Review of relationship between PNPI and NDVI indices

(Case study: monitoring of drought in Azarbaijan - Iran 2000- 2005)

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Abstract

Droughts are natural hazards with varying patterns in space, time, and intensity. This phenomenon is a major natural disaster that has caused many problems in many countries. Awareness of drought status, with the prediction and area mapping of drought intensity can due to considerable decrease in risk of this phenomenon. Prediction of droughts with use of suitable index and providing of drought intensity maps with help of remote sensing technology with minimum time and cost is important step for managing this phenomenon. The purpose of this study was to investigate the possibility of drought monitoring using normalized difference vegetation index (NDVI) and remote sensing technology, with an area of 47,830 square kilometers of East Azarbaijan province. And also to identify the worst drought in years is studied. East Azarbaijan province is one of the Iran's provinces that have been faced with severe drought in recent years. In this study, the drought index PNPI (percent of normal precipitation index) and NDVI index (normalized difference vegetation index) were reviewed in order to monitor drought in East Azarbaijan province. For this goal were calculated PNPI index for 12 meteorological major stations (2000 to 2005) in this province and then drought area map, according to that index, was provided. Then NDVI maps with use of images of 10-day maximum normalized vegetation were provided. The result show, that 2001 with minimum NDVI has most severe drought and also there is .8 correlation between average PNPI index and average NDVI index. There is therefore possibility of producing drought maps with the NDVI index.

Key words: Drought, Remote sensing, PNPI, NDVI

1. Introduction

Drought is a complex natural phenomenon that occurs in all regions. Drought is one of the main natural hazards affecting the economy and the environment of large areas (Obasi 1994, Bruce 1994). Drought is a complex phenomenon which involves different human and natural factors that determine the risk and vulnerability to drought.

Although the definition of drought is very complex (Wilhite and Glantz 1985), it is usually related to a long and sustained period in which water availability becomes scarce (Dracup et al. 1980, Redmond 2002) The outbreak of this phenomenon had always had high losses thus statistics of this losses revolve the necessity of investigation and monitoring of drought is so important. Mohseni Saravi et al (2005) in his paper expressed that the drought is one of the most chronic and loss natural disasters That Affect the human population and cause many problems for them. Number and frequency of this phenomenon is more than other events. Sabzi parvar (1382) with some indices aridity and drought resulted in a 27-year period severe drought in the Hamadan province has occurred during 78-77. Lucas et al (2003) using data from 28 stations with during 40 years (2000-1960) to calculate and compare the three drought indices, this indices were included in this study SPI (Standardized Precipitation Index) , PNPI and precipitation z index. They first calculated those three indices for the time scale of 3, 6, 12, 24 month, then they compare above indices, the result showed that all three indices had same performance in determining the severity and continuation of drought.

There are a number of indicators for drought monitoring and assessment. Every indicator has its successes and limitations in drought detection. Meteorological drought indicators assimilate information on rainfall, stored soil moisture or water supply but they do not express much local spatial detail l(Brown et al, 2002). Also, drought indices calculated at one location is only valid for single location. Thus, a major drawback of climate based drought indicators is their lack of spatial detail as well as they are dependent on data collected at weather stations which sometimes are sparsely distributed affecting the reliability of the drought indices (Brown et al. 2002). But after appearance of remote sensing technology the possibility of supervising on vegetation is provide. Assessment of vegetation with uses of reflectance remote sensing data with lowest cost and time is one the best methods for monitoring the condition of drought. The purpose of this study was to investigate the possibility of drought monitoring using normalized difference vegetation index (NDVI) and remote sensing technology.

2. Data and Material

The study area in this paper is East Azarbaijan province.The province is located in the northwest of Iran (is bounded by longitudes 32°20'–34°52'E and latitudes 27°45'–31°10'N) and covers an area of approximately 47,830 sq. km. in this study 12 meteorological major stations data were used (2000 to 2005) and also MODIS (Moderate Resolution Imaging Spectra Radio-meter) images during 10 days period was used. Also Topographic map (1:25000) for geometric correction and study of area was used.

3. Research Methodology

3-1 Producing drought area map

For providing drought area map 12 meteorological major stations data is used.

