NDVI-based land surface greenings spatial extent variability analysis (2014-2024) in Sheikan Locality – Sudan

Dr.Aisha A. ELdosogi University of Kordofan

Prof. AbdElaziz E. Elshiekh Mohammed University of Khartom

Dr. Ibrahim M. Eltom Ibrahim University of Kordofan

Abstract:

The NDVI generated from multi-spectral data of Landsat enabled to depict the spatial variability of the land surface vegetation greenness conditions. The main objective of the current study is to assess landscape vegetation greenness in Sheikan locality, North Kordofan, Sudan based on the seasonal NDVI image differencing (2014 -2018 – 2024). Remote sensing data (landsat-8 OLI) of 2014, 2018 and 2024 seasons were obtained from USGS web. Two GIS softwares were used for processing the NDVI analysis, which are ArcMap 10.8 and Erdas Imagine 2015. The results showed that the NDVI minus values ranges are – 0.31 to 0.01, - 0.34 to 0.01, and – 0.31 to 0.02 for the years 2014, 2018 and 2024 respectively. The maximum values are calculated for the fifth class that classified as very high NDVI greenings showed slight variation in area coverages to be 0.18-05, 0.18-49, and 0.18-48 in 2014, 2018 and 2024 respectively. NDVI image differencing interpreted using pair periods analysis (2014 – 2018), (2014-2024) and (2018-2024) showing positive and negative changes.

Keywords: NDVI , greenness , landsat-8 , image differencing

تحليل التباين المكاني لامتدادات المساحات الخضراء على سطح الأرض استنادًا إلى مؤشر الغطاء النباتي الطبيعي (IVDN) (2014-2024) في محلية شيكان – السودان

أ.د عبد العزيز الأمين الشيخ - أستاذ- قسم الجغرافيا- كلية التربية - جامعة كردفان

د.إبراهيم محمد التوم - أستاذ مشارك – كلية علوم الجغرافيا والبيئة – جامعة الخرطوم

د.عائشة عبد الباقي الدسوقي - أستاذ مشارك قسم الجغرافيا- كلية التربية- جامعة كردفان

يمكّن مؤشر الغطاء النباتي الطبيعي (NDVI) المشتق من بيانات المرئيات متعددة الأطياف من قمر الصناعي لاندسات، من تصوير التباين المكاني لظروف اخضرار الغطاء النباتي على سطح الأرض. الهدف الرئيسي من هذه الدراسة هو تقييم اخضرار الغطاء النباتي في محلية شيكان، ولاية شمال كردفان، السودان، استنادًا إلى التباين الموسمي لمؤشر الغطاء النباتي الطبيعي (2014-2018-2024). تم الحصول على بيانات الاستشعار عن بُعد من موقع هيئة المساحة الجيولوجية الإمريكية (USGS) لمواسم 2014 و2018 و2024. استُخدم برنامجان من برامجيات معالجة وتحليل المرئيات الفضائية للحصول على مؤشر الغطاء النباتي الطبيعي هما: برنامج نظم المعلومات الجغرافية Arc-Map 10.8 و برنامج إيرداس (ERADS IMAGINE). أظهرت النتائج أن نطاقات قيم مؤشر الغطاء النباتي الطبيعي (NDVI) السالبة تتراوح بين - 0.31 و0.01، وبين - 0.34 و0.01، وبين - 0.31 و0.02 للأعوام 2014 و2018 و2024 على التوالي. حُسبت القيم القصوى للفئة الخامسة، المصنفة على أنها خضرة ذات مؤشر NDVI مرتفع جدًا، حيث أظهرت تباينًا طفيفًا في التغطية المساحية، حيث تراوحت بين 0.18 و0.05، و0.18 و49، و0.18 و48 في الأعوام 2014 و2018 و2024 على التوالي. وقد فُسِّرت اختلافات صور مؤشر الغطاء النباتي الطبيعي باستخدام تحليل الفترات الزوجية (2014-2018)، و(2014-2024)، و(2018-2024)، مما أظهر تغيرات إيجابية وسلبية.

الكلمات المفتاحية: مؤشر الغطاء النباتي الطبيعي، الإخضرار ، لاند سات -8 ،اختلاف المرئية

1-Introduction:

Seasonal vegetation cover change is one of the continuous updating environmental issues affecting the nature of landscape at different spatial extents. Reliance on field survey data alone is limited to monitor a comprehensive and accuracy vegetation cover changes at a regional scale, particularly, if the area is inaccessible to be traversed regularly. Obtaining satellite imageries and using NDVI index is a perfect for comprehensive coverage of historical as well as current vegetation conditions.

Timely monitoring vegetation cover change has always been a top priority for evaluation environmental degradation. This argument

is true as the changing land surface occurred as the result of human induced activities that affecting the forest and trees by all means of cutting and clearance. Seasonal vegetation conditions varies and influenced by many factors such as the annual amount of rainfall effectiveness and distribution of the rainfall and the capability of the soils to preserve the moisture content.

Determination of landscape green cover associated with the climatic and anthropogenic factors, wasn't been recently phenomenon. Since the human practiced their activities, vegetation cover quality is continuously degraded. Natural forests and grazing lands capacities were exposed to permanent seasonally changes. In monitoring vegetation cover conditions, it is effective and recommended to use satellite data and NDVI of spectral indices. The possibility of using satellite monitoring operations is that it has online free access to obtain satellite imageries with 30*30 spatial resolution for Landsat 8 OLI kevel 2. This image spatial resolution is good for processing NDVI to determine the conditions of the land surface greenings.

Remote sensing help solving the complex spatial coverage to monitor or inventory change in vegetation cover and land use transformations. Remote sensed data covered vast areas instead of surveying only sample areas to represent the target problem. Due to increase of both spatial (from km to cm) and spectral resolution (from wide band range to narrow band) of remote sensing data, it is possible to work in micro level. Satellite images are required to prepare NDVI by the GIS software. It is an indicator of vegetation health (Sumanta Bid, 2016).

Spectral indices among them NDVI have significant benefits on depicted quality of vegetation cover conditions change. This paper interested on NDVI calculation to evaluate quality of greenness using NIR and Red channels of Electromagnetic spectral (EMS). Most of the vegetation indices can potentially use to extract image greening occur-

rence against surrounding barren or less vegetated lands.

For NDVI, Spatio-temporal remote sensing data can be used for the assessment of the land surface greenings. Spatial indices are many, and each has its specified spectral channels to derive NDVI, NDWI, NDBI, VCI and others. As stated by Jensen (2000), Landsat TM spectral channels are chosen specifically to map vegetation type, soil moisture, and other key landscape features.

Matthias et al., 2013 determined the trend change detection in NDVI time series and discussed the effects of Inter-annual variability and methodology. They stated that trends from NDVI time series differ substantially depending on analyzed satellite dataset. Many authors associated NDVI method with the land cover classification and mapping, such as the study of Yuhao et al., 2018 that studied land cover mapping using random forest classification and incorporating NDVI time-series and texture. Urban vegetation classification with NDVI threshold value method with very high resolution (NHR) imagery was studied by Haslina et al., 2019. They were associated the use of Pleiades imagery to extract the data of urban vegetation. Mohamed et al., 2019, demonstrated the evaluation of the classification accuracy of NDVI index in the preparation of land cover map. In (2020), Kiranmai et al., studied the land cover classification using NDVI index in ArcGIS environment. NDVI data processed were Landsat 8 for different dates from which they derived NDVI values. Jayanand and Mehmet (2020), studied the temporal NDVI change detection using Modis imagery. They analyzed vegetation change detection between 2001 and 2016 using Terra Modis 13A3 monthly 1 Km resolution time series data. Urooj et al., 2020, examined the potential of vegetation index (NDVI) for land use/cover classification using Landsat 8 data. Hamideh et al., 2020, used the NDVI approach to estimate the greenness and evapotranspiration of urban green spaces. Samnel and Hanna (2023), published a paper about

the analysis of vegetation change using satellite imagery and NDVI. Also change detection vegetation cover by NDVI technique using GIS and RS in the agricultural region was studied by Intessar (2023). The integration of Landsat time series vegetation indices improves consistency of change detection has been examined by Mingxing et al., 2023, as they considered the spatial and temporal consistency of the VIs (EVI, NBR, NDMI and NDVI). The index of NDVI has been used by her to measure the area of vegetation cover for filed and protected agricultural crops grown under normal sub light. They performed important topic that related changes landuse due to increasing residential at expense of agriculture and surface green land. Claive et al., (2024), depicted change in observed long term greening evidence from a three decades NDVI time series and its relationship with climate and land cover. In 2024, Muthi et al., examined the vegetation change using NDVI. They computed NDVI using Landsat 7 ETM and Landsat 8 OLI data from 2003 to 2023. They calculated the areas classified classes per hectares and interpreted the differencing.

