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# HYDROLOGICAL DATA ANALYSIS FOR THE IDENTIFICATION OF DROUGHTS IN ANANTAPUR DISTRICT, ANDHRA PRADESH

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## ABSTRACT

The agricultural productivity, especially in dry land agriculture, depends upon chiefly the occurrence and distribution of rainfall in a particular region, but due to non-uniform distribution of rainfall and prolonged dry spells during monsoon season and crop period, the dry land agriculture in arid and semiarid regions is becoming difficult. The identification of dry spells and wet spells to find out drought occurring conditions are complex because of the fact that, it requires to analyse the vast hydrological data in a systematic order. The laborious process can be made easy with the advent of using computers and the appropriate data management software. Anantapur is one of the drought-affected districts in Andhra Pradesh due to its location in the rain shadow region of Western Ghats. Due to prolonged dry spells and ill distributed rainfall the district underwent a metamorphosis from drought to desert prone area. Keeping this in view, the present study has been carried out to identify the droughts in Anantapur district by analysing the daily rainfall and evaporation data for a period of 21 years from 1979 to 2000 by the application of Data Base Management System (DBMS) approach by developing programs using Microsoft Visual FoxPro Software.

From the data analysis, dry days, dry spells, wet days, wet spells, monthly, seasonal and annual rainfall, and driest and wettest months were obtained. From the results it is possible to identify the likelihood of occurrence of dry spells and wet spells. The onset of monsoons was late and consequently the late sowing of crops which results in crop failure in Anantapur district. Thus, knowledge of likelihood of occurrence of dry spells will greatly help in protection of crop from wilting. The identification of dry spells is, therefore, helpful in agricultural planning, reservoir operations, releasing of water to canals for irrigation and for planning cloud seeding operations.

## INTRODUCTION

Meteorology as well as hydrology are concerned with the atmospheric and land phases of hydrologic cycle with emphasis on the interrelationships involved. The water resources of a region mainly depends upon the precipitation, which in turn depends upon the meteorology parameters such as temperature and evaporation etc., whereas industrialization, deforestation and modern living leading to the phenomenon called global warming. The warming of the earth's surface could cause large scale climatic changes, especially affecting rainfall pattern, which greatly alters both agriculture and natural vegetation. Worldwide decrease in forest area is also affecting the climate, which has direct physical affects on water balance of the earth by altering the temperature, monsoon pattern and, thus, affecting agricultural production. Water is one of the nature's wonderful and most precious gift to the earth, the most crucial for sustaining life and is required in almost all the activities of man. All the civilizations have flourished along the waterbodies in the world. Providing water in the desired quantity and quality, and at the right time and place, has been a constant endeavour of all civilizations, and no other natural resource has had such an overwhelming influence on human

history and life. As the human population increases, as people express their desire for a better standard of living, and as economic activities continue to expand in scale and diversity, the demand on freshwater resources will continue to grow. However, the water resources in a region are limited considering the future demands. Moreover, the rainfall is confined to the monsoon season and is unevenly distributed, both in space and time, even during the monsoon season. Hence, the conservation and use of water forms one of the main elements in the development planning.

A large number of studies have been made on the rainfall pattern in various parts of India, of which many are related to agriculture (Jeevananda 2000, Rao 2002, Singh et al. 1994, Krishna Murthy et al. 1949, Baburao et al. 1999, Khambate 1992, 1993, Huda et al. 1993, Reddy et al. 2000), but hardly any comprehensive study has been carried out in Anantpur district of Andhra Pradesh on this aspect, hence this study has been undertaken.

The present study deals with the identification of droughts in Anantapur district by analysing the daily rainfall and evaporation data for a period of 21 years from 1979 to 2000 by the application of Data Base Management System approach by developing programs using Microsoft Visual FoxPro Software.

