Drought and its effect on vegetation, comparison of NDVI for drought and non-drought years related to Land use classifications

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Abstract

The purpose of this study is to analyze the effects of drought on various land use types. This study uses a combination of remote sensing data, field observations and information from local people to analyze the effects of drought on various land use changes for 2 years 1999 and 2004 in Isfahan. Imagery was selected for both drought and non-drought conditions based on precipitation data. The Normalized Difference Vegetation Index (NDVI) was then calculated for both images in order to detect the amount of change within the study area. The NDVI images were then analyzed for land use classification to determine which classification was the most susceptible to drought in terms of reduced NDVI values. Overall there was a decrease in the NDVI values for drought conditions as expected. The results of this experiment indicated that the rangeland classification had the highest percent change between the two NDVI images; mean NDVI value change from 0.199 to 0.895 resulting in a 63.6 percent change due to drought effects. Therefore rangeland were the most effected land classification; however there are several factors that occur in this class including grazing, exclosure and harvest that could have skewed the results.

Key words: Drought, NDVI, Land Use

1. Introduction

Drought are natural phenomena that occur throughout history. drought are associated with a shortage of water resources over a large geographical area, which extends for a significant period of time. There is not a universally accepted definition of drought at is depends on wide variety of climatological parameters, with significant spatial variability. Drought occurs in both high and low rainfall areas and virtually all climate regimes.

As Obasi mentioned, droughts had affected 50% of 2.8 billion people who suffered from weather-related disasters. Moreover, 1.3 million people have died due to the direct and indirect cause of drought during 1967–1991.

Remote sensing methods are based on brightness values of the land cover types and enable the characterization of the land cover. Because vegetation differentially absorbs visible incident solar radiant and reflects much of the near infrared (NIR), data on vegetation biophysical characteristics can be derived from visible and NIR and mid-infrared portions of the electromagnetic spectrum. Several vegetation indices have been introduced using ratios of these reflections.

The purpose of this project will be to determine drought effects on NDVI in the Semirom region (Isfahan) and also the effects on selected land use types within the region to determine which type is most susceptible to drought conditions. Iran is currently under severe drought conditions and has been for the previous year. Precipitation data suggests that rainfall is several milimeter below normal. In order to determine the effects of drought and make a statistical comparison to non-drought years it is necessary to identify drought periods. Rain gauge data was used to determine dry periods and Landsat imagery will be used to derive NDVI using Erdas software.

Normalized Difference Vegetation Index (NDVI)

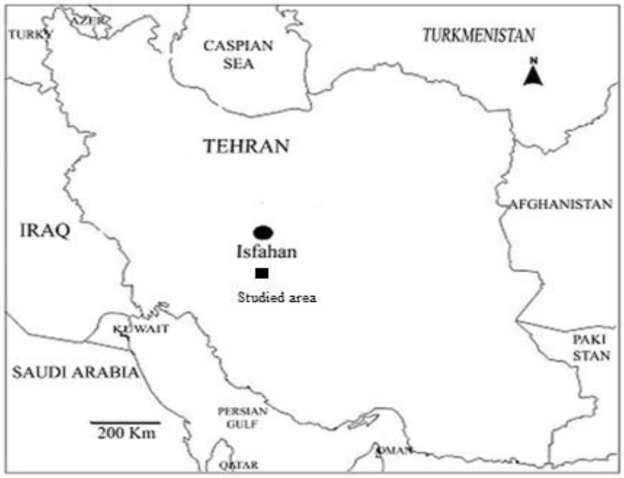
Many researchers have been able to determine vegetation state using vegetation indices such as the (NDVI). The NDVI approach is based on the fact that healthy vegetation has a low reflectance in the visible portion of the electromagnetic spectrum due to absorption by chlorophyll and other pigments, and high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of a green leaf. NDVI can be calculated as the ratio of red and the NIR bands of a sensor system and is represented by the following equation: $NDVI = (NIR - RED)/(NIR + RED)$

NDVI values range from -1 to +1. Because of high reflectance in the NIR portion of the electromagnetic spectrum, healthy vegetation is represented by high NDVI values between 0.05 and 1. Conversely, nonvegetated surfaces such as water bodies yield negative values of NDVI. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the electromagnetic spectrum.

2. Data and Material

A. Study Area

For this project a study was selected in the Semirom region (Isfahan). Figure 1 illustrates the geographic extent of the study area. The specific area was refined by using a Land Use shape files in order to simplify classification. Five LU tiles were selected from the LU shape file which comprised an area of, 1541 Square kilometer. The types represented and the areas for each type in the study area are provided in Table I. Figure 2 provides the geographic extent for each LU class in the study area.