2-Problem identification:

The problem of this research is exclusively environmental one that related to the biogeographical settings of the land surfaces. The main product of the forest is the trees that exposed daily to illegal cutting caused environmental degradation to the components of the vegetation cover.

3- Study area:

The study selected one of the most important localities in Western Sudan. Geographical area of the Sheikan locality is located in the center of North Kordofan State, Sudan. Latitudinal and longitudinal extensions of the locality is 12º 13’ E to 14º 25’ N and 29º 35’ to 30º 30’ E. the total area of the locality is 8.312 square kilometers that bounded by UmRuaba on east, bara locality on North, Al-Nuhud locality on

west and El-Dialing on South. The locality subdivided into four rural councils includes Abu Haraz, Kazgiel, Khor Tagat and Um Usheria that vary in their areas. Fig (1). The area of study is a part of the semi-arid climate. The annual mean rainfall is 354 mm with rain peak on September, while the mean annual temperature is 23 C min (Jan) and 43 C in summer (May). The vegetation of the study area is diverse with its difference components; forests, shrubs, herbs, and grassy lands. Forests surroundings towns had been exposed to severe degrading signs due to new urban extensions. The common tree species are …….., …… ……., while the seasonal water bodies species are the annual shrubs and grasses.

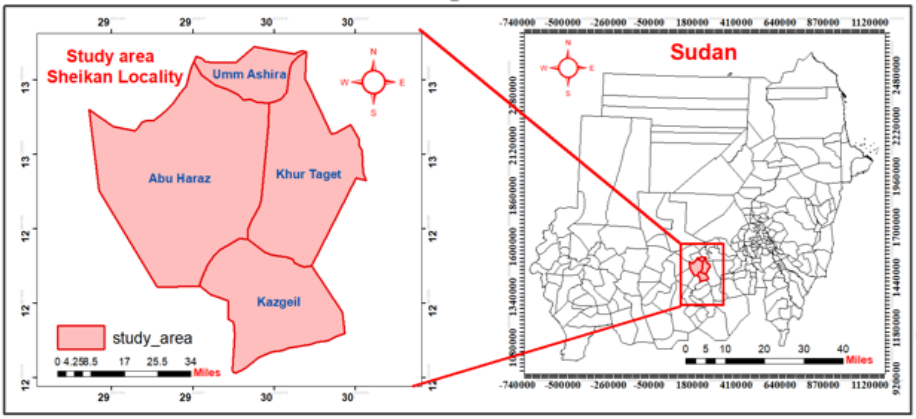

Fig (1): The study area – Sheikan Locality – Sudan

4-Methodology:

The standard function of the NDVI method is utilized to derive quantitative assessment of land surface greenness that monitor areas' sub-divisions NDVI value changes during period (December 2014, 2018 and 2024). The methodology outlined in this study based on the structure for the operations of the NDVI index processes. It also depends on the implementation for the satellite image pre-processing and the identification of particular space and time. Fig (2) presents the methodological workflow showed the steps of pro-

cessing different research p

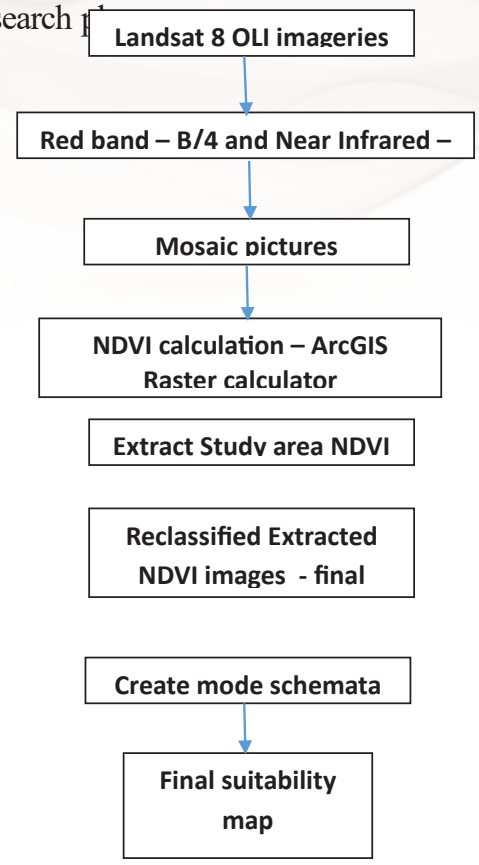

Fig (2): Flow Chart of research methodology

4-1 Data preparation:

Satellite imagery refers to significant data which is commonly used in extracting change values of land cover (Nath B et al., 2014). An important step in the utilization of satellite data to monitor change is the ability to compare images from different dates, for different plots on different scenes (Coops et al., 2008).

The multi-spectral data collections from Multi-spectral Remote Sensing provide resourceful information and an improved perspective on Earth's environment, (Ahmadi H et al., 2012). Remote sensing data

can image the land in different intervals at different resolutions, so they provide the necessary information quickly, and in a trustworthy manner (OZYAVUZ, 2015).

Satellite data used are downloaded from the USGS web site for land sat -8 (OLI). Landsat-8 is the main source of data used. Path and Row for this study is identified from the spatial extent of Sudan Index shape file (174/51 and 175/51) indicated that the area is covered by two scenes Fig (3). Table (1) shows the image bands characteristics, while table (2) shows the main specifications and features of the downloaded images used for NDVI analysis.

Table (1): Landsat-8 OLI characteristics

band	Band name	Wavelength mm	Characteristics - uses
1	Coastal aerosol	0.45 – 0.43	
2	Blue	0.51 – 0.45	
3	Green	0.59 – 0.53	
4	Red	0.67 – 0.64	
5	(Near Infrared (NIR	0.88 – 0.85	
6	SWIR 1	1.65 – 1.56	
7	SWIR 2	2.29 – 2.11	

Table (2): Main landsat-8 data features

Date	Path/Row	Month	Projection	Datum	Zone	Pixel size
2014	174/51	30/12	UTM	WGS84	36	m 30*30
	175/51	21/12	UTM	WGS84	36	m 30*30
2018	174/51	25/12	UTM	WGS84	36	m 30*30
	175/51	16/12	UTM	WGS84	36	m 30*30
2024	174/51	25/12	UTM	WGS84	36	m 30*30
	175/51	24/12	UTM	WGS84	36	m 30*30

The landsat-8 OLI images used in this paper is a subset image extract from entire Landsat acquired December 2014, 2018, and

2024 over North Kordofan State. Each pixel in these OLI data presents 30×30 square meter that indicated the spatial resolution with seven multispectral bands. The data of the three seasons has good quality and directly used for processing NDVI.

4-2 Methods of Analysis:

This concerns the image processing software used for analyzing data used. Erdas imagine for digital image processing 2015 and ArcGIS for GIS analysis 10.8 software are used. ArcGIS was mainly applied for pre-processing such as sub setting the AOI and built the attributes table with new data as required for the NDVI assessment area calculations. In addition, the Arc map software was used for computing NDVI using Map Algebra – Raster calculator. Erdas imagine help in mosaicking the images and visual interpretations.

For the benefit of the NDVI outputs in order to interpret land surface greenings variability, images were reclassified using spatial analyst tools (reclassify function) in ArcMap 10.5 environment. For the assessment of vegetation cover greenness, NDVI Index is used in this study at five different ranges represented the map identified five classes. Each class has its low and upper limits that indicates the NDVI minimum and maximum values.

4-2-1 **Spectral indices**:

This related to the process of electromagnetic energy during the operation of satellite band formations. As the image consists of multi bands, these bands can be combined to give different features. Vegetation indices calculated from satellite images can be used for monitoring temporal changes associated with vegetation (Ehsan and Kazem, 2013).

