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# Geographical Information System(GIS) based Agricultural Drought Assessment: A Knowledge Based Methodology

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**Abstract**—***Agricultural drought is considered to be one of the man's worst natural enemy. Its beginning is subtle, its progress is insidious and its effect can be devastating. In a country like India, drought is considered to be a major factor of uncertainty due to vagarious of monsoon. Once there was not effective drought assessment and monitoring system, but now remote sensing plays an important role and the facilities like Geographic Information System(GIS) facilitate effective drought assessment and monitoring. The methodology list out an assessment and monitoring procedure for Agricultural drought for a given district. Interpretation of satellite based vegetation index(VI) with their ground parameter through GIS. For this study different maps viz, Landuse map, Soil map, Mandal/Municipal map, Hydrogeological map and data's viz Rainfall, Ground water levels, Major Crop sown details, Source wise irrigation details need to be collected, digitised and entered in the database. From the created database agricultural landuse area should be extracted and VI need to be generated. This generated Vegetative Index and the available fortnightly Rainfall data of couple of years from the current years assessment should be plotted against time(fortnightly interval) for the selected mandals/municipalities constituting different crops, soil and rainfall distribution. Based on the normal crop performance of previous years, the relative drought assessment for the current year should be made, and the drought severity level is obtained. The results may isolate few from the selected mandals/municipalities which may fall under mild/moderated drought level.***

Keywords: **Drought, Remote Sensing, GIS, Vegetative Index(VI), Satellite**

## I. Introduction

Agriculture is the main stay in India, about 69% of the population depend on agriculture. The total geographical area is of 328 million hectares, out of which the total cropped area is about 174 million hectares while 142 million hectares, are rainfed depending on monsoon. But due to vagaries of monsoon, drought is considered to be a major factor of uncertainty in India. Agricultural Drought assessment is considered to be one of the man's worst natural enemy. Its beginning is subtle, its progress is insidious and its effects can be devastating. According to Dai (2011) states that Drought is a temporary, extremely dry period over land with limited precipitation, lasting months to years. Drought may start at any time, last indefinitely and attain many degrees of severity. It can also occur in any region of the world with an impact ranging from slight personal inconvenience to endangered nationhood. Once there were not effective drought assessment and monitoring system. But now remote sensing plays an important role with advancement in computing technique and facilities like Geographic Information System(GIS) facilitate effective drought assessment and monitoring.

## II. Objectives and Methodology

To device a methodology for a partial decision making information system for drought assessment and monitoring with the help of GIS for mandals/municipalities where the sequence of activities are:

1. To design and create a database of input parameters having effects on the drought phenomenon to a varied degree which also includes historic data.
2. To relate these input parameters with the Satellite based Vegetation index.
3. To assess the drought situation for the current year by fixing an index based on Rainfall, Normalised Difference Vegetation Index(NDVI) trends of present and previous year.

Agricultural indicator such as delayed sowing, decrease in crop acreage, decrease in crop vigour, change in cropping pattern from irrigated wet to irrigated dry crops for a small area can be studied from high spatial resolution(less than 80 m) sensors of LANDSAT/SPOT/IRS SATELLITES (or) from the low resolution(1.1 km) of the NOAA Data which provide average information over large areas. However NOAA data has the advantage of being available everyday for its wide coverage, it is possible to get cloud free pictures of earth surface due to frequent time intervals. Thus effective drought monitoring should envisage integration of objective time effective reliable satellite data with details of ground observation.

The primary dependence on remotely sensed data is from meteorological NOAA Satellite, supplemented and supported by ground observation of rainfall and agricultural conditions. (Thiruvengadachari 1988). Here satellite sensors provide direct areal information on vegetation stress caused by drought conditions. The Agricultural Drought Assessment and Monitoring System(ADAMS) under development provide more efficient and timely monitoring capability by integrating the

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timely and objective space observations with details of ground perceptions.

Vegetation Indices are particular combination of spectral responses in different wave length bands with emphasize a particular feature of vegetation. Use of vegetation indices is guided by three general objectives.

- To enhance through appropriate combination of spectral bands, the relevant vegetation features. Ideally the indices should have a better defined relationship with physiological properties of crop than individual spectral measurement.

- To standardize the representation of crop spectral responses (useful in region to region (or) year to year comparison).

