirschmugl, M., Gallaun, H., Dees, M., Datta, P., Deutscher, J., Koutsias, N., and Schardt, M. 2017. Methods for Mapping Forest Disturbance and Degradation from Optical Earth Observation Data: a Review. Current Forestry Reports 3: 32–45.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R.S., Brockhaus, M., Verchot, L., Angelsen, A., and Romijn, E. 2012. An assessment of deforestation and forest degradation drivers in developing countries. Environmental Research Letters 7: 044009.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Hu, Y. and Hu, Y. 2020. Detecting Forest Disturbance and Recovery in Primorsky Krai, Russia, Using Annual Landsat Time Series and Multi–Source Land Cover Products. Remote Sensing 12: 1–21.

Joshi, N., Mitchard, E.T.A., Woo, N., Torres, J., Moll-Rocek, J., Ehammer, A., Collins, M., Jepsen, M.R., and Fensholt, R. 2015. Mapping dynamics of deforestation and forest degradation in tropical forests using radar satellite data. Environmental Research Letters 10:34014.

Kautz, M., Meddens, A.J.H., Hall, R.J., and Arneth, A. 2017. Biotic disturbances in Northern Hemisphere forests – a synthesis of recent data, uncertainties and implications for forest monitoring and modelling. Global Ecology and Biogeography 26: 533-552.

Murphy, P.G., and Lugo, A.E. 1986. Ecology of tropical dry forest. Annual Review of Ecology and Systematics 17: 67-88.

NDDC/UNDP, 2006. *Sudan National Action Programme (SNAP)*, Republic of Sudan-Ministry of Agriculture and Forestry National Drought and Desertification Control Unit, Khartoum, Sudan.

Paudel, N.S., Khatri, D.B., Karki, R., Paudel, G., and Fenton, D. 2014. Understanding of deforestation and forest degradation in Nepal : potential policies and measures for REDD +.Unasylva 62: 238.

Randhir, T.O., and Erol, A., 2013. Emerging Threats to Forests: Resilience and Strategies at System Scale. American Journal of Plant Science 4: 739-748.

Referowska-Chodak, E. 2019. Pressures and threats to nature related to human activities in European urban and suburban forests. Forests10: 765-771.

Seidl, R., Thom, D., Kautz, M., Martin-Benito, D., Peltoniemi, M., Vacchiano, G., Wild, J., Ascoli, D., Petr, M., Honkaniemi, J., Lexer, M.J., Trotsiuk, V., Mairota, P., Svoboda, M., Fabrika, M., Nagel, T.A., and Reyer, C.P.O. 2017. Forest disturbances under climate

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

change. Nature Climate Change 7: 395-402

Sierota, Z., Grodzki, W., and Szczepkowski, A. 2019. Abiotic and biotic disturbances affecting forest health in Poland over the past 30 years: Impacts of climate and forest management. Forests 10: 1–17.

Silayo, D.S., and Macrice, S.A. 2016. Disturbances and threats in village forest reserves potential for community based forest management in Ludewa. Njombe, Tanzania.

Tegegne, Y.T., Lindner, M., Fobissie, K., and Kanninen, M. 2016. Evolution of drivers of deforestation and forest degradation in the Congo Basin forests : Exploring possible policy options to address forest loss. Land Use Policy 51: 312–324.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

تقييم ونمذجة المضطربات والمهددات بغابة ود البشير الاستوائية-الجافة، ولاية القضارف، السودان*

نصرالدين جادالله[1]، عبد الناصر هنو[2] وعمر موسى[3]

كلية الغابات، جامعة الخرطوم، ولاية الخرطوم، السودان

مستخلص البحث: توفر الغابات الاستوائية الجافة في السودان منتجات وخدمات متعددة وحيوية لإستدامة المجتمعات والنظم البيئية؛ ومع ذلك، فإن العديد من المضطربات والمهددات ذات الصلة لها آثار خطيرة على بقائها واستدامتها. لذا يهدف هذا البحث إلى تقييم وتخريط وإنشاء معلومات عن وجود، شدة وخطورة هذه المضطربات والمهددات الناتجة عن الأنشطة البشرية والأحيائية وغير الأحيائية بناءً على الظروف الحالية في غابة ود البشير بولاية القضارف السودانية، بهدف الحد من آثارها وتعزيز إستدامة هذه الغابات وبالتالي مكافحة وتخفيف الآثار السلبية للجفاف والتصحر. تم استخدام طريقة المسح الأرضي لجمع البيانات من خلال أخذ عينات منتظمة (800 * 800 م) حيث تمت زيارة 54 نموذج عينة دائرية (نصف القطر 100 م = 400،31 م^2 - تمثل حوالي 5٪ من مساحة منطقة الدراسة) بمساعدة جهاز تحديد المواقع الجغرافية (GPS)، حيث تم في كل نموذج عينة تسجيل الآثار السلبية لأنشطة الإنسان، الآفات، الأمراض، الحرائق، الرعي، الأنشطة الزراعية وآثار الرياح . ثم تم تصنيف البيانات التي تم جمعها بناءً على ثلاثة معايير: وجود المضطربات والمهددات ، كثافتها و فترات حدوثها، ومن ثم تم تحليلها من خلال أداة الاستيفاء/النمذجة في برنامج ArcMap وتم إخراجها في خرائط وفقًا لتأثيراتها المدمرة الى: شديدة، طفيفة، خفيفة وغير موجودة على التوالي. أظهرت النتائج العديد من المضطربات والمهددات الغابية في منطقة الدراسة والتي اختلفت في حجم تأثيرها والتوزيع المكاني. كانت المضطربات المتفشية من الأنشطة البشرية هي الأنشطة الزراعية متبوعة بالقطع غير القانوني للأشجار والرعي الجائر. بينما كانت المضطربات الحيوية الشائعة هي الأنواع الغازية (اللعوت)، المتسلقات والآفات (سوسة الطلح) على التوالي. بينما كانت المهددات غير الحيوية الموجودة هي الرياح والحرائق بالتتابع. خلص البحث الى أن أضرار مهددات ومضطربات الغابات موجودة في غابة ود البشير بدرجات مختلفة على الرغم من الجهود المتواصلة التي تبذلها سلطات أدارة الغابات، الأمر الذي يستدعي بذل جهود إضافية لاستدامتها. وبالتالي فإن حماية هذه الغابات أمر ضروري مع زيادة طلب الإنسان على منتجاتها. لذا نوصي بتمثيل أكثر يضم كل المضطربات والمهددات الغابية في جميع غابات السودان التي تراعي بشكل أفضل التقلبات المكانية والزمانية وتوزيعها على المدى الطويل، ونظام متطور لرصد ومتابعة الغابات بهدف توفير بيانات دقيقة ومتسقة عن شدة وحدوث هذه المهددات.

---

*جزء من اطروحة تقدم بها الباحث الأول لجامعة الخرطوم للحصول على درجة الماجستير في دراسات التصحر

[1]طالب دراسات عليا سابقا، حاليا استاذ بقسم صيانة ووقاية الغابات - جامعة الخرطوم، ولاية الخرطوم، السودان

[2]أستاذ مساعد بقسم صيانة ووقاية الغابات بجامعة الخرطوم، بحري، ولاية الخرطوم، السودان و منسق التشجير الغابي بمعهد دراسات التصحر واستزراع الصحراء، بحري، ولاية الخرطوم، السودان

[3]أستاذ مشارك بقسم صيانة ووقاية الغابات بجامعة الخرطوم، بحري، ولاية الخرطوم، السودان

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)