4-2-2 NDVI index:

Normalized Difference Vegetation Index (NDVI) was developed by W. Rose and colleagues in 1973. NDVI classified as a multi facets technique that to monitor, measure, quantify and depict vegetation cover changes, biomass production from satellite data. The main function of this index is to depict landscape greenness via measuring the difference between Near-infrared and Red light.

It is an important index of vegetation widely used in research on global climate and environmental change (Gao et al., 1996). The NDVI map is ordinarily used for the investigation of vegetation vigour and coverage on the ground (Keiji Osaki, 2000). The development of vegetation indices from brightness values is based on the differential absorption, transmittance, and reflectance of energy by the vegetation in the red and near-infrared portions of the electromagnetic spectrum (Derring and Haas, 1980; Lyon and McCarthy, 1995; Jensen, 1996

The NDVI parameters represent the main functions of the NDVI, which are input raster (the multispectral raster); visible band ID (identifies the band ID that represents the red extent of the EMS); and infrared band ID that identifies the band ID represent near-infrared range of EMS.

In general, NDVI described by many characteristics such as, it's a grade for plants, it is easy to calculate, it is used universally and it's a simple statistical indicator for synthetically active radiation (Kunkel et al., 2011; Demirell et al., 2010; Zhang et al., 2009). It is one of the most effective spectral indices related to plant greenness associated to photo synthetically active radiation (AAR).

Though it is the high significant index for vegetation index, there are

many factors affecting the NDVI, such as atmospheric conditions, satellite geometry and calibration and other vegetation structure such as crop canopy (Holben, 1986).

4-2-3 NDVI calculations:

It is a simple equation that calculate the NDVI values, which range from – 1 to + 1 used as satellite image-based proxy for vegetation pattern (Zhang et al., 2009; KunKel. 2011).

The wider familiar of the NDVI calculation is the equation that computed using NDVI algorithm. The NDVI outputs are the matter of subtracts the Red reflectance value (B/4) from the near-Inferred (B/5) divided by the sum of (B/5) and (B/4).

The explanation of this equation is that IR represents pixel values from the infrared band, while R represents pixel value from the red band.

If the area characterizes low reflectance (or low value) in the Red channel and high reflectance in NIR channel, this gives a high NDVI value. On the other hand, the high reflectance (or high value) in the Red channel and low reflectance in NIR channel, this produces a low NIR value.

There are specific bands that used from the standard spectral indices through formula using NIR (Near Infrared) and Red wavelength of the electromagnetic spectral. The default equation used to calculate NDVI and derive the rating values outputs is:

$$NDVI = (NIR - Red) / (NIR + Red)$$

$$Landsat\text{-}8 = (B/5 - B/4) / (B/5 + B/4)$$

NIR represents the spectral reflectance in near-infrared band

and R represents Red band

Band 5 NIR (0.85 – 0.879 mm)

Band 4 Red (0.636 – 0.673 mm)

3-1-5 Colour Ram used:

To bring the NFVI image outputs into effect, this require a certain type of formatting includes colour specification that match the value ranges, which indicated the amount of greenness. The NDVI classes were classified and each class has its identifiable colour that suit its NDVI value ranges management based on colour ram index that gives observational values of the RGB presented in table (3).

Table (3): Specifications of the colour ram used for NDVI classification

Classes	Colour name	RGB colour value ranges		
		R	G	B
1	Ultra blue	0	77	168
2	Ginger Penk	255	115	223
3	Solar Yellow	255	255	0
4	Medium apple	76	230	0
5	Pecoock green	0	115	76

3-1-6 NDVI Interpretation:

As far as the vegetation components are concerned. Malo et al., 1990 stated that this index measures the capability of leaves, which evaluate the health and unhealthy vegetation cover. NDVI interpretation is based on the outputs calculated that ranging from -1 to +1. Positive values differ in their components of health dense vegetation to sparse coverages. Dense vegetation yields high NDVI positive values, while sparse surfaces showed low NDVI positive values. Different researchers and authors have different interpretive scale for evaluation. Table (4) presents the scale label used for this study to present the classified classes with interpretive language that indicated the actual land surface greenness conditions based on NDVI values.

.

Table (): NDVI interpretation scale used

Range of NDVI Value	Object Names
to – 0.01 0.02 -	No or less greenings
to 0.12 0	Low greenings
to 0.14 0.13	Medium greenings
to 0.16 0.15	High greenings
to 0.50 0.17	Very high greenings

5- Results and interpretation:

After data was downloaded the second step was to do pre-processing operations such as extraction of the study area using extract by mask and processed NDVI using Map Algebra (Raster Calculator), and then mosaicked the NDVI images (174/51-175/51) in Erdas Imagine software.

The NDVI values are categorized into five different classes ranges from minimum (in all cases indicated the minus value), and the maximum that have positive high value. The classes labeled no or less, low, medium, high and Very high greenings, with specific values differ from season to another. In general, the high NDVI values indicated the good and healthy vegetation on earth surface and the lower NDVI values depicts the less surface greenings.

5-1 NDVI statistical analysis:

The output of the reclassifying NDVI images attached descriptive statistical results of an image that showed the range of the NDVI max and min values (the lower limit of the first class and upper limit of the fifth class). Total number of the pixels, mean and standard deviation are main statistical parameters obtained from image classification output process.

5-1-1 2014 image-based NDVI statistical analysis:

In 2014 there are variation in the minus NDVI values across the study area sub-divisions as presented in table (5). From the table Um Usheria has (-0.16) the near - 0 value followed by Kazgiel (-0.23), Khor Tagat (0.24) and Abu Haraz (-0.31). The overall statistics of the locality showed – 0.31 as the minimum value for the whole area with maximum NDVI value (0.50), with the mean of 0.143 value, compared with the means of the Abu Harz, Kazgiel, Khor Tagat, and Um Usheria, which are 0.133, 0.131, 0.121 and 0.143 respectively. The maximum NDVI value over the area is occurred in Kazgiel rural council (0.50) compared with the Khor Tagat (0.48), Um Usheria (0.40) and Abu Harz (0.38).

Table (5): 2014 NDVI reclassified Statistics

Councils	No. of pixels %	Min	Max	mean	STD
Abu Haraz	4461908	0.31 -	0.38	0.133	0.019
Kazgiel	1961177	0.23 -	0.50	0.131	0.022
Khor Tagat	2388659	0.24 -	0.48	0.121	0.020
Um Usheria	606130	0.16 -	0.40	0.143	0.016
Overall Locality	9417874	0.31 -	0.50	0.143	0.023

5-1-2 2018 image-based NDVI statistical analysis:

In 2018 there are variation in the minus NDVI values across the study area sub-divisions as presented in table (6). From the table Um Usheria has (-0.14) the near - 0 value followed by Kazgiel (-0.25), Khor Tagat (0.29) and Abu Haraz (-0.34) showed slight increased differences with same values in 2014. The overall statistics of the locality showed – 0.34 as the minimum value for the whole area with maximum NDVI value (0.49), with the mean of 0.136 value, compared with the means of the Abu Harz, Kazgiel, Khor Tagat, and Um Usheria, which are 0.145, 0.129, 0.126 and 0.136 respectively. The maximum NDVI value over

the area is occurred in Um Usheria (0.49) rural council compared with Kazgiel (0.46) the Khor Tagat (0.46), and Abu Harz (0.41).

Table (6): 2018 NDVI reclassified Statistics

Councils	No. of pixels	%	Min	Max	mean	STD
Abu Haraz	4461914	47.34	0.34 -	0.41	0.145	0.025
Kazgiel	1961161	20.81	0.25 -	0.46	0.129	0.029
Khor Tagat	2388667	25.35	0.29 -	0.46	0.126	0.023
Um Usheria	612644	6.50	0.14 -	0.49	0.136	0.016
Locality	**9424380**	**100**	**0.34 -**	**0.49**	**0.136**	**0.025**

5-1-3 2024 image-based NDVI statistical analysis:

In 2018 there are variation in the minus NDVI values across the study area sub-divisions as presented in table (7). From the table Um Usheria has (-0.12) the near - 0 value followed by Abu Haraz (-0.27), Kazgiel (-0.29), Khor Tagat (- 0.31) and showed slight increased differences with same values in 2014 and 2018. The overall statistics of the locality showed – 0.31 as the minimum value for the whole area with maximum NDVI value (0.48), with the mean of 0.135 value, compared with the means of the Abu Harz, Kazgiel, Khor Tagat, and Um Usheria, which are 0.138, 0.135, 0.128 and 0.141 respectively. The maximum NDVI value over the area is occurred in Kazgiel (0.48) rural council compared with Khor Tagat (0.45) the Abu Haraz (0.48), and Um Usheria (0.48).

