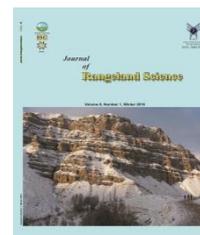## Contents available at ISC and SID

Journal homepage: www.rangeland.ir

Research and Full Length Article:

Rangeland Degradation Assessment in the South Slope of the Al-Jabal Al-Akhdar, Northeast Libya Using Remote Sensing Technology

Adel M. A. Mahmoud[A], Mohd Hasmadi Bin Ismail[B], Alias Mohamad Sood[C], Mohamad Azani Alias[D]

[A]Faculty of Forestry University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia (Corresponding Author), Email: adelborabha@yahoo.com.my
[B, C, D]Faculty of Forestry University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

Abstract. The degradation rate of Mediterranean steppes, especially in North Africa is 1% per year, and this considered as high a rate of degradation. This study conducted in 2014 in the south slope of the Al-Jabal Al-Akhdar, northeast Libya to quantify the vegetation recovery rate and assess selected Vegetation Indices (VIs) for mapping rangelands degradation status using remote sensing technology. Through a review of VIs we found that NDVI (Normalized Difference Vegetation Index) and $MSAVI_2$ (Modified Soil Adjusted Vegetation Index) are the most useful indices for the study area to achieve the research objectives. Two Landsat (ETM+) satellite images (captured in September 2006 and 2014) used to map, monitor and assess the patterns of changes in plant cover. Three exclosures (fenced areas) with moderately to severely degraded soil and vegetation, were selected along a strong north-south rainfall gradient. Landscape Function Analysis (LFA) technique used to calculate Total Patch Area (TPA) for comparison purpose. According to the results, NDVI and $MSAVI_2$ can be employed as a consistent and comparatively simple to use a tool in management and assessment of desertification processes in the Mediterranean rangelands. It seems that $MSAVI_2$ more reliable than NDVI when the vegetation cover is very low. Overall, the plant cover did not change or increase for a large portion of regions at a time when 80% of the study area still under very severe and severe conditions of land degradation status.

Key words: Al-Jabal Al-Akhdar, Libya $MSAVI_2$, Total patch area, Vegetation indices

Introduction

The degradation rate of Mediterranean steppes especially in North Africa is 1% per year, and this considered as high rate of degradation (Le Houerou, 2000; Le Houerou, 2001). Many factors and human activities have cause rangeland degradation and led to significant changes in the landscape and original plant flora of the southern Mediterranean countries over the past 100 years (Le Houerou, 2000; Mahmoud *et al.,* 2008; Zatout, 2014).

These activities include overgrazing, deforestation, inappropriate agricultural practices, fire, urban expansion and industrial activities. All the above mentioned activities lead to destruction of the native plant flora and cause an increase in sand blowing and emission of dust. Also, incorrect policies regarding control of desertification have paradoxically increased the amount of area prone for desertification and also delayed recovery of degraded land. There are about 12672 km^2 of the Libyan rangelands considered as degrading areas, which is affecting about half millions of people (Bai *et al.,* 2008).

Signs of densification in the study area include marked reduction or complete loss of vegetation cover, Accelerated soil erosion, Increased frequency of dust storms, Edaphic drying, Reduced biodiversity, Reduced habitat diversity and Reduced primary productivity (crop yield, animal productivity).

This study aimed to quantify the vegetation recovery rate in the south slope of the Al-Jabal Al-Akhdar area, northeast Libya and assess selected vegetation indices for mapping rangelands degradation status using remote sensing technology.

Since remote sensing collects its data via space satellites that can cover a vast land area in a short span of time and can revisit an area when needed both the time and logistic issues of monitoring rangelands degradation.

Materials and Methods
Vegetation Indices

Through a review of VIs we found that NDVI and MSAVI$_2$ are the most useful indices to achieve the research objectives. (Gao, 1996; Jackson and Huete, 1991; Karmieli *et al.,* 2013; Mróz and Sobieraj, 2004; Yeganeh *et al.,* 2014).

