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# Study Drought in Khouzestan Province and Effect on Increase Dust

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**KEYWORDS**

Drought,
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**A B S T R A C T**

In recent years, there was a dust phenomenon in arid and semi – arid areas of Iran, which have less precipitation mean, that lead to great worry. Dust is one of the atmosphere phenomena that rest unsuitable environmental consequences. Drought is one of the most important phenomenons, which effect on dust rate. In this paper, we investigate drought and increasing dust days in Khuzestan state. In this order, we adopt precipitation and dust days rate in Khuzestan synoptic stations, and we apply SPi climatic index or Standard Precipitation Index to determine drought rate. This index is used to determine precipitation lack in different time periods. When the drought time increased, the number of dust says increased, too. In this project, also, we investigate geological and geomorphologic condition and water resources in this state and their role in increasing dust. Drought index SPi is accounted for all state stations and present in tables 3-12. The results showed that in all of stations, any increase in drought severity cause to increase in dust days. The only exception here is, Bandar Emam Station, and its reason refer to relatively high humidity in this place.

## Introduction

Dust storms are one of the Meteorological phenomena that observe in arid and semi-arid areas and they usually occur when the hurricanes flow in the speed of more than threshold limit. In this condition, the dust separate from its bed in different particles and move as a mutation, creep or suspend conditions and carry to far areas. Also, the dust production centers are located in arid areas of the world. These areas have a precipitation rate lesser than 200-250mm annually and they locate in the bathetic areas of the world topographically.

Iran, Sudan, Syria and all of the countries around Persian Gulf domain, have highest frequencies of dust storms. during a year and frequently, Iran experience dust storms, in one hand due to variations in air flow pass through country and from other hand due to approach to dust resources. In this situation, western and eastern sections of Iran plateau experience highest frequencies occurrence in dust storms during a year, with regard to access to dust resources and severe and stable flows in lower level of the atmosphere (Keramat, 1389).

There have been increased in desertification and destruction of vegetation and unsuitable and more using from agricultural lands and as a result, weaken fertility and soil durability, which lead to increase in population; and it causes to form and spread deserts and increase wind erosion and create desertification in this country (Marsafari *et al.*, 1390).

## Geographical Situation of Studied Area

Khuzestan with an area about 64057 Square Kilometers is located in Iran western –south, next to the Persian Gulf and Arvand Rood (Shatt – al arab) and is oil extraction center in Iran. Ahvaz city is capital of Khuzestan State. Khuzestan is limited to Lorestan from north, to Isfahan from north – east, to Chaharmahal – bakhtiari from eastern – north and east, to Persian Gulf from South, and to Iraq from west.

This state has a population around 4274979 (1385 census) and it has about 866913 families. Khuzestan is located in 47 degree and 42 minutes to 50 degree and 39 minutes of eastern longitude, and 29 degree and 58 minutes to 32 degree and 58 minutes northern from line of Greenwich meridian. Khuzestan is one of the best plain in Iran in terms of land and dust fertility and productivity, which sometimes we can harvest products twice a year depend on climate properties. Huge water, width and fertility of dust and natural variations cause to this city known as a blessed and auriferous plain. If we have a subtle plan about correct use and perfect planning about agriculture and mechanization, it can provide whole agricultural products of Iran lonely. whatever we have reached to it in this state is for sake of that traditional method and if we perform correct productivity from it ; Khuzestan will well-known as a place for not only “black Gold” (oil), but also as a “ green Gold” ( agriculture). Without doubt, there are not such rivers and roaring waters and wide plains in any parts of the country (Khuzestan meteorological organization, 1391).

## Background of Dust in the World

One of the latest synoptic – telemetric measures about dust, is investigating one of the severe dust storm in Africa – Desert north (Libya) that after passing through Mediterranean sea, reach to Egypt. In this measurement, we investigate the analysis of this storm, which occurred in April, via Modis sensor data. Accordingly, in dust peak day, amount of optical depth in “Crete” of Egypt even reached to 4. While the average amount of this season is 0.31. Amount of Standard Swing Particle is about 75/5microgram to cubic meters (the average from January to December is about 63 to 90 microgram to cubic meters).this amount I “Crete” of Egypt in day occurring storm even reached to 2500. The spring season is a season of abundance of this phenomenon in eastern Mediterranean areas. With regard to findings in this research, when storm happened, there was a most optical deep. (the most atmosphere darkness and more decreased in entrance light to sensor). In other hand, the important point of this research is behavior complexity and variability of dust transferring. According to this research, and according to NASA Atmospheric Organization, this phenomenon is one of the natural destruction phenomena. also, in the spring, Siclons that called flux cause the dust transfer to eastern Mediterranean, so that in the summer, central areas of Sahra is source of these storms.

In the last summer, some of these storms reach to western Mediterranean (Kaskaoutis, 2007).in china, some researchers investigate dust severity from 1980 to 2007. The results showed that the there was a most dust in 1983. The results also showed that dust had a decreasing trend from 1984 to 1999 and increasing trend from 2000 to 2007 (Tan, 2014). In Australia, the wind erosion was investigated via meteorological data of 1965 to 2011. Precipitation has a most influences on dust occurring, so as in that years that we had decrease in precipitation, there was an increase in dust (O'Liongsigh, 2014). Also, we investigate dust climatology in Middle East. The results showed that the most occurrence of dust in western and eastern parts of Middle East was respectively in winter and summer (Rezazadeh, 2013)

With regard to research results, it was determined that in spite of deep effects of dust phenomena on human communities such as east-Asia, just applying a dust strong monitoring model via coincidence using of satellite technology, and numerical and GIS models can be effective to predict and manage this phenomena ( Barkan,2005)

In china and Japan, they investigate dust events via time interval (1972-2004) of dust, and information from meteorological stations and SOI. The results showed a meaningful decreasing trend in day's number of dust in "Gobi" Desert. However, in the last years of mentioned period, they observed an increasing trend in Japan. In this area, the influx of arctic air has an important role on dust formation. The important point is that in this area, the direction of dust in el-nino and lanino phases change frequently (Levy, 2007).