Table (7): 2024 NDVI reclassification Statistics

Councils	No. of pixels	%	Min	Max	mean	STD
Abu Haraz	4461895	47.40	0.27 -	0.38	0.138	0.019
Kazgiel	1961169	20.83	0.29 -	0.48	0.135	0.028
Khor Tagat	2388675	25.37	0.31 -	0.45	0.128	0.025
Um Usheria	602129	6.40	0.12 -	0.38	0.141	0.013
Locality	**9413868**	**100**	**0.31 -**	**0.48**	**0.135**	**0.023**

6- Image-based NDVI surface area analysis:

The NDVI rating value ranges converted for assessment as no or less, low, medium, high, and a very High greenings. For assessing the variation in surface covered by greenings based on the study area sub-deviations (rural councils), area calculated based on the number of pixels (counts) in the attribute tables for each of the classes. Each count is an area of 30*30 square meters as informed from the image properties. Each class counts were multiplied by the 900 m^2, and also calculated per hectare. Using figures and tables created we can interpret the variation of NDVI values for different changes based on study area sub-divisions.

6-1 Overall NDVI surface area analysis:

Fig (4) and tables (8 –a-b-c), represented the three seasons variation in area covered by greenings as calculated from the reclassified NDVI images. The first class showed the less area covered by greenings 421.92, 466.83 and 469.89 hectares in 2014, 2018 and 2024 respectively. In 2018 and 2024 the area covered by greenings correspond to the first class is nearly similar, while in 2014 is lesser by about 421.92 and 47.97 hectares from that in 2018 and 2024 respectively. The large area covered by greenings in 2014 is class 3 (medium greenings) 300072.6 (35%), while in 2018 it's also class 3 has an area of 332225.46 hectares (39%) and in 2024 is also class 3 383758.11 hectares (45%). This indicated that class 3 (medium greenings) is dominant area.

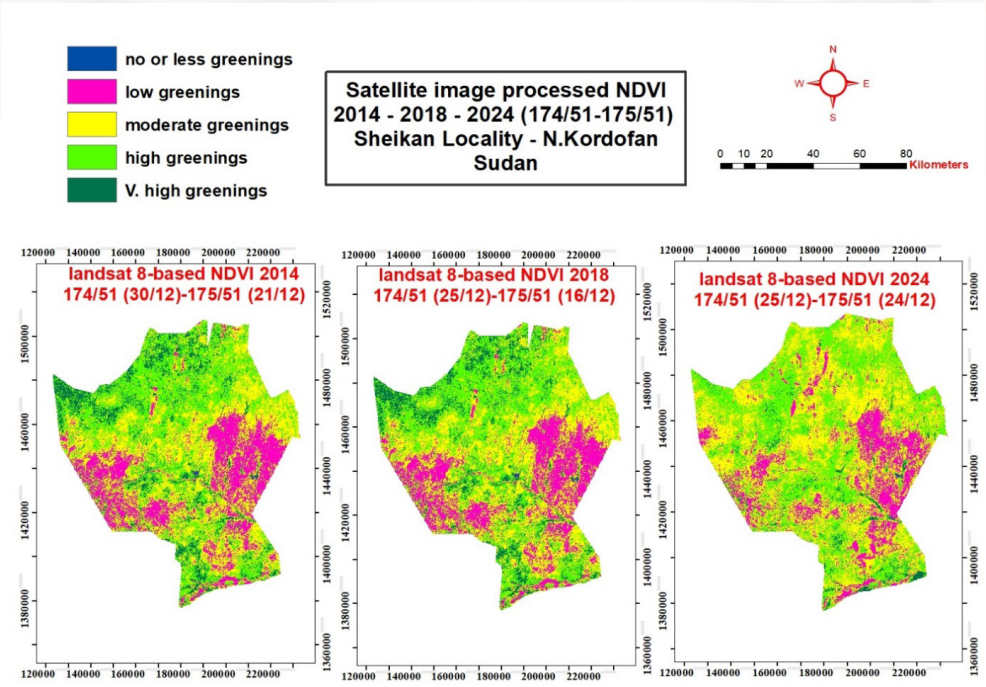

Fig (4): NDVI seasonal variability (2014-18-24)

Table (8- a): Sheikan Locality NDVI Surface area statistics (dec-2014)

class	number of pixels	AREAM2	AREA_HA	PERCENT
1	4688	4219200	421.92	**0**
2	1854238	1668814200	166881.42	**20**
3	3334140	3000726000	300072.6	**35**
4	3203141	2882826900	288282.69	**34**
5	1021667	919500300	91950.03	**11**

Table (8 -b): Sheikan Locality NDVI Surface area statistics (dec-2018)

classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	5187	4668300	466.83	0
2	2010403	1809362700	180936.27	21
3	3691394	3322254600	332225.46	39
4	2930203	2637182700	263718.27	31
5	787199	708479100	70847.91	8

Table (8-c): Sheikan Locality NDVI Surface area statistics (dec-2024)

Classes	No of pixels	AREAM2	AREAHA	PERCENT
1	5221	4698900	469.89	0
2	1515808	1364227200	136422.72	16
3	4263979	3837581100	383758.11	45
4	3286610	2957949000	295794.9	35
5	342250	308025000	30802.5	4

6-2 2014 Sub-divisions NDVI surface area analysis:

Considering the information in Fig (5) and Table (9-a-b-c-d), class 1 'no or less greenings' showed variable NDVI areas per hectares. Um Usheria showed large area classified as no or less greenings (5257.3) ha, followed by Khor Tagat (199.8) and Abu Haraz (135.7) and of less area occurred in Kazgiel (14.4).

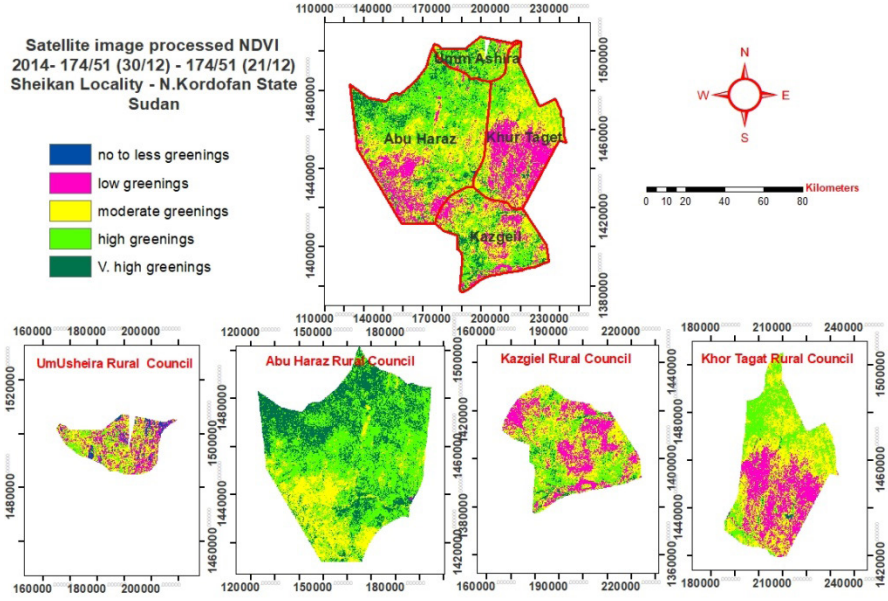

Fig (5): 2014 Sub-divisions NDVI surface area (ha)

Class 2 'low greenings' indicated that Abu Haraz occupied less area correspond to greenings as classified as low greenings (134.37) hectares. The larger area classified as low greenings is in Khor Tagat

(65665.3) hectares, followed by Kazgiel (51977.07) and Um Usheria (1749.96) hectares.