Fi 1: Study area

Table I: land use and areas within study area

Land use Code	Description	Square kilometer
1	Residential	2.361
2	Agriculture	122.031
3	Rangeland	1358.452
4	Rock	29.823
5	Orchard	28.557

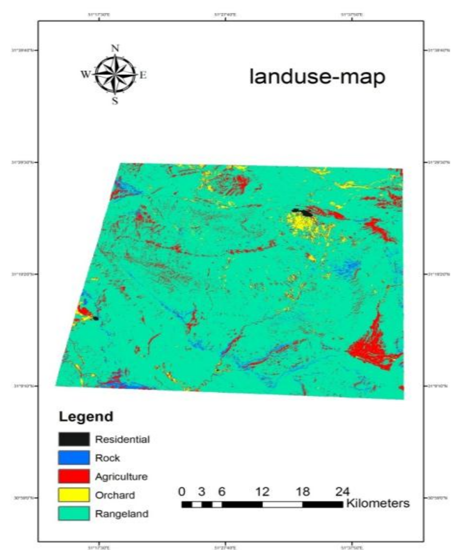


Fig.2 Land use map

3. Research Methodology

precipitation data were collected at 21 synoptic stations in the study area over a seventeen year period from 1993 to 2009. Data from a number of other rainfall stations present in the study area were not used due to the fact that their validity could not be verified. precipitation data was compiled in order to determine years of drought vs. non-drought conditions using the yearly average of precipitation. Normal rainfall for Semirom region (Isfahan) is approximately 310 millimeter per year. The data analyzed (1993 to 2009) revealed two dry periods. These include the current drought condition and a dry period that took place in 2007. Figure 3 presents the yearly precipitation data 21 synoptic stations in the study area over a. seventeen-year period from 1993 to 2009. Figure 4 presents monthly precipitation data 1993 - 2009. from Figures 3 it is easily observed that there are two years suitable to analyze imagery for drought conditions. These are 1999 and 2007. For this study 1999 will be used to analyze drought conditions as 1999 had precipitation levels 25 millimeter below normal. The year 2004 will be used for non-drought conditions. It should be noted that even though the rainfall appeared normal for the 2004 image, much of the Isfahan area was still under drought conditions.

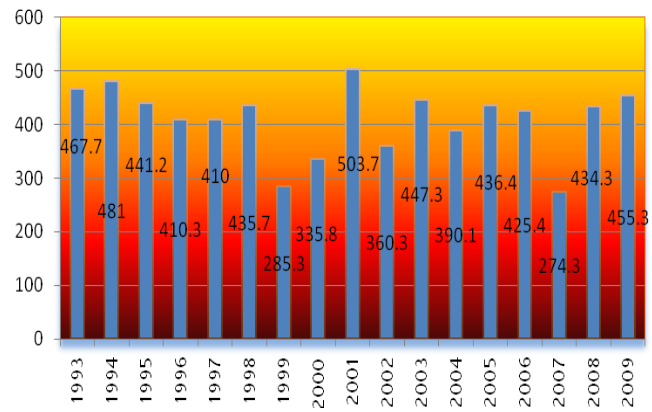


Fig. 3 yearly precipitation (mm.)

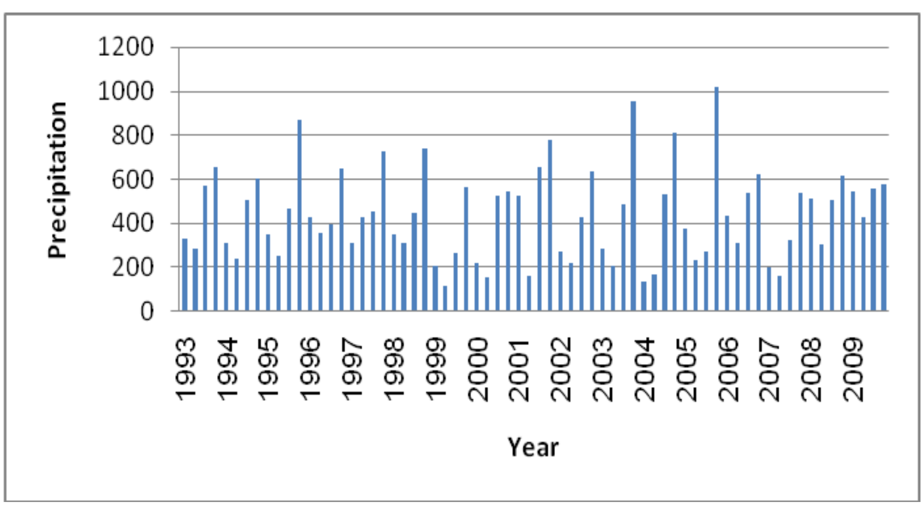


Fig. 4 Monthly Precipitation Data 1993 -2009

C. Imagery Data:

The 1999 image was acquired 8/26/1999. The 2004 image was acquired 9/10/2004. These images were also selected due to their closeness in seasonal timeframe. Land use map were created for both the 1999 and 2004 using the Erdas software.