## Materials and Methods

In recent years, the west south in the country observed micro-dust phenomenon frequently, due to geographical situation. The precipitation rate and dust days and drought in this states how the meaningful relation between drought and dust days, which this phenomenon hold this state in the rank with the most important social, economical and bioenvironmental problems. Khuzestan state with the 64055 Kilometers area is located in 29 degree and 57 minute to 33 north latitude degree and between 47 degree and 40 minute to 50 degree and 33 minute in eastern length. Climatologically, low areas of these states like Ahwaz and Abadan are dry and hot, and the areas with higher altitude are steppe areas with winter rains. This research considers drought in synoptic stations of Khuzestan via SPI and then investigates its effect on increasing dust in this province.

We used precipitation data of synoptic stations during 1985 -2010 to consider droughts. the precipitation properties in mentioned stations are describe in table 1 (some of the synoptic stations of this states such as Behbahan, Bandar Emam, and Bostan have a lesser statistics than other stations, but this matter did not disturb the research process. so, it is shown both the drought rate and meaningful relation between drought and dust days).

According to available data collected from precipitation rate in every month from synoptic stations, we use SPI (Standard precipitation index) to determine drought severity based on available data on precipitation during mentioned years.

One of the most important phenomena affecting on dust rate in this province, is drought phenomenon, and by increasing in this period, the dust days has increased, too. In this order, we compare the precipitation rate and dust days in synoptic stations of Khuzestan and we apply Standard Precipitation Index or SPI climate index to determine drought. This index was used to determine lack of precipitation in different time periods. In all of the mentioned stations, there is a meaningful relation between drought and increasing dust days.

## Discussion and Conclusion

The Khuzestan state is subjected to dust storms, more than other provinces, due to low width, being plain and proximity to big deserts of neighbor country. Geomorpholics and geographical situations of Khuzestan lead to wind erosion. Wide sections of this state cover with young alluvial sediments that largely are related to Quaternary period. And we describe them as following:

### Present Era Sediments

In studied area, the present era sediments are observed in plain surface which including granule alluvial sediments, eolian, evaporative and organic deposits.

### Granule Alluvial Sediments

These sediments are alike Siltures and are formed along the turning route of the rivers. The mentioned sediments result from water erosion of rock units in watershed basins of these rivers in proximate areas. There are different formations in Karoon watershed basins, which transfer to Khuzestan plain via water erosion. And part of it flow to Arvand rood and Persian Gulf and rest of it flow to Khuzestan plain and settle among water.

### Flood Deposits

Flood deposits remain during flood in wide section of plain. The mentioned deposits are formed clay layers, silts clay, and sand, which frequently put on together. Main parts of surface deposits in this area are river sediments.

### Eolian sediments

In addition to whatever we said, there are wind deposits along the Khuzestan Rivers. These sands create sections called dunes, which can observe in ranges with low extent in the plain. Many rivers that are drained from Zagros Mountains to this state largely have high sediments that bring from up-stream. In recent years, the water in rivers, in down-stream, was reduced via wide inhibition of water and building several dams on them, and wide sections of rivers bed was dried.

This matter become more important when we know that rivers in Khuzestan divide to several branches due to slope reduction in bed; it means that they have a plat form motion instead of central motion. Recent years drought severe intense these situations; so many rivers branches were dried completely. It is natural that in such situations, wind van easily move in beds alluvial sediments of Khuzestan rivers and carry them. Several big and small plains in this province, largely, cover with alluvial deposits and granule sediments of Karkheh, Karoon Dez, Jerahi, and Hindi Jan and their branches, and provide suitable bed to for transforming to dust and wind erosion focus. About 60 percent of Khuzestan are plains and foothills that more of them cover with young quaternary sediments.

## The Most Important Dust Focuses and Prone Regions

Many areas in this state are dust focus or subject to become dust focus.

### Abadan's Delta

Abadan's Delta is one of the most important focuses to create dust that completely cover with sediments of Karoon and Arvand Rood. Extreme heat and also recent winds.

Current condition of wetlands, aquifers, runoff and springs in Khuzestan are signs of drought in this province. Effects from drought are wide on environment, because some of these signs are not determined in short –term and are shown in long term. The long – term and stable effects are shown more in wetlands ecosystems, because these ecosystems are located in end of watershed basins largely and bear the most pressures from less-water and drought on these resources. Drought in wetlands, effect on weather quality, soil erosion and increasing desertification are the most important environmental effects of drought on wetlands.

What are reported from runoffs in Khuzestan and especially from Karron, Dez, and Karkheh, are 53 percent reduction sediments rather than natural condition. In other word, the collections of sediments in rivers in this state are about 16 billiard and 83 million cubic meters. But currently this rate is about 7 billiard and 526million cubic meters. We should warn about crisis situation in rivers basin in Karkheh, Karoon and Dez.lack of regular and suitable rains in drought situations are shown as snow in up-stream are and are as rains in down-stream.

Current situation in Great Karoon is critical, Karoon River sediments are reduced 37 percent rather than natural years and Dez River is reduced 60percent rather than natural years. In comparison with other water basins of state, Maroon basin with 21 reduction rather than natural years had a better situation. All of the water springs in 4 cities of this state is dried due to recent droughts. All springs in Izeh, Baghamlak, Andimeshk, and Dezful are dried. SPI drought index is computed for all stations and they are presented in tables 3-12.

Changes in frequency and rate of dewatering in lakes and wetlands may cause to significant fluctuations in dust rate in seasonal and annually scale and finally cause to increase dust storms. Also, construction of beaches and roads cause to similar effects, so that when tide occur, several kilometers of beaches cover with water, and the ground become wet and as a result, the wind cannot move the sands; but if the great construction actions occur in these places, this great land do not get wet or if it get wet, it is in limit section, that increasingly is sensitive to wind and finally cause to desertification and increase in dust storms.

## The Most Important Factors to Create Wind Dust

1- Drought
2- flood and alluvial sediments
3-lack of vegetation and growing desertification in wind erosion focuses
4-Atrophic erosion

With regard to above information, we can express following cases to improve state situation and consolidate environmental conditions to reduce dust. Some of these actions are general and need to regional cooperation and others, though they seem simple and cheap, but they can affect on reducing tiny particles of dust. We apply different methods to control dust storms. Of these actions, we can mention to:

1-Hold international environmental conventions and create regional convergence to desertification.

2-Accelerate desertification program and inhibit wind erosion in Khuzestan.

3-Prevent from any disturbance in rivers limitation.