Table (9 -a): Abu Haraz Rural Council NDVI statistics -2014

Classes	No. of pixels	AREAM2	AREA_HA	PERCENT
1	1485	1336500	133.65	0
2	1493	1343700	134.37	0
3	829998	746998200	74699.82	19
4	2217773	1995995700	199599.57	50
5	1411159	1270043100	127004.31	32

Class 3 'medium greenings' showed great variations in NDVI class area calculated. Khor Tagat accounted the large area covered by medium greenings (92881.8) hectares, followed by Abu Haraz (74699.82), Kazgiel (69179.76) and Um Usheria (21.333.69) hectares.

Table (9-b): kazgiel Rural Council NDVI statistics -2014

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	160	144000	14.4	0
2	577523	519770700	51977.07	29
3	768664	691797600	69179.76	39
4	507385	456646500	45664.65	26
5	107445	96700500	9670.05	5

The classified NDVI class 4 is 'high greenings' indicated that Abu Haraz has a good land surface greenings covered (199599.57) hectares, while Khor Tagat, Kazgiel and Um Usheria the class covered (54958.32), (45664.65) and (10390.14) hectares.

Table (9-c): Khor Tagat Rural Council NDVI statistics -2014

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	2220	1998000	199.8	0
2	729614	656652600	65665.26	31
3	1032020	928818000	92881.8	43
4	610648	549583200	54958.32	26
5	14157	12741300	1274.13	1

Table (9-d): Um Usheria Rural Council NDVI statistics-2014

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	58414	52572600	5257.26	10
2	194344	174909600	17490.96	32
3	237041	213336900	21333.69	39
4	115446	103901400	10390.14	19
5	885	796500	79.65	0

In 2014, the very high NDVI greenings classified class showed significant variation. Abu Haraz council ranking the top in NDVI greenings coverage over the area of study (127004.31) hectares. Merging the 'high greenings' class with 'very high greening' class, Abu Haraz council is based on these two classes accounted (326603.9) hectares.

Fig (6) presents chart that explains the variability in NDVI classified classes in 2014. Class one indicated that 3 councils has lesser calculated areas less than the range of (0-50000) hectares, which are (133.65), (199.8) and (14.4) hectares in Abu Haraz, Khor Tagat and Kazgiel respectively. Class 2 missed Abu Haraz area because the area calculated lesser than the chart scale only (134.37) hectares. Class 5 missed Khor Tagat and Um Usheria that both calculated area lesser than the chart scale.

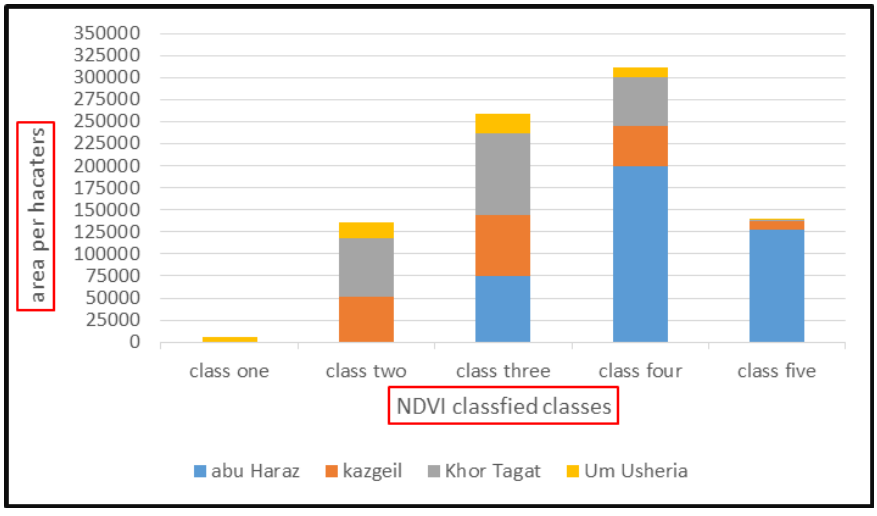

Fig (6): NDVI-based classified areas variability (2014)

6-3 2018 Sub-divisions NDVI area analysis:

Based on the Fig (7) and table (10-a-b-c-d), the NDVI classes calculated areas for the locality of Sheikan sub-divisions in 2018 were interpreted. The class 1 classified 'no or less greenings', showed the less area covered by vegetation greenness all through the councils. Um Usheria is the council that calculated large area of this class (9915.27) hectares, while Kazgiel calculated the lesser area of this class (105.39) hectares. In addition to Khor Tagat and Abu Haraz that calculated (225.72) and (105.39) hectares respectively.

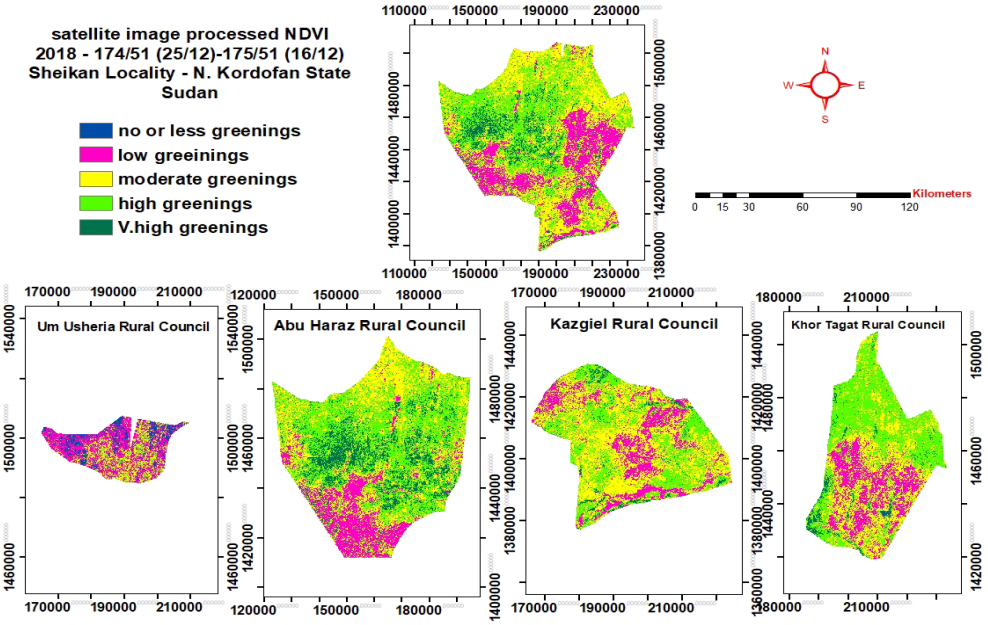

Fig (7): 2018 Sub-divisions NDVI area (ha)

Table (10-a): Abu Haraz Rural Council NDVI statistics- 2018

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	1832	1648800	164.88	0
2	646726	582053400	58205.34	14
3	1419368	1277431200	127743.12	32
4	1739772	1565794800	156579.48	39
5	654216	588794400	58879.44	15

Class 2 (low greenings) area calculated for each classes showed that Abu Harz is covered by large area (58205.34) hectares, followed by Khor Tagat (43113.42), Kazgiel (34581.87) and Um Usheria (28003.4) hectares.

Table (10-b): kazgiel Rural Council NDVI statistics -2018

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	1171	1053900	105.39	0
2	384243	345818700	34581.87	20
3	920698	828628200	82862.82	47
4	584061	525654900	52565.49	30
5	70988	63889200	6388.92	4

Class 3 areas calculated for different councils showed the great differences between Abu Haraz NDVI greenings covered by medium greenings (127743.12) hectares, if compared with Kazgiel, Khor Tagat and Um Usheria that calculated varied areas (82862.82), (78103.44) and (13770.45) hectares respectively. Abu Haraz is unique as it has lesser area that classified 'no or less greenings', while has larger areas of high and very high greenings classes indicated good vegetation cover over the councils.

Table (10-c): Khor Tagat Rural Council NDVI statistics -2018

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	2508	2257200	225.72	0
2	479038	431134200	43113.42	20
3	867816	781034400	78103.44	36
4	941610	847449000	84744.9	39
5	97695	87925500	8792.55	4

Class 4 as classified as 'high greenings', showed that Abu Haraz occupied large area for this class (156579.48) hectares, followed by Khor Tagat (84744.9), Kazgiel (52565.49) and Um Usheria (3942.72) hectares.