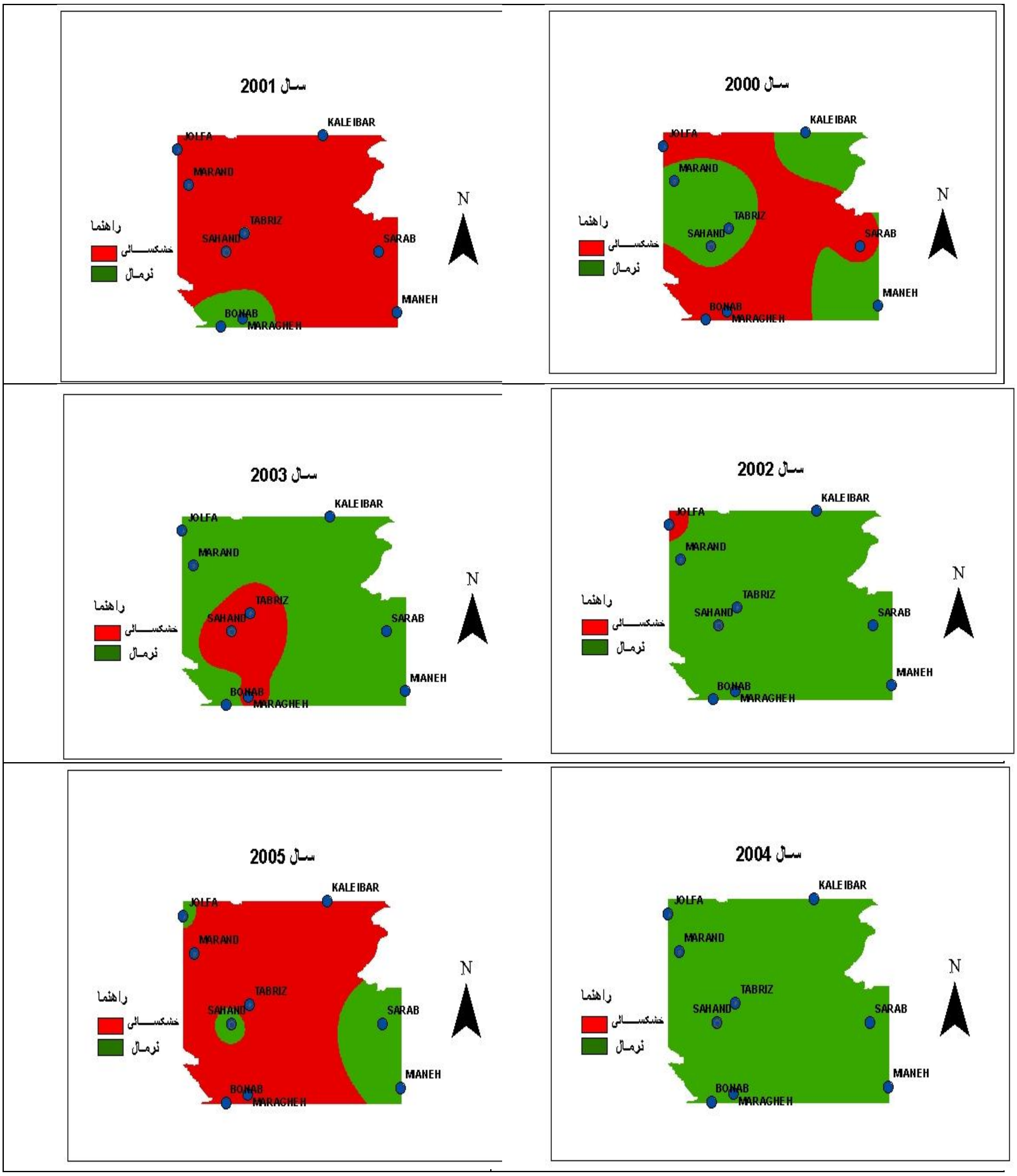

Fig 1. Drought area map from 2001-2005, green class related to normal area and red class related to drought-affected area, 2001 had most severe drought.

this data contain 2000 to 2005.the drought index that use in this study is PNPI (Percent of Normal Precipitation Index) this index is calculated by the formula given in (1):

$$PNPI = \frac{Pi}{\bar{p}} * 100 \qquad (1)$$

p_i Stand for the annual rainfall size, and $\overline{p}$ is long time mean.

After calculating of PNPI index for each station, drought area map with IDW (inverse distance weighted) interpolation method (due to the mountainous nature of the study area)

was produced for 2000 to 2005. Then threshold was determined, different areas were reclassified into two classes consist of normal and drought-affected classes (Figure1). For doing this step we used ARC GIS 9.3 software.