## STUDY AREA

Anantapur district is one of the drought-affected areas of Andhra Pradesh, located in the middle of the peninsular India, which renders it the driest part of the State. Being far away from the east coast, it does not enjoy the full benefits of south-west monsoon. Being cut off by the high Western Ghats, the north-east monsoon is also prevented from penetrating in this area. It is, therefore, seen that the entire area of Anantapur district is deprived of both the monsoons and is subjected to frequent droughts. The predominant causes for drought are undependable and ill distributed rainfall with prolonged dry spells between successive rains during the crop period, intensive wet spells of short duration causing soil erosion, and no significant perennial water resources in the district. These causes have resulted the district to undergo a metamorphosis from a drought to desert prone area. The district falls between the northern latitudes of 13°04' and 15°15' and eastern longitudes of 76°50' and 78°30'. The normal annual rainfall in the district is 520mm whereas the normal rainfall of Andhra Pradesh as a whole is 925 mm. The number of rainy days on an average in a year is only 36. The normal rainfall during the south-west monsoon (June to September) is 296 mm which forms about 57% of the total rainfall in the year. The rainfall during north-east monsoon (October-December) is 140 mm which forms 27% of the rainfall in the year. Sometimes, intense storms occur even in the drier regions because of severe cyclonic activity in the Bay of Bengal. The gross cultivated area is only 55% of the total geographical area (19163 $km^2$), while the average area cultivated more than once is only 6% of the total area. The percentage of the gross irrigated area both from surface and ground water to the culturable area works out to be only 11.7%, which is very low. Groundnut and sunflower are the major crops grown in dry land agriculture in Anantapur district. Owing to prolonged dry spells, the yield of the crop is greatly reduced, resulting in the weak economic position of the cultivators in this area.

## NECESSITY, SCOPE AND OBJECTIVES OF THE STUDY

The identification of dry spells and wettest months is helpful in crop planning, and pre and postagricultural activities in semi-arid areas such as Anantapur District. After the estimation of the likelihood of occurrence of prolonged dry spells, it is possible to select the type of crops which are

to be raised in a particular area, which can withstand the moisture stress. Sufficient moisture is necessarily required for the crop during the critical periods. The critical periods may vary from one crop to the other. If the prolonged dry spells occur during the critical stages of crop, then the crop will not be able to survive and results in decrease in yield, even after sufficient rainfall occurs after reaching the ultimate wilting point of the crop. This is because of the greater moisture stress to the plant. In such situations, the knowledge of likely hood of occurrence of dry spells will greatly help to protect the crop from wilting, by supplying the minimum moisture required for the survival of the crop. This can be achieved by following various methods even in dry land agriculture, such as construction of farm ponds and utilizing the stored water using modern methods of application of water to the crops. The identification of wet spells is very much helpful in reservoir operation and planning and for releasing water to the canals for irrigating crops and for planning and carrying out cloud seeding operations.

The present conditions of occurrence of rainfall and availability of water resources at Anantapur district indicate that there is neither adequate rainfall nor adequate irrigation facilities in the district. The Anantapur area has, therefore, classified as chronically drought affected area. It is evident that the available irrigation facilities in the district are not sufficient to mitigate the drought conditions. Rainwater management is crucial for improving agricultural productivity. Keeping the present drought conditions in view, the strategy of drought prone area programme and desert development programmes have been initiated in the watersheds of Anantapur district. National Remote Sensing Agency (NRSA) and Andhra Pradesh State Remote Sensing Application Centre (APSRAC) prioritised entire district into 50 macro-watersheds and 610 micro-watersheds based on the Dr. Hanumantha Rao Committee recommendations, and strategies were arrived for tackling drinking water problem, soil conservation, ground water depletion and crop productivity. After the implementation of various watershed programmes in Anantapur district, some of them were organized and maintained in good manner but in most of the watersheds the implementation of the programmes were not up to the expectation. Past research in this area was concentrated on irrigation water management, drought mitigation and alternative crops etc. Though, various strategies were developed, they could not come to be effective because of ignorance of the dry land agriculture in terms of rainwater management. The implementation of the watershed development programmes has faced certain limitations and only few isolated pockets were developed. Hence, in the present study, Anantapur district was selected as study area and the hydrological analysis of vast meteorological data was carried out on watershed development and management as basic criteria.

The Various objectives of the study are:

1. Identification of droughts in Anantapur district by analysing the daily rainfall and evaporation data for a period of 21 years.
2. Analysing data by the application of DBMS approach using Microsoft Visual FoxPro software and obtaining dry spells , wet spells, driest months and wettest months and classify dry spells.

## METHODOLOGY

### Data Base Management Systems (DBMS)

A Database Management System( DBMS) is a software designed to assist in maintaining and utilizing large collections of data (Raghurama Krishnan & Johnnes 2000). DBMS consists of a collection of interrelated data and efficiently used in retrieving and storing information for the manipulation.

DBMS provides users with an abstract view of the large data. A database is a collection of data, typically describing the activities of one or more related events. For example, the hydrological database might contain information about the following.