Table (10-d): Um Usheria Rural Council NDVI statistics- 2018

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	103503	93152700	9315.27	17
2	311149	280034100	28003.41	51
3	153005	137704500	13770.45	25
4	43808	39427200	3942.72	7
5	1179	1061100	106.11	0

Class 5 'very high greenings', showed that Um Usheria has the lesser calculated area (106.11) hectares, while in Abu Haraz, this class covered (58879.44) hectares. Kazgiel and Khor Tagat calculated (6388.92) and (8792.55) hectares respectively. Fig () presented the variation of the NDVI classes areas.

Fig (8) presents chart that explains the variability in NDVI classified classes in 2018. Class one indicated that 3 councils has calculated areas less than the range of (0-50000) hectares, which are (154.88), (225.72) and (105.39) hectares in Abu Haraz, Khor Tagat and Kazgiel respectively. Class 2, 3 and 4 represented all councils have different NDVI greenings areas as 'medium greenings'. Class 5 depicted that Um Usheria has a very low area covered by 'very high greenings'

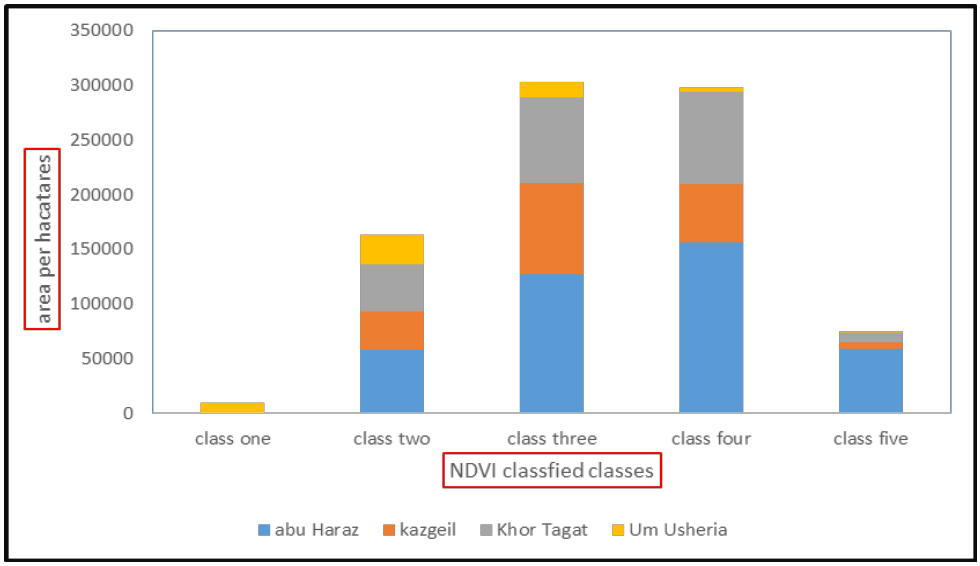

Fig (8): NDVI-based classified areas variability (2018)

6-4 2024 Sub-divisions NDVI area analysis:

In December 2024, the NDVI class's area calculated depicted variability among the rural councils. Class 1 showed different areas, Um Usheria accounted the larger area for this class (3653.19) hectares, while Abu Haraz accounted only (32.94) hectares, indicated that no or less greenings. Khor Tagat and Kazgiel areas calculated were (288) and (149.63) hectares respectively Fig (9) and table (11-a-b-c-d)..

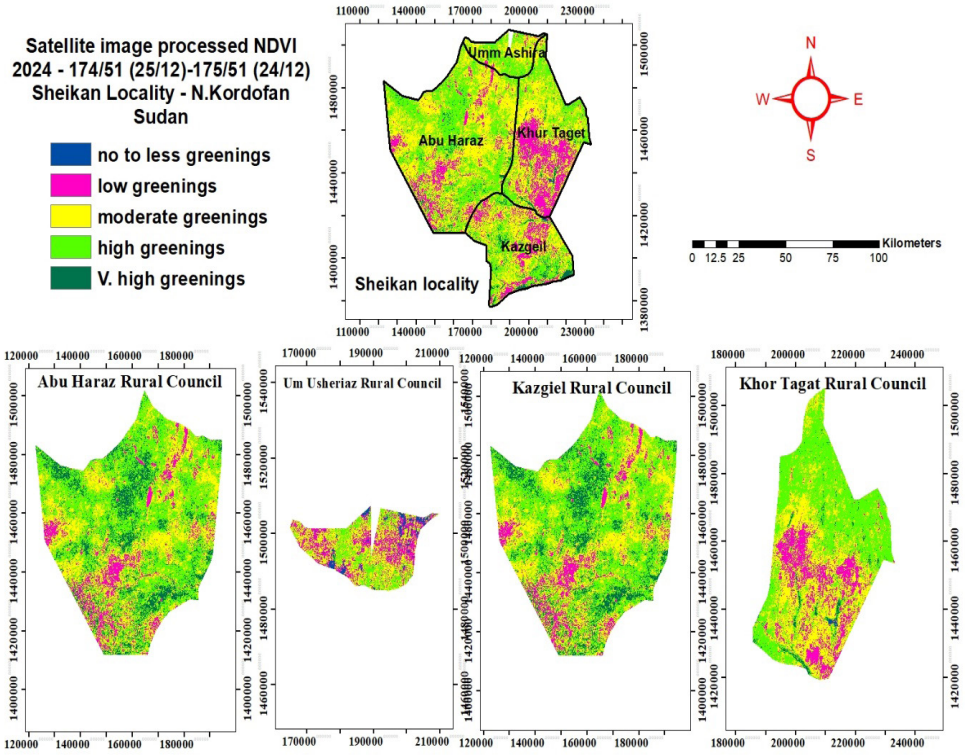

Fig (9): 2024 Sub-divisions NDVI area (ha)

Class 2 'low NDVI greetings', calculated nearly similar areas for Abu Haraz, Kazgiel and Khor Tagat (39027.8), (29926.89) and (34443.18) hectares respectively, while Um Usheria calculated lesser (16069.32) hectares.

Table (11-a): Abu Haraz Rural Council NDVI statistics -2024

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	366	329400	32.94	0
2	433644	390279600	39027.96	10
3	1442139	1297925100	129792.51	32
4	1957462	1761715800	176171.58	44
5	628284	565455600	56545.56	14

Class 3 the 'medium NDVI greenings', depicted that Abu Haraz has a larger area (129792.51) hectares, followed by Kazgiel and Khor Tagat, both has closely calculated area (84156.57) and (81163.89) hectares respectively, while Um Usheria calculated lower area value for this class (21564.99) hectares.

Table (11-b): kazgiel Rural Council NDVI statistics -2024

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	1663	1496700	149.67	0
2	332521	299268900	29926.89	17
3	935073	841565700	84156.57	48
4	594975	535477500	53547.75	30
5	96937	87243300	8724.33	5

Class 4 'high NDVI greetings' area, showed increasing trend in Abu Haraz as usual in 2014 and 2018. The areas covered by this class NDVI are (176171.58), (94054.68), (53547.75) and (12822.12) hectares in Abu Haraz, Kazgiel, Khor Tagat and Um Usheria respectively.

Table (11-c): Khor Tagat Rural Council NDVI statistics -2024

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	3200	2880000	288	0
2	382702	344431800	34443.18	16
3	901821	811638900	81163.89	38
4	1045052	940546800	94054.68	44
5	55900	50310000	5031	2

Class 4 typical interpretation can be true for the class 5 that classified

'very High NDVI area' as Abu Haraz calculated the larger area for this class (56545.56) hectares, compared with the lesser calculated areas (8744.33), (5032) and (81.99) hectares in Kazgiel Khor Tagat and Um Usheria respectively.