They have been widely used in remote sensing applications of rangeland management, also it is used in available software in markets.

Normalized Difference Vegetation Index (NDVI)

The NDVI has been extensively applied in rangeland researches. NDVI minimizes the topographic and atmospheric effects (Rouse Jr *et al.,* 1974), but it is quite sensitive to soil color and brightness, higher NDVI values are led by darker soil substrates under incomplete canopies (Bannari *et al.,* 1995; Mróz and Sobieraj, 2004) (Equation 1).

$$NDVI = \frac{NIR - R}{NIR + R} \qquad \text{(Equation 1)}$$

where NIR is Near Infra-Red band, and R is the red band.

Soil Adjusted Vegetation Indices (SAVI and MSAVI)

Soil Adjusted Vegetation Index (SAVI) dealing with the soil brightness so it is useful in the study area where the vegetation cover is very low and CoCa$_3$ is quite high and causes high soil brightness (Huete and Jackson, 1988) (Equation 2). A correction factor (L) which ranges from 0 for very high vegetation cover to 1 for very low vegetation cover is used to reduce soil brightness effects, the most used value is 0.5 which for medium vegetation cover.

$$SAVI = \frac{NIR - R}{NIR + R + L} * (1 + L) \qquad \text{(Equation 2)}$$

Qi *et al.* (1994) found that L is not stable. Additionally, it differs contrarily with the measure of vegetation present. For this reason, they proposed the Modified Soil Adjusted Vegetation Index (MSAVI) to

reduce the effects of inter patch areas on SAVI.

MSAVI is suitable for the rangelands that have different soil brightness coefficients (Gaitán *et al.,* 2013).

Because of the mentioned advantage we selected MSAVI. Moreover, it is usually has a strong correlation relationship with the field data related to vegetation cover (Chen, 1999; Senseman *et al.,* 1996), also it is very useful for degradation classification to monitor desertification (Liu *et al.,* 2005), as well as the estimation of biomass (Phillips *et al.,* 2009).

The calculation of MSAVI is same as SAVI; the difference is how to calculate the correction factor. In MSAVI L is calculated as (Equation 3),

$$L = 1 - (2 * S * NDVI * WDVI)$$
(Equation 3)

Where S is the slope of the soil line from a plot of red versus near infrared brightness values, WDVI is the Weighted Difference Vegetation Index (Clevers, 1988) (Equation 4).

$$WDVI = (NIR - S * R)$$ (Equation 4)

Qi *et al.* (1994) completely solved the problem of L factor by developed MSAVI$_2$ as (Equation 5),

$$MSAVI2 = \frac{\left[2 * NIR + 1 - \sqrt{(2 * NIR + 1)^2 - 8 * (NIR - R)}\right]}{2}$$

(Equation 5)

Methodology
The study area
The study area as shown in Fig. 1, is located on the south slope of the Al-Jabal Al-Akhdar area, northeast Libya located approximately 32° N, and 21° E, with an area of about 3000 km².

The climate is Mediterranean characterized by winter rainfall (November to March or April).

The rainfall range in the region is < 50 to 250 mm per year and temperatures reach below Zero in January and up to 35C in July and August. Fog is a common in the winter months (Fig. 1).

Fig. 1. The Study Area

The vegetation in the study area at lower elevations and reduced rainfall, a belt of dwarf shrub steppe consisting of *Artemisia herba-alba* and *Haloxylon scoparium* occupies the low hills, and the undulating and narrower alluvial plains. Further south, a steppe of stem and leaf succulents occupy the board flat alluvial plains and drier undulating plains. Species in this formation include *Haloxylon scoparium, Anabasis articulata, Suaeda pruinosa*, and *Salsola tetrandra* (Mahmoud *et al.,* 2008).

