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Drought Analysis using Geo-Spatial Techniques for Hisar District, Haryana

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Abstract: ***Hisar district of Haryana has been known for water scarcity. The recent recurring water scarcity in the Hisar region has alarmed the scientific community and the policy makers alike. The absence of appropriate scientific work to analyze the recurring pattern of the drought, and the relation between meteorological, hydrological, and agricultural drought has further perplexed the decision makers. This study attempts to use the range of indices on drought monitoring and different software such as Arc-GIS 9.3, ENVI 4.4, Map Info and Erdas Imagine 9.1.This information has been tabulated and converted into pictorial representation to illustrate the intensity and frequency of the droughts. It presents an intelligent information base to assist the decision makers and mitigation analysts in taking decisions for drought mitigation action. It was concluded that blocks (Adampur, Agroha and Hisar) there was no severe drought condition in the district during the study period. It varies from block to block in each year. Meteorological drought analysis was carried out at district level and it was analyzed that in 2002, 2006 and in 2009 rainfall was deviate than normal rainfall. . It was observed that hydrological drought in pre- monsoon and post- monsoon was varying. According to hydrological drought result analysis based on IDW technique, the study area of Hisar district was facing ground water crisis. Frequency analysis of drought defined the vulnerability condition of drought in the district.***

Keywords: Drought, NDVI, hazard, vulnerability and risk

1. Introduction

Drought is a natural hazard with a slow and creeping onset. Drought may be defined as an extended period of month or years, when a region notes a deficiency in water supply, whether surface or underground water. Generally this occurs when a region gets below average precipitation. The starting of these phenomena is slow but can prolong for the larger period of time. The severity of the drought is also difficult to the measurement. And the severity of this hazard can be increased for a long time period. This hazard impacts have on many other sectors such as economic, social and environmental. The information for drought is required for various planning purposes and can be reduced through mitigation and preparedness. Also this information is required to develop plans to deal with these extended periods of water shortage. Drought can be meteorological, hydrological and agricultural. At present drought recent technologies of remote sensing, satellite imaging, geographical information systems (GIS) and geographical positioning system (GPS) offer two principal advantages, if incorporated in drought research and mitigation. First, it allows long-term time-series studies and set of information that may prove invaluable in future assessments and decisions. Secondly, GIS/RS improves information accessibility and accuracy.

Hisar district is one of the most important districts in Haryana with fast developing economy and frequent human activities. Rapidly decreasing water table created a crisis of drinking water. In some of the areas the poor people face the crisis of water problem from February/March to end of June. There are several manifestations of drought like late arrival of rains, early withdrawal, long break in between, lack of sufficient water in reservoirs and drying up of wells leading to crop failure and even un-sowing of the crops which ultimately curtail livelihood and may lead to migration. The proposed study will scientifically identify and assess the hazards and vulnerability on spatial scales, by using remote sensing and GIS techniques. The aim of the study is to develop a drought vulnerability map for the region which is not available till date and can serve as a major basis for management, planning and programmes monitoring framework.

2. Methodology

2.1 Study Area

Agroha, Adampur, Hisar-I and Hisar-II blocks of Hisar district occupies the east and west central part of Haryana state and suffers frequent scarcity of water in southern and south-western part. It is situated between 28°53’45” to 29°25’15” N latitudes and 75°13’15” to 75°55’01” E longitudes, with a total area of 2099.16 km^2. Most of the people in Hisar district are engaged in agricultural activities for their livelihood. The location map of the study area is shown in Figure-1. There is no any natural drainage system. This area is comprised of old alluvial plain and sand dunes. The general altitude of the area varies from 203 to 225 m amsl and having a gentle slope towards south-westerly direction. The topographic pattern of Hisar district has close affinity with climatic aridity.

