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Assessment and Mapping of Land Cover/ Use Aided by Remote Sensing and GIS Techniques in Elnour Natural Forest, Blue Nile State, Sudan

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ABSTRACT

The main aim of this study was to assess and mapping of land cover (LC) / land use (LU), using Remote Sensing (RS) and Geographical Information System (GIS) techniques in Elnor natural forest reserve, Blue Nile state Sudan. The study attempted also to update some information in the study area such as LC and contour map by using different methods of data transformation and analysis such as Normalized Different Vegetation Index (NDVI), interpolation and supervised classification. Thematic Mapper (TM), Landsat Enhanced Thematic Mapper (ETM+) and Landsat8 images were used in LCLU changes and supported by field observation. The study area was affected by cutting the mother trees and overgrazing. Closed forests during 2000, 2010 and 2019 decreased from – 36.9%, 28.5% and 18.7% respectively. Moreover, the total area of bare soil increased by about 14.4%, 47.2% and 39.7% in 2000, 2010 and 2019 respectively. The open forest (grassland) decreased from 48.7% in (2000) to 41.7% in (2019). A Digital land cover map was produced using LCCS software; depending on the fieldwork data they were found four Classes. Mixed Woodland Single Layer, Semi-Deciduous Shrub land with Open Herbaceous, Open Grassland, Single XII Layer and Hardpans. The study revealed that there are some indicators of land degradation during the last 20 years (2000, 2010 and 2019) and is expected to continue increasing unless serious measures are carried out to reduce it.

Keywords: Land cover/land use evaluations, NDVI, wood cutting, overgrazing, deforestation, LCCS Remote Sensing and GIS.

Introduction

Change detection, as one of the most important applications of remote sensing, determines changes both quantitatively as well as qualitatively. It rests upon the assumption that under the same atmospheric conditions and sensor characteristics the major source for the difference in a pixel's brightness is a change of surface cover. There are two basic methods of change detection by means of remote sensing, explicitly post-classification and pre-classification methods (Lunetta, 1999). Land use and cover data are collected through the combination of direct observation and remote sensing, with the latter being the most widely used method (Campbell, 2007). Satellite data has been valuable in partnership with socioeconomic surveys and census data for a better understanding of land use/cover dynamics and the factors that drive them (Dale, 1997). The land is one of the most important natural resources since life and development activities are based on it. The land is one of our most precious assets, it provides food, filters and stores water; and it is the basis for urban and industrial development, leisure, and a wide range of social and economic activities. The land is a production factor because of the vegetation and crops that can be grown on it. The Land is threatened by degradation and desertification, mainly as a result of human activities and climate changes. This will, eventually, lead to some changes in land use/ land cover. Digital change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data. Land use refers to the type of utilization to which man has put the land. It also refers to the evaluation of the land with respect to various natural characteristics. But land cover describes the vegetal attributes of the land. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as buildings or pavement and other features of the natural environment, such as soil type, biodiversity, and surface and groundwater (Singh, 1989). Digital change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data. Change detection is the process of differences in the state of an object or phenomenon by observing it at different times (Singh *et. al.*, 2003).

Change detection is an important process in monitoring and managing natural resources and urban development because it provides a quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land use change analysis, monitoring, shifting, cultivation, assessment of deforestation and desertification, the study of change in vegetation phonology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes

(Singh *et. al.*, 1989). The Blue Nile River, which originates from the steep mountains of the Ethiopian Plateau, is the major source of sediment loads in the Nile basin. Soil erosion from the upstream of the basin and the subsequent sedimentation in the downstream area is an immense problem threatening the existing and future water resources development in the Nile basin (Elhag *et. al.*, 2018). The benefits gained by the construction of micro-dams in the Upper Nile are threatened by the rapid loss of storage volume due to excessive sedimentation (Elswaify and Hurni, 1996; Tamene *et. al.*, 2006). Moreover, the green water storage of the Ethiopian highlands, where rain-fed agriculture prevails has diminished because of topsoil loss and this has caused frequent agricultural drought (Hurni, 1993; Elswaify and Hurni, 1996). In the downstream part of the basin, (e.g., in Sudan and Egypt) excessive sediment load led to massive operation costs of irrigation canals de-silting and sediment dredging in front of hydropower turbines. For example, the Sinnar dam has lost 65% of its original storage after 62 years of operation (Shahin, 1993). Both the Nile Basin Initiative and the Ethiopian government are developing ambitious plans for water resources projects in the Upper Blue Nile basin, locally called the Abbay basin (BCEOM, 1999; World Bank, 2006). Thus, an insight into the soil erosion/sedimentation mechanisms and the mitigation measures play an indispensable role in the sustainable water resources development in the region. Remote sensing and GIS are successful techniques for monitoring and assessing Spatio-temporal variation of LULC changes so, many works were conducted in Sudan e.g., (Ali *et al. 2012;* Biro *et al. 2013*; Adam *et al. 2014;* Abdelwahab, *et al. 2014*; Fadl *et al. 2014*; Mohammedzain, *et al. 2015*; Elhaja, *et al. 2017;* Abuzied, *et al. 2017).*

