ASSESSMENT OF AGRICULTURAL DROUGHT IN VIRUDHUNAGAR DISTRICT USING GEO INFORMATICS TECHNIQUES

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Abstract

Agricultural drought assessment has been performed by different researchers using various methods. Most of the agricultural drought methods depends on information related to drought such as weather condition, soil condition and water availability. The present study is carried out in the Virudhunagar district, which comes under southern plateau and hilly agro climatic zone. Here, in the present study, agricultural drought assessment is carried out using secondary data and satellite imageries. This research paper presents an efficient method for agricultural drought risk assessment using geographical information system. This is done by using the first session multi-thematic map layers viz., physical, climatic, soil and socio economic conditions including fifteen parameters and the second session drought indices. The agricultural drought risk assessment is done based on the raster overlay by ranking method in GIS. Based on the agricultural drought risk conditions pertaining to each parameter, it has been classified into three categories viz., high, moderate and mild risk for agricultural drought and ranks has been allotted appropriately. Finally overlay has been done to delineate the agricultural drought risk zones in block wise. The specific objectives include, preparing of drought indices maps from satellite images for a drought period to calculate the percentage of drought affected area and to show the effectiveness of satellite derived drought indices as an assessment and to identify the most drought risk prone area. Based on the above discussion the methodology for the present study is being framed and accordingly the following geospatial database is being collected.

Key words: agricultural drought, multi thematic layer, physical parameter, climatic parameter, soil properties and socio economic condition, NDVI, NDWI, SAVI, NDMI, TCI, GIS.

Introduction

Agriculture sector is most affected by the onset of drought as it is highly reliable on the physical parameters, climate, soil moisture and socio economic conditions. Agricultural drought is nothing but the decline in the productivity of crops due to irregularities in rainfall, increase in the rate of temperature which causes a decrease in the soil moisture. The role of remote sensing and GIS in agricultural drought detection, assessment and management is becoming crucial in these days as they provide up to date information in different range of spatial and temporal scales which is time consuming when done by using various secondary data (Thenkabail, et.al., (2004), Arshad, et.al., (2008), Hasan and Saiful, (2011), Brian et.al, (2012)). Agricultural drought depends upon physical factors such as topography, climatic characteristics, soil, irrigation facilities and the socio economic conditions of the people. The physical factors directly influence the nature of agricultural drought whereas the socio-economic conditions have an indirect influence on it. All these factors have been taken into consideration in the present study of agricultural drought assessment. Agricultural drought assessment has been performed by different researchers using various methods. Many previous studies in the assessment of agricultural drought focus their remote sensing imagery based analysis. The present consist of drought indices using the imagery by fallow the reference Ticker (1979), Ayyangar (1981), Mishra (2007), Jeyaseelan (2002), Krishnaveni (1993), Bhuiyan (2004), Nageswara Rao (2005), Prasad (2007), Gao (2011), Tao (2011) and Son et.al., (2012) to assess the agricultural drought conditions.

The present study is carried out in the southern district of Tamil Nadu namely Virudhunagar, which comes under Southern plateau and hill of agro climatic zone. The present study area holds a majority of the population dependent on agricultural activities. So the area is highly affected by the occurrence of agricultural drought. The decrease in total population and agriculture dependent population is also evidenced in the study area. The difference in the spatial distribution of population within the district is also evidenced. So the present study has gained its importance for the assessment of agricultural drought. Here, in the present study, assessment of agricultural drought is carried out using both the secondary data (multi-thematic layers) and primary data (drought indices) by GIS techniques. Moreover GIS techniques are used to analyses the drought using the secondary data particularly the climatic condition, soil. The present study area has received more annual rainfall. But the agricultural practices and irrigation system has failure, because the soil and climatic parameters does not support agriculture. The general objective of this present research work is to delineate drought risk areas using GIS techniques for various multi-thematic layer maps in Virudhunagar district. The specific objectives include, preparing of drought indices maps from satellite images for a drought period to calculate the percentage of drought affected area and to show the effectiveness of satellite derived drought indices as an assessment and to identify the most drought risk prone area. Based on the above discussion the methodology for the present study is being framed and accordingly the following geospatial database is being collected.

Study Area

Virudhunagar district is divided into 8 taluks. The taluk is further divided into 11 blocks, which is further divided into 600 villages. It is a plain area with a slope of less than 45º. It is bounded on the north and north-east by Madurai district, south-east by Sivagangai District, on the south by Thirunelveli District and on the west by Virudhunagar taluk. The location of the study area is given in figure 1. The present study area covers 1538.22sq.km. The physiographic of the study area is predominantly plain falling in three different region viz., western hilly region, Central foothills and the eastern plain region. The study area is rich in minerals like limestone, sand clay, gypsum and granite. The study area is predominantly covered by black loamy soil. The climatic condition of the study area is semiarid tropical monsoon, whereas, it has been experiencing hot and dry condition. A maximum mean temperature of 28°C to 32°C recorded in the month of December and 38°to 42°C is the month of June. The minimum temperature of 17.6°C to 23°C is recorded in the month of February and 23°C to 26°C in the month of May. The trend of the temperature is found to be decreasing towards the west. The temperature is higher in the north-eastern part of the study area. Sometimes in the eastern part there is the occurrence of heat waves. Eastern part of Virudhunagar district receives an annual rainfall in of 827.2mm per year, which is lesser than the state average of 1,008 mm. The south west monsoon, which onset in June and lasting up to August, brings scanty rainfall. Most of the