Table (11-d): Um Usheria Rural Council NDVI statistics -204

Classes	No. of pixels	AREAM2	AREAHA	PERCENT
1	40591	36531900	3653.19	7
2	178548	160693200	16069.32	30
3	239611	215649900	21564.99	40
4	142468	128221200	12822.12	24
5	911	819900	81.99	0

Fig (10) presents chart that explains the variability in NDVI classified classes in 2024. Class one indicated that 3 councils has calculated areas less than the range of (0-50000) hectares, which are (32.94), (149.67) and (288) hectares in Abu Haraz, Kazgiel and Khor Tagat respectively. Class 2, 3 and 4 represented all councils have different NDVI greenings areas as 'medium DVI greenings'. In chart, Class 5 missed Usheria council for its lower value not represented by the scale of the chart.

Fig (10): NDVI-based classified areas variability (2024)

5-5 NDVI rating value ranges analysis:

Standard NDVI value rating ranges are obtained from the NDVI image calculated with specific extracted area of study by the reclassify tool in spatial analyst tools in Arc Map 10.8 environment. The subdivided councils were also extracted from the generated NDVI image to produce different NDVI maps that showed the variability in the surface greenings that highly affected by local factors of the areas.

The overall of NDVI values ranges differ from season to season showing NDVI image differencing. Based on the scale used by many research-

ers NDVI value greater than 0.5 is classified as dense healthy forest. NDVI value greater than 0.5 in 2014 occurred in Kazgiel and Khor Tagat rural councils, but Abu Haraz and Um Usheria NDVI max values are 0.41 and 0.34 respectively. In 2018 , three rural councils; Kazgiel, Khor Tagat and Um Usheria calculated NDVI max (0.5), while Abu Haraz showed 0.41 similar value in 2014. In 2024, rural councils calculated NDVI (0.5) are Kazgiel and Khor Tagat, while Abu Haraz and Um Usheria calculated max value to be 0.4 for both councils.

In 2014 the minus NDVI values are -0.31, -0.23, -0.24 and – 0.16 from the first class in Abu Haraz, Kazgiel, Khor Tagat and Um Usheria respectively. This showed a slight differences between kazgiel and Khor Tagat councils. In 2018 the minus NDVI values are -0.34, -0.25, -0.30 and – 0.01 from the first class in Abu Haraz, Kazgiel, Khor Tagat and Um Usheria respectively. This showed a slight differences between Abu Haraz and Khor Tagat councils. In season 2024, the first class showed the minimum NDVI values that varied based on the greenings areas in Abu Haraz, Kazgiel, Khor Tagat and Um Usheria, which are - 0.27, - 0.25, - 0.31 and – 0.12 respectively, Table (12).

The NDVI minus values across the locality ranges are – 0.31 to 0.01, - 0.34 to 0.01, and – 0.31 to 0.02 for the years 2014, 2018 and 2024 respectively. The maximum values ranges are 0.18 to 0.05 , and 0.18 to 0.49 and 0.18 to 0.48 in 2014, 2018 and 2024 respectively that rated all season has a very high greenings areas Fig (11-a-b-c).

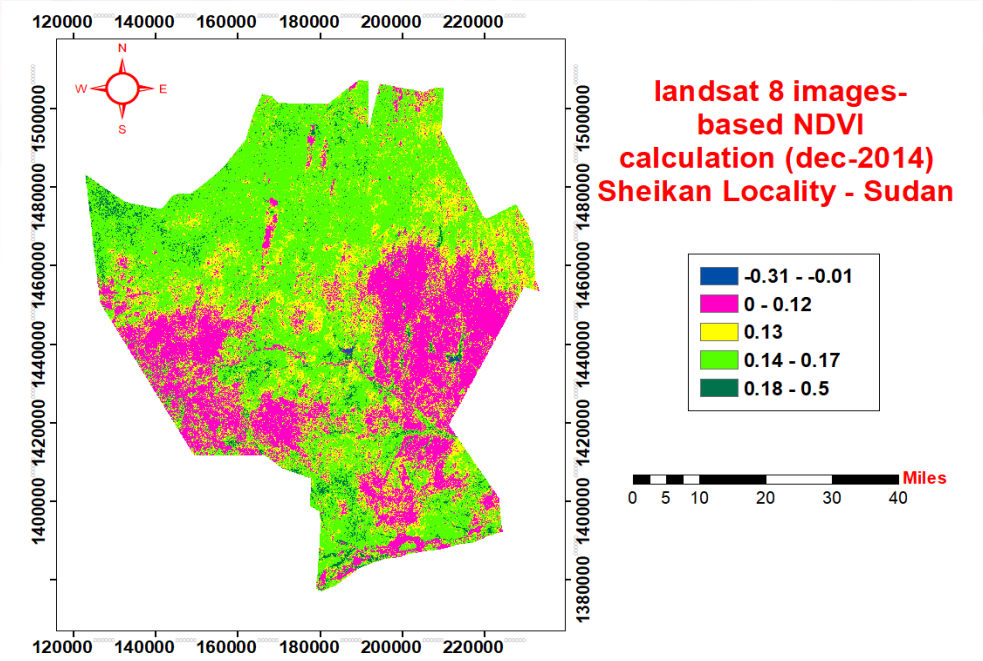

Fig (11 – a): NDVI rating value ranges (2014)

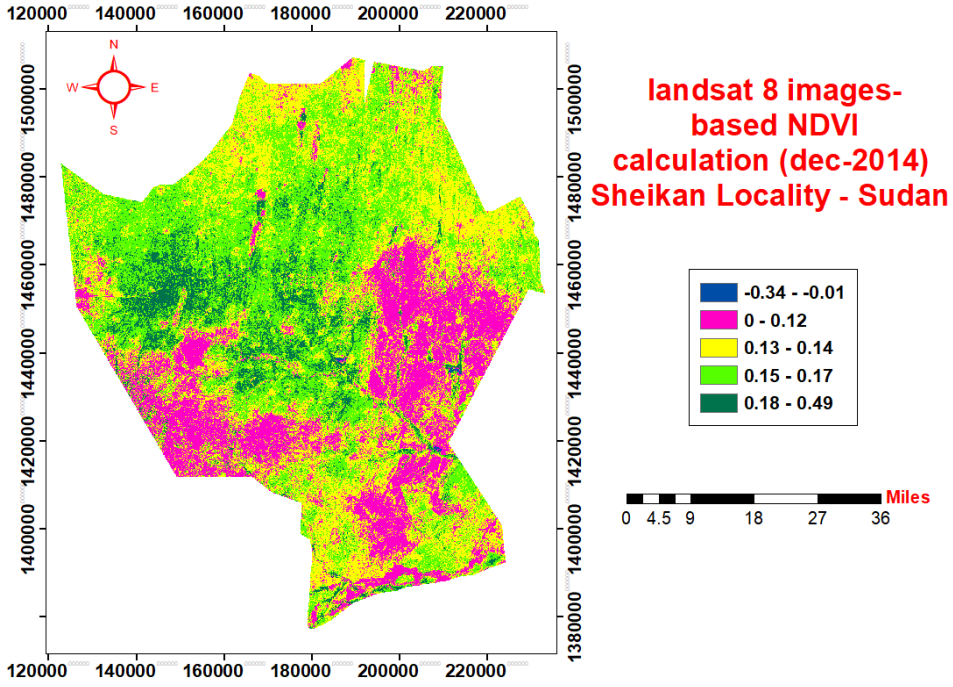

Fig (11 – b): NDVI rating value ranges (2014

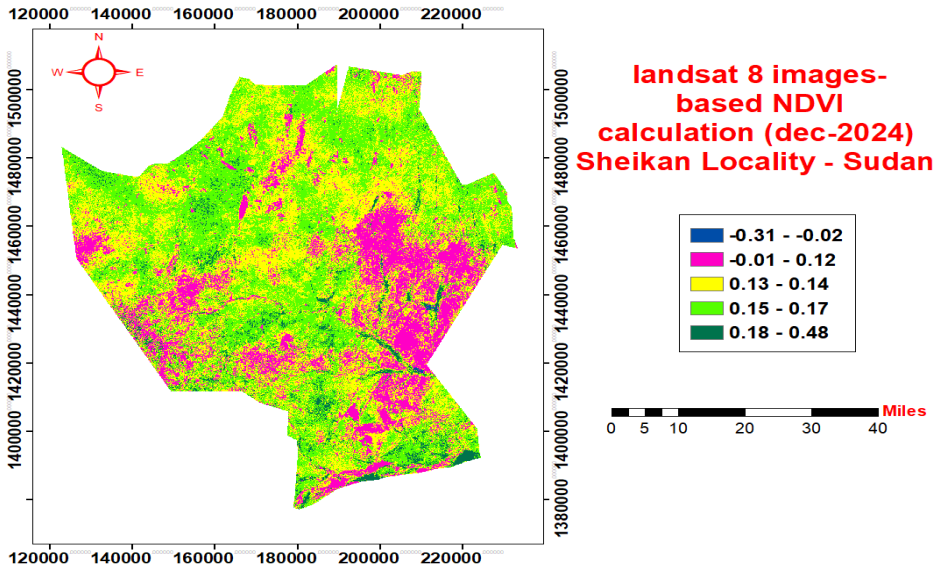

Fig (11 – C): NDVI rating value ranges (2014)

