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Analysis of Precipitation Climate and Evapotranspiration in Kerman of Iran

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Rainfall and evapotranspiration are the two most popular climatic factors which have crucial function on agricultural production. Rainfall can be directly measured easily in an area but evapotranspiration is estimated from weather data. In this study reference evapotranspiration ETo was estimated using Penman–Monteith equation. Monthly rainfall and evapotarnspiration were plotted and compared in order to determine moisture deficit periods for two main several stations in Kerman Province which located in south east of I.R. of Iran. Temporal variation of annual rainfall was analysed using rainfall anomaly index. It was found that the moisture deficit in both stations is obvious for whole year and irrigation requirement is high for agricultural production. ETo showed relatively low variation with time while year-to-year rainfall variability was very high. Rainfall Anomaly Index (RAI) values was plotted and from these plots information on rainfall pattern over the past 33 years, such as drought years was obtained. **[Shahram Karimi-Googhari. Analysis of Precipitation Climate and Evapotranspiration in Kerman of Iran. International Journal of Agricultural Science, Research and Technology, 2011; 1(3):105-108].**

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1. Introduction

In the next few decades the world's population is expected to grow faster and it is clear that achieving food security in developing countries will continue to pose major challenges to decision-makers in the next few decades. Islamic Republic of Iran (I.R. of Iran) consists of more arid and semi-arid lands that supporting a part of needed for population and livestock. I.R. of Iran is one of the developing countries which it has currently a population of 70 million people with a growth rate of less than 1.5%. This, combined with the limited water availability to extend productive lands, has resulted less productive land, mainly the drier areas, resulting in rapid land degradation.

Precipitation climates have been studied in different regions such as; Austria (Holawe and Dutter, 1999); the Ijzer watershed 'in western Belgium and northern France' (Mallants and Feyen, 1990); USA (Guttman, 1993); Spain (Esteban-Parra et al., 1998) and Myanmar (Roy and Kaur, 2000). Each of these studies used different type and/or number of variables to delineate precipitation climates. For example, Guttman (1993) used seven geographic and climatic variables while Mallants and Feyen (1990) used only daily precipitation data. There seems no general guide for determining the type and number of variables used in precipitation climate studies. Rainfall has been used in drought index calculations since it is the most important hydrological variable and generally one of the only meteorological measurements made in arid and semi-arid areas. Rainfall variability indices have been used to identify droughts and to establish some arbitrary values for drought identification. These simple indices with rainfall as the only input perform comparatively well compared with more complicated indices in depicting periods and density of droughts (Oladipo, 1985). An index used to explain annual rainfall variability is the van Rooy (1965) rainfall anomaly index (RAI), which has been modified to account for non-normality. The RAI of van Rooy has been shown to be a very effective index for detecting drought periods, and it compared favorably well with the more complex indices of Palmer and Bholme-Mooley (Oladipo, 1985).

Evapotranspiration is another main climatic factor in the arid and semi-arid areas, but its accurate estimation is very difficult. The FAO Penman-Monteith method is maintained as the sole standard method for the computation of refrence evapotraspiration (ETo) from meteorological data (Allen et al., 1998).

The southeast of Iran has for a long time been an area neglected by major climatologically studies. However, repeated droughts badly affect the region. It is true that long-term annual rainfall series in dry land countries are limited (Ogallo, 1983). However, some authors (e.g. Dennett et al., 1985) would argue that long-term records are not needed, since it is more appropriate to use the last 20 or 30 years of annual rainfall data to plan effective development and rehabilitation strategies.

Decision making for developing projects in arid and semi-arid areas is faced with the following constraints: limited and unreliable rainfall, high variability in rainfall pattern and high evapotranspiration rate. Therefore, it is necessary to understand the spatial and temporal variability of the amount of rainfall received and its relationship with evapotranspiration rate in order to develop effective management strategies. The critical importance of rainfall to the area is noted in the recent drought years. However, scarcity of meteorological stations, poor-quality data, and the problem of obtaining recent data complicate frequency analysis of rainfall and evapotranspiration in these study areas.

2. Material and Methods

2.1 Study Area

The study area, Kerman province, is located in south east of I.R. of Iran. For this study the data of more than 11 meteorological stations were collected (Table 1). The range of data in most of them is not adequate to agricultural draught investigation. The basic data consists of weather data for 2 main stations in Kerman and Bam cities. The study area encompasses the arid and semi-arid region of Kerman and Bam cities (Figure 1). Monthly rainfall, maximum and minimum temperature, relative humidity, wind speed and sunshine hour's data were obtained from Meteorological data Services from the period as early as 1971s for both stations. In order to obtain uninterrupted data series, missing values were synthesized by correlation with neighboring stations. For many agrometeorological purposes the WMO recommended that length of 30 years would be quite adequate. This is especially the case for agricultural planning purposes where most of the decisions are made relative to the immediate, rather than the most distant past (Todorov, 1985).