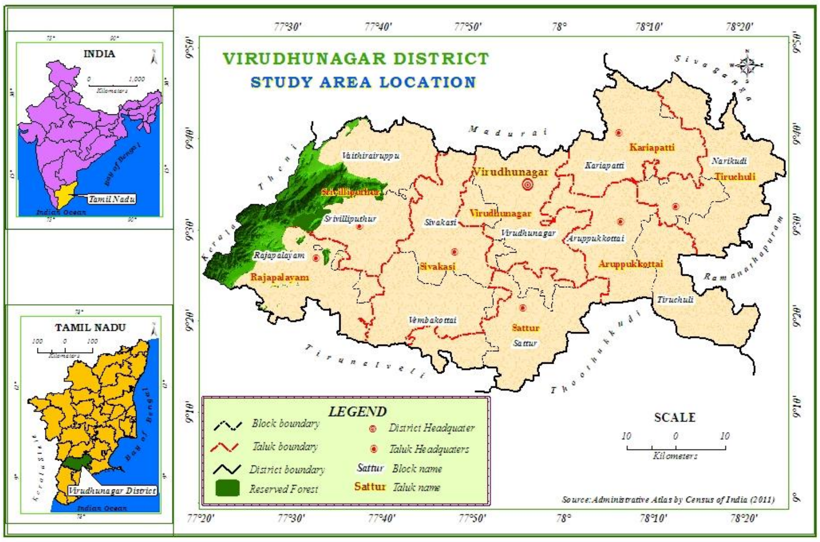


Figure 1

rainfall is received during the North East monsoon in the months of October, November and December. The population of the district is 17.51 lakes as per 2001census. In 2011, the population of the study area is 19.43 lakes. The growth of the population is less (10.96%) during 2011 as compared to that of the previous decades in 2001(11.9%). According to 2011 census Virudhunagar district had a population of 19, 43,309 persons.

The rainfall receiving in the eastern zone is high and in the western zone is normal and in the study area is mostly cultivated by dry crops. Wet crops like paddy and sugarcane are also cultivated. The major crops of the study area are cotton, pulses, oilseeds and millets. The dry crops are predominantly seen in the eastern zone (642.28sq.km), whereas the other two zones viz., central and western share nearly 459.85sq.km and 424.69sq.km respectively. In contrary the wet crops are predominantly seen in the western zone (212.85sq.km). The other two zones share 182.01sq.km (eastern and 121.75sq.km (central zone). The study area covers equally agricultural activities and non-agricultural activities mostly the industries. The education and infrastructural facilities are also well developed.

From the above discussions it is clear that the study area is resource full and climatic factors determine the development. As this is a drought prone area and there is larger scope for dry faming activates which will be useful in the development of this area and so the research in seen in this view point.

Methods and database

The data related to the inducing parameters were collected from various sources such as collateral data (mosaic of 12 topographic maps of Survey of India (SOI), viz., 58G/6, 58G/7, 58G/10, 58G/11, 58G/14, 58G/15, 58G/16, 58K/1, 58K/2, 58K/3,58K/6, and 58K/7 at 1:50,000 scale). Secondary data meteorological data, physical parameters like soil and lithounit, soil irrigability, soil permeability, soil water holding capacity, soil land suitability has been collected from Soil Atlas published by the department of soil, Virudhunagar district are used in the present study. The 2001 data is used in the assessment of drought and for delinating the risk zones as the year 2002 has been categorised and officially announced as the drought year (District profile, 2010 and Farmer's portal, Ministry of Agriculture). The Landsat imagery is a multispectral imagery with respect to aerial coverage and organization of data into several sets of multispectral digital values that overlay to form an image. From the satellite imagery data (Landsat TM) for the selected year the agricultural drought indices like NDVI, NDWI, NDMI, SAVI, TCI and Land use / Land cover were derived for the agricultural drought risk assessment using Arc Map GIS software.

Methods of Agricultural drought risk assessment

The agricultural drought risk assessment includes various methods of extracting information about drought level, which has been discussed in the study.

In the first session, agricultural drought assessment studies for the delineation of agricultural drought risk zones (ADRZ) has been attempted based on two approaches namely secondary data based multi-thematic layer overlay and primary data or satellite imagery indices based agricultural drought risk assessment. The first approach of agricultural drought risk assessment has been done with the use of suitable drought parameters derived by using the multi-thematic layers created from the secondary data. According to literature, this method of drought monitoring is laborious, difficult and time consuming (Prasad et.al, 2007) and the beginning and ending of drought is unpredictable. In the second approach, the satellite imagery based indices is followed to identify the agricultural drought risk zones of the present study area, and this method is easy and predictable of agricultural drought risk prone area.

All the parameters are used for the ranking and it is assigned to reflect of the importance of each parameter with respect to the risk of agricultural drought. The mentioned spatial data has been ranked and weight age of each parameter is attributed and has been integrated to finally delineate the agricultural drought risk prone area. The rating scales viz., 1 to 3 denotes the drought classes such as 1 is for mild, 2 is for moderate and 3 is for high risk for agricultural drought. All these 15 factors have to be taken into consideration in the present study of agricultural drought assessment and the risk zones are delineated. The present study area has a forest cover of 271.25sq.km (6.4%) in the western part. As the study is focused on agricultural drought conditions the forest area is excluded from further analysis by masking tool of Arc Map software. They are integrated finally to delineate the agricultural drought prone area by using the raster overlay by ranking methods. Finally the agricultural drought risk is estimated at block level.