4-Prevent from uncontrolled using from underground water especial in critical areas.

5-Applying best methods to irrigate.

6-Prevent from entering seasonal floods to area via their precession to back of dams.

**Table.1**

table 1 :The precipitation properties in Khuzestan stations

| station | mean | median | Standard deviation | Variance | maximum | minimum | range | skewness | kurtosis |
|---|---|---|---|---|---|---|---|---|---|
| Ahwaz | 224.1 | 223.65 | 89.69 | 8043.67 | 468.8 | 76.9 | 392 | 5.84 | -1.42 |
| Abadan | 164.86 | 154.65 | 59.07 | 3489.12 | 297.9 | 81.3 | 216.6 | 0.07 | -0.01 |
| Agajari | 263.3 | 259.3 | 83.57 | 6984.82 | 410 | 97.7 | 313 | -0.03 | -0.88 |
| Behbahan | 320.56 | 322.7 | 104.73 | 10968.11 | 489.9 | 112.4 | 370.5 | -0.72 | 0.17 |
| Bandar Emam | 214.21 | 202.85 | 76.9 | 5912.92 | 349.5 | 99 | 250.5 | 0.53 | -0.71 |
| Bostan | 201.44 | 182.2 | 84.04 | 7061.95 | 396.7 | 75.2 | 321.5 | 0.77 | 0.28 |
| Dezful | 396.52 | 365.05 | 122.04 | 14894.6 | 705.7 | 168.3 | 537.4 | 0.49 | 0.33 |
| Soleiman Mosque | 432.28 | 419.5 | 143.18 | 20499.32 | 759.1 | 194.2 | 564.9 | 0.4 | -0.5 |
| Omidieh | 257.4 | 235.95 | 87.19 | 7728.28 | 410.8 | 103.8 | 307 | 0.26 | -0.96 |
| Ramhormoz | 309.26 | 310.5 | 105.51 | 11132.95 | 515.3 | 135.1 | 380.2 | 0.12 | -0.96 |

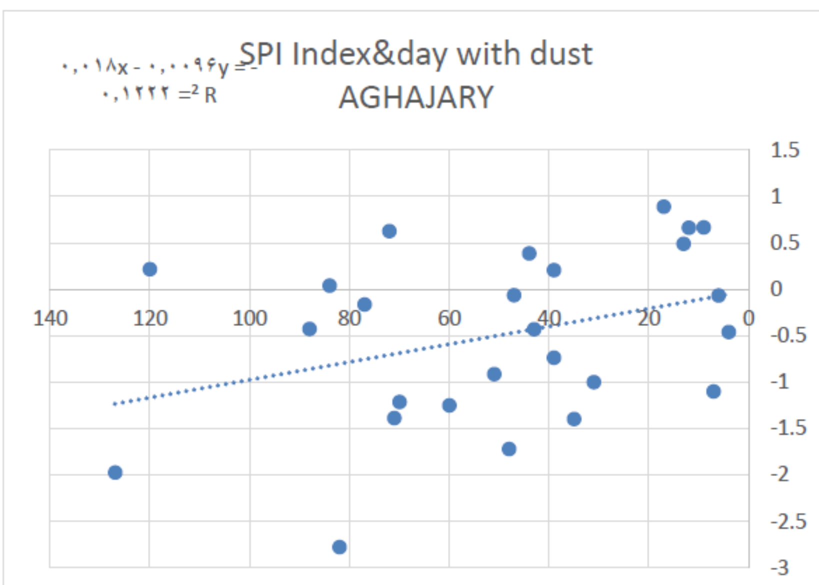
**Table.2** Different levels of investigated drought index (SPI)

| Index precipitation abnormalities (SPI) | Rank | Drought severity levels |
|---|---|---|
| - | • | Normal |
| 0 - (-0.99) | 1 | Weak drought |
| (-1.44) - 1 | 2 | Middle drought |
| (-1.44) – 1.5 | 3 | Severe drought |
| -2.0 | 4 | Intense drought |

## 1- Aqajary Station

**Table.3** Drought index in Aqajary Station

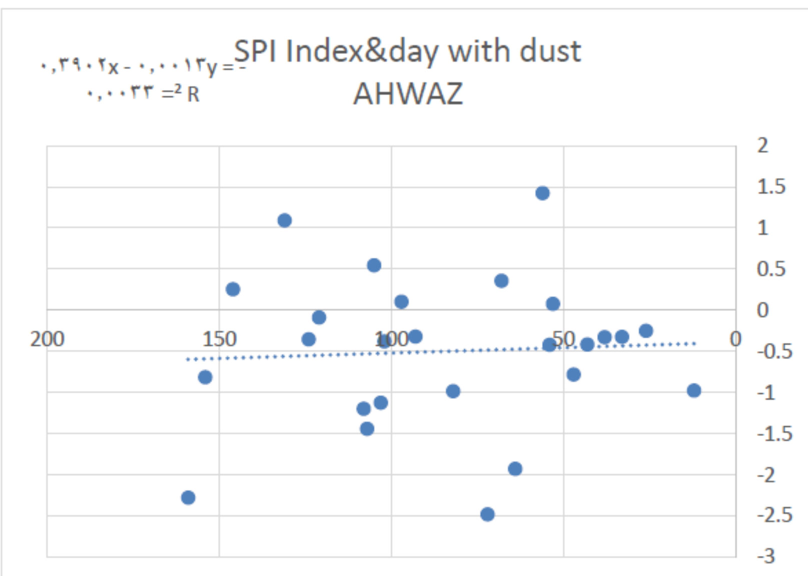
| aqajary | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | | | |
| | 1985 | -1.72051019 | Severely dry |
| | 1986 | 0.38794149 | Near normal |
| | 1987 | -0.91421065 | Near normal |
| | 1988 | -0.99989973 | Near normal |
| | 1989 | -0.7364295 | Near normal |
| | 1990 | -1.39691317 | Moderately dry |
| | 1991 | 0.040411324 | Near normal |
| | 1992 | -0.42689331 | Near normal |
| | 1993 | -0.42917515 | Near normal |
| | 1994 | 0.624782359 | Near normal |
| | 1995 | 0.489097354 | Near normal |
| | 1996 | -0.06833066 | Near normal |
| | 1997 | 0.662380529 | Near normal |
| | 1998 | -0.45903823 | Near normal |
| | 1999 | 0.664620752 | Near normal |
| | 2000 | -1.24845596 | Moderately dry |
| | 2001 | -1.10137253 | Moderately dry |
| | 2002 | 0.889345473 | Near normal |
| | 2003 | -1.21235951 | Moderately dry |
| | 2004 | -0.06243596 | Near normal |
| | 2005 | -0.16256969 | Near normal |
| | 2006 | 0.207182984 | Near normal |
| | 2007 | -1.3874351 | Moderately dry |
| | 2008 | -1.9737822 | Severely dry |
| | 2009 | 0.2168724 | Near normal |
| | 2010 | -2.7745862 | Extremely dry |