Land cover /land use (LCLU) changes play a major role in the study of global change. Negative human activities on natural resources have a substantial impact resulting in deforestation, biodiversity loss, global warming and an increase in natural disasters.

The assessment and monitoring of the extent of LCLU in Sudan are essential for preparing control measures in affected areas that leads ultimately to agricultural development and natural resources sustainability. Thus, the present study was undertaken to achieve the following objectives:

1. To generate quantitative data on the trend of land status that may help in designing restoration projects of degraded areas.
2. To determine the land cover and land use types which are dominant in the study area.
3. To investigate the impact of human activities on lands in the study area.
4. To make recommendations which may assist the agricultural authority in solving the troubles facing agricultural sustainability in the study area

2. Materials and Methods

2.1. Materials

2.1.1. Study area

The study area was carried out on Elnour natural forest reserve (4851 hectares), which is an important natural forest in the Blue Nile State. It extends between latitudes 11°52.5 33.4 & 11° 48 31.8 N and longitudes 34° 30 38.2 & 34° 29.5 23.05 E. (Fig. 1)Have more than 55 tree species dominated by *Acacia seyal and Var seyal*, according to(Osman and Idris, 2012). Elnour forest is sharply divided into two extreme soil types, dark cracking clays in the east, and established sand dunes in the west. These two contrasting types of vegetation are found on the two soil types, which have been 34 distinguished as low rainfall woodland savannah on clay and on sand respectively. The topography of Elnour is generally flat with cracked clay soil in the northern part and sandy soil in the southern part of the forest. The forest is surrounded by a number of villages and nomadic camps and generally falls within the route of daily trips of animal movement to and from water resources provided by the Blue Nile River. People living around the forest are either small-scale farmers or nomads investing in animal production. The main animal herds found in the area include goats, sheep, cattle and camels (Osman and Idris, 2012).

2.1.2. Remote Sensing Images

Three sub-images of the year (2000, 2010, 2019) from Landsat (ETM+, TM and Landsat 8) and Digital Elevation Models covering the study area were used. All the images were a false colour composite (FCC). Images 2000, 2010 and 2019 were Enhance Thematic mapper (ETM+), Thematic Mapper (TM) and landsat8. DEM was used to extract the cantor map of the study area. The characteristics of these images are shown in Table 1.

Table 1. Characteristics of imageries used in this study

Image and date	Path/Row	Sensor	Band	Resolution/m	Area (km^2)
1/ 2000	172/52	TM	432	30m	185*180
2/ 2010	172/52	ETM+	432	30m+15	185*180
3 / 2019	172/52	Landsat8	432	30m+15	185*180

Source: www.earthexplorer.USGS.Gove.