Spatial distribution of agricultural drought inducing multi thematic parameters

The physical parameters that are considered in the present research study are slope, drainage density, geomorphology and lithounit. The slope of the study area viz. hilly and plain area is categorized with respect to drought condition. The residual hills are present in western part of the study area and have a slope of greater than 3% is occupying about 6% of the total area. The present study area is predominated by 94% of area covering the plains in the eastern region. The slope category below 3% represented for mild drought condition and above 3% is represented for moderate drought condition. As the area comes under only one category of slope, this parameter is not included for the spatial analysis of agricultural drought assessment. The second parameter is drainage density calculated by dividing the length of the streams with that of the area of the block. The drainage density of the study area ranges from 1.86km/sq.km to 2.84km/sq.km. The density is higher in hilly region in the western zone. The geomorphic unit like uplands are (309.67sq.km) seen in the eastern part and it is reclassified into highly drought prone area. Whereas, the pediment inselberg complex and the buried pediments occupy more than 329.2sq.km of the total area is reclassified into moderate drought risk and mild drought prone area, and are seen in predominantly in the study area covering nearly 3301sq.km. The lithounit alluvium and charnockite is seen in the eastern and western side and are reclassified in to mildly drought risk prone area. The study area is dominated by migmatite complex and is seen in the central and western part of the study area and is reclassified into the moderate drought risk prone area. The reclassified maps of physical parameters are shown in figure2a. The climatic parameters temperature, rainfall and evapotranspiration with reference to drought condition and are reclassified into mild, moderate and high agricultural drought risk (figure 2b). The temperature of the present study area varies in between 29.3˚C to 36˚C. According to drought condition temperature has been classified into three categories viz., less than 32˚C, 32˚C-34˚C, and greater than 34˚C. The lower temperature (<32˚C) is recorded in the western part and Vembakottai block of the central part. The central region records moderate level of 32˚C to 34˚C of temperature. The rainfall ranges from less than 700mm, 700-800mm and greater than 800mm. These ranges are reclassified to drought risk areas. The variation in evapotranspiration rate is being classified in to less than 3, 3-3.5 and greater than 3.5 mm/per day. Evapotranspiration is low in the south and eastern region and it is higher in the north east and central region. The low level of <3mm/day is seen in the eastern part and part of Vembakottai block of central zone in the study area. The soil parameters that are considered in the present study are soil permeability, soil land capability, soil irrigability and soil water holding capacity (figure 2c). The soil permeability is categorised into three categories of soil namely high, medium and low. Highly permeable soil is present in nearly 305sq.km and based on the drought condition it has been reclassified into mild drought risk prone area. Medium permeable soil is present in 1399sq.km and is reclassified into moderate drought risk prone area and low permeable is present in 2122sq.km and is reclassified into high drought risk prone. Soil irrigability classes are defined in terms of soil properties that express their degree of limitation for development and their requirement for management it has based on the drought conditions and is reclassified into three classes like soil drainage limitation is mild risk for agricultural drought conditions (predominantly seen in the study area 3442sq.km). The second category is soil/topographic limitation, which covers nearly 261sq.km and it is reclassified as moderate drought risk prone area. The topographic limitation is seen in the western part of study area (270sq.km) including the hills and foothill zone and it has been categorised into high drought risk prone area. The land capability of the study area is categories into four classes namely as Root zone limitation, Root zone wetness limitation, Erosion and Runoff, Root zone limitation Erosion and Runoff. On reclassification based on agricultural drought risk condition, Root zone limitation and Root zone limitation wetness area is categorised into mild risk area (3422sq.km). Whereas the erosion and runoff limitation category comes under moderately risk prone areas and root zone erosion and runoff limitation in categorised into highly drought risk prone area (289sq.km). On the basis of soil land capability nearly 90% of the study area comes under mild drought risk prone area. The water holding capacity has been reclassified based nature of risk towards the drought. The characteristics of water holding capacity of the soil in the entire study area is divided into four categories namely excessively drained, moderately drained, poorly and very poorly drained. The excessively drained soil of 261sq.km is reclassified into highly drought risk prone area and is distributed in patches in the study area. The moderately risk prone is seen in lager patches and is also distributed throughout the study area (1371sq.km) adjacent to excessively drained soil. The poorly and very poorly drained soils are reclassified into mildly drought prone area and it covers about 2341sq.km (see figure 2d). The ground water level of the study area less then 10m below ground and is reclassified as mild drought prone area. The moderate level of groundwater (10-15m) is predominantly seen in the study area and is reclassified into mild risk for agricultural drought conditions. Whereas very deep ground water (>15m) is seen in Sivakasi block in the central zone and the eastern part. This category is reclassified as high risk prone area of agricultural drought conditions. The present study area is mainly rain fed in case of irrigation support and it is divided into two cateogies. Rajapalayam, Vaithiraieruppu, Sattur, Vembakottai and part of Srivillipudhur have irrigated area. Sivakasi, Virudhunagar and eastern part of study area is unirrigated and rainfed agricultural practice is followed. The eastern part of study area has dry soil. The western and part of central region have moderately dry to wet area, and is unirrigated. Whereas the foot hill of study area have irrigation dependent cultivation. The irrigated area is reclassified into moderate risk for agricultural drought and the unirrigated areas are reclassified into high risk for agricultural drought condition. The water body, agricultural land including crop land, plantation and current fallow land are reclassified into mild drought risk which covers an areal extent of 1267sq.km. The permanent fallow and open scrub area are reclassified into moderate drought risk covering an area of 2397sq.km. The settlements, rocky outcrop, waste land and barren land are classified into high agricultural drought risk area and covers about 345sq.km. Agriculture is the basic income of the present study area in which 62% of the population depends on agricultural practices earning 90% of the total income. In the study area cultivators and agricultural labourers are predominantely present in the western part. The cultivators and agricultural labourers, who are the agriculture dependent population are divided into three classes viz less than 50%, 50-75% and greater than 75%. The villages with less than 50% agriculture dependent population are classified into mild drought risk prone area, mostly seen in the central zone. The western zone has 20-75% of population dependent on agriculture and is highly prone to agricultural drought risk.

All these fifteen layers under the three categories of physical, climatic soil and socio economic parameters inducing agricultural drought are overlaid in GIS platform to identify the various risk zone in the study area. The integration of all the thematic layers was carried out to come out with an integrated drought severity assessment using Arc GIS software package. The integration is done by raster overlay by ranking method. The details of the rank of various categories in each parameter are given in table 1.