- To reduce dimension of data set i.e. an index reduces to one data set, then which contribute to its calculations (Torselli ed)

Normalised Difference Vegetation Index(NDVI) is defined as the ratio of difference between the near infrared and red reflectance's to their sum.

$$NDVI = \frac{NEAR\ INFRARED - RED}{NEAR\ INFRARED + RED}$$

in LANDSAT MSS terms:

$$NDVI = \frac{BD7 - BD5}{BD7 + BD5}$$

in AVHRR terms:

$$NDVI = \frac{CH2 - CH1}{CH2 + CH1}$$

The index is called normalised because it is divided by the sum of radiances and thus normalizes somewhat for differences in solar spectral irradiances. The NDVI is dimensionless and takes the value 0 to 1. In certain types of dry soils we get negative values. The values of NDVI is mainly determined by difference between near infrared response which increases with increase vegetation in the scene and the red response which decreases with decreasing vegetation.

NDVI value is used for vegetation monitoring because it partially compensates for changing illumination conditions, surface slopes and viewing aspect. Also the clouds, water and snow have larger reflectance's in the visible than in the near infrared, leads to negative NDVI, rocks and bare soil have similar reflectance's in these two bands and result in vegetation is zero. For vegetation the NDVI ranges from 0.1 to 0.6, higher values are associated with greater density, larger green biomass of the canopy compared to lower NDVI values.

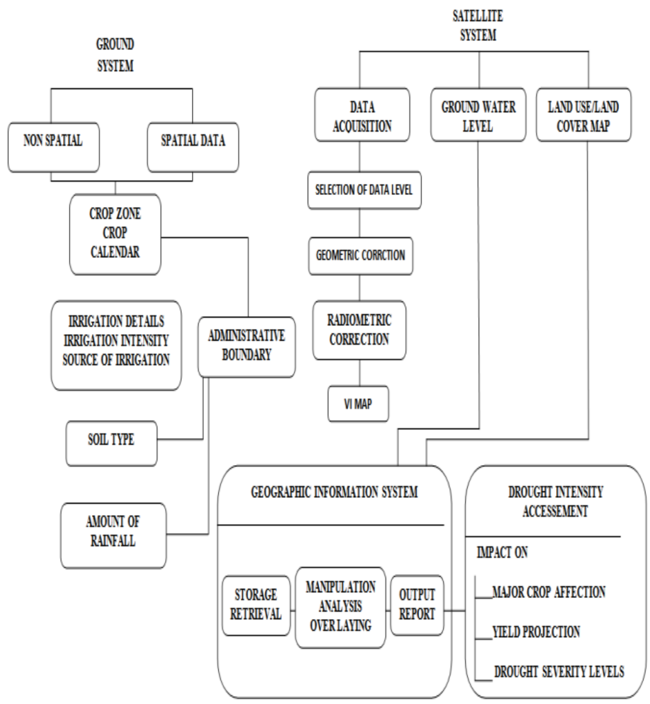
The major advantages of a GIS are that it allows identifying the spatial relationship between map features. Especially, a GIS gives ability attributes to map features and then store these in the coverage's feature attribute table.

Usually the district level drought was made based on the time series of vegetation index correlated for the major crop condition. This study aims to develop a methodology over agricultural area using GIS for varying soil type, crop type and rainfall. This section discusses about the typical study area and the methodology adopted.

A typical study area need to be selected where its Soil Type, Landuse pattern, Cropping pattern, Climate changes, Drought prone indices are observed.

Mandal boundary map used in NDVI generation in the NADAMS procedure are transferred to GIS environment with each mandal as different polygon. And this is considered as a base map for all the coverages for overlaying and further analysis. GIS database is created by digitisation of Landuse, Soil, Hydrogeological etc,. Figure 1.1 shows the typical flow chart methodology of drought assessment.

**Figure 1.1 Methodology for Drought Assessment**




The GIS model for the study area need to facilitate interpretations of NOAA AVHRR based vegetation index with other ground parameters. Input parameters, creation of database and derived outputs and brief methodology adopted for drought assessment.Input Data

1) Landuse Map
2) Soil Map
3) Mandal/Municipality Map
4) Hydrogeological Map
5) Command Area Boundary Map
6) Observatory well locations and Rain gauge stations
7) NDVI Maps

All the above thematic maps are to be digitised to create each as a separate layer using GIS. Rainfall Isohyetal maps were generated for the previous years from the current year (say last 3 to 5 years). Table 1.1 and 1.2 shows list of type and derived maps.