## 2- Ahwaz Station

**Table.3** Drought index Ahwaz Station

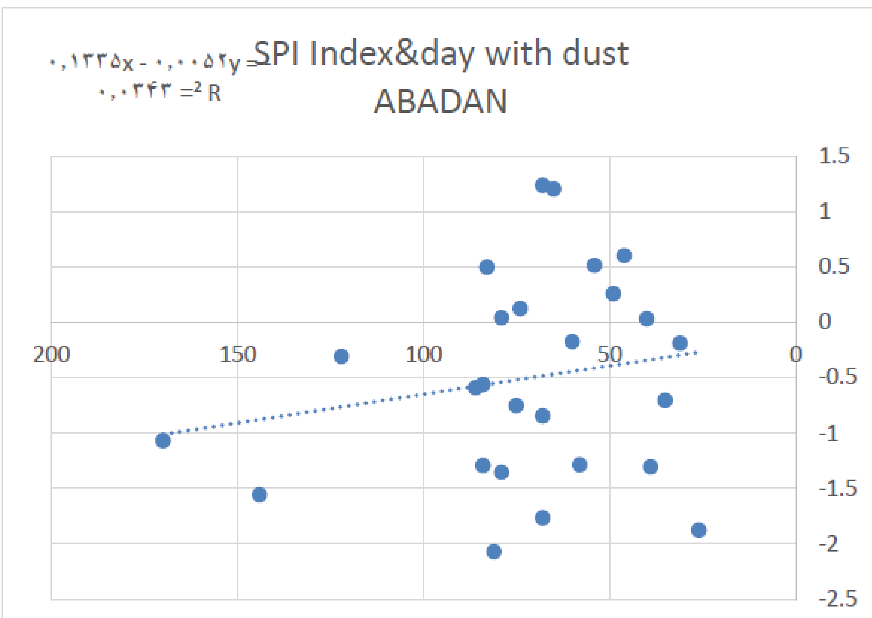
| ahwaz | year | SPI Index | Drought Severity |
|---|---|---|---|
| | 1985 | -1.123164543 | Moderately dry |
| | 1986 | 0.549070155 | Near normal |
| | 1987 | -0.087724658 | Near normal |
| | 1988 | -0.813988355 | Near normal |
| | 1989 | -0.353376576 | Near normal |
| | 1990 | -1.439335092 | Moderately dry |
| | 1991 | 1.094245643 | Moderately wet |
| | 1992 | 0.359917217 | Near normal |
| | 1993 | -0.415992405 | Near normal |
| | 1994 | -0.316875002 | Near normal |
| | 1995 | -2.276006183 | Extremely dry |
| | 1996 | 0.258284061 | Near normal |
| | 1997 | 1.423301398 | Moderately wet |
| | 1998 | -0.98015398 | Near normal |
| | 1999 | -0.321137402 | Near normal |
| | 2000 | -0.247731328 | Near normal |
| | 2001 | -0.32647726 | Near normal |
| | 2002 | -0.975306944 | Near normal |
| | 2003 | -0.419338968 | Near normal |
| | 2004 | 0.104169569 | Near normal |
| | 2005 | -0.77867375 | Near normal |
| | 2006 | 0.080274827 | Near normal |
| | 2007 | -1.196854118 | Moderately dry |
| | 2008 | -1.926116894 | Severely dry |
| | 2009 | -0.378423927 | Near normal |
| | 2010 | -2.478546592 | Extremely dry |



## 3- Abadan Station

**Table.5** Drought index in Abadan Station

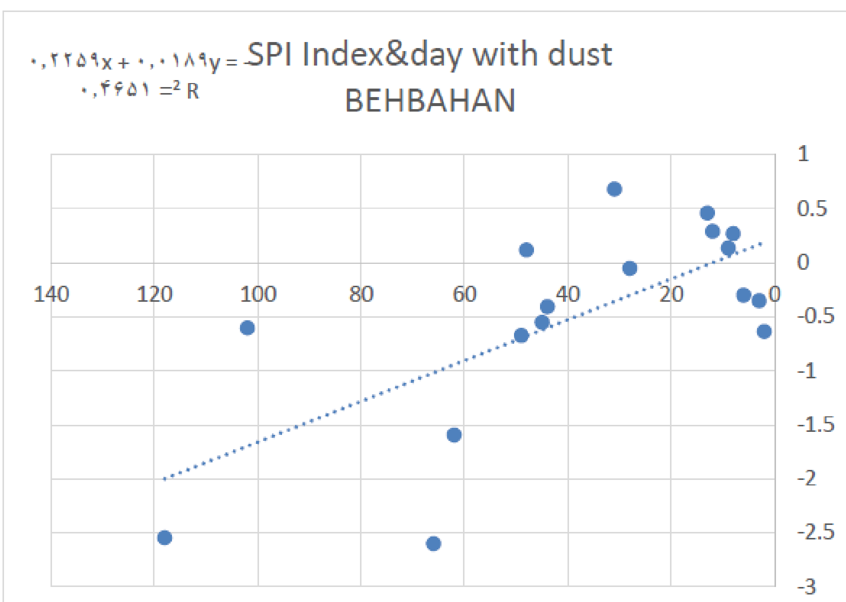
| abadan | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1985 | -0.30484743 | Near normal |
| | 1986 | -1.76348215 | Severely dry |
| | 1987 | 1.24110732 | Moderately wet |
| | 1988 | -1.35271876 | Moderately dry |
| | 1989 | -0.84201001 | Near normal |
| | 1990 | -1.28325246 | Moderately dry |
| | 1991 | -2.06771714 | Extremely dry |
| | 1992 | 1.2085394 | Moderately wet |
| | 1993 | -0.5882785 | Near normal |
| | 1994 | -0.17015967 | Near normal |
| | 1995 | 0.50000843 | Near normal |
| | 1996 | -0.70183943 | Near normal |
| | 1997 | -0.18422859 | Near normal |
| | 1998 | 0.60774404 | Near normal |
| | 1999 | -1.87445874 | Severely dry |
| | 2000 | 0.51786802 | Near normal |
| | 2001 | -0.56042888 | Near normal |
| | 2002 | 0.03439568 | Near normal |
| | 2003 | -1.301491 | Moderately dry |
| | 2004 | -1.2893202 | Moderately dry |
| | 2005 | 0.26273105 | Near normal |
| | 2006 | 0.04439856 | Near normal |
| | 2007 | 0.12851616 | Near normal |
| | 2008 | -0.75138252 | Near normal |
| | 2009 | -1.55553139 | Severely dry |
| | 2010 | -1.06651439 | Moderately dry |