Table1. Agricultural drought parameters and their categories with rank respect to drought

S.No	***Drought Parameter***	***Class***	***Rating***
1	*Slope %*	*< 30*	*2*
		> 30	*3*
2	*Drainage Density*	*<2*	*1*
		2-2.5	*2*
		>2.5	*3*
3	*Mean of Temperature (ºC) in Drought Year*	*<32*	*1*
		32-34	*2*
		>34	*3*
4	*Rainfall (mm) in Drought Year*	*<700*	*3*
		700-800	*2*
		>800	*1*
5	*Evapotranspiration (mm) in Drought Year*	*< 3*	*1*
		3-3.5	*2*
		>3.5	*3*
6	*Geomorphology*	*BPS/P/FP/BZ*	*1*
		BPD/PI	*2*
		UPL	*3*
7	*Lithounits*	*Charnockite / Alluvium*	*1*
		Migmatite complex /Lime stone	*2*
		Sandstone	*3*
8	*Soil Permeability*	*Rapid*	*1*
		Moderately Slow	*2*
		Slow	*3*
9	*Soil/Land Irrigability*	*Soil Limitation / Drainage Hazard*	*1*

		Soil Limitation / Topographic Limitation	*2*
		Topographic Limitation	*3*
10	*Land Capability*	*Root Zone Limitation / Wetness*	*1*
		Erosion and Runoff	*2*
		Root Zone Limitation/ Erosion and Runoff	*3*
11	*Water Holding Capacity*	*Low*	*1*
		Medium	*2*
		High	*3*
12	*Ground water level (M)*	*<10*	*1*
		10-15	*2*
		>15	*3*
13	*Irrigation Support*	*Irrigation area*	*2*
		un irrigation area	*3*
14	*Land use*	*Tank/River/Agriculturalland/ Plantation/ Current Fallow*	*1*
		Fallow land / Open Scrub	*2*
		Settlements/ Rocky outcrop/ Waste land/ Barren Land	*3*
15	*Agriculture Dependent Population %*	*<50%*	*1*
		50% - 75%	*2*
		>75%	*3*

Block Name	***Drought Risk Condition (Area in sq.km)***		
	Mild	***Moderate***	***High***
Kariapatti	11	167	234
Narikudi	39	179	161
Tiruchuli	118	238	53
Aruppukottai	69	207	34
Sattur	16	264	63
Virudhunagar	27	243	207
Sivakasi	4	217	151
Vembakottai	121	269	9
Rajapalayam	91	229	12
Srivilliputhur	52	189	41
Vathiraierupp u	78	163	16
Total of District	626	2365	981

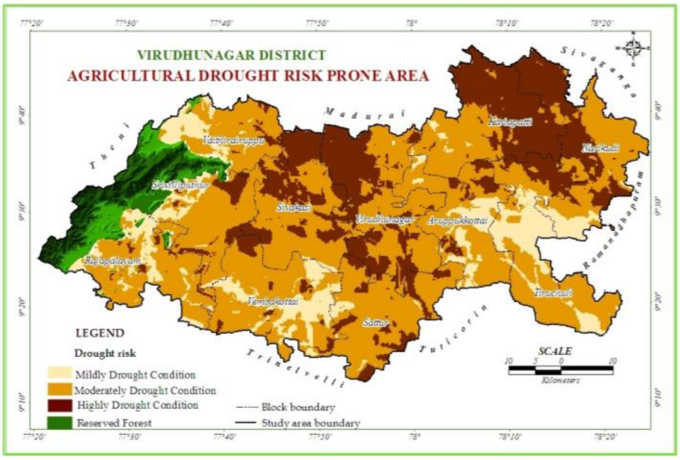


Figure 2

The figure 2shows the spatial variation of integrated drought severity of the study area. The integrated map is categorised into various classes viz., mild, moderate and high degree of agricultural drought risk. It is observed from the figure that 29% of the study area is categorised under mild risk prone area and 35% of the area is under moderate risk and remaining area have high risk. The table2 shows the block wise areal extent of various categories in the study area influenced by agricultural drought. The figure 2 shows the block wise integrated drought severity map of Virudhunagar district.

Out of 11 blocks, Kariapatti block is highly risk prone and the remaining ten blocks are Narikudi, Tiruchuli, Aruppukottai, Sattur, Virudhunagar, Sivakasi, Vembakottai, Rajapalayam, Srivilliputhur and Vaithiraieruppu have been categorised under moderately affected by agricultural drought. The multi-thematic layer overlay approach of agricultural drought assessment depends on fifteen secondary parameters and the starting and ending of the dynamic drought phenomenon is difficult to be assessed. Moreover the collection of secondary data is also time consuming and so satellite data has been used for the assessment of drought and the result is discussed in detail.

Spatial distribution of agricultural drought inducing satellite image parameters

The primary data based assessment methodology use Landsat TM7 satellite image. The satellite image indices used in the present study are NDVI, NDWI, NDMI, SAVI and TCI. As the risk of drought depends on the major land use, the land use / land cover categories at level I are also considered in the present study. All these factors have to be taken into consideration in the present study of agricultural drought assessment.

Landsat TM data is used for the computation of NDVI for selected drought year image (2001) that represents the healthy condition of vegetation. It has been observed in the selected year the minimum NDVI value is -0.7446 and the maximum value is +0.6964 which can be used to assess the vegetation healthiness. It is found out that nearly 532.42sq.km area is categorised as >0.2 and is reclassified as mild agricultural drought risk prone area in the western zone. The spatial distribution of normalized differencial vegetation indices of the study area is given in figure 3a and the areal extent in sq.km is given in table 3. The highly drought risk prone area is about 1026.324sq.km having less than zero NDVI values, and finally the remaining area of 2437.345 sq.km has moderate agricultural drought risk. From the present study, it is clearly observed that the healthy vegetation is present in the western part of the study area inVaithiraieruppu, Srivilliputhur and Rajapalayam which forms the foothill area of the reserved forest cover. The NDVI observed values indicates the presence of unhealthy vegetation in the eastern part of the study area.