Table 1. Range of rainfall data of the weather stations

Station	Rainfall data range	longitude(degree, minute)	Latitude (degree, minute)	Altitude (m)
Kerman	1971- 2003	56-58E	30-15N	1753
Bam	1971- 2003	58-21E	29-06N	1067

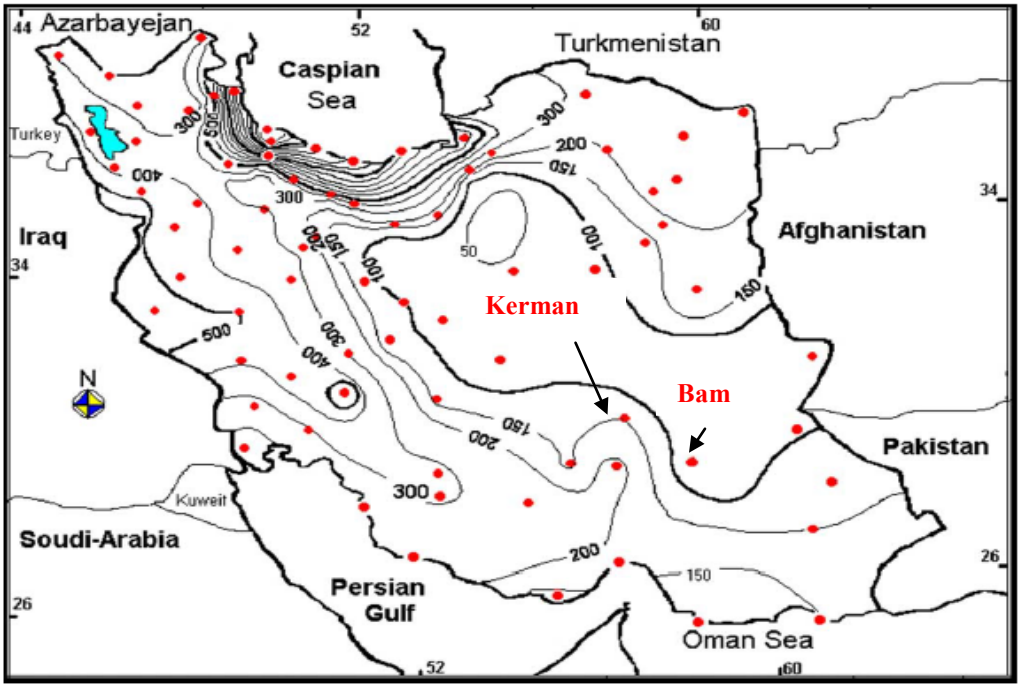

Figure 1: The mean annual precipitation (mm) in Iran during 1956–1998 (Dinpashoh et al., 2004).

2.2 Rainfall Anomaly Index (RAI)

Rainfall was used in drought index calculations since it is the most important hydrological variable and generally one of the only meteorological measurements made in arid and semi-arid areas. An index used to describe annual rainfall variability was the van Rooy (1965) rainfall anomaly index (RAI), which has been modified to account for non-normality, and is calculated as follows for positive anomalies:

$$\mathrm{RAI} = +3\left[\frac{\mathrm{RF} - M_{\mathrm{RF}}}{M_{\mathrm{H10}} - M_{\mathrm{RF}}}\right] \quad (1)$$

and for negative anomalies

$$\mathrm{RAI} = -3\left[\frac{\mathrm{RF} - M_{\mathrm{RF}}}{M_{\mathrm{L10}} - M_{\mathrm{RF}}}\right], \quad (2)$$

where RAI represents the annual RAI, RF the actual rainfall for a given year, MRF mean for the total length of record, MH10 the mean of the 10 highest values of rainfall on record, and ML10 the mean of the 10 lowest values of rainfall on record. The RAI of van Rooy has been shown to be a very effective index for detecting drought periods, and it compared favorably well with the more complex indices of Palmer and Bholme-Mooley (Oladipo, 1985).

2.3 Evapotranspiration

While analysing drought periods, evapotranspiration is another factor, which should be considered. There are several methods to estimate evaporative power of the atmosphere with different data requirements. These range from the simplest Hargarve method which depends only on temperature to the complex FAO Penman–Montheith method (Allen et al., 1998).

Monthly reference evapo-transpiration was calculated using the FAO Penman–Monteith equation (Allen et al., 1998) given as:

$$\mathrm{ET_o} = \frac{0.408\Delta(R_n - G) + \gamma[900/(T+273)]u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}, \quad (3)$$

where ETo is the reference evapo-transpiration (mm/day), Rn is the net radiation at the crop surface (MJ/m2/day), G is the soil heat flux density (MJ/m2/day), T is the air temperature (°C), u2 is the wind speed at 2 m height (m/s), es is the saturation vapor pressure (kPa), ea is the actual vapor pressure (kPa), (es – ea) is the saturation vapor pressure deficit (kPa), Δ is the slope of vapor pressure curve (kPa/°C), and γ is the psychrometric constant (kPa/°C). In the Penman–Monteith method, ETo can be determined using temperature, relative humidity, wind speed, and sunshine hours f(T,H,U,n). Monthly evapo-transpiration estimation and compare with the monthly rainfall is helpful in determining the moisture deficit and the periods when the need for irrigation is high.