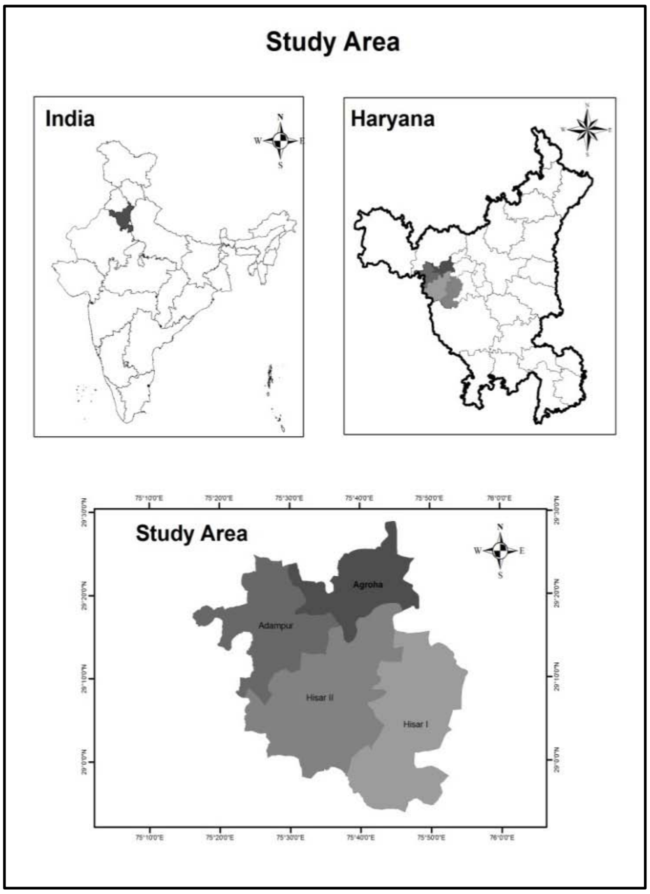

Figure 1: Study Area Map

Temperature increases rapidly in the month of May. Temperature reaches up to 41˚ to 48˚C. Rainfall in the district is erratic in nature. The soils of these blocks of Hisar are broadly classified in desert soil or sandy soil, sandy loam soil and loamy soil. The water table (unconfined) aquifers occurs from 10 m to 60 m depth below ground level in the district. The ground water in unconfined condition is abstracted through hand pumps, dug wells and shallow irrigation tubewells.

2.2 Methods

Methodology was based on three elements meteorological data, hydrological data (ground water well information of pre monsoon and post monsoon) and agricultural data (NDVI).

2.2.1 Meteorological Data Processing

Prevailing literature has been reviewed in order to understand and select the suitable drought indices appropriate for study of drought in Hisar region.

2.2.1.1 Percent by Normal

The percent of normal precipitation is one of the simplest measurements of rainfall for a location. Analysis using the percent of normal are very effective when used for a single region or a single season. Resulted details of criteria were given in table 4.1. Percent below normal was calculated as following:

$$\textbf{Percent by normal} = \frac{(\text{Actual })}{\text{Normal}} * 100$$

Table 1: Percent by Normal

Percent by Normal	
+/-19%	Severely
20 to 59%	Moderate
>60%	Normal

2.2.2 Hydrological Data Processing

The present study was based on administrative boundary of each block of the district. So ground water well data within Hisar district were taken. Hydrological drought index was manuplated by using Arc-GIS 9.3 and MS-Office(excel and ms-acess).

2.2.2.1 Interpolation method for Ground water observation

The groundwater database exported to Arc-GIS and manuplated into point shp file. For calculating the ground water level below surface through Arc- GIS 9.3 's spatial analyst tool (IDW) technique. This method provides Surface water index and criteria as following as given table 2.

Table 2: Weightages to categories (SWI)

SWI Values (mbgl)	*Ground water conditions*
0	Very Good
5-10	Good
10-15	Low
> 15	Very Low

2.2.3 Satellite Image processing for agricultural drought

Satellite images (MODIS) for the years 2002 to 2012 were processed and the study area was subset using ENVI 4.4.

2.2.3 .1Normalized Difference Vegetation Index

NDVI reflects vegetation vigour, density and biomass. It varies in a range of -1 to +1. Among all the available vegetation indices, it is a universally acceptable index for operational drought assessment.
NDVI was derived as under;

$$\textbf{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$$

Where, near Infra Red and Red are the reflected radiations in these two spectral bands.

2.2.3.2 NDVI differencing

In ENVI software using band math tool NDVI differences were calculated by subtraction each year normal NDVI from 12 years average NDVI. It was computed as:-

$\textbf{NDVI differencing} = \text{NDVI}_i - \text{NDVI}_j$

$\textbf{NDVI}_\textbf{i} = \text{normal NDVI of ith year}$

$\textbf{NDVI}_\textbf{j} = \text{average NDVI of twelve years}(2001 - 2012)$

Images classified into three categories. Higher values(+2) of NDVI values(0 to2) represented in green colour for normal vegetation condition while the NDVI all negative values in red colour represents the stressed condition of the vegetation. Details of NDVI categories were given in table 3.

Table 3: Weightages to categories (NDVI)

Values	Vegetation Condition
-0 (all negative values)	poor
0 to 2	normal
+ 2	good

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2.2.4 Post processing and data analysis

The broad outline of the analysis was done during the study. The results were used based on their corresponding drought index classification scheme.

2.2.5 Frequency analysis

Frequency of drought occurrence during the period of study was noted. Frequencies were then classified into different classes i.e. extremely high, high, moderate and mild separately for each type of drought.

3. Results and Discussion

Outcome of the analytical study on different aspects of meteorological, hydrological and agricultural drought in blocks of Hisar region in Haryana is presented in the following sections:

3.1 Meteorological Drought

Results of "Percent by normal" indicate the increasing frequency of moderate droughts occurrence in the district as given in table 4.