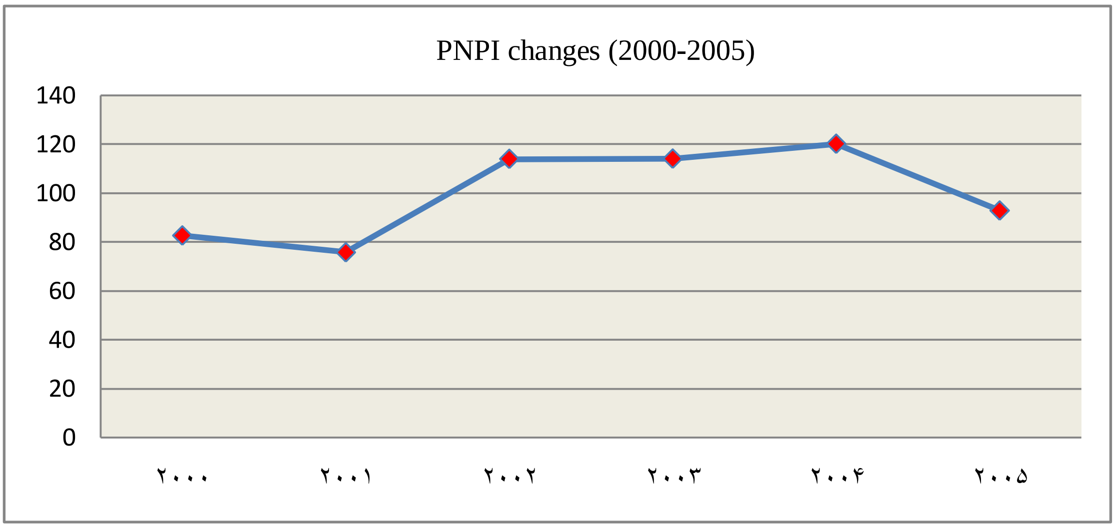

Diagram 1. PNPI drought index diagram based on year during 2000-2005, 2001 had lowest PNPI and had severe drought and had most severe drought in years of study

Year	Average PNPI (Percent)
2000	82.7699
2001	75.9
2002	114.03
2003	114.136
2004	120
2005	92.95

Table 1. Average PNPI (2000-2005)

(2001 had lowest PNPI)

3-2 producing NDVI map

3-2-1 preprocessing satellite images

Before using images for producing NDVI map, preprocessing steps should be done. This steps consist of conversion of HDF format to tif format, geometric correction using topographic with choosing enough ground control points, atmospheric correction etc.

All of mentioned points were done in ERDAS 9.1 and ENVI 4.6 software.

3-2-2 prouducing NDVI map

For the first time tuckler in 1967 introduced NDVI as vegetation density and health indicator. NDVI is calculated from the red and near-infrared light reflected by vegetation. Healthy vegetation absorbs most of the red light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more red light and less near-infrared light. Nearly all satellite Vegetation Indices employs this difference formula to quantify the density of plant growth on the Earth. The result of this formula is called the Normalized Difference Vegetation Index (NDVI). Written mathematically, the formula is (2):

$$NDVI = (NIR - R)/ (NIR + R) \qquad (2)$$

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves. For producing NDVI map we use combination of 10 days NDVI images in each year (Figure 2).

For doing this step we used ARC GIS 9.3 and ENVI 4.6 software.

