A survey of drought and variation of vegetation by statistical indexes and remote sensing (Case study: Jahad forest in Bandar Abbas)

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Abstract. The damages of drought as a climatic and creeping phenomenon are very enormous specially in deserts. Necessity of management and conflict with it is clear. In this case vegetation are damaged too, and even are changed faster. This paper describes the process of vegetation changes and surveys it with drought indexes such as statistical and remote sensing indexes and correlation between temperature and relative humidity by Geographical Information System (GIS) and Remote Sensing (RS) in forest park of Bandar Abbas in successive years. At the end the regression and determination-coefficient for showing the importance of drought's survey are computed. Results revealed that the correlation between vegetation and indexes was 0.5. The humidity had maximum correlation and when we close to 2009 the period of droughts increase and time intervals decrease that influence vegetation enormously and cause the more area lost its vegetation.

1. Introduction
Drought is a climatic phenomenon that is known as a creeping ones because its effects are revealed slow. Iran are influenced by drought in recent decades, alternatively and its effects on human life are obvious [11] as its occurrence frequency is noticeable especially in arid and semi-arid regions. One of these region is Bandar Abbas that has most occurrence (50%) [9]. Asiyayi [2] points out that each index is valid just for specific operation in specific regions because of variable meteorological conditions are responsible for creating drought, so we can use same drought indexes in same climatic regions. Presenting appropriate and long-term data of climatic and hydrological parameters is really necessary. It is impossible to study drought without these data. Although precipitation is main factor in control,
creation, extension and continuation of drought, evaporation and transpiration are most important factors that can explain drought behavior. In spite of above, precipitation is known as a most appropriate and quite accessible climatic parameter for creating and computing drought indexes because of calculating problems of evaporation and transpiration. In fact, indexes that are based on precipitation data are more suitable in comparison with complicated hydrological indexes. Standardized Precipitation Index (SPI) is accuracy and validity enough that is used for Iran, Khorasan province[2] that is accepted by scientific societies and operators so SPI is incorporated in this study. Because of drought and its environmental damages are not restricted to a region and they can risk the whole environment in long and medium terms, finding scientific solutions for reducing drought impacts is essential. In regard to vegetation significance for governmental and nongovernmental organization in the world and critical problem of removing green spaces due to drought and other disasters such as flood and fire that are followed by environmental damages and desertification, providing more information about vegetation conditions such as its amount and dispersal is vitally important. To use satellite data, extensive study on vegetation is possible. Vegetation indexes can be considered for declining radiation effects of other ground phenomena and major concern in vegetation information. In fact, vegetation indexes are demanded for distinguishing vegetation from other phenomena that it is not possible by single-bands [10]. Vegetation indexes make it possible to apply mathematical analysis on data. To operate Geographical Information System (GIS) and Remote Sensing (RS), we can study these regions. Capability of GIS in integrating layers that are made in RS is more effective than traditional procedures and results are more clear and more accurate [4] and to use of them we can assess vegetation changes in successive years. Normalized Difference Vegetation Index (NDVI) is sought to survey and assess vegetation [12]. Drought intensity is determined in a 30 years statistical period for 20 stations in 3 temporal scales, 6, 12 and 24 months that results indicated Fars province had trouble with drought in many years and its intensity in recent years is much more than prior years and other results reveal, short-term droughts have much fluctuations and variation and they are more sensitive to humidity variations and severe droughts have long continuation periods in long term temporal scales. Tipaniat and Nitin [12] surveyed the area variation of Mangro Forests by ETM + of Landsat satellite RGB- NDVI (Red-Blue-Green Normalized Difference Vegetation Index) classification technique, in Kraby, Thailand.

Feyzizadeh and Hajimirrahimi [6] applied TM images of Landsat and HDR (High Dynamic range) of Spot satellites and studied green spaces variation of Tabriz and stated that more than 46% of green spaces of Tabriz had destroyed in a years of interested time period. Some researchers [14-13- 8- 3- 15] surveyed the reply of plants to weather fluctuations by NDVI (Normalized Difference Vegetation Index ).The correlation between NDVI and precipitation is estimated almost 200-500 mm in growth season [7]. Yang et al [15] studied correlation between temperature and NDVI (Normalized Difference Vegetation Index ) of Nebraska in U.S.A and found out a high correlation between NDVI (Normalized Difference Vegetation Index) and soil temperature so it can be confirmed that temperature has a direct impact on plant growth. Sensors of satellites receive different information from vegetation that different vegetation to some extent can be distinguished by analyzing these information.

One of the most important factors that influence vegetation conditions are climatic factors. One of the most significant applications of remote sensing is assessing quantitative correlation between vegetation and climatic factors in regional and world scales. Precipitation and temperature influence on water equation directly and affect soil moisture and plant growth [1].