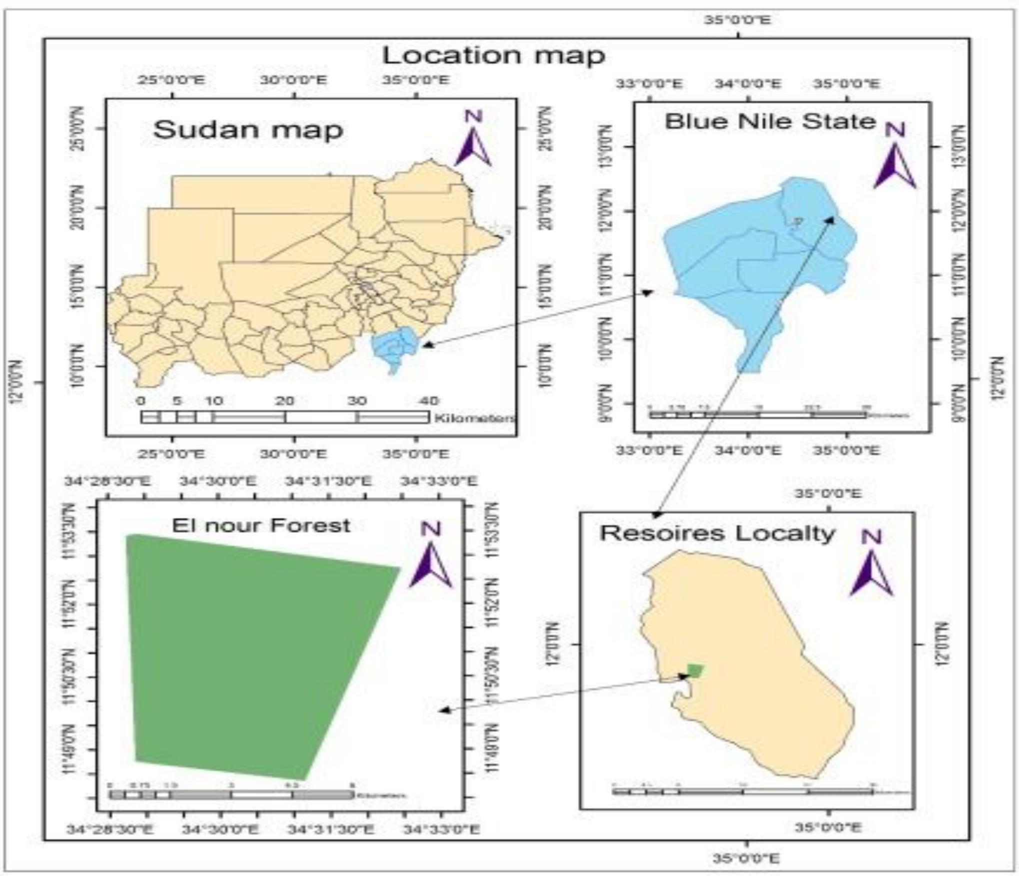

Fig.1. Location map of the study area

2.2. Methods

2.2.1. Fieldwork

Fieldwork was conducted during the period 24th February 2020 to 21st Marsh, 2020 in a total area of approximately 4851ha, which represents the study area. GPS (Garmin 60C) was used to navigate among check samples and to record the coordinates X, Y and Z values of each check sample. The study area was193 sample plots (Fig.2) represented by intensity10% sample plot size =56.83m. In each sample plot, land cover, tree type, their number, diameter at breast height, total height, crown diameter, bole height, tree seedlings samplings and grasses were recorded.

2.2.2. Software Work

Global and Linear Enhancement was conducted, in addition to radiometric and geometric correction with Geo-referencing images to ground control points and first-order transformation with an error < 1.0 pixel. Contrast enhancement, called global enhancement, was used for the Transformation of raw data using the statistics computed over the whole data set. Linear stretching and histogram equalization was used to enhance specific data ranges. Special enhancement procedures that result in image pixel value modification, (based on the pixel values) in its immediate vicinity (local enhancement) were used to emphasize low-frequency features and to suppress the high-frequency component of an image using low paths filters. High-pass filters do just the reverse. Geo-referencing was used to correct and adapt the maps geometrically; an image-to-image keyboard model through Erdas imagine 9.1 was used to correct the other map and Global Positioning System (GPS) Garmin 60 was used to locate the position. NDVI, Supervised, unsupervised classification and visual interpretation was carried out. Areas and percentage of the areas that were covered by different types of land cover, and then post-classification change detection approach was adopted based on map calculation which was applied to determine the dynamic of change in land cover. Geographical Information System (GIS) ARCGIS10.2 was used for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modelling and output; an intersection was performed between the classified image and the survey data of the study area in order to improve the classification results.