**4- Behbahan Station**

**Table.6** Drought index in Behbahan Station

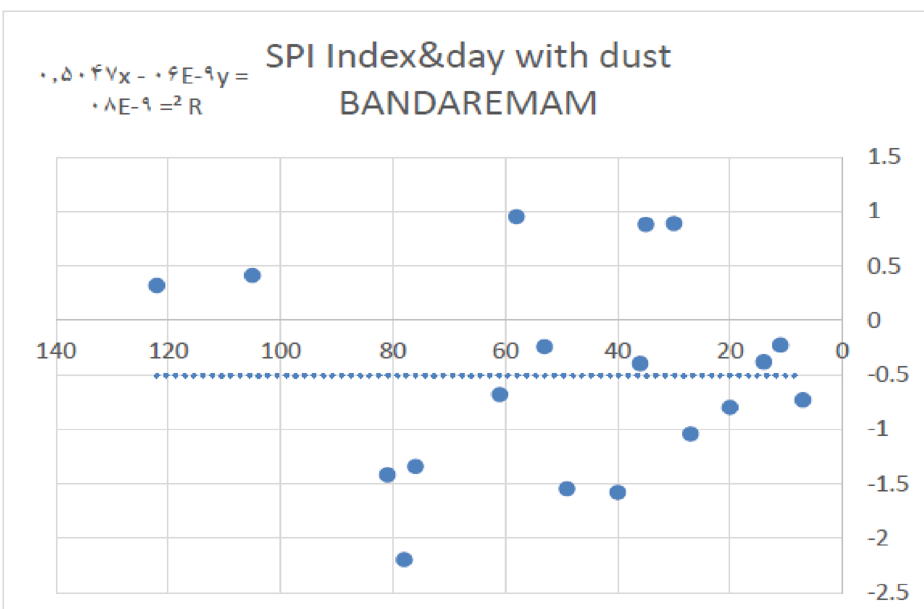
| behbahan | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1994 | 0.12056945 | Near normal |
| | 1995 | -0.6363699 | Near normal |
| | 1996 | 0.1356886 | Near normal |
| | 1997 | 0.29177016 | Near normal |
| | 1998 | 0.26891979 | Near normal |
| | 1999 | 0.46170355 | Near normal |
| | 2000 | -1.5937553 | Severely dry |
| | 2001 | -0.2970298 | Near normal |
| | 2002 | -0.3521946 | Near normal |
| | 2003 | -0.6719618 | Near normal |
| | 2004 | 0.68096719 | Near normal |
| | 2005 | -0.4037732 | Near normal |
| | 2006 | -0.048168 | Near normal |
| | 2007 | -0.5505496 | Near normal |
| | 2008 | -2.545651 | Extremely dry |
| | 2009 | -0.6027405 | Near normal |
| | 2010 | -2.598891 | Extremely dry |



**5- Bandar Emam Station**

**Table.7** Drought index in Bandar Eman Station

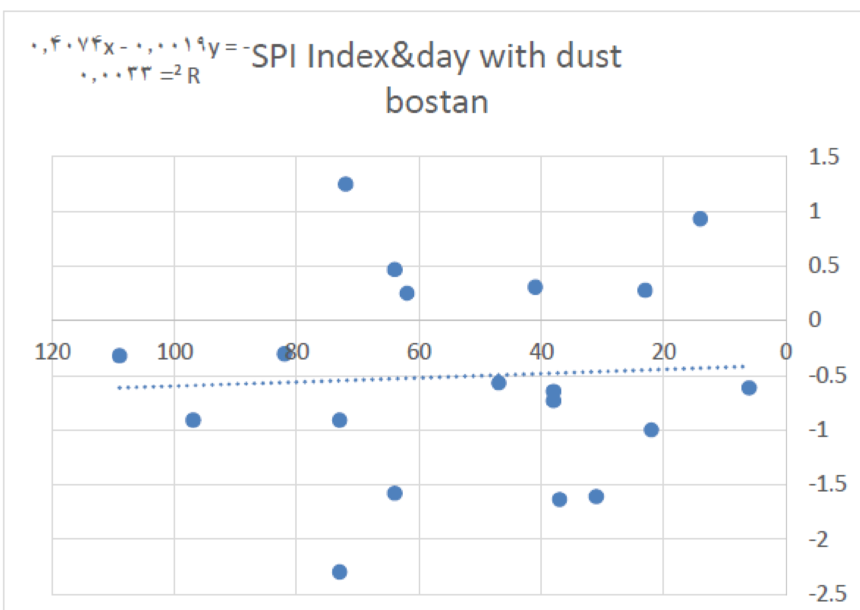
| bandar emam | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1988 | -1.5745028 | Severely dry |
| | 1989 | -1.4151837 | Moderately dry |
| | 1990 | -2.1951639 | Extremely dry |
| | 1991 | 0.41489046 | Near normal |
| | 1992 | 0.32272989 | Near normal |
| | 1993 | -0.2379934 | Near normal |
| | 1994 | 0.95508633 | Near normal |
| | 1995 | -0.3797165 | Near normal |
| | 1996 | -0.225747 | Near normal |
| | 1997 | 0.89144933 | Near normal |
| | 1998 | -0.7271648 | Near normal |
| | 1999 | 0.8819026 | Near normal |
| | 2000 | -1.3385407 | Moderately dry |
| | 2001 | -0.7958949 | Near normal |
| | 2002 | -1.0379402 | Moderately dry |
| | 2003 | -1.543983 | Severely dry |
| | 2004 | -0.3941114 | Near normal |
| | 2005 | -0.676484 | Near normal |