It was used to refine the study area and also for comparison of effects of drought on different Land use classifications in terms of drought effects on vegetation (NDVI).

D. Image Preprocessing:

Image preprocessing included clipping the original images to the study area. This was accomplished by creating a shape file in ArcGis from the Land use shape file, which was imported into ENVI and used to clip the original images. The Dark Object Subtract method was used to adjust images to remove all atmospheric interference.

E. Change Detection:

In order to determine the effects of drought condition the Normalized Difference Vegetation Index (NDVI) was used. As Yingxin Gu (2007) mentioned there is strong relationships among NDVI, NDWI and drought conditions.

NDVI images were created for both the 1999 and 2004 using the ENVI. For this study change is defined as a change in the mean of the NDVI pixel values for the study area between the two images (1994 and 2004). Change was evaluated for 1) overall change in NDVI pixel vales for the entire study and 2) selected LU classification areas. The individual change detection for each LU class was performed in order to determine which class was most affected by the drought conditions during 1999. In order to find the change for selected land classes it was necessary to first merge all polygons of the same classification in the LU shapefile into one polygon for each 5 class. After merging polygons selected LUs were exported to individual shapefiles and then imported into the ENVI software to use as Regions of Interest (ROI). This allowed for computation of NDVI statistics for each ROI/LU classification for the NDVI images. The selected LU classification types used to detect change are also provided in Table I This process was performed for both the 1999 and 2004 images (drought and non-drought conditions), and the results were compared to determine the droughts effects upon selected LU types.

4. Results and Analysis

The NDVI images for 1999 and 2004 demonstrated a noticeable change in the overall NDVI values. Figure 5 presents the NDVIs for both years. There are more pronounced and concentrated low NDVI areas for the 1999 and 2004 image (yellow); but the 2004 has a larger area that is affected by the drought and is represented by the yellow areas.

The range land classification had the highest percent change between the two NDVI images; mean NDVI value change form 0.199 to 0.895 resulting in a 63.6 percent change due to drought effects. Table II presents descriptive statistics and percent changes for the selected land classifications evaluated. Residential and Rock classification (LU 1 and 4) experienced the least effects from the drought as the two classes changed 9 and 17 percent respectively.

Table II: Descriptive statistics for NDVI values for selected Land use classifications

Code	Land Classification	1999 NDVI Values				2004 NDVI Values				%Change
		min	**max**	**mean**	**sted**	**min**	**max**	**mean**	**sted**	
1	**Residential**	**-0.17**	**0.50**	**0.13**	**0.15**	**-0.13**	**0.59**	**0.16**	**0.16**	**9.21**
2	**Agriculture**	**-0.61**	**0.50**	**0.27**	**0.03**	**-0.43**	**0.78**	**0.65**	**0.15**	**41.3**
3	**Rangeland**	**-0.35**	**0.79**	**0.19**	**0.11**	**-0.18**	**0.99**	**0.89**	**0.12**	**63.6**
4	**Rock**	**-0.31**	**0.36**	**0.08**	**0.17**	**-0.26**	**0.50**	**0.12**	**0.03**	**17.1**
5	**Orchard**	**-0.42**	**0.66**	**0.23**	**0.14**	**-0.18**	**0.71**	**45**	**0.18**	**32.3**