Quantify the recovery rate of vegetation

Three exclosures (fenced areas) with moderately to severely degraded soil and vegetation, were selected along a strong north-south rainfall gradient (Table 1). Landscape Function Analysis (LFA) technique used to calculate TPA index for each exclosure (Tongway and Hindley, 2004). LFA-SSA-data-entry spreadsheet (Tongway and Ludwig, 2011) was used to calculate TPA index. TPA, NDVI and MSAVI used to quantify the recovery rate of rangelands plant cover between 2006 and 2014. Since TPA, NDVI and MSAVI reflect or related to the vegetation cover, we simply calculated the increasing or decreasing for which as percentages for each study area, then the represented areas were calculated for

each index, and finally, we calculated the recovery rate of rangelands plant cover per year, this calculation is helpful for judging which VIs is closer to the field data. A raised NDVI and MSAVI values for a certain pixel stands for a bigger

change in the degradation status. In the surface area the pixel represents. The ground region with a decline in the vegetation cover was represented by a negative slope pixel.

Table 1. Summary description of study areas

Exclosure area ha	Installation Date	Average of Rainfall mm/year
125	2001	250
220	1993	150
25	2002	100

VIs data sources and analysis

Previous researches indicated that Landsat Enhanced Thematic Mapper Plus (ETM+) may useful in calculation Vegetation Indices values for monitoring and mapping rangeland degradation in a large area (Fernández *et al.,* 2010; Ikeda *et al.,* 1999; Karnieli *et al.,* 2013; Najeeb, 2009). So, we tried to test this free source which covers a vast area and saves time and money. Two Landsat satellite images used to monitor and assess the patterns of changes in plant cover. The satellite images captured from Landsat-7 (ETM+) in September (2006 and 2014) with eight bands ranging from first to the eightieth. There was an application of micrometer, with pixel size $30 \times 30m$.

Image preprocessing

ERDAS Imagine software V.9 employed to correct the satellite image's radiometric and geometric errors, and calculate VIs values. The most common radiometric errors usually occur in the images of Landsat ETM+ are striping and line dropout. The striping is caused by errors in the detector adjustment, and the

result is reading very high or very low comparing to the reality. It should be noted that these errors have been minimized in the new devices of sensors. When the detector completely or temporary fail to function, Lines dropout is a result. This problem solved by replacing the effected line with the mean of the nearest two lines. We used the dark pixel subtraction method to deal with the atmospheric errors (Hall *et al.,* 2006). The UTM coordinator system used to correct the imageries geometrically. The GIS data of 28 monitoring sites (ground control points) used to correct and validate the geometric errors. This system enhanced the exact location of sites for field monitoring within the data that was remotely sensed.

Image classification

As present in Table 2, to classify degradation status, rangelands degradation severity in the study area divided into four Thresholds using The Jenks Optimization method (Jenks, 1967).

Table 2. Degradation severity classification

Degradation Severity Classes	Vegetation Cover %	Thresholds	
		NDVI	MSAVI
Very severe	< 10	0 – 0.07	-1 – -0.8
Severe	10 - 25	0.07 – 0.09	-.81 – -0.7
Moderate	25 - 40	0.09 – 0.16	-0.71 – -0.6
Slight	> 40	0.16 – 1	-0.61 – 1

Results and Discussion
Recovery rate of vegetation

In the northern part which receives the highest average of rainfall in the study

area (250 mm/year), NDVI and MSAVI indicated an increase by the same rate (1%) which considered very low comparing to the rate related to field data

(TPA). On the other hand, the rate of perennial plant recovery was same according to TPA and NDVI calculation (4%) in the area that receive the medium average of rainfall, whilst MSAVI$_2$ represented a recovery rate of 1% in the same area (Table 3). The exclosure that located in the south part of the study area had a negative rate of change per year

according to MSAVI$_2$ and TPA which shows the same percentage of change (-9%), while NDVI shows the lowest declining rate of vegetation cover. This may attribute to the very low vegetation cover in southern the study area as well as the high percentage of sand, silt and Calcium Carbonate which affected NDVI by increasing soil brightness.