1. Entities such as rainfall, evaporation, humidity, temperature, wind, velocity.
2. Relationships between entities such as rainfall, evaporation and humidity.

A DBMS allows a user to define the data to be stored in terms of data model, which is a collection of high level data description constructs, which hide many low level storage details. A database system provides two different types of languages, one to specify the database scheme and the other to express database queries and updates. The relational data model is based on a collection of tables. The user of the data base system may query these tables, insert new tables, delete tables and update (modify) tables. The overall design of the database is specified by a set of definitions that are expressed by a Data-Definition Language (DDL). A Data-Manipulation Language (DML) is a language that enables users to access or manipulate data. There are several languages for expressing these operations numerous relational data base products, which are now commercially available. Data base products for personal computers include MS Access, Dbase and Microsoft Visual Fox Pro. Visual FoxPro software is an extremely powerful tool for quickly building database applications and components. It is a great tool for building database solutions of all sizes. Its data-centric and object-oriented language offer developers a robust set of tools for building database applications for the desktop, client-server environments, or the web. Developers will have the necessary tools to manage data from organizing tables of information, running queries and creating an integrated relational database management system (DBMS) to programming a fully developed data management application for end users.

In the present study, daily rainfall and evaporation data for Anantapur district for a period of 21 years from 1979 to 2000 was obtained and analysed using MicroSoft Visual Foxpro software employing personal computer. In order to calculate the dry days the daily rainfall and evaporation amount in mm were taken into consideration. The condition for a dry day in that if rainfall £ evaporation.

If there are more than three dry days occurred successively, then the entire period is considered as dry spell. The dry days and the dry spells were calculated between 1$^{st}$ March (as starting date) of a particular year and 28$^{th}$ of February (as ending date) of the next year as the Rabi season ends with February normally. In leap year 29$^{th}$ of February is considered as an ending date.

The condition for a wet day is that if rainfall > evaporation. If there are one or more wet days occurred successively, then the entire period during which the above condition is satisfied was considered as wet spell. The wet days and the wet spells were calculated between the starting date (1$^{st}$ January) and the end (31$^{st}$ Dec) of a particular year.

**Application of Microsoft Visual FoxPro Software**

Analysis of daily rainfall and evaporation data for a period of 21 years from 1979 to 2000 can be done by application of data base management system approach by developing programs using Microsoft Visual FoxPro Software. Programs were written in Visual FoxPro to display main menu, data entry screen, dry days and wet days, identification of dry spells, wet spells and displaying answer table.

## ANALYSIS OF DATA

### Dry Days and Dry Spells Analysis

The dry days and dry spells greater than 3 days duration were computed. It was indicated that on an average about 14 days spells were occurred per year. The minimum number of dry spells were 10 during 1994-95 and the minimum number of dry spells were 18 during 1983-84. It was also observed that the dry spells having maximum duration, i.e., 122 days occurred during Rabi season in 1995-96. Mostly the dry spells having greater than 60 dry days occurred during Rabi season in almost all the 21 years period of the study. During monsoon season, i.e., from July to November, the maximum dry spell having 65 days duration occurred in 1989-90. During hot weather season, the maximum dry spells with more than 90 days duration were found in 1984, 1986, 1990, 1991, 1992, 1993.

### Wet Days and Wet Spells Analysis

It was observed from the results of wet days and wet spells that mostly one day duration wet spells occurred in all the 21 years period of study. The wet spell having maximum duration, i.e., 7 days occurred during the August in 1988. The number of wet spells was varying from minimum of 10 in 1980-81 to maximum of 23 in 1996-97. The number of wet days per year were varying from 15 to 35 and on an average, the number of wet days were 23 per year. The average number of wet spells per year was worked out to be 18. The number of wet days were minimum of 15 in 1980-81 and maximum of 35 in 1988-89.

### Monthly Dry Days and Wet Days Analysis

The monthly dry days and monthly wet days during south west and north east monsoon seasons starting from July to November for the period of 21 years from 1979-2000 were obtained from the analysis. It is indicated that, September and October were the wettest months. This indicates that the maximum number of wet days occurred in September, and the minimum number of wet days in June.

### Monthly and Seasonal Rainfall Computation and Analysis

The monthly and seasonal rainfall was calculated from the daily rainfall data for a period of 21 years from 1979 to 2000. The careful observation of the data reveals that most of the rainfall events in Anantapur district occurred during monsoon season from July to November. In the 21 years rainfall data, the highest was 937.0 during 1998 and the lowest was 223.0 in 1980. The average annual rainfall at Anantapur district was worked out to be 547.5 mm. The average monthly rainfall over a period of 21 years indicated that the highest rainfall of 127.6 mm occurred in September.