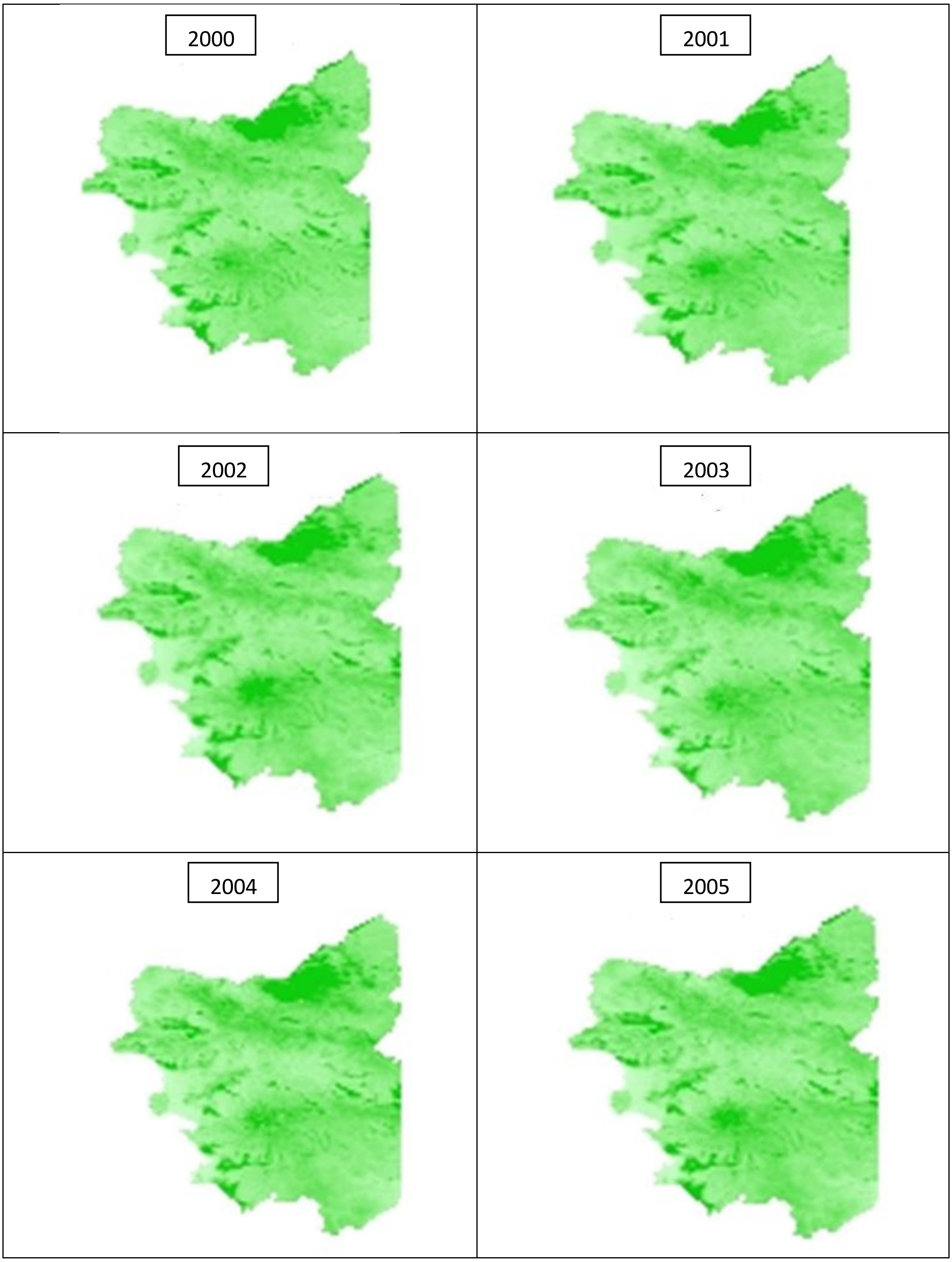

Fig 2. Annual mean NDVI map from 2001-2005, combination of 10 days NDVI images in each year.

4. Results and Analysis

Calculating of average NDVI revolved that there was a decreasing trend in the vegetation since 2000-2001 and increasing trend between 2001 to 2003 but again we confront with decreasing trend until 2005 (diagram 2).