Table 3. Calculation of perennial plant recovery rate inside the Exclosures Using the TPA, NDVI and MSAVI$_2$

Indices	Precipitation mm Per Year	Area of Plant Cover (hectares)		
		2006	2014	
	250	0.0360	0.0390	+ 1
NDVI	150	0.0610	0.0800	+ 4
	100	0.0008	0.0006	- 3
	250	0.0360	0.0390	+ 1
MSAVI$_2$	150	0.0610	0.0650	+ 1
	100	0.0008	0.0002	- 9
	250	0.0360	0.0650	+ 10
TPA	150	0.0610	0.0798	+ 4
	100	0.0008	0.0002	- 9

Note: the calculation based on the vegetation cover in 2006, it is not based on the exclosure area

It seems that MSAVI more reliable than NDVI when the vegetation cover is very low because of the increasing of soil brightness with the decreasing of vegetation cover. The results noted that NDVI effected by the average of rainfall which affected on the vegetation cover density. This results supported a findings demonstrated that there exists a good linear relationship between rainfall and NDVI (Nicholson *et al.,* 1990). In general, Results indicated that, there is an increasing in the vegetation cover in the study area, this probably attribute to increasing in the average of rainfall noted in the last two years in the study area.

Rangelands degradation assessment
The calculation of NDVI and MSAVI$_2$ areas showed a positive changes related

to vegetation recovery process in the study area between 2006 and 2014. The NDVI and MSAVI$_2$ distribution from 2006 to 2014 represented moderate and low vegetation densities positive pattern. The positive changes are noted in all classes of degradation severity. The findings showed that the very severe degradation area decreased by about 831 Km^2 and 1229 Km^2 for NDVI and MSAVI$_2$ respectively, which considered as a very positive changing (Table 4). According to the NDVI distribution, these areas transferred to moderate severity condition while the MSAVI$_2$ distribution showed that, most the study area became under sever degradation status (Fig. 2).

Table 4. NDVI and MSAVI calculation of area changing for each severity class

Rangeland Degradation Severity	NDVI			MSAVI		
	Area Km^2		Change Km^2	Area Km^2		Change Km^2
	2006	2014		2006	2014	
Very Severe	854.12	22.77	- 831.34	1229.79	0.97	- 1228.82
Severe	1042.94	785.01	- 257.92	1005.15	1827.29	+ 822.14
Moderate	366.55	1420.32	+1053.77	39.37	426.87	+ 387.51
Slight	10.66	46.14	+ 35.47	0.00	17.94	+ 17.94
Total	2274.29	2274.26		2274.32	2273.10	

The findings demonstrated that, during the period of eight years, many changes that affected the vegetation cover came from classes 1 and 2 (very severe and severe) within the NDVI as well as MSAVI maps (Figs. 2 and 3). The Severe and Very severe classes were mostly observed in the south part of the study area that receives a low average of rainfall. For this area of study, Structural characteristics were vastly variable, since NDVI ranged between 0.06 – 0.13. The high variability reduced by MSAVI which range between -0.8 – -0.6.

The high range of NDVI values is a result of different soil brightness coefficients since there are different types of soil in the study area. Our result is conformation of other similar results of previous studies which conducted that, MSAVI is suitable for the rangelands that have different soil brightness coefficients, and usually it has a strong correlation relationship with the field data related to vegetation cover (Chen, 1999; Gaitán *et al.,* 2013; Liu *et al.,* 2005; Owusu, 2013; Senseman *et al.,* 1996; Yeganeh *et al.,* 2014). However, the plant cover did not change or increase for a large portion of regions at a time when 80% of the study area still under very severe and severe conditions of degradation status.
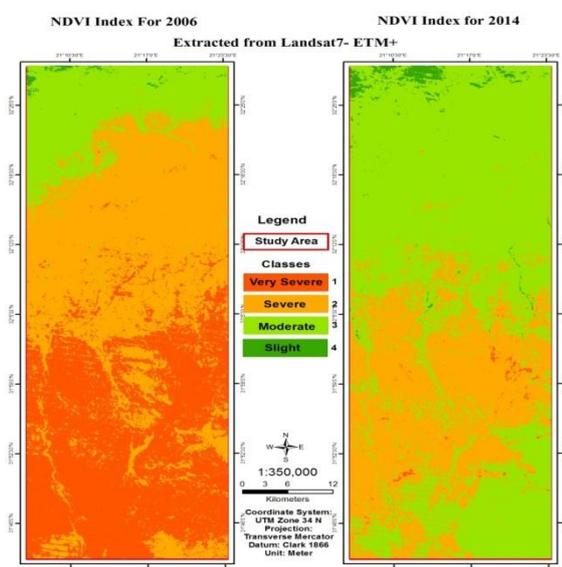