## 6- Bostan Station

**Table.8** Drought index in Bostan Station

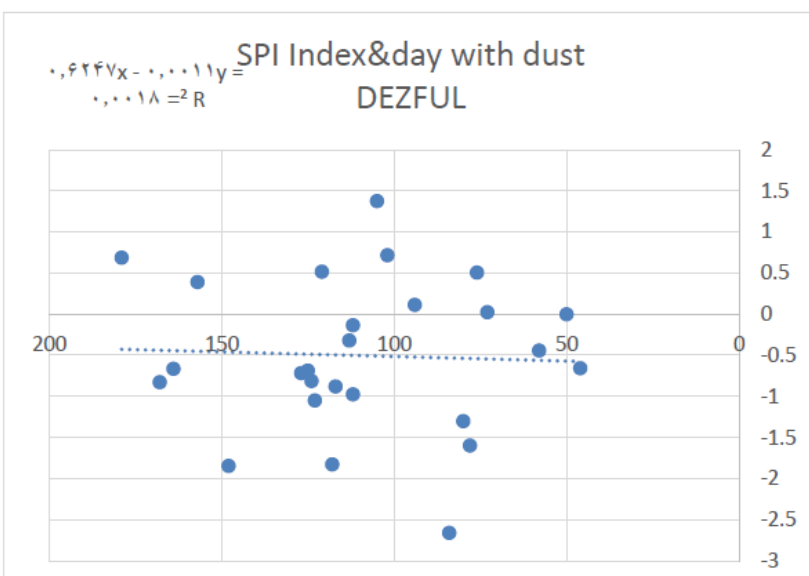
| bostan | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | | | |
| | 1987 | -1.57785909 | Severely dry |
| | 1988 | -0.64633497 | Near normal |
| | 1989 | -0.90843532 | Near normal |
| | 1990 | -2.2977678 | Extremely dry |
| | 1991 | 1.25092211 | Moderately wet |
| | 1992 | 0.46725544 | Near normal |
| | 1993 | 0.30877418 | Near normal |
| | 1994 | -0.56762825 | Near normal |
| | 1995 | -1.60977654 | Severely dry |
| | 1996 | 0.27774035 | Near normal |
| | 1997 | 0.93223131 | Near normal |
| | 1998 | -0.6120249 | Near normal |
| | 1999 | -0.73076364 | Near normal |
| | 2000 | -0.30293245 | Near normal |
| | 2001 | -0.99684473 | Near normal |
| | 2002 | -1.63526549 | Severely dry |
| | 2003 | -0.3215406 | Near normal |
| | 2004 | 0.25171301 | Near normal |
| | 2005 | -0.90843532 | Near normal |



## 7- Dezful station

**Table.9** Drought index in Dezful station

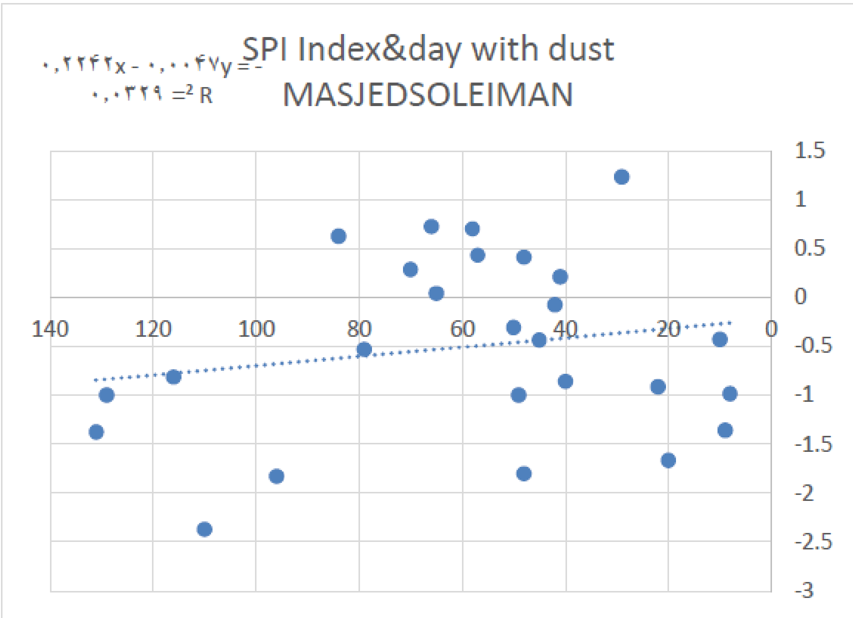
| dezful | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1985 | -1.05010621 | Moderately dry |
| | 1986 | 0.390702461 | Near normal |
| | 1987 | -0.71667167 | Near normal |
| | 1988 | -0.32104699 | Near normal |
| | 1989 | -0.68671923 | Near normal |
| | 1990 | -1.84787889 | Severely dry |
| | 1991 | 0.684387857 | Near normal |
| | 1992 | -0.82655914 | Near normal |
| | 1993 | -0.66478942 | Near normal |
| | 1994 | 0.715993381 | Near normal |
| | 1995 | -1.59756408 | Severely dry |
| | 1996 | 0.024231433 | Near normal |
| | 1997 | 1.375411503 | Moderately wet |
| | 1998 | -0.00386762 | Near normal |
| | 1999 | 0.506275419 | Near normal |
| | 2000 | -0.13748636 | Near normal |
| | 2001 | -0.65776545 | Near normal |
| | 2002 | -0.44339606 | Near normal |
| | 2003 | -0.81275631 | Near normal |
| | 2004 | 0.110733103 | Near normal |
| | 2005 | -0.88143961 | Near normal |
| | 2006 | 0.516554936 | Near normal |
| | 2007 | -1.30361928 | Moderately dry |
| | 2008 | -1.82629669 | Severely dry |
| | 2009 | -0.97581073 | Near normal |
| | 2010 | -2.66003709 | Extremely dry |