Assessment of space correlation between NDVI (Normalized Difference Vegetation Index) and climatic factors is employed severally and there is a high correlation between NDVI and rainfall extent in dry
lands. The correlation between NDVI and temperature is less but considerable. Regarding such as these researches, correlation between precipitation and NDVI is discovered and basing on them, we can acknowledge that weather variations causes vegetation variations. The main purpose of our research is drought survey with vegetation variations of Jahad Bandar Abbas Forest park, using satellite images and correlation between drought indexes and climatic factors and vegetation variations in 25 years time period.

2. Material and Methods
Case study: The case study selected for studying is Jahad forest park, a 2190 ha area located in Bandar Abbas city, Hormozgan Province. It is constructed in 1993 and its central portion is implemented at the distance of 8 kilometers from east of city. This park is situated between 56° 24.23 and 56° 24.33 of east length and 27° 16.37 and 27° 16.54 north width (Figure 1). This park ends to the old path of Bandar Abbas in north, national properties in south and Hormozgan university in east. A very good cover with Prosopis juliflora is observed in This area. The north of region were planted few years ago. Hammada salicorniaca can be mentioned that it grows in dry lands and deserts. The natural and native species such as Prosopis Mimosaceae, Acacia ehrenbergiana, Ziziphus spina-christi, Acacia nilotica and Prosopis juliflora are covered this region. Besides ecological and conservative impacts, this cover makes a beautiful view for region.

![Figure 1](image_url)

**Figure 1:** Geographical position of Jahad Forest park of Bandar Abbas.

The same and long term time base of statistical periods are used in order to survey and comparison of drought indexes.
3. Standardized Precipitation Index (SPI)
This index is presented by Mackee et al in 1995. Many researchers point out to its flexibility of drought-based. SPI index (Standardized Precipitation Index) is computed in base of long-term precipitation registration for each region. For determining SPI index, first step is suiting a $\alpha$ distribution to precipitation data for each station, next step is converting accumulation probability from acquired $\alpha$ distribution to accumulation standard normal distribution with zero average and one variation [10]. Positive amounts of SPI (Standardized Precipitation Index), show more than precipitation medium and negative amounts, indicate less than precipitation medium. Whenever SPI amounts are negative and show -1 or less, drought is occurred and its positive ones reveal the end of drought (Table 1) [2].

$$g(x) = \frac{1}{\beta^\alpha \Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta} \quad x > 0$$

$\alpha = \text{Shape parameter}$

$\beta = \text{scale parameter}$

$x = \text{precipitation amount}$

$\Gamma(\alpha) = \alpha$ function

| Classification of SPI index          |          |
|-------------------------------------|----------|
| Quite severe wet year               | $2 <$    |
| Very moist                          | 1.55 to 1.99 |
| Medium wet year                     | 1 to 1.49 |
| Almost normal                       | 0.99 to -0.99 |
| Medium drought                      | -1 to -1.49 |
| Severe drought                      | -1.99 to -1.5 |
| Quite severe drought                | $-2 >$  |

4. Normalized Difference Vegetation Index (NDVI)
NDVI index sometimes is called NVI [2]. In this research ENVI 4.7 software of remote sensing was operated for extracting vegetation index from Tm-5 sensor images with 30 m resolution that was downloaded from http://earthexplorer. Usgs.gov/. All of 3 downloaded images belonged to May, in turn there was possibility of comparison and monitoring of changes. The temporal point of images were 15 May 1984, before establishing park, 22 May 1998, 5 years after establishing park and 20 May 2009, 16 years after establishing park. During this temporal extent, region was faced with several drought periods. The NDVI of three images above is more than 0.5. In fact, NDVI reveals density of vegetation. More NDVI demonstrates denser vegetation. Whereas vegetation indexes are designed based on spectrum features of vegetation, amounts resulted from them reflects vegetation richness within aimed pixel [2] and NDVI (Normalized Difference Vegetation Index) is calculated as:

$$NDVI = NIR - R/NIR + R$$
Then, we took regression between images by EDRISI KLIMANJARO software and results were analyzed. At the end, SPSS statistics 17 was applied for statistical analysis of data of climatic parameters, statistical indexes and normalized vegetation index.

5. Results
As results indicates, during 25 years period, 1984, 2003, 2004, 2007 had mean drought periods and 1985, 1994, 2001 had severe drought. Closing to 2009, drought periods have increased and interval between them have decreased (table 2 and figure2).

Table 2: Data of Standarded Precipitation index.