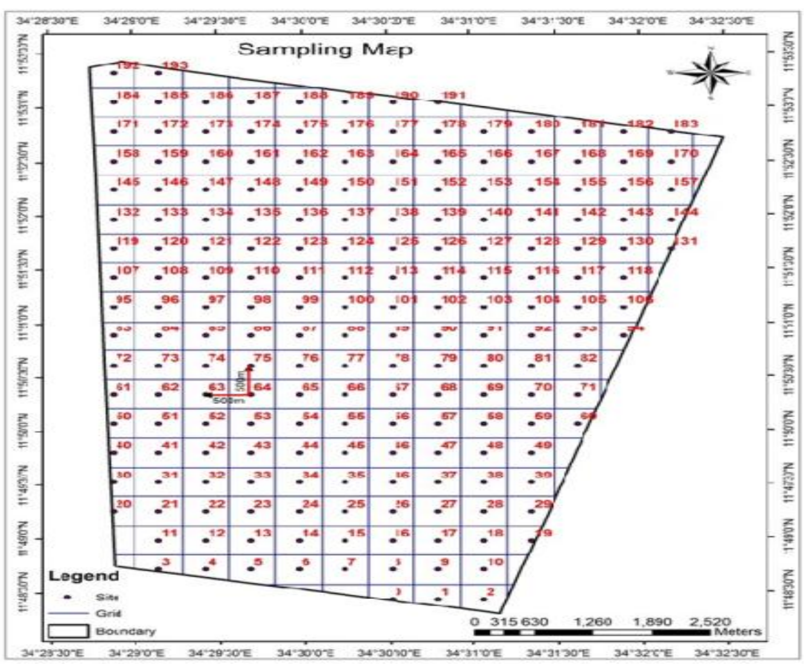

Fig.2. Sampling map of the study area

3. Results and Discussion

3.1. Vegetation cover

The presence of different tree species in the study area may be assumed to be a function of characteristics such as soil and social interventions (Abdalla, 2017). In general, tree species increase from the east toward the west, following the trend of rainfall, overcutting, overgrazing, and the effect of rainfall, which is the most important climatic factor in species distribution and this finding agrees with (Abdalla,2017).

3.1.1. Tree disruption

The forest stands showed high variation in terms of species composition, there are four species found in the area sampled, with a high percentage of, *Sterculia setiger* (table 2). This may imply that strong environmental changes caused by human activities and microclimate, are slowly converging to the previous conditions with an increase of fallow age and may influence the changes in species composition. Species cover the mean number of the crown of trees covering the area (Jennings *et. al.*,1999). This may be attributed to over-cultivation, overgrazing and over-exploitation of major resources. Such a result is in line with that of (Canham, *et. al.*, 1990), who stated that the cover plays a critical role in defining current and future forest characteristics via species composition and structure. In this study, patterns of diversity was investigated at a 56.8m^2 sample plot. It was found that, most of the variation in tree size class reflected distance variables (human impact). This fact agree with previous studies that found strong correlations between the patterns of plant richness and climate (Francis and Currie 2003; Hawkins *et. al.*, 2003; Kreft and Jetz 2007; O'Brien 1998).

Table 2. Tree type and size distributions

No.	Species	N	DBH (m)			Height (m)			Bole height			Crown diameter		
			Mean	SE	CV %	Mean	SE	CV%	Mean	SE	CV%	Mean	SE	CV %
1	Anogeissus leiocarpus	6	0.46	0.13	21.4	21.3	1.0	29.1	16.3	0.91	30.2	3.7	0.62	31.5
2	Combretum hartmannianum	4	0.53	0.15	17.6	18.8	1.2	33.6	14.3	1.3	47.4	2.5	0.59	28.3
3	Sterculia setiger	97	0.68	0.05	30.6	38.2	0.3	25.6	19.1	0.29	41.4	8.3	0.22	0.95
4	Terminalia laxiflora	6	0.56	0.14	20.9	28.3	1.3	36.5	27.0	1.4	41.2	NA	NA	NA

3.2. The analytical results

The Survey data and Remote sensing data (three images) showed that there were three land cover classes depicted in table 3 and Figs. 3,4, and 5

3.2.1. Closed Forest

The results showed that forests decreased from 2000, 2010 and 2019 by 36.9%, 28.5 and 18.7 respectively. This result may attribute to the periodical drought spells and negative human activities such as overgrazing and wood cutting for charcoal (table 3). This finding agrees with (Di Gregorio, A. and Jansen L.J.M 2000, and FAO 2010).

3.2.2. Open forest

The results indicated that grassland decreased from 2000 to 2010 by 24.4% this result corresponds to a decrease in rainfall and an increase in grazing and movement of people. But in 2019 the grassland increased by 17.4% (table.3) the result indicate that there was a decrease in the extension of agricultural activities and an increase in the annual rainfall during the period (2010-2019) (Abdalla,2017; Elhag,2007and Hassan,2010)

3.2.3. Bare soil

Bare soil of the study area was recorded as the highest percentage in the year 2010 compared with the years, 2000 and 2019, and this could be attributed to the extent of expansion of agriculture and some non-irrigated areas such as the rain-fed area in the study area and around it during the year, 2000 and 2019 (table 3). The result agreed with (Abdalla 2017 and Hassan 2010).