Fig. 2. NDVI Map of changing in Degradation Status (2006 – 2014)

Fig. 3. MSAVI Map of changing in Degradation Status (2006 – 2014)

For several years now, accelerated erosion has been taking a great toll on Jabal Akhdar region resulting in continuous deterioration of the environment which can eventually lead to degradation. It should be noted that according to the results of this study the aridity and overgrazing are the main reasons to increase the degradation rate. Look at all their theories to explain the changes in rangeland vegetation cover the most plausible explanation is that all these changes have occurred due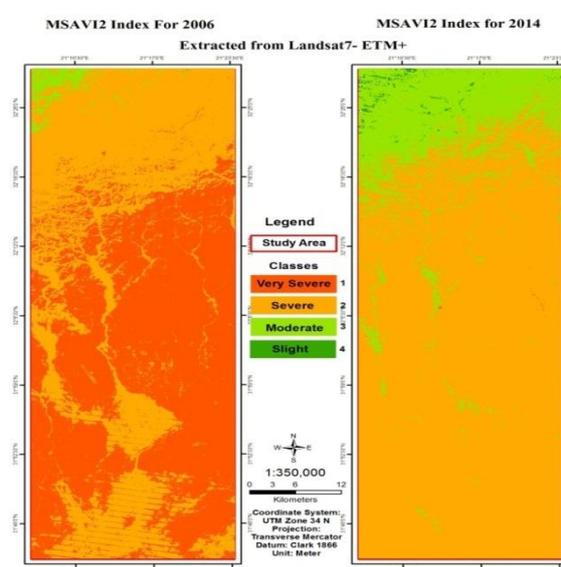 to human activities. The selected VIs equate to earlier field-founded studies and provide how can be employed in assessing changes in ecosystem performance over extensive special scales, it is very intricate and expensive to attain when employing only field-based assessment. Therefore, NDVI and $MSAVI_2$ can be employed as a consistent and comparatively simple to use a tool in management and assessment of degradation processes in the Mediterranean rangeland steppes. The different parameters that must be kept in mind while analyzing land degradation

are the amount of rainfall, nutrient content of the soil and the grazing patterns of that area along with socio-economic studies.

Conclusion

Climatic variability can cause land degradation, so also can human activities in the form of overgrazing, deforestation, and others activities. NDVI and MSAVI$_2$ were able to determine the improvement in the vegetation cover, thus leading to the emergence of green vegetation as well as minimum soil quantities coupled with litter spectral characteristics. It tends to advance the idea that pressure reduction on rangelands may be the answer to the ending of the degradation processes. This has made it essential to adopt all-inclusive programs that will help in the preservation of natural resources for the generation that follows.

Acknowledgements

Literature Cited

Bai, Z., Dent, D., Olsson, L. and Schaepman, M., 2008. Global assessment of land degradation and improvement 1: Identification by remote sensing. *Report 2008/01, FAO/ISRIC-Rome/Wageningen.*

Bannari, A., Morin, D., Bonn, F. and Huete, A., 1995. A review of vegetation indices. *Remote Sensing Reviews*, 13(1-2): 95-120.

Chen, Y., 1999. Correlation of saltbush cover measurements to tm wavebands and vegetation indices. *Geoscience and Remote Sensing Symposium, 1999. IGARSS'99 Proceedings. IEEE 1999 International*: 2590-2592.

Clevers, J., 1988. The derivation of a simplified reflectance model for the estimation of leaf area index. *Remote Sensing of Environment*, 25(1): 53-69.

Fernández, N., Paruelo, J. M. and Delibes, M., 2010. Ecosystem functioning of protected and altered mediterranean environments: A remote sensing classification in doñana, spain. *Remote Sensing of Environment*, 114(1): 211-220.