The landsat TM sensor data is used for the present study of NDWI. The spectral bands namely band4 (NIR) and band7 (SWIR) is used for the computation of NDWI for selected year to represent the intercellular water content of the leaves. The observed NDWI values of the present study ranges from -0.765 to 0.9253.The NDWI of vegetation is reclassified based on the drought risk as mild, moderate and high. The NDWI has 324.42sq.km area and is reclassified as mild risk prone area and 946.23sq.km is highly risk prone area and finally the remaining area of 2689.35sq.km is categorised as moderately risk prone area (figure 3b). The forest area of 264.66 sq.km is excluded from the study.

Block Name	Drought Risk Condition

NDMI is generated by using of band 4 and band 5 computed for the selected year. The spatial pattern of normalized difference moisture index indicate that the value of present study area ranges from -0.4871 to 0.682. The maximum of +0.6821 values represent the high moisture condition in the soil surface and the minimum value -0.4871 to 0 represent the moderate soil moisture condition. The high soil moisture condition is predominant in the western region of the present study area and the moderate moisture condition is present in the eastern part and the centre zone of the study area.The NDMI has been reclassified into mild agricultural drought risk zone of 787.68sq.km and high risk zone in 2039.26sq.km the remaining area of 1536.45sq.km is classified into moderate risk (figure 3c).

	Area in Sq.km		
	Drought Risk		
	Mild	Moderate	High
Kariapatti	28	117	267
Narikudi	41	139	213
Tiruchuli	27	221	171
Aruppukottai	31	116	164
Sattur	43	96	204
Virudhunagar	81	247	123
Sivakasi	72	189	111
Vembakottai	41	117	241
Rajapalayam	106	102	125
Srivilliputhur	71	107	104
Vathiraieruppu	126	93	38
	667	1544	1761

The soil adjusted vegetation index has been computed using the landsat TM band 4 and band 3. The SAVI values range between +1 to -1. The positive values of SAVI represent the suitability of soil for healthy vegetation and the negative values represent the non-suitability of soil for vegetation. It has less nutrient and moisture condition. The areas with low value of SAVI of 832.63 sq.km are reclassified into mild agricultural drought and 2137.458sq.km is highly risk prone for agricultural drought and the remaining area of 1236.491 sq.km is moderately prone to agricultural drought (refers with figure 3d).

The 6th band of landsat TM data is the thermal band. This band is being used for TCI calculation. TCI is developed based on the brightness value due to temperature. The TCI values range between 0-100%. The observed values of TCI in selected year for the study area range from a maximum of 45% indicating the normal condition or no drought area. The TCI values ranging from 45-50% indicates moderate drought condition. The values above 50% are representing high level of drought and is seen in the eastern and the central part of the present study area. The TCI shows nearly 924.31sq.km of mild risk area and the temperature conditions of 1983.42sq.km is highly risk prone and the remaining area of 1024.98sq.km has moderately risk prone of agricultural drought (refer figure 3e).

Land use / land cover analysis of the present study is done for the selected year. The land use/ land cover classes are built up, water bodies, cultivated area (crop, plantation) fallow land, waste land (barren & eroded) and open scrub area. The fallow land & open scrub land are predominant seen in the present study area. The open scrub is highly present in the eastern and central part. The central and western part is dominanted by fallow land. The cultivated area is seen in the western part of the study area. Based on the land use / land cover classes, the study area shows mild drought in the western part, medium drought risk in the central and high level agricultural drought in the eastern part (refer figure 3). The agricultural drought is highly occurring in the eastern part of the study area especially in Kariapatti and Narikudi blocks having an area of about 267sq.km and 213sq.km respectively. In the southern part Vembakottai is highly prone to agricultural drought. The foot hill or the western zone viz Vathiraieruppu, Srivilliputhur and Rajapalayam has mild level of risk especially Vathiraieruppu has nearly 126sq.km drought out of 257sq.km. The agricultural drought risk level (see table 3) shows the block wise spatial variation of integrated drought severity of the study area. It is observed from the figure 3 that 36.05% of the study area is coming under mild risk, 27.04% of the area is having high drought risk prone area and 37.01% of the area is coming under moderate risk. Table 3 gives the block wise areal extent of study area influenced by agricultural drought. Out of the 11 blocks Vathiraieruppu block is alone mildly risk prone and moderately risk prone blocks are Srivilliputhur, Sivakasi, Virudhunagar and Tiruchuli

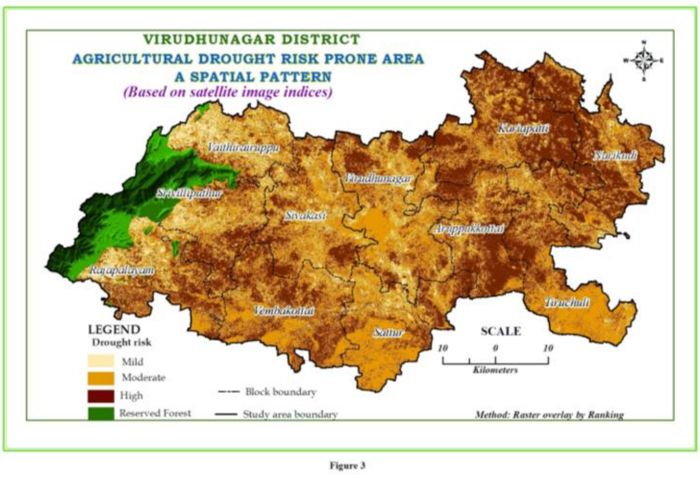


Figure 3

blocks and high risk prone blocks are Narikudi, Kariapatti, Aruppukottai and part of Sattur, Vembakottai and Rajapalayam. The block wise areal extent of drought risk in the study area is shown in the figure 3.