Table 4: Percent by normal Hisar district 2000 to 2012

Year	*June*	*July*	*August*	*September*	*Percent by normal (June-September)*
2000	118.1	142.1	45.8	17.3	80.9
2001	157.9	80.8	61.7	49.1	87.4
2002	57.9	**13.5**	43.2	97.1	**52.2**
2003	**16.8**	198.2	81.4	38.8	83.8
2004	139.2	**0**	58.9	63.07	65.3
2005	165.7	139.2	6.3	278.9	147.5
2006	54.3	98.8	**5.3**	107.3	66.5
2007	389.9	**14.9**	46.8	71.2	130.7
2008	195.1	82.1	42.9	5.07	81.3
2009	119.5	**8.1**	85.2	0	**53.3**
2010	343.5	61.5	55.7	0	115.2
2011	113.5	55.2	82.8	0	62.9
2012	76.4	103.7	16.1	16.7	**53.3**

During the year 2002, 2009 and 2012, the district experienced severe meteorological drought since the district received only 52.9%, 53.2% and 53.2% rainfall, respectively and this rainfall is much lower than the normal rainfall (>60%) expected during monsoon season (Figure-5.1).

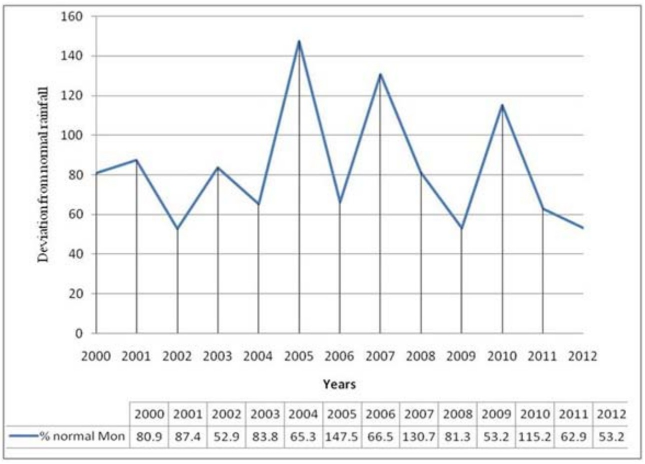

Figure 2: Percent by Normal

Early season monsoon rainfall was as low as 13.5% of the rainfall in July 2002, 8.1% in 2009 (table-5.1) which is crucial since the district having large area i.e. 92% under agricultural activities.

3.2 Hydrological drought

Results obtained from SWI for pre-monsoon and post monsoon season from 2001 to 2011 are displayed in the figure 2 and figure 3 hydrological droughts.