### Computation and Analysis of Year-wise Dry Days, Wet Days and Total Rainfall

The yearly Dry days, Wet days and the Total rainfall were calculated. The results indicate that when the number of wet days are less than 22, the amount of rainfall is also less than the average annual rainfall (547.5mm) except in one or two cases over the 21 years period of study. When the number of rainy days are greater than or equal to 30, the annual rainfall amount was greater than or equal to the average annual rainfall and the rainfall was distributed in all the monsoon months. During such periods the agriculture yield was not much affected.

## DRY SPELL CLASSIFICATION

The number of dry spells of different durations during monsoon period over the 21 years period of the study and the total number of dry spells greater than 10 days duration was obtained and presented in Table 1.

The dry spell duration was classified into five categories viz., Cat. 1: 10 to 20 days, Cat. 2: 21 to 30 days, Cat. 3: 31 to 40 days, Cat. 4: 41 to 50 days and Cat. 5: greater than 50 days.

The maximum number of dry spells (> 10 days) were maximum, i.e., 8 in 1982-83, 1985-86 and 1992-93 and the corresponding rainfall was 604.3, 404.4 and 433.8 mm respectively. The number of dry spells (> 10 days) were minimum, i.e., 3 in 1979-80 and in 1988-89 and the corresponding rainfall was 610 and 927.6 mm respectively.

## COMPUTATION AND ANALYSIS OF DRIEST AND WETTEST MONTHS DURING 1979-2000

The interpretation of the results from the tables, the months with maximum number of rainy days and maximum number of dry days were calculated and tabulated in the Table 2. It can be noted that in 15 years out of 21 years, September was seen to be the wettest month and the next was October. The driest months were June and July in 15 years out of 21 years. From the statistics of the rainfall data and from the interpretation of the results, it was observed that the onset of monsoons was late in almost all the years over the period of study, due to which the sowing of crops was not done within the correct time, resulting in reduction of yield. It was also observed that the annual rainfall was even less than the normal annual rainfall in most of the years and once in four years, the annual rainfall exceeded the normal annual rainfall, resulting in drought conditions prevailing in Anantapur district. Because of the number of rainy days, which are also nonuniformly distributed during the S-W and N-E monsoon period, and the prolonged dry spells during monsoons, the yield of crops was affected and has resulted in frequent droughts in Anantapur district.

## DISCUSSION

From the analysis of the results, the likelihood of occurrence of dry spells can be estimated so that the remedial measures can be taken in advance. The identification of dry spells and wettest months is also helpful in crop planning, and pre and postagricultural activities. After the estimation of the likelihood of occurrence of prolonged dry spells, it is possible to select the crops which are to be raised in a particular area and can withstand the moisture stress. Sufficient moisture is necessarily required for the crop during the critical periods. The critical periods may vary from one crop to the other. Unless the required water is not supplied, the crop starts wilting. If the prolonged dry spells occur during the critical stages of crops, the crop will not be able to survive and results in decrease in yield, even after sufficient rainfall occurs after reaching the ultimate wilting point of the crop. This is because of greater moisture stress of the plant. In such situation, the knowledge of likelihood of occurrence of dry spells will greatly help to protect the crop from wilting by supplying the minimum moisture required for the survival of the crop. It can be concluded from the above analysis that, whenever the annual rainfall in a particular year is less than normal annual rainfall, the wet spells are less than 23 and dry spells are more 5, then that year may be identified as a drought year. It was also concluded that if the dry spells with more than 30 days duration occur during June, July and August months, the yield of the crop would be very much affected.

Table 1: Yearwise dry spells of different durations (1979-2000) during monsoon season in Ananatpur dist.