Gao, B. C., 1996. Ndwia normalized difference water index for remote sensing of vegetation liquid water from space. *Remote sensing of environment*, 58(3): 257-266.

Gaitán, J. J., Bran, D., Oliva, G., Ciari, G., Nakamatsu, V., Salomone, J., Ferrante, D., Buono, G., Massara, V. and Humano, G., 2013. Evaluating the performance of multiple remote sensing indices to predict the spatial variability of ecosystem structure and functioning in patagonian steppes. *Ecological indicators*, 34: 181-191.

Hall, R., Skakun, R., Arsenault, E. and Case, B., 2006. Modeling forest stand structure attributes using landsat ETM+ data: Application to mapping of aboveground biomass and stand volume. *Forest Ecology and Management*, 225(1): 378-390.

Huete, A. and Jackson, R., 1988. Soil and atmosphere influences on the spectra of partial canopies. *Remote Sensing of Environment*, 25(1): 89-105.

Ikeda, H., Okamoto, K. and Fukuhara, M., 1999. Estimation of aboveground grassland phytomass with a growth model using landsat tm and climate data. *International Jour. Remote Sensing*, 20(11): 2283-2294.

Jackson, R. D. and Huete, A. R., 1991. Interpreting vegetation indices. *Preventive Veterinary Medicine*, 11(3): 185-200.

Jenks, George F., 1967. "The Data Model Concept in Statistical Mapping", International Yearbook of Cartography 7: 186–190.

Karnieli, A., Bayarjargal, Y., Bayasgalan, M., Mandakh, B., Dugarjav, C., Burgheimer, J., Khudulmur, S., Bazha, S. and Gunin, P., 2013. Do vegetation indices provide a reliable indication of vegetation degradation? A case study in the mongolian pastures. *International Jour. Remote Sensing*, 34(17): 6243-6262.

Le Houerou, H. N., 2000. Restoration and rehabilitation of arid and semiarid mediterranean ecosystems in north africa and west asia: A review. *Arid Soil Research and Rehabilitation*, 14(1): 3-14.

Le Houérou, H. N., 2001. Biogeography of the arid steppeland north of the sahara. *Jour. Arid Environments,* 48(2): 103-128.

Liu, A., Wang, J., Liu, Z. and Wang, J., 2005. Monitoring desertification in arid and semi-arid areas of china with noaa-avhrr and modis data. *Geoscience and Remote Sensing Symposium,*

2005. IGARSS'05. Proceedings. 2005 IEEE International: 2362-2364.

Mahmoud, A., Gadallah, A., Mohemmed, S., Mohamed, M., Abdel-Ghani, A., Alhendawi, R. and Russell, P. J., 2008. Aspects of range condition recovery in the southern jebel al akhdar, northeastern libya. *Proceedings of the XXI International Grassland Congress and the VIII International Rangeland Congress (volume I)*, China.

Mróz, M. and Sobieraj, A., 2004. Comparison of several vegetation indices calculated on the basis of a seasonal spot xs time series, and their suitability for land cover and agricultural crop identification. *Technical Sciences*, 7: 39-66.

Najeeb, A. A., 2009. Estimation of the normalized difference vegetation index (ndvi) variation for selected regions in iraq for two years. *Jour. University of Anbar for pure science*, 3(3): 1991- 8941.

Nicholson, S. E., Davenport, M. L. and Malo, A. R., 1990. A comparison of the vegetation response to rainfall in the sahel and east africa, using normalized difference vegetation index from noaa avhrr. *Climatic Change*, 17(2-3): 209-241.

Owusu, A. B., 2013. Detecting and quantifying desertification in the upper east region of ghana using multi-spatial and multi-temporal normalized difference vegetation index. *Jour. Environment and Earth Science*, 3(10): 62-78.

Phillips, R., Beeri, O., Scholljegerdes, E., Bjergaard, D. and Hendrickson, J., 2009. Integration of geospatial and cattle nutrition information to estimate paddock grazing capacity in northern us prairie. *Agricultural systems*, 100(1): 72-79.