The present study demonstrates the application of an integrated remote sensing and GIS based methodology for drought assessment in an risk prone area. Since the satellite images are available at the time period, these can be used for prediction of drought events. The drought model generated in the present study is an appropriate method for identifying the of drought risk of any study area and can be used for further research.Table 3. Risk prone area of agricultural drought Virudhunagar District – based on satellite image indices overlay

A comparison Agricultural Drought Risk Zones derived from the two approaches

The agricultural drought assessment has been done by two different approaches namely satellite image indices and multi-thematic overlay techniques in Arc map. Based on the comparision, the suitable method for agricultural drought vulnerability is found out. The results of the two approaches are compared as follows. The results are found to be similar in both of the different approaches adopted in the present study. In the three blocks namely Vathiraieruppu, Srivilliputhur and Rajapalayam of the western zone, 69sq.km comes under high risk for agricultural drought condition whereas 581sq.km is delinated as moderate drought condition and 221sq.km is delinated as mild drought risk condition using the multithematic layer overlay approach. But using satellite image indices based overlay method, 403sq.km comes under high agricultural drought risk, 276sq.km comes under moderate agricultural drought risk and only 193sq.km comes under mild drought risk condition. The difference in the areal extent depends on the inducing parameters namely geomorphology, drainage density and agriculture dependent population of the multi-thematic overlay approach. These three parameters are common for all the users depicting spatial variation and do not change with specific drought year.

The satellite image indices based approach depicts the spatial variation and is sensitive to vegetation cover, which is directly dependent on climatic condition. The central zone consisting of Virudhunagar, Sattur, Vembakottai and Sivakasi blocks show difference predominantly in moderate and high risk zone areas. The satellite image indices based overlay results an areal extent of 850sq.km is high agricultural drought risk zone. It has an area of 415sq.km of moderate drought risk and 100sq.km mild risk. The difference is a result of drainage density which is dependent on the relief of the area. Similarly in the eastern zone, the result of multithematic layer overlay shows an areal extent of 482sq.km under high agricultural drought risk zone. Nearly 911sq.km comes under moderate risk and 237sq.km under mild risk zone. According to the satellite image indices based analysis 1269sq.km comes under high risk zone, 206sq.km comes under moderate and 60sq.km comes under mild. The different depends on the geomorphology and rainfall of the area.

Table 4 Block wise areal extent of agricultural drought risk using the two approaches

Block Name	***Drought Risk Condition (Area in sq.km)***					
	Satellite image indices			***Multi-thematic overlay***		
	Mild	***Moderate***	***High***	***Mild***	***Moderate***	***High***
Kariapatti	28	117	267	11	167	234
Narikudi	41	139	213	39	179	161
Tiruchuli	27	221	171	118	238	53
Aruppukottai	31	116	164	69	207	34
Sattur	43	96	204	16	264	63
Virudhunagar	81	247	123	27	243	207
Sivakasi	72	189	111	4	217	151
Vembakottai	41	117	241	121	269	9
Rajapalayam	106	102	125	91	229	12
Srivilliputhur	71	107	104	52	189	41
Vathiraieruppu	126	93	38	78	163	16
Total of District	667	1544	1761	626	2365	981

From the above discussion it is evident that the differences in the level drought risk mostly varies with that of the physical conditions which are specific to the area under study, when it is analyses using the secondary data. So, it is necessary to use remotely sensed satellite image data, as the analysis solely depend on the vegetation, temperature and moisture conditions of the existing agricultural crops. In this regard, the second approach of satellite image indices based raster overlay method is used for further analysis of vulnerability mapping and is discussed in detail in the following section.

Conclusion

These drought inducing parameters have been reclassified with ranks (1, 2 and 3) in to various degrees of drought risk based on the influence of the particular parameters to drought conditions viz., mild, moderate and high drought risk. The drought condition of the area is assessed and integrated by using raster overlay by ranking method to delineate area at the block level of drought risk. The purpose of this assessment is to assemble the existing knowledge in a coherent form so as to enable a clear vision of the nature of drought and to understand the remedies of the future drought in the study area.

ACKNOWLEDGEMENTS

The authors their gratefulness to the DST Inspire award for the financial assistance extended for this research work.