3. Results and Discussions

Monthly evapo-transpiration was estimated and compared with the monthly rainfall (Figures 2 and 3). This is helpful in determining the moisture deficit and the periods when the need for irrigation is high. Figure 2 shows that the difference between ETo and rainfall is high throughout the summers (June-September) and it is quite lower in winters (December-February). This difference is much more in Bam station in whole year of Kerman station, comparatively. The moisture deficit in both regions is obvious and irrigation requirement is high for agricultural production. Respect to water scarcity in this area cultivation of tolerable or high economic worth plants is recommended. Using modern irrigation system can enhance the water application efficiency and reduce he irrigation costs.

The RAI for Kerman ranges from +6.46 in 1995 to -5.11 in 1999 (Fig. 4). This value ranges from +7.03 in 1995 to -4.58 in 2001 for Bam (Fig. 5). The rainfall varied a lot around the mean. Values of the RAI <-3 normally evaluate as drought. In the both station, the rainfall was below the mean in the recent half decade and the region suffer two most extreme droughts in last decades in 1993 and 2001. RAI index shows sever and persistence drought condition in long term existing data. There is no clear evidence of rainfall pattern changes in both regions. The evidence available does not show conclusively the aspect of permanent changes in climate on a historical time-scale. However, it is now widely recognized that significant variations do occur in the ‘‘average’’ climatic conditions in recent decade in the studied areas.

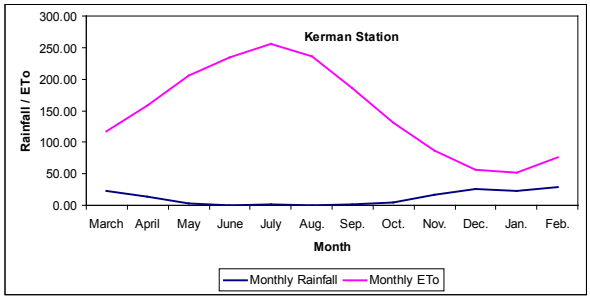

Figure 2. Monthly rainfall and evapotranspiration in Kerman station

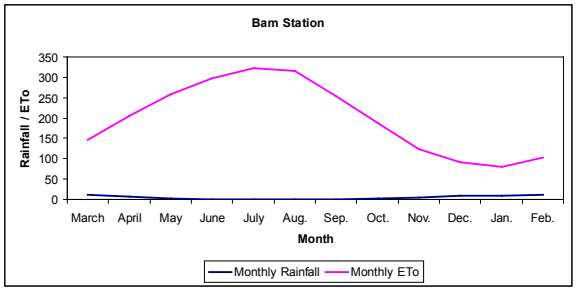

Figure 3. Monthly rainfall and evapotranspiration in Bam station

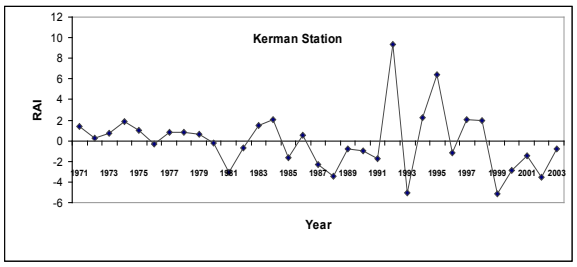

Figure 4. RAI amounts for Kerman station

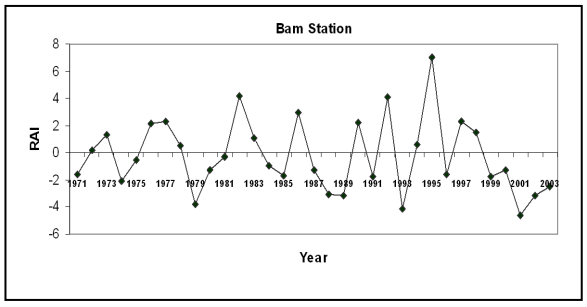

Figure 5. RAI amounts for Bam station

4. Conclusion

Successful agricultural planning in arid and semi-arid zones can be obtained only with having a scientific information about the variation of the climatic factors; rainfall being the major climatic parameter which can be measured. Other parameters can be used for evapotraspiration calculating. In comparison, evapotranspiration does not show much variation with time versus rainfall, because of low variation in the weather factors used to calculate this parameter over the years. Therefore during agricultural planning, rainfall variability should be given much attention than evapotranspiration. From the comparison of rainfall and evapotranspiration time-series, it has been remarked that in the both main climatology station in south east of I.R. of Iran experience moisture deficit and irrigation should be consider seriously.

The drought occurrence was not varied temporarily in the two stations, but the degree of droughts was more extreme in Bam station where located nearby the central desert of I.R. of Iran. For both stations 2001 was the driest year. Generally, the rainfall amount in recent years was below the long-term normal. In these region where annual rainfall variability is high, recurrent droughts are in fact a part of climate, therefore, to be considered as expected events. The coming up of the rainfall to normal do not imply that the problem is over.

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