| S. No. | Year | No. of dry spells (days) during monsoon months (June-Nov.) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 10-20Cat.1 | 21-30Cat.2 | 31-40Cat.3 | 41-50Cat.4 | >50Cat.5 | Total > 10 days |
| 1 | 1979-1980 | 1 | 1 | - | - | 1 | 3 |
| 2 | 80-81 | 4 | 1 | - | - | 1 | 6 |
| 3 | 81-82 | 1 | 2 | 1 | 1 | - | 5 |
| 4 | 82-83 | 7 | - | - | - | 1 | 8 |
| 5 | 83-84 | 4 | 1 | 1 | - | - | 6 |
| 6 | 84-85 | 2 | - | 3 | - | - | 5 |
| 7 | 85-86 | 4 | 2 | - | 2 | - | 8 |
| 8 | 86-87 | 1 | 1 | 2 | - | - | 5 |
| 9 | 87-88 | 3 | 2 | 1 | - | - | 6 |
| 10 | 88-89 | 1 | - | 1 | - | 1 | 3 |
| 11 | 89-90 | 2 | 3 | - | - | 2 | 7 |
| 12 | 90-91 | 3 | - | 1 | - | 1 | 5 |
| 13 | 91-92 | 4 | 1 | 1 | - | - | 6 |
| 14 | 92-93 | 1 | 1 | - | - | - | 8 |
| 15 | 93-94 | 4 | 2 | 1 | - | - | 7 |
| 16 | 94-95 | - | 2 | 2 | - | - | 4 |
| 17 | 95-96 | 4 | 1 | 1 | - | - | 6 |
| 18 | 96-97 | 2 | 1 | - | 1 | - | 4 |
| 19 | 97-98 | 4 | - | - | - | 1 | 5 |
| 20 | 98-99 | 4 | 1 | - | - | - | 5 |
| 21 | 1999-2000 | 5 | 2 | - | - | - | 7 |

Table 2: Driest and wettest months during 1979-2000.

| Year | Total rainfall (mm) | No. of rainy days (Wet days) | No. of dry spells> 10 days duration | Max wet days months | Maximum dry days months |
|---|---|---|---|---|---|
| 1979-1980 | 610.0 | 23 | 3 | Sept, Nov. | June, July, Aug. |
| 80-81 | 223.0 | 15 | 6 | Sept, Nov. | June, July, Aug. |
| 81-82 | 526.7 | 32 | 5 | Sept, Nov. | June, July, Aug. |
| 82-83 | 604.3 | 28 | 8 | Sept, Nov. | Aug |
| 83-84 | 665.5 | 30 | 6 | Aug, Sept. | July, Nov |
| 84-85 | 273.2 | 18 | 5 | July, Oct. | June, Aug, Nov |
| 85-86 | 404.4 | 28 | 8 | July, Sept, Oct. | July,Aug, Nov |
| 86-87 | 423.5 | 19 | 5 | Sept, Oct | July, Nov |
| 87-88 | 505.5 | 19 | 6 | Aug, Oct | July, Sept |
| 88-89 | 927.6 | 35 | 3 | July,Sept | June, Nov |
| 89-90 | 826.0 | 25 | 7 | July, Sept | Aug, Oct, Nov |
| 90-91 | 539.6 | 26 | 5 | Aug, Oct | July |
| 91-92 | 433.8 | 19 | 6 | June, Oct, Nov | July, Aug |
| 92-93 | 498.7 | 25 | 8 | Sept, Oct, Nov | June, Aug |
| 93-94 | 699.6 | 32 | 7 | Aug, Sept, Oct | June, July |
| 94-95 | 395.1 | 19 | 4 | Oct, Nov | July, Aug, Sept |
| 95-96 | 762.5 | 24 | 6 | Aug, Oct | June, July |
| 96-97 | 853.9 | 32 | 4 | June, Sept, Oct | Aug, Nov |
| 97-98 | 502.4 | 17 | 5 | Sept. | July, Oct, Nov |
| 98-99 | 937.0 | 25 | 5 | Sept, Oct | June |
| 1999-2000 | 472.6 | 21 | 7 | Aug, Sept | June, July |

## CONCLUSIONS

It was observed that the onset of monsoons was late in almost all the years during period of the study and consequently the late sowing of crops results in decrease in yield. It can be concluded that, the annual rainfall was even less than normal annual rainfall in most of the years and once in four years, the annual rainfall exceeded the normal annual rainfall over the 21 years period of study, which results in drought conditions prevailing in Anantapur district. The average number of rainy days were less than 30 days which are also non-uniformly distributed during the S-W and N-E monsoon resulting in prolonged dry spells to occur in Anantapur district. The knowledge of likelihood of occurrence of dry spells will greatly help in protection of crop from wilting by supplying minimum quantity of stored water from farm ponds and check dams etc. using modern methods of application of water. The identification of dry spells and wettest months will be helpful in crop planning and in pre and postagricultural operations. The identification of dry spells is, therefore, helpful in agricultural planning, reservoir operations, releasing of water to canals for irrigation and for planning cloud seeding operations.

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