Table 3. Changes in land cover types during the years 2000, 2010 and 2019.

Land cover type	2000		2010		2019	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Closed forest	1790.7	36.9	1382.7	28.5	905.4	18.7
Open forest	2360.8	48.7	1178.4	24.3	2021.0	41.7
Bare soil	699.5	14.4	2291.4	47.2	1925.5	39.7
Total	4851	100	4851	100	4851	100

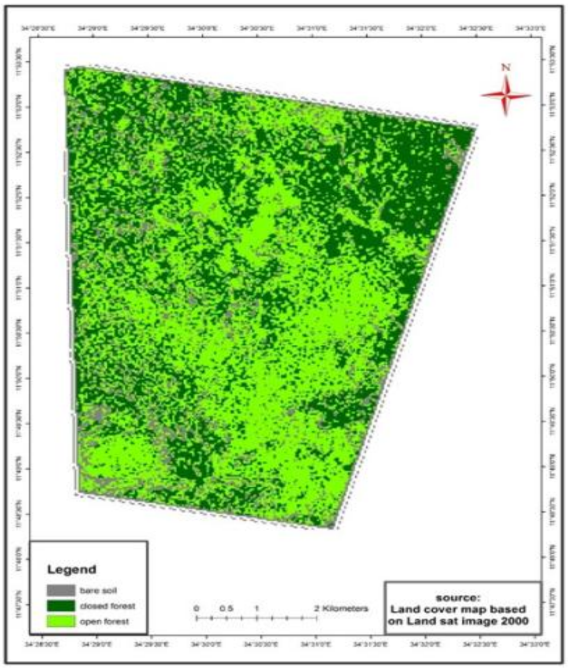

Fig.3. Land covers of the study area in 2000

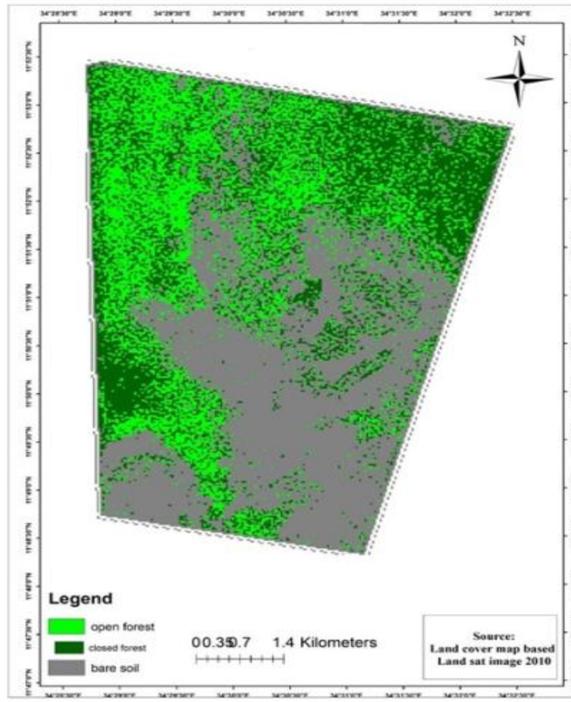

Fig.4. Land covers of the study area in 2010

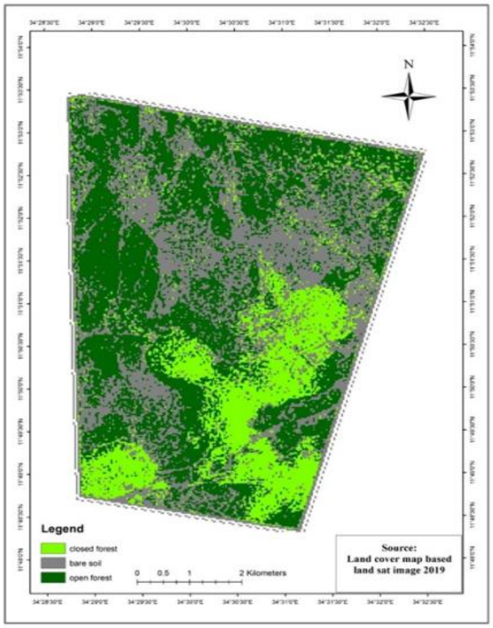

Fig.5. Land covers of the study area in 2019

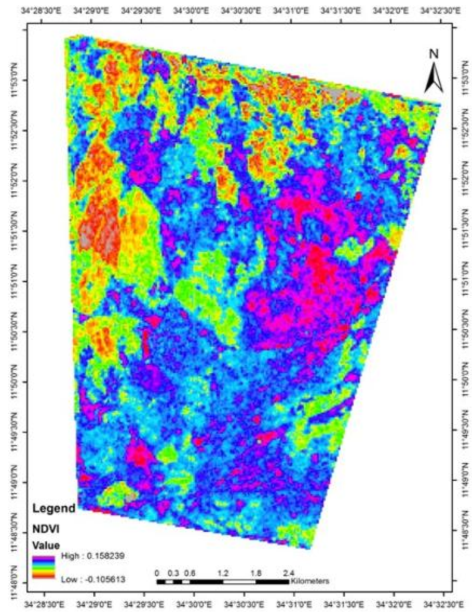

Fig.6. NDVI of the study area in 2019

NDVI technique and supervisor classification system during the year 2019 showed the same result as presented in Table 2. The grassland was highly reflected in the north part (Fig 6), whereas the south part gave a view reflection of trees. Moreover, the centre of the forest and the bare soil scattered throughout entire the forest agreed to the supervisor's classification of the training site.

4. Conclusion and Recommendation

4.1. Conclusion

The study revealed that there are different signs of land degradation and deforestation in the study area as judged by the change in land cover and land use. These changes indicated a decrease in vegetation cover (trees), and an increase in settlement areas.

The major Land cover classes present in the study area are closed forest, open forest and bare soil. Open forests constitute the major land cover, the increase in open forest areas due to the cutting of trees and grazing activities besides favourite environmental factors. This was confirmed by the decreasing areas of closed forest. Field observation and the vegetation cover decreased as indicated by NDVI from landsat8 image. Remote sensing and GIS methods used in this study prove a high potential to illustrate vegetation cover changes. However, results showed that vegetation cover in the northern part covered with clay soil type is more deteriorated than the southern part. Based on these results this study concludes the following:

1. Remote sensing and GIS are powerful techniques for monitoring and mapping temporal and spatial variation of LCLU Thus, it is recommended to carry out periodical assessments of intensity wind erosion (IWE) using remote sensing data.