## 8- Masjed Soleiman station

**Table.10** Drought index in Masjed Soleiman station

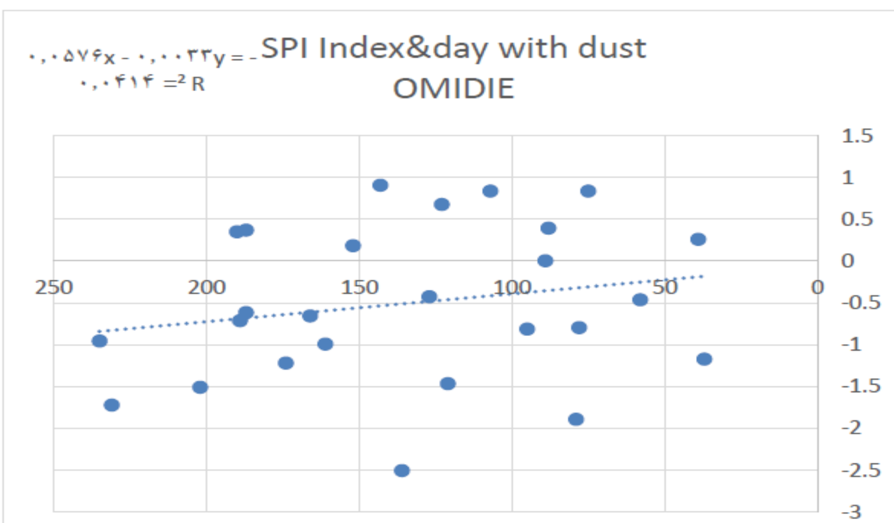
| masjedso | | | |
|---|---|---|---|
| | YEAR | SPI Index | Drought Severity |
| | 1985 | -0.91347871 | Near normal |
| | 1986 | 1.231350233 | Moderately wet |
| | 1987 | -0.07215382 | Near normal |
| | 1988 | -0.42652498 | Near normal |
| | 1989 | -1.66392369 | Severely dry |
| | 1990 | -1.35793922 | Moderately dry |
| | 1991 | 0.412201269 | Near normal |
| | 1992 | 0.625499596 | Near normal |
| | 1993 | 0.702177692 | Near normal |
| | 1994 | 0.725503453 | Near normal |
| | 1995 | -1.79901964 | Severely dry |
| | 1996 | 0.432105252 | Near normal |
| | 1997 | 0.28541623 | Near normal |
| | 1998 | -0.98380108 | Near normal |
| | 1999 | -0.30630081 | Near normal |
| | 2000 | -0.8136676 | Near normal |
| | 2001 | -0.85509672 | Near normal |
| | 2002 | -0.43489761 | Near normal |
| | 2003 | -0.99553687 | Near normal |
| | 2004 | 0.043695343 | Near normal |
| | 2005 | -0.53133281 | Near normal |
| | 2006 | 0.213777994 | Near normal |
| | 2007 | -0.99553687 | Near normal |
| | 2008 | -2.36983182 | Extremely dry |
| | 2009 | -1.37187207 | Moderately dry |
| | 2010 | -1.82732518 | Severely dry |



## 9- Omidieh Station

**Table.11** Drought index in Omidieh Station

| omidie | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1985 | -1.465749177 | Moderately dry |
| | 1986 | 0.908207695 | Near normal |
| | 1987 | -0.614895084 | Near normal |
| | 1988 | -0.424825548 | Near normal |
| | 1989 | 0.005021669 | Near normal |
| | 1990 | -1.889849366 | Severely dry |
| | 1991 | 0.677048465 | Near normal |
| | 1992 | -0.810048563 | Near normal |
| | 1993 | -0.796550115 | Near normal |
| | 1994 | 0.837986268 | Near normal |
| | 1995 | -1.169996627 | Moderately dry |
| | 1996 | 0.260665508 | Near normal |
| | 1997 | 0.395573644 | Near normal |
| | 1998 | -0.460935223 | Near normal |
| | 1999 | 0.838669602 | Near normal |
| | 2000 | -1.218046723 | Moderately dry |
| | 2001 | -0.990526694 | Near normal |
| | 2002 | 0.184396877 | Near normal |
| | 2003 | -0.956242334 | Near normal |
| | 2004 | -0.654600452 | Near normal |
| | 2005 | -0.712240487 | Near normal |
| | 2006 | 0.350285386 | Near normal |
| | 2007 | -1.508787541 | Severely dry |
| | 2008 | -1.720111219 | Severely dry |
| | 2009 | 0.372217958 | Near normal |
| | 2010 | -2.502740216 | Extremely dry |



**10- Ramhormoz Station**

**Table.12** Drought index in Ramhormoz Station

| ramhormo | YEAR | SPI Index | Drought Severity |
|---|---|---|---|
| | 1988 | -0.249327196 | Near normal |
| | 1989 | -0.02313595 | Near normal |
| | 1990 | -1.590980994 | Severely dry |
| | 1991 | 0.376737243 | Near normal |
| | 1992 | -0.372482298 | Near normal |
| | 1993 | 0.110066397 | Near normal |
| | 1994 | -0.365317675 | Near normal |
| | 1995 | -1.303291456 | Moderately dry |
| | 1996 | 0.862046304 | Near normal |
| | 1997 | 1.007050911 | Moderately wet |
| | 1998 | -0.934748575 | Near normal |
| | 1999 | 0.268307174 | Near normal |
| | 2000 | -0.548462156 | Near normal |
| | 2001 | -0.661034769 | Near normal |
| | 2002 | 0.229493158 | Near normal |
| | 2003 | -1.701951818 | Severely dry |
| | 2004 | 0.560192862 | Near normal |
| | 2005 | -0.362636626 | Near normal |
| | 2006 | 0.235771201 | Near normal |
| | 2007 | -1.620725628 | Severely dry |
| | 2008 | -2.10367203 | Extremely dry |
| | 2009 | -0.936668508 | Near normal |
| | 2010 | -2.303211765 | Extremely dry |