REFERENCE

- **Hoyt, J. C**. 1936. Droughts of 1930-1934. USGS Water Supply Paper No. 680. USGS, Washington, D.C.
- Blumenstock, G., Jr. 1942. Drought in the U.S. analyzed by means of the theory of probability. USDA Tech. Bull. 819. GPO, Washington, D.C.
- **Sumanta Das, Malini Roy Choudhury & Sachikanta Nanda (2013**), Geospatial Assessment of Agricultural Drought (A Case Study Of Bankura District, West Bengal), International Journal of Agricultural Science and Research (IJASR)Vol. 3, 1-28, TJPRC Pvt. Ltd, Department of Civil Engineering, Faculty of Engineering and Technology, SRM University, SRM Nagar, Kattankulathur, Tamilnadu, India
- **Kaushaly Ramachandran (2011),** Assessing agricultural vulnerability to climate change using NDVI data products, Geospatial Technologies For natural resource management, pp345-362,CRIDA,Hyderabad.
- **Chakraborty and V.K. Sehgal (2010),** Assessment of Agricultural Drought Using Modis Derived Normalized Difference Water Index, Journal of Agricultural Physics Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi - 110 012 vol. 10, pp. 28-36.
- **Roy, P. S., Joshi, P. C., Murthy, C. S. and Kishtawal**, C. M., 2006, "Geoinformatics for Drought Assessment", in Drought Management Strategies in India (Eds. J. S. Samra, Gurbachan Singh & J. C. Dagar), 23-60. ICAR, NEW Delhi, India.
- **Gadgil, S., Vinayachandran, P. N. and Francis**, P. A., 2003, "Droughts of the Indian summer monsoon : Role of clouds over the Indian ocean", Current Science, 85, 1713-1719.
- **Wilhelmi, V.O. and Wilhite, D.A., (2002)**, Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study, Natural Hazards, Vol. 25: pp. 37-58.
- **Thiruvengadachari, S. and Kogan Felix**, 1993, et.al., "The role of NOAA satellite data in drought early warning and monitoring : Selected studies, in Drought Assessment, Management and Planning: Theory and case studies", edited by Donald A. Wilhite, Kulwer Academic Publishers.
- **Thiruvengadachari, S., Prasad, T. S. and Harikishan, J. (1987).** Satellite monitoring of agricultural drought in Anantapur district in Andhra Pradesh State. Report No.: RSAM - NRSA - DRM - TR - 03/87. India: Drought Mission Team, Department of Space, Government of India. pp. 35.
- **Sastry, A. S. R. A. S., Ramakrishna, Y. S, and Ramana Rao**, B. V., 1981, "A new methods of classification of agricultural droughts", Arch. Fur. Met.Geoph.And Biokl. Ser. B., 29, 293-297.
- **Palmer, W. C**. 1968. Keeping track of crop moisture conditions, nationwide: The new crop moisture index. Weatherwise 21(4):156-161.
- **Ramdas, D. A.** 1960. Crops and weather in India. ICAR, New Delhi, India.
- **Palmer, W. C.** 1957. Drought-A normal part of climate. In Weekly Weather and Crop Bulletin 44, No. la (January 10):6-8.
- **Condra, G. E.** 1944. Drought, its effects and measure of control in Nebraska. Conservation Bulletin 25. Conservation and Survey Division, University of Nebraska Lincoln.

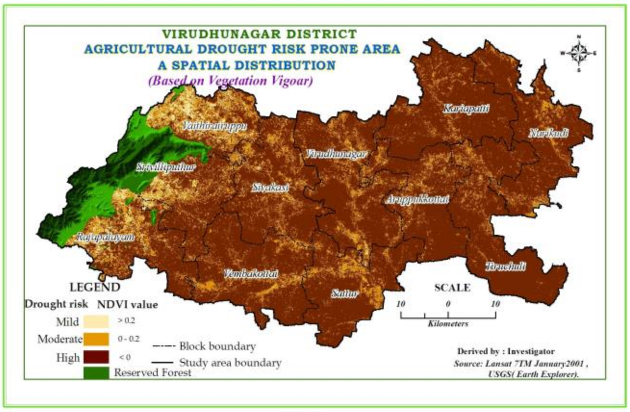
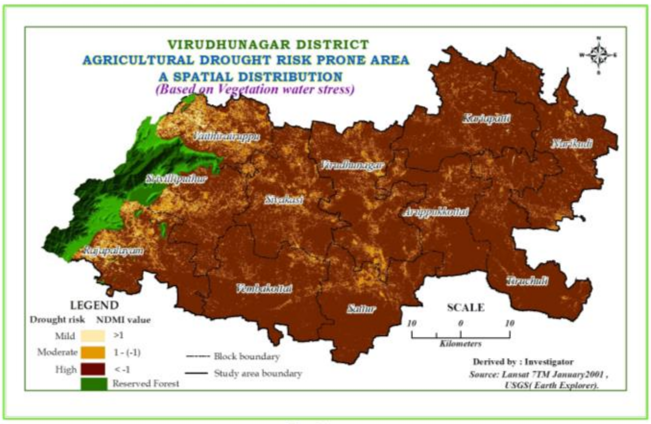
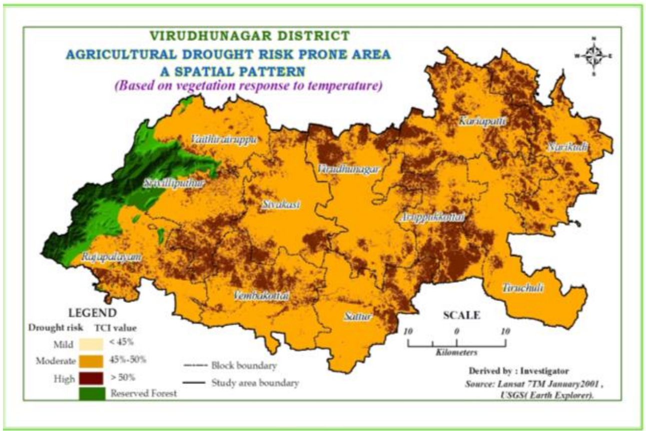


Figure 3.a





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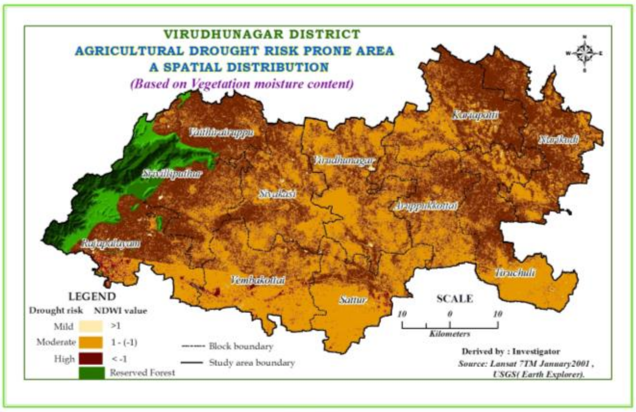