2. NDVI effectively measures to assess vegetation cover changes and is a a significant indicator of vegetation degradation in the study area.
3. The results showed that forests decreased from 2000, 2010 and 2019 by 36.9%, 28.5 and 18.7 respectively. This result may attribute to the periodical drought spells and negative human activities

4. In general, tree species increase from the east toward the west, and these changes in tree species composition correspond directly to adverse human activities and climate factors.
5. Post-classification change detection methods show direct patterns of change in land cover classes while pre-classification methods are contradictory with each other and give general indications.

4.2. Recommendations

1. Remote sensing is a powerful technique for assessment, monitoring, and mapping temporal and spatial variation of LCLU. Thus, it is recommended to carry out periodical assessments of natural resources using remote sensing data.
2. Adoption of governmental forest policy with the continuation of afforestation programs to achieve natural resources sustainability.
3. Encouragement of the people in the study area to adopt rational land uses besides exploiting new energy sources friendly to the environment to stop cutting firewood
4. Conduction of in-depth detailed studies in this area with a high emphasis on local level of land cover changes and vegetation cover using remotely sensed hyper-spectral data and advanced digital analysis techniques such as spectral un-mixing analysis
5. The study revealed that there are some indicators of land degradation during the last 20 years (2000, 2010 and 2019) and is expected to continue increasing unless serious measures are carried out to reduce it.

References

[1]. Abdelwahab, M.H Mohammed Ali, E.D, and Mustafa, M.A. (2014). Assessment of wind erosion using remote sensing techniques in Atbara Area, River Nile State, Sudan. *Sudan Journal of Desertification Research* 6:1-14.

[2]. Abuzied, H. MA; Hamid, A.A. and Mustafa, M. A. (2017). Assessment of wind erosion in Central Part of the Northern State, *Sudan. Sudan J. Des. Res*. 7(1): 29-41.