| Year | Intensity of drought | SPI index |
|------|----------------------|-----------|
| 1980 | almost normal        | -0.707637316 |
| 1981 | almost normal        | -0.032190447 |
| 1982 | almost normal        | 0.975114317 |
| 1983 | almost normal        | -0.32118949 |
| 1984 | mean drought         | -1.01158475 |
| 1985 | sever drought        | -1.739238441 |
| 1986 | almost normal        | -0.754647306 |
| 1987 | almost normal        | -0.416620251 |
| 1988 | almost normal        | -0.058180841 |
| 1989 | almost normal        | 0.258038969 |
| 1990 | almost normal        | -0.610751044 |
| 1991 | almost normal        | 0.164224222 |
| 1992 | almost normal        | 0.782053717 |
| 1993 | almost normal        | 0.175548352 |
| 1994 | sever drought        | -1.981181637 |
| 1995 | almost normal        | 0.228822869 |
| 1996 | almost normal        | 0.66937414 |
| 1997 | almost normal        | 0.708254908 |
| 1998 | almost normal        | -0.010440846 |
| 1999 | almost normal        | -0.866809398 |
| 2000 | almost normal        | -0.021277067 |
| 2001 | sever drought        | -1.68472519 |
| 2002 | almost normal        | -0.854047686 |
| 2003 | mean drought         | -1.178597318 |
| 2004 | mean drought         | -1.323182471 |
| 2005 | almost normal        | -0.462500596 |
| 2006 | almost normal        | -0.425006386 |
| 2007 | mean drought         | -1.3438112 |
| 2008 | almost normal        | -0.960339275 |
| 2009 | almost normal        | -0.105438931 |
6. Normalized Difference Vegetation Index

Different amounts of NDVI (Normalized Difference Vegetation Index) display different vegetation, for instance NDVI of dispersed vegetation start from 0.05 [5]. Considering Jahad Bandar Abbas Forest park is placed within warm coastal dry lands, this research assessed vegetation with NDVI more than 0.05. In image of 15 May 1984, before park established, most of vegetation is wild. Drought indexes reveal that there is not any drought in region between 1980-1984. In this time NDVI more than 0.05 cover almost 6.5 percent of area that is equal with 146.4859 ha (Figure 4). In second image of 22 May 1998, 5 year after park established, planting of trees was started by natural resources office. Drought indexes show there is no continues drought between 1984-1998 in region except 1985 and 1995 that took place quite severe drought. In this time up to 1998 the vegetation with NDVI more than 0.05 establish in 44.25 percent of area that is equal with 969.3614 ha, it means the vegetation is increased equivalent to 82.8755 ha in this interval time (Figure 5).

In third image of 20 May 2009, 16 years after park established, drought indexes indicate drought since 1998 to 2009. In this temporal extent, 16.16 percent of area have vegetation with NDVI more than 0.05 that is equal with 354.1106 ha (Figure 6). Extracting of NDVI (Normalized Difference Vegetation Index) found vegetation increasing between 1984 to 1998, during this time there were no continuous drought periods but region was faced with continuous drought periods after 1998, in turn vegetation reduced (Figure 1).

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**Figure 2:** Column Diagram of Standardized Precipitation Index during 1980-2009 in Hamdidi Bandar Abbas Station.

**Figure 3:** Vegetation percentage changes during 25 years as ha.
Figure 4: Vegetation index of 15 May 1984.

Figure 5: Vegetation index of 22 May 1998.
7. Discussion and conclusion

Statistical analysis of area vegetation, climatic parameters such as temperature and relative humidity and drought indexes of objected region exhibit most correlation between vegetation area and relative humidity as 0.94 and after that most correlation is between vegetation area and temperature, there is also fairly high correlation with precipitation and drought indexes (table 3).

|           | Relative humidity | temperature | Precipitation | SPI |
|-----------|-------------------|-------------|---------------|-----|
| correlation matrix | 0.94              | 0.91        | 0.77          | 0.75|

After estimating vegetation in 1984, 1998 and 2009 and extracting NDVI, each image entered in Idrisi Kilimanjaro software for statistical calculations.

It has been found that correlation between NDVI of 1984 and 1998 is 0.53, whereas determination coefficient between these two years is 0.28, this points out that 0.28 percent of NDVI of 1998 is same with NDVI of 1984. Also correlation examination between NDVI of 1998 and 2009 points to correlation as 0.49 with determination coefficient as 0.24, this indicates a same vegetation between 1998 and 2009 as 0.72 with determination coefficient as 0.51 that denotes a common negotiation as 0.51 between 1998 and 2009 (table 4).
Table 4: Correlation coefficient matrices ($r$) and determination coefficient ($R^2$) between vegetation.

| Year | $R$ | $R^2$ | $R$ | $R^2$ | $R$ | $R^2$ |
|------|-----|-------|-----|-------|-----|-------|
| 1984 | 1   | 1     | 0.53 | 0.28  | 0.49 | **0.24** |
| 1998 | 0.53 | 0.28  | 1   | 1     | 0.72 | **0.51** |
| 2009 | 0.49 | 0.24  | 0.72 | 0.51  | 1   | 1     |

As results are obvious, after each period, vegetation changes and its area percentage reduced considerably. It is likely to continue vegetation reduction process that it demonstrate necessity of monitoring and drought management because not only this issue cause environmental problems but also is followed by social-economic problems that their effects are uncompensated or it is compensated, in long way. For drought effects, main components of adjustment and preparing, should contain, drought monitoring, primary awareness, damage estimation and response to it.

Although a disaster like drought does not display its effects suddenly and endangers human's life and properties in long time, with appropriate information about drought monitoring and its beginning time we can assess its intensity and extension and restrict its calamity and reduce environmental and economical damages [2].

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