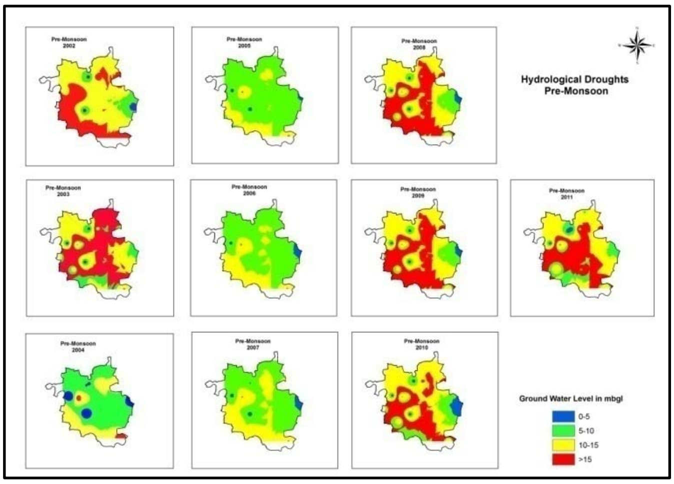

Figure 3: Hydrological Droughts condition during Pre-Monsoon

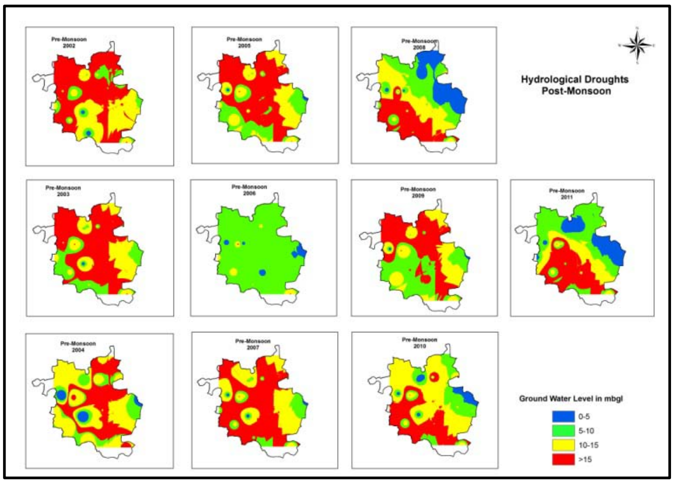

Figure 4: Hydrological Droughts condition during Pre-Monsoon

It should be noticed that these blocks also experienced meteorological drought in the same year. In 2002, Hydrological drought became more intense and covered a wider area if compared from pre to post monsoon scene. There was a remarkable difference in pre and post monsoon scene. In post monsoon scene almost entire area is under normal. Visual interpretation key analysis suggested that southern part of the Hisar district's block was affected by the hydrological drought during pre-monsoon and post-monsoon season.

3.3 Agricultural Drought

NDVI anomaly is one of the basic techniques to analysis the crop's health status. It is most commonly used for drought detection and monitoring. NDVI Anomaly images indicated changing drought conditions spatially during the study period 2002 to 2012. NDVI Anomaly characterized by three colours, red colour is indicated for severe drought condition, yellow colour is indicated for moderate and green colour for healthy vegetation condition. Results obtained for NDVI Anomaly for September month of each year from 2001 to 2012 are displayed in figure 4.

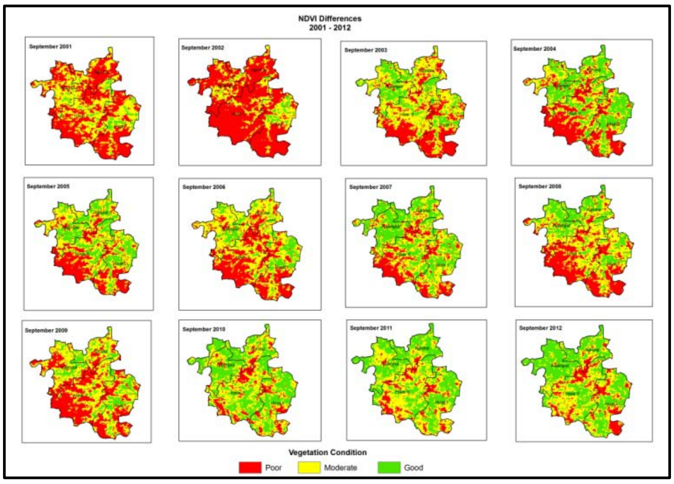

Figure 5: Agricultural Droughts condition during Pre-Monsoon

3.4 Drought Vulnerability

Drought vulnerability is accessed on the criteria of drought frequency computation and analysis. Drought frequency is classified in four categories: extremely high, high, moderate and mild or no drought condition.

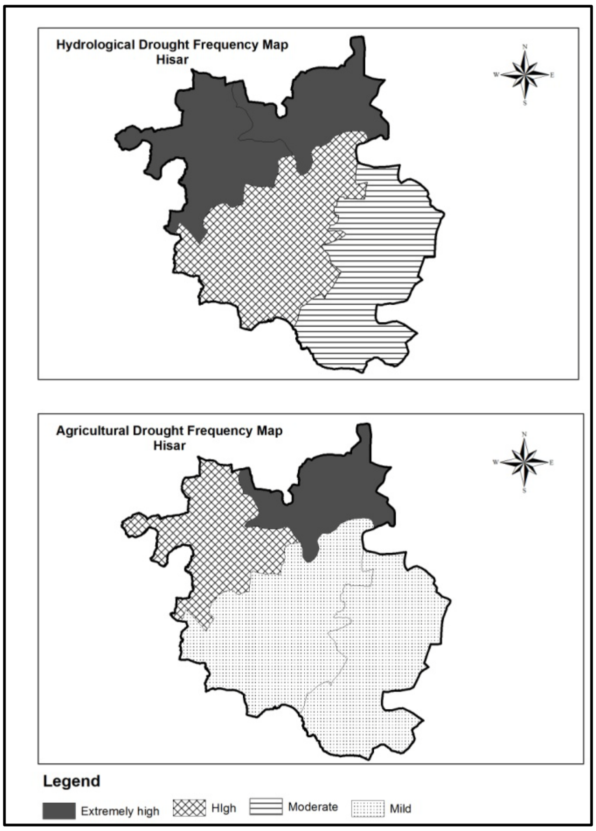

Figure 6: Drought Frequency

3.5 Comparative Analysis

Comparative analysis of agricultural, hydrological and meteorological drought of these blocks is resulted to indicate that Adampur, Agroha have more probability of agricultural drought comparison to hydrological drought (Figure 5.5).

4. Conclusion

The use of such techniques may be helpful for different study areas and preparedness resulting in better prioritization of action at spatial and temporal action. The techniques have vital use in different areas of drought prone.

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Author Profile

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