[3]. Adam, A.H, Elhag, A.M. Salih, A. and Adam, S.M. (2014). Land degradation Assessment in the Rawashda area, Gedaref State, Sudan using remote sensing, GIS and soil techniques. *International Journal of Scientific and Research Publications*, Vol. 4(2): 1-9.

[4]. Ali, H. O. Almalik, E. M. Augusseau, X. and Eljack, E. A. (2012). Assessment and mapping of soil degradation at gadambalyia schemes, Elgedaref State, Sudan. *Sudan J. Des. Res*.4(1):95-110.

[5]. Biro, K. B. Pradhan, M. Buchroithner and F. Makeschin. (2013). Land use/land cover change analysis and its impact on soil properties in the northern part of Gadaref region, Sudan. *Land Degradation and Development* 24: 90–102.

[6]. Canham, C.D., Denslow, J.S., Platt, W.J., Runkle, J.R., Spies, T.A., and White, P.S. (1990). Light regimes beneath closed canopies and treefall gaps in temperate and tropical forests. *Can. J. For. Res.* 20: 620631.

[7]. Di Gregorio, A. and Jansen, L.J.M. (2000). Land Cover Classification System (LCCS). Classification Concepts and User Manual. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy. 80p and 99p of appendices.

[8]. Elhag, H. A (2007). Assessment of threat of sand encroachment in Gezira and Managil agricultural scheme, Sudan, Postgraduate Diploma(PGD), African Regional Center for Space Science and Technology Education in English (ARCSSTEE), Obafemi Awolowo University Campus (OAU), ILE –IFE.

[9]. Elhaja, M.E., Elhag, M.M., Adam, H.E., Khalifa, A.S. and Fadlelkerim, I.A. (2017). Assessment and mapping of desertification using remote sensing and GIS techniques in Khor Abu Habil area, Northern Kordofan State, Sudan. *Sudan J. Des. Res*. 9(1): 1-13.

[10]. Fadl, K.M.; Abdalwahid, A.A. and Abutaba, Y. M. (2014). Impact of drought and desertification on land use in Northern Kordofan State, Sudan. *Sudan J. Des. Res.* 6(1): 15-27.

[11]. FAO (2010). Global forest resources assessment 2010—country report, Ethiopia. Food and Agriculture Organization (FAO), Rome, Italy. www.fao.org/forestry/fra/fra2010/en/.
[12]. Francis, A. P., and D. J. Currie. (2003). A globally consistent richness climate relationship for angiosperms. *American Naturalist* 161:523–536.
[13]. Hassan, E., (2010). Technische Universität Dresden, Institute of Photogrammetry and Remote Sensing, Germany.
[14]. Hawkins, B. A., E. E. Porter, and J. A. F. Diniz-Filho. (2003). Productivity and history as predictors of the latitudinal diversity gradient for terrestrial birds. Ecology 84:1608–1623.
[15]. Jennings, SB., Brown, N.D., and Sheil, D. (1999). Assessing forest canopies and understory illumination: canopy closure, canopy cover and other measures. *Forestry* 7 2(1): 5974.
[16]. Kreft, H. And Jetz, W.(2007). Global patterns and determinants of vascular plant diversity. Proc.Natl Acad. Sci. USA 104,59255930. doi:10.1073/pnas.0608361104
[17]. Mishra, K.A., Singh, V.P. (2003). Analysis of Drought severity–area–frequency curves using a general circulation model and scenario uncertainty. *Journal of Geophysical Research: Atmospheres*, volume 114 m. Issue D6.
[18]. Mohammedzain, M.A., Elmobarak, A.A., Eltayb, A. and Elkhalil, S.A. (2015). Mapping and assessment of sand dunes by remote sensing and GIS techniques in Sufia Project Area, White Nile State, Sudan. Sudan J. Des. Res. 7(1): 1-12.
[19]. O'Brien, E. M. (1998). Water energy dynamics, climate, and prediction of woody plant species richness: an interim general model. *J. Biogeogr*.25, 79398.doi:10.1046/j.13652699.1998.252166.x
[20]. Singh, R., Sahoo, P., Rai, A. (2003). Use of Remote Sensing and GIS Technology in agricultural surveys from: http://www.gisdevelopment.net/application/agriculture/cropping/mio368.htm
[21]. Singh, A., (1989). Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, 10 (6): 989-1003.