**Table 1.1 Lists of Thematic Maps and Feature Type**

| S No | Thematical | Type |
|---|---|---|
| 1 | Landuse Maps | Line / Polygons |
| 2 | Soil Map | Polygons |
| 3 | Mandal Map | Polygons |
| 4 | Hydrogeological Map | Polygons |
| 5 | Command Area Map | Polygons |
| 6 | Observatory wells and Raingauge stations | Points |
| 7 | NDVI maps | Polygons |

**Table 1.2 Lists of Thematic Maps and Feature Type**

| S No | Thematic Layer | Type | Source |
|---|---|---|---|
| 1 | Isohyetal Maps | Lines / Polygons | From Rainfall data |
| 2 | NDVI Maps | Polygons | From NDVI Maps |
| 3 | Isohyetal Maps | Points / Lines / Polygons | Ground water potential |
| 4 | Hydrogeological Map | Lines / Polygons | From all coverages |

III. **Results and Discussions**

By overlaying soil, landuse maps and mandal/municipal coverage, the selected representative mandal/municipal with major crops such as (Jowar, Groundnut, Paddy, Redgram and Cotton) with different soil type, hydrogeological and rainfall region. The selected representative mandals agricultural area from the landuse coverage is intersected with NDVI maps of 7-10th fortnights in order to extract the statistics details of vegetation index within agricultural area from GIS environment.

As the critical state of growth for the major crop falls between vegetation stage and maturity stage the Mean Normalised Difference Vegetation Index(MNDVI) extraction from 7-10th fortnights of previous years say 3 to 5 years from the current year should be extracted for each mandal/municipality from the NDVI map. For the corresponding period, rainfall is also extracted and the plot should be made with respect to NDVI. Rainfall Vs Time and NDVI vs Time are plotted and the drought severity level should be arrived. Figure 1.2 shows the drought severity level.

**Table 1.3 Drought Severity Level**

| Delay in Vegetation Growth | VI Anomaly Compared to Normal Year(in %) | Drought Severity Level |
|---|---|---|
| Upto 1 Fortnight | Upto 10 | NORMAL |
| 1 – 2 Fortnight | Above 10 but Below 25 | MILD |
| 2 – 4 Fortnight | Above 25 but Below 50 | MODERATE |
| More than 4 Fortnight | Above 50 | SEVERE |

Initially the comparison of district average fortnightly profile for the previous years of the same period should be arrived. The present NDVI need to be compared with the previous year's same period. If there is reduction in current NDVI then there is reduction due to occurrence of low rainfall. Though the district average assessment condition is reflective of only major crop condition for example Jowar, the impact on individual crops will be reflected from the crop specific mandals. Further, by considering the vegetation development only in the agricultural area by excluding forest and non agricultural area, the more realistic assessment can be made.

Mandalwise Agricultural area, separation within district has more impact in the assessment due to it low percent cover. However within mandals, has impact in assessment can be seen in the Agricultural intensive mandals. In order to study the effect on vegetation due to varying agriculture intensity, few mandals can be selected. Fortnightly NDVI for the previous years over mandal and over agricultural area may be plotted for comparison. Thus vegetation index generated from agricultural intensive area is more stable than by considering the mandal average NDVI.

The fortnightly vegetation index should be generated from agricultural area for the previous years from current year over the peak growth period is compared with the rainfall pattern, based on the know crop performance in the previous year, the relative drought assessment for current year is thus made.

In order to interpret remotely sensed data and to integrate with ground data, Geographical Information System, will be immense use for drought related studies especially agricultural drought. It is expressed that this procedure will improve the objectivity, reliability and time effectiveness of drought information.

## IV. Conclusion

The conventional method of taking the combined landuse pattern into considering for determining district average has been modified. Here the agricultural landuse and the predominant crop has been taken for analysing the Vegetative Index (VI). Its evaluation with the ground evidence of a normal year will give good result and realistic information of the severity of the drought affected area. Hence delineation of predominant crop and agricultural landuse is very much necessary for evaluating the drought severity level based on Vegetation Index (VI) and should be considered hence forth.

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