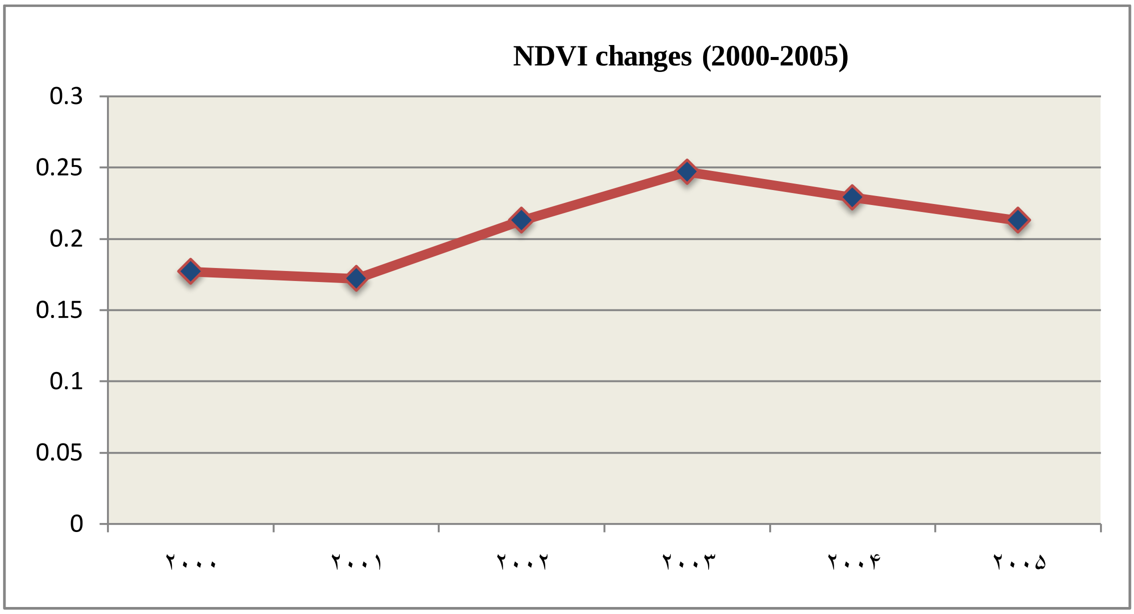

Diagram 2. NDVI changes (2000-2005), 2001 had lowest NDVI

year	Average NDVI
2000	.177
2001	**.172**
2002	.213
2003	.247
2004	.229
2005	.213

Table 2. Average NDVI (2000-2005), 2001 had lowest NDVI

by comparing these values with PNPI average values observe that there is a direct relation between NDVI and PNPI changes (diagram 2).

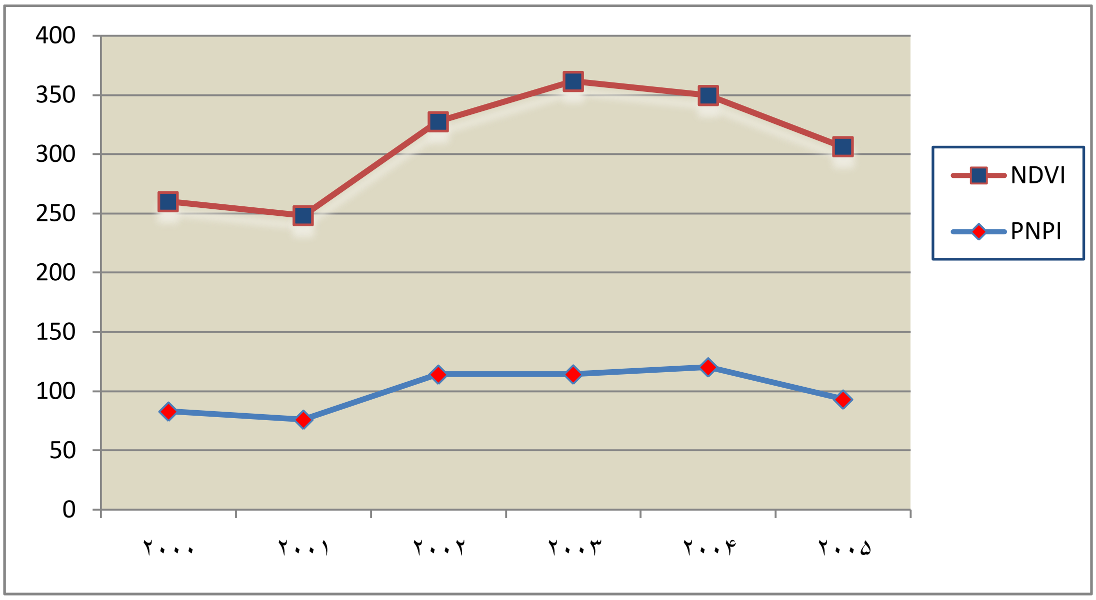

Diagram 3. Comparison PNPI & NDVI changes (2000-2005)

As shown in the diagram with increasing severity of drought we faced to decrease of NDVI value.

5. Conclusions

As result of calculating the correlation coefficient between NDVI average and PNPI average that correlation is .8. With producing of drought area map determined 2001 had most severe drought in other words drought covered vast majority of the provine's area and NDVI had also been at the minimum. Comparison of diagram show that a direct relation between two indices; therefore we can use NDVI index for providing drought area map and managing drought across the province.

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