Figure 3. b

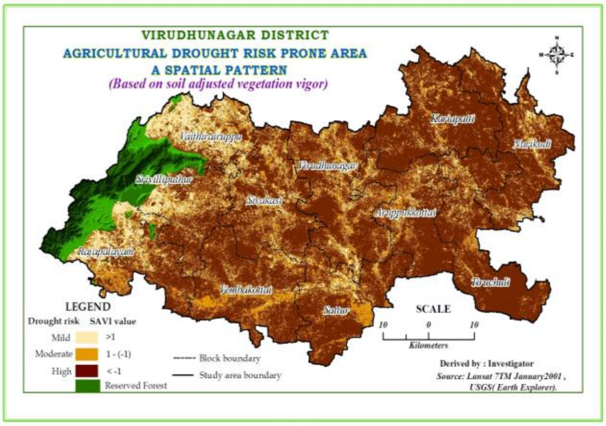
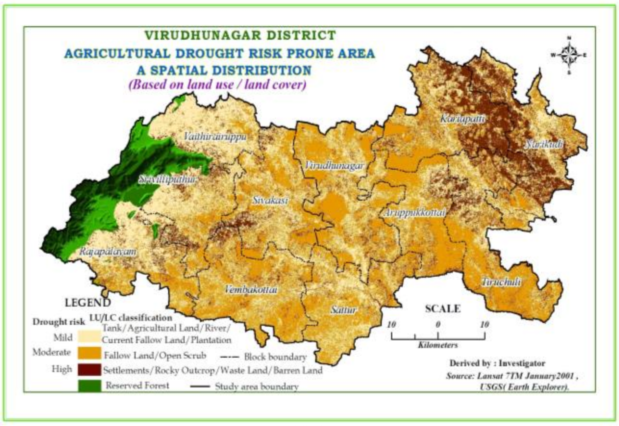


Figure 3 d



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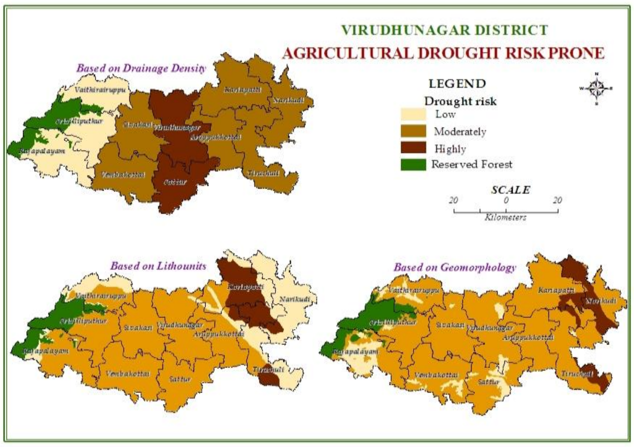

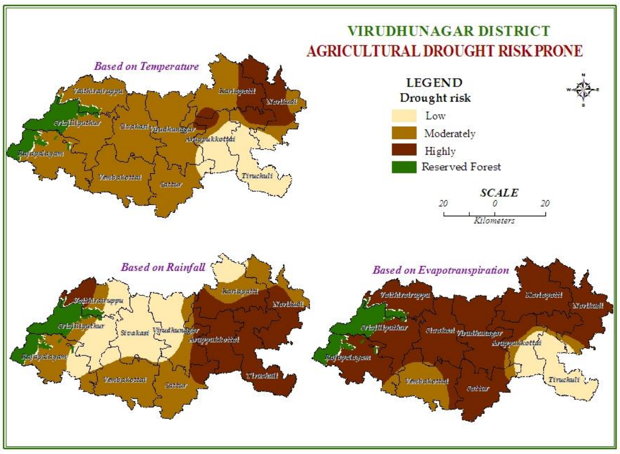

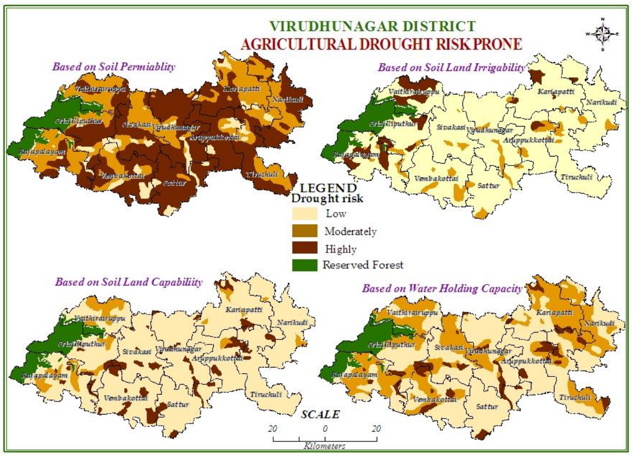

Figure 2c

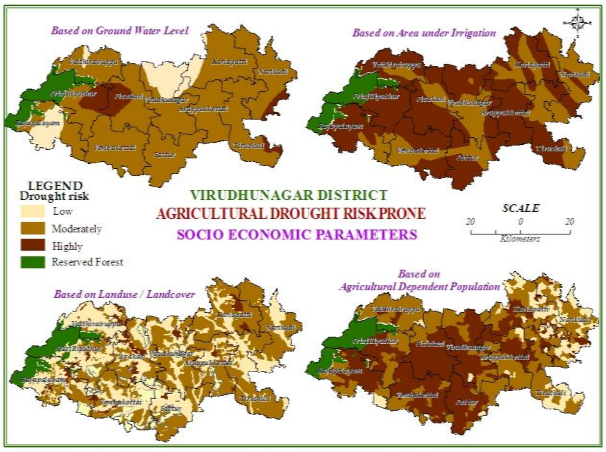

Figure 2d