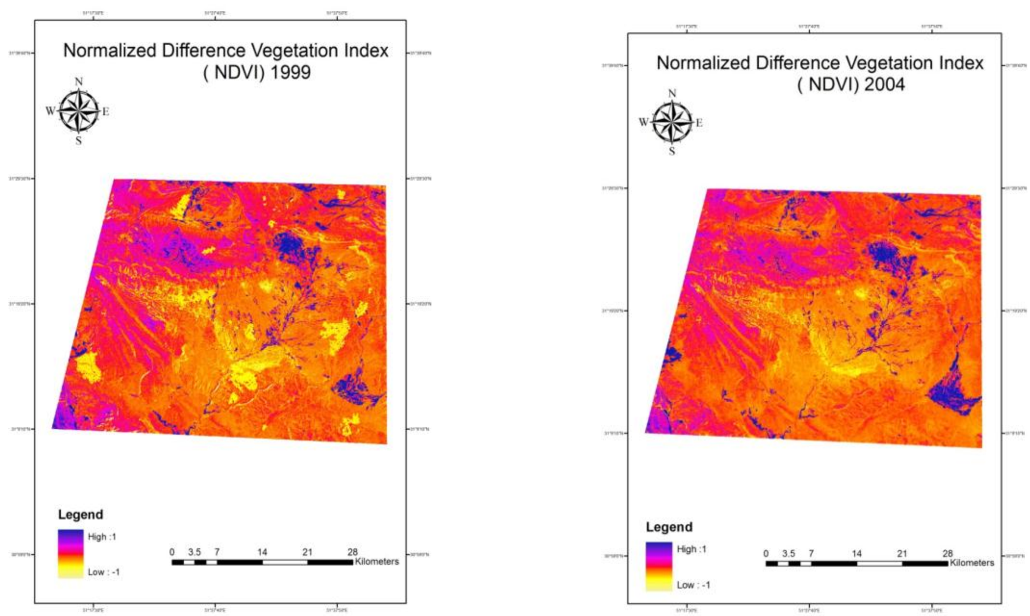


Fig. 5 Normalized Difference Vegetation Index (NDVI) for 1999-2004

5. Conclusions

Overall there was a decrease in the NDVI values for drought conditions, as expected of the specific land classifications that were evaluated the non-native vegetation types appeared to be more negatively effected by drought.

Rangeland were the most effected land classification; however there are several factors that occur in this class including grazing, exclosure and harvest that could have skewed the results. The NDVI method used to evaluate the vegetation health could have been flawed. Additionally, the LU shapefile used to create the ROIs for this study are generalized and may be, in some areas, out of date. The land use classification could be further refined using the

ENVI software to create more precise classifications which could be used to identify land cover types that provide a more accurate measure of the effects of drought. However, this technique would be subject to operator discretion and could provide different results between studies based on the operators classifications. This technique could be applied to any number of thematic map types including soil types, elevation, eco-regions etc. It provides a simple tool to evaluate the effects of the classification type on the NDVI. However, caution should be observed as there are many factors that contribute to the NDVI, most importantly, drought.

Acknowledgements

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References

A. Loukas, L. Vasiliades, 2002. "Hydroclimatic Variability of Regional Drought in Greece Using the Palmer Moisture Anomaly Index", Nordic Hydrology; 33,5: 425-442.

B. C. Reed, J. F. Brown, D. Vanderzee, T. R. Loveland, J. W. Merchant, D. O. Ohlen, 1994. " Measuring phenological variability from satellite imagery", Journal of Vegetation Sciences 5, 703–714.

C. Tucker, 1979. "Red and photographic infrared linear combination for monitoring vegetation". Remote Sensing of Environment; 8,127–150.

G. John, D. Yuan, R. S. Lunetta, C. D. Elvidge, 1998. "A change detection experiment using vegetation indices", Photogrammetric Engineering and Remote Sensing 62, 143–150.

G. Yingxin. 2007. A five-year analysis of Modis NDVI and NDWI for grassland drought assessment over the central Great Plains of the United States. Geophysical Research Letters; 34, 6.

J. B. Campbell, 1987 "Introduction to Remote Sensing", The Guilford Press, New York..

J. Keyantash, A. Dracup, 2002. "The Quantifoication of Drought: An Evaluation of Drought Indices", Bulletin of American meteorological Society;1167-1180.

J.P. Malingreau, S.B. Belward, 1992. "Scale consideration in vegetation monitoring using AVHRR data", International Journal of Remote Sensing 13, 12: 2289–2307.

L. Di, D.C. Rundquist., L. Han, 1994. " Modeling relationships between NDVI and precipitation during vegetative growth cycles", International Journal of Remote Sensing. 15, 10: 2121–2136

N. R . Dalezios, Z.G. Papazafiriou, 1991. "Drought assessment for the potential of precipitation enhancement in Northern Greece" , Theor Appl. Climatol; 44: 75-88.

O. P. Obasi, 1994. " WMO's role in the international decade for natural disaster reduction", Bulletin of the American Meteorological Society;75, 1655–1661.

P. Rahimzadeh Bajgiran, A. Darvishsefat,. 2008. "Using AVHRR-based vegetation indices for drought monitoring in the Northwest of Iran", Journal of Arid Environments; 72, 1086–1096.

S. E. Marsh, J. L. Walsh, 1992. “Comparison of multi-temporal NOAA-AVHRR and SPOT-XS satellite data for mapping land cover dynamics in the West African Sahel”, International Journal of Remote Sensing 13, 2997–3016.

S. N. Goward, B. Markham, D. G. Dye, 1991. “Normalized difference vegetation index measurements from AVHRR”, Remote Sensing of Environment; 35, 257–277.

T. M. Lillesand, W. Keifer, 1994. “Remote Sensing and Image Interpretation. Wiley”, New York.

W. Yang, L. Yang, J. M. Merchant, 1998. “An assessment of AVHRR/NDVI ecoclimatological relations in Nebraska”, USA. International Journal of Remote Sensing ;18 , 10: 2161–2180.