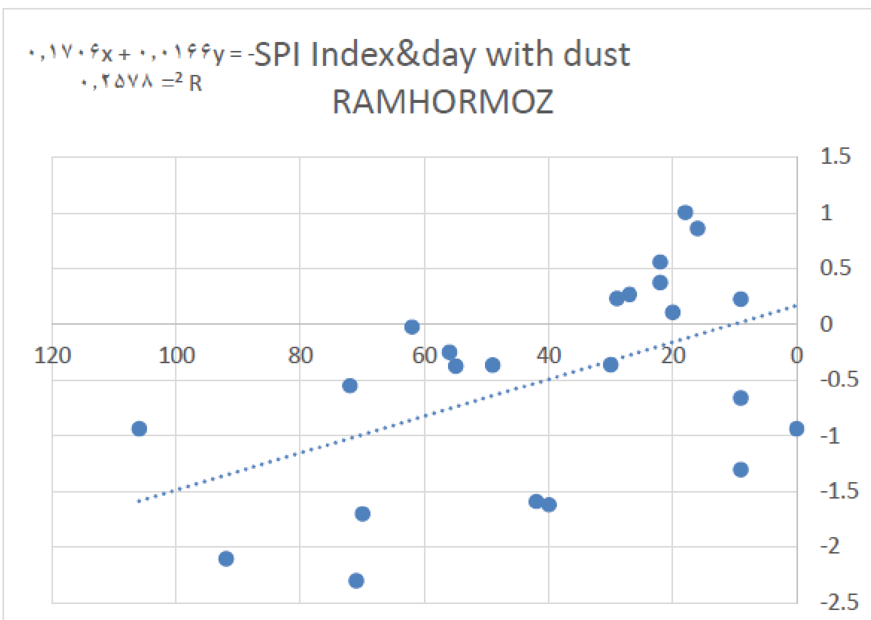
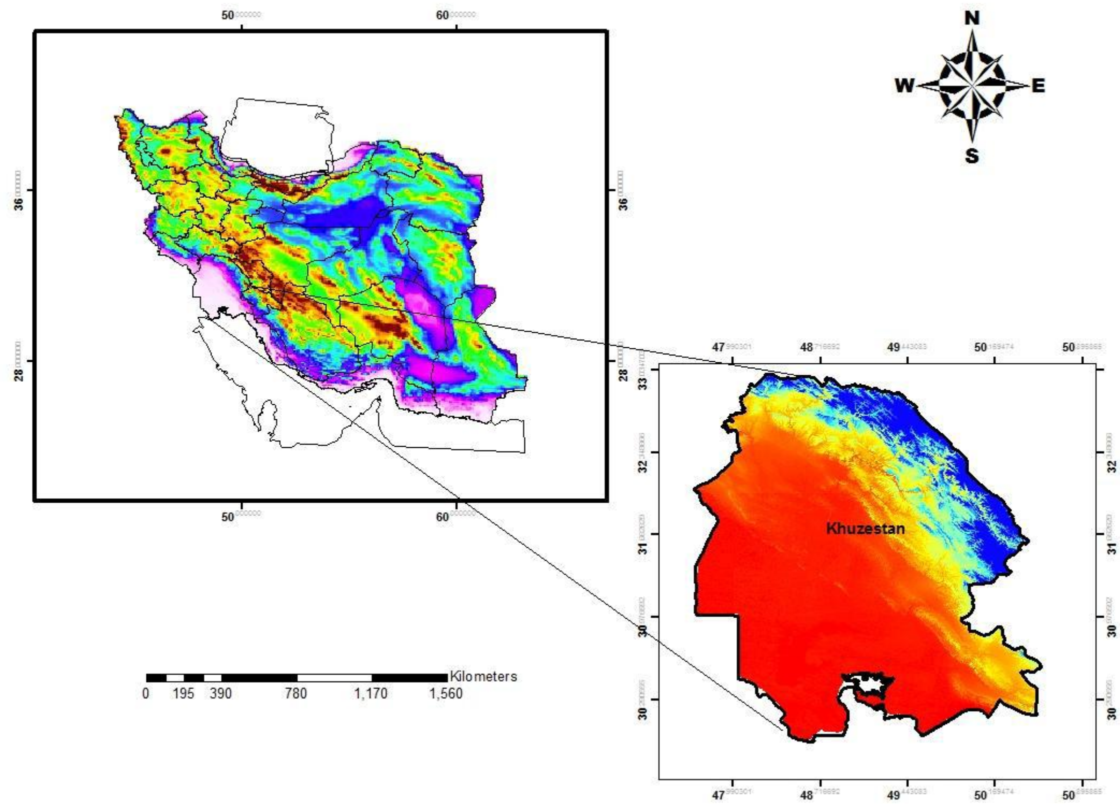


**Figure.1** The map of Geographical situation in Khuzestan




Dams and water resources management is other method to control and prevent dust storms. The most significant ways are to prevent from dying important areas and critical focuses that form dust. Mechanical methods such as apply covering including especial plant or artificial material such as polyethylene and polymeric covers to consolidate sand hills.

Generally, stable desert and grassland ecosystems management, controlling effective factors to destroy land, correction activities and revival methods, increasing vegetations and improving economic and social situations in countries with dust sources, are the most important approaches to inhibit dust and mini-particles.

So, using trees- resistance to dust, especially in west and south part of country, can help to revival vegetation. The last step is preparing against dust and use from plants and trees which are resistance against desertification such as evaporation, high temperature, low precipitation and wind. We hope these actions help to decrease pollution and increase citizens healthy.

With regard to this matter that Iran and its western neighbors are located in arid and semi-arid belt and more than two-third of Iran area is located in arid and semi-arid ; and in other hand the national annual precipitation average is half than of world precipitation average, so Iran is supposed to dust phenomena in local, regional and world scale. The western areas of country are subjected to dust phenomena due to geographical and climatology condition and approximation to neighbors deserts such as

Iraq, Syria, and Arab countries. Dust storms are one of the most severe climate adventures in the entire world. And regional climate variables play an important role in affecting dust storm activities. One of the consequences of long-term drought is creating and increasing possibility of occurring dust phenomena. Main reason of this phenomenon is severe winds that occur due to change in air and temperature pressure in special times of year in different areas. Wide diffusions of sand plains with a human or natural source, long-term droughts in summer, lack of vegetation, and strong winds cause to provide suitable situation for this phenomena. To better understand of drought effect on increasing dust days in Khuzestan state, dust days average and SPI were computed in all of synoptic stations. In all stations, increasing drought severity cause to increase in dust days, the only exception is Bandar Imam Station and this is because of relative high humid in this station.

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