Table (12): NDVI rating value ranges assessment 2014-2018-2024

Rural Councils	Interval Years	Reclassified classes 1	2	3	4	5
Abu Haraz	2014	-0.08 0.31- -	0.04 – -0.07	0.11 – 0.05	0.14 – 0.12	0.4 – 0.15
	2018	0.02 – 0.34 -	0.12 – 0.03	0.14 – 0.13	0.17 – 0.15	0.41 – 0.18
	2024	0 - 0.27 -	0.12 – -01 0	0.14 – 0.13	0.15 – 0.14	-0.4 0.16
Kazgiel	2014	-0.02 0.23 -	0.03-0.12	0.013-0.14	0.015-0.18	0.5 – 0.19
	2018	-0.03 - 0.25 -	0.11 – 0.02 -	0.14 – 0.12	0.17 – 0.15	0.5 – 0.18
	2024	-0.03 - 0.3 -	0.12 – 0.02 -	0.14 – 0.13	0.18 – 0.15	0.5 – 0.19
Khor Tagat	2014	-0.01 - 0.24 -	0.11 – 0	0.13 – 0.12	0.18 – 0.14	0.5 – 0.19
	2018	-0.02 0.3- -	0.11 – 0.01 -	-0.13 0.12	0.16 – 0.14	0.5 – 0.17
	2024	-0.02 - 0.31 -	0.11 – 0.01 -	0.13 – 0.12	0.17 – 0.14	0.5 – 0.18
Um Usheria	2014	0.13 – 0.16 -	0.14 – 0.13	0.16 – 0.15	0.21 – 0.17	0.4 – 0.22
	2018	0.13 – 0.01 -	0.14 – 0.13	-0.16 0.15	0.24 – 0.17	0.5 – 0.25
	2024	0.12 – 0.12 -	0.14 – 0.13	0.15 – 0.14	-0.19 0.16	0.4 – 0.20
Locality Sum	2014	**0.01 - - 0.31 -**	**0.12 – 0**	**0.13 – 0.12**	**0.16 – 0.14**	**0.5 - 0.17**
	2018	**-0.01 - 0.34 -**	**0.12 – 0**	**0.14 – 0.13**	**-0.17 0.15**	**0.49 – 0.18**
	2024	**-0.02 - 0.31 -**	**-0.12 0.01 -**	**0.14 – 0.13**	**0.17 – 0.15**	**0.48 – 0.18**

8- Discussion:

The study examined and assessed with analytical procedures the effective of Normalized Difference Vegetation Index (NDVI) on land surface greenings cover conditions and its potential in vegetation change monitoring. As far as the vegetation cover is concerned, one of the three group that identify this study is that it's a seasonal change assessment. Vegetation cover also can be studied from its gradual changes or abrupt changes approaches.

The valuable advanced technologies of remote sensing and GIS paved the way for researchers to use most update sensing data for depicting changes occurred seasonally on land surfaces.

The results showed that the no or less greenings documented the smallest area in the Sheikan locality as class 1. The case also applicable when calculating at administrative sub-divisions. The larger area of greenings classes is the medium greenings, which is occurred over larger portions in all seasons, followed by high greenings class.

The significant no or less land surface greenings occurred surrounding the junction of the rural councils where the ElObeid city built up area continuously growing.

9- Conclusion:

Year by year over the western Sudan, the quality quantity of vegetation cover has been decreasing progressively left a severe environmental degradation. During the last 30 years, the urban new extensions caused the removal of thousands of hectares of forests surrounding main towns such as ElObeid and Um-Rwaba. Shrinkage in vegetation cover all over the locality lead to change in land surface greenness that will have adverse impacts upon the local vegetation cover and soil properties.

Based on the spectral reflectance measurements, Normalized Difference Vegetation Index (NDVI) is one of the standard spectral indices used as the potential method and data source for vegetation assessment. The study initiated to give wide spectrum for land surface greenness in Sheikan locality, Sudan.

The present study has generated comparative satellite image data, which provided the basis for assessing the land surface vegetation greenness change via Spatio-temporal approach.

References:

(1) Ahmadi,H., & Nusrath, A. (2010). Vegetation change detection of Neka River in Iran by using remote sensing and GIS. Journal of geography and geology, 2(1), 58.

(2) Coops, N., Bi, H., Barnett, P., & Ryan, P., (1999). Estimating Mean and Current Annual Increments of Stand Volume in a Regrowth Eucalypt Forest Using Historical Landsat Multi Spectral Scanner Imagery, Journal of Sustainable Forestry, 9:3-4, pp 149-168, DOI: 10.1300/J091v09n03_07.

(3) Demirel, H., Ozcinar, C.,& Anbarjafari, G. (2009).Satellite image contrast enhancement using discrete wavelet transform and singular value decomposition. IEEE Geoscience and remote sensing letters, 7(2), 333-337.

(4) Derring, D., and R. Haas, 1980. Using Landsat Digital Data for Estimating Green Biomass, NASA Technical Memorandum #80727, 21 p.

(5) Ehsan Sahebjalal and Kazem Dashtekian (2013): Analysis of land use-land covers changes using normalized difference vegetation index (NDVI) differencing and classification methods. African Journal of Agricultural Research, Vol. 8(37), pp. 4614-4622, 26 September, 2013 DOI:10.5897/AJAR11.1825 ISSN 1991-637X ©2013 Academic Journals http://www.academicjournals.org/AJAR.

(6) Keiji Osaki (2000): SEASONAL CHANGE OF NDVI CALCULATED BY JERS DATA WITH HIGHER SPATIAL RESOLUTION. International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Supplement B7.

(7) Kunkel, M.L., Flores, A.N., Smith. T.J., McNamara, J.P., Benner, S.G., (2011). A simplified approach for estimating soil carbon and nitrogen stocks in semi-arid complex terrain, Geoderma,165, pp.1–11.

(8) Gao, B. C. (1996). NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. Remote sensing of environment, 58(3), 257-266.

(9)Lyon, J., and J. McCarthy, 1995. Wetland and Environmental Applications of GIs, CRCJLewis Publishers, Boca Raton, Florida, 373 P.

(10)Jensen, J., 1996. Introductory Digital Image Processing, Prentice-Hall, Englewood Cliffs, New Jersey, 316 p.

(11)Malo, A.R., & Nicholson, S.E., (1990). A study of Rainfall dynamics in African Sahel using Normalized Difference Vegetation Index, Journal of Arid Environment, 19, pp.1-24.

(12)Nath, B. (2014). Quantitative assessment of forest cover change of a part of Bandarban Hill tracts using NDVI techniques. Journal of Geosciences and Geomatics, 2(1), 21-27.

(13)Sumanta Bid (2016): Change Detection of Vegetation Cover by NDVI Technique on Catchment Area of the Panchet Hill Dam, India. International Journal of Research in Geography (IJRG) Volume 2, Issue 3, 2016, PP 11-20 ISSN 2454-8685 (Online) DOI: http://dx.doi.org/10.20431/2454-8685.0203002 www.arcjournals.

(14)Özyavuz, Murat ; Cemil Bilgili; and Aylin Salıcı (2015): DETERMINATION OF VEGETATION CHANGES WITH NDVI METHOD. Journal of Environmental Protection and Ecology 16, No 1, 264–273.

(15)Zhang, X., Hu, Y., Zhuang, D., Qi, Y., & Ma, X. (2009). NDVI spatial pattern and its differentiation on the Mongolian Plateau. Journal of geographical sciences, 19(4), 403- 415