Qi, J., Chehbouni, A., Huete, A., Kerr, Y. and Sorooshian, S., 1994. A modified soil adjusted vegetation index. *Remote Sensing of Environment*, 48(2): 119-126.

Rouse Jr, J., Haas, R., Schell, J. and Deering, D., 1974. Monitoring vegetation systems in the great plains with erts. *NASA special publication*, 351: 309.

Senseman, G. M., Tweddale, S. A., Anderson, A. B. and Bagley, C. F. 1996. Correlation of land condition trend analysis (lcta) rangeland cover measures to satellite-imagery-derived vegetation indices. DTIC Document.

Tongway, D. and Hindley, N., 2004. Landscape function analysis: A system for monitoring rangeland function. *African Jour. Range and Forage Science,* 21(2): 109-113.

Tongway, D. J. and Ludwig, J. A., 2011. Restoring disturbed landscapes: Putting principles into practice, Island Press.

Yeganeh, H., jamale Khajedein, S., Amiri, F. and Shariff, A. R. B. M., 2014. Monitoring rangeland ground cover vegetation using multitemporal modis data. *Arabian Jour. Geosciences*, 7(1): 287-298.

Zatout, M. M., 2014. Effect of negative human activities on plant diversity in the jabal akhdar pastures. *International Jour. Bioassays*, 3(9): 3324-3328.

ارزیابی تخریب مراتع در شیب جنوبی الجبال-الاخدار، شمال شرقی لیبی با استفاده از تکنولوژی سنجش از دور

عادل م. الف. محمود^{الف}، محاد هاسمادی بن اسمائیل^ب، آلیاس محمد سوود^ج، محمد ازانی الیاس^د

^{الف}دانشکده جنگلداری، دانشگاه پوترا مالزی (نگارنده مسئول)، پست الکترونیک: adelborabha@yahoo.com.my

^{ب، ج، د}دانشکده جنگلداری، دانشگاه پوترا مالزی

چکیده. نرخ تخریب استپ‌های مدیترانه‌ای بخصوص در شمال آفریقا یک درصد در سال است و این موضوع نشان دهنده نرخ تخریب بالا در منطقه است. این مطالعه در سال ۱۳۹۳ در شیب جنوبی منطقه الجبال-الاخدار شمال شرقی لیبی جهت تعیین نرخ احیا پوشش گیاهی انجام شد. شاخص پوشش گیاهی برای تهیه نقشه تخریب مراتع منطقه با استفاده از تکنولوژی سنجش از راه دور بکار رفت. در طی این مطالعه مشخص شد که شاخص‌های NDVI و MSAVI مناسب منطقه برای رسیدن به اهداف تحقیق می‌باشند. دو نوع تصویر ماهواره لندست +ETM (گرفته شده در بین سال‌های ۲۰۰۶ الی ۲۰۱۴) برای ارزیابی پوشش گیاهی منطقه مورد استفاده قرار گرفت. سه منطقه قرق (محافظت شده با حصار) با شدت‌های تخریب متوسط تا سنگین به لحاظ خاک و پوشش گیاهی با تغییرات شدید بارش از شمال به جنوب در نظر گرفته شد. روش آنالیز عملکرد منظرگاه برای منطقه و مقایسه تخریب‌ها بکار رفت. نتایج نشان دادند که دو شاخص مورد اشاره به عنوان ابزاری ساده و در عین حال ثابت برای فرآیند بیابانزایی مراتع مدیترانه‌ای مناسب شناخته شدند. همچنین نتایج نشان داد که در زمانی که پوشش گیاهی خیلی کم است شاخص MSAVI مناسب تر از شاخص NDVI است. در مجموع نتایج نشان داد که در قسمت زیادی از منطقه تغییری در میزان پوشش گیاهی دیده نشد و حتی وقتی ۸۰ درصد منطقه تحت وضعیت‌های تخریب شدید تا خیلی شدید قرار گرفته‌اند.

کلمات کلیدی: الجبال الاخدار، لیبی، شاخصهای گیاهی، روش TPA