Original Research Article

IDENTIFICATION OF 'START OF SEASON'IN MAJOR RAINFED CROPS OF TAMIL NADU, INDIA USING REMOTE SENSING TECHNOLOGY

ABSTRACT

Cropping seasons are the seasons in which a particular crop is grown. Identification of cropping seasons is crucial for successful cropping in rainfed areas. This research study focuses on the identification of major rainfed crop growing seasons in rainfed areas of Tamil Nadu using remote sensing technology. The MODIS (Moderate-Resolution Image Spectroradiometer) satellite product MOD13Q1 is utilized to produce NDVI (Normalized Difference Vegetation Index) of the study region. Then the NDVI values for each rainfed ground truth point were extracted and the value was used to produce a line graph representing the crop growing period. Likewise, multiple lines were produced for major rainfed crops: Rice, Maize, Pearl millet, Sorghum, Groundnut, Moth bean, Cotton and Chilli. The result reveals that the Maize and Cotton growing season starts in June-July, mostly single crop per year. Rice, Pearl millet, Sorghum and Chilli are also grown as a single crop per year, sowing by the month of October-November. Besides, there was a double-cropping area of Groundnut- Black gram and Groundnut-Moth Bean raised during June-July and October-November respectively.

Keywords: MODIS, NDVI, Rainfed agriculture, Cropping season

INTRODUCTION

Rainfed agriculture refers to cropping completely dependent upon rainfall for agricultural production. Around 60 per cent of India's land is used for rainfed agriculture, accounting for a major portion of the country's total food grain production. Tamil Nadu has a geographical area of about 13 million hectares, of which 5.90 million hectares are cultivated lands, with rainfed crop production accounting for nearly 40 to 50 percent of the total. Rainfed agriculture occupies almost 67 percent of the net sown area of the state, producing 44 per cent of the food grain and employing 40 per cent of the state population (Kumaraperumal *et al.*, 2019). Farmer's troubles have been exacerbated by erratic monsoon behavior, poor infrastructure, insufficient credit and fragmented landholdings, and uneven fertilization, resulting in a low seed replacement rate. Hence, technology packages should focus on improving rainfed farming systems' production by considering drought in upland areas and submergence in rainfed lowlands (Gumma *et al.*, 2015). Due to excessive and incorrect use of resources, TN districts are also confronting some of the most critical agro ecological issues, such as diminishing productivity and dropping ground water tables, growing soil salinity and agricultural insect problems. The necessity to map and monitor changes in cropping systems more often and on a regular basis has been highlighted as a result of greater awareness of environmental issues and the need to strive for sustainable management of natural resources (Panigrahy *et al.*, 2010).

Remote sensing offers instruments for managing complex cropping systems (Panigrahy *et al.*, 2002). Using remotely sensed data allows for a more comprehensive investigation of cropping systems and changes over time at the local and regional levels. For monitoring and identifying vegetation and land cover change, vegetation indices (VIs) and derived metrics have been widely utilized (Agrawal *et al.*, 2003).Several investigations employing various remote-sensing systems at various resolutions were undertaken in different parts of the world (Ambast *et al.*, 2002; Gumma *et al.*, 2011). Previous research has demonstrated the value of MODIS satellite imagery in monitoring agricultural changes, particularly the dynamics of change in agriculture, between water-surplus and water-deficit years (Biggs *et al.*, 2010). These researches have been ongoing for a few years, providing insights and methodologies for assessing short- to long-term changes in land use (Lu *et al.*, 2004). The VEGETATION (VGT) sensor onboard the SPOT-4 satellite was launched in 1998 and provided unique imaging data to map land cover. It is the first moderate resolution sensor intended particularly for the study of vegetation and the ground surface (Biradar and Xiao, 2011). Even though these maps are insufficient to provide information about cropping seasons, these technologies are rarely utilized to determine how rainfed areas are affected by climate change. In this context, the current work employs the MODIS satellite product to provide information on a number of cropping seasons in rainfed cropland areas in Tamil Nadu, India. Work carried out in Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore.

STUDY AREA

The current study region is Tamil Nadu, located in the south-eastern part of the Indian continent, and there are about 38 districts in the state, as depicted in Figure 1. The state's geographical range is between 08°00' N to 13°30' N latitude and from 76°15' E to 80°18' E longitude. Tamil Nadu is India's 11th largest state, with a total area of 1,30,058 km^2. Tamil Nadu is bordered on the north by Andhra Pradesh and Karnataka and on the west by Kerala besides, on the east by the Bay of Bengal and on the south by the Indian Ocean. Pondicherry, an union territory is located on the state's eastern border. The major source of farmers' income is rainfed farming. The state has an average annual rainfall of 998 mm (Kavitha *et al.*, 2020). The Southwest monsoon (June to September) and Northeast monsoon (October to December) are the predominant monsoon seasons of the state. Tamil Nadu experiences more rainfall exclusively during the northeast monsoon, whereas other Indian states get higher rainfall during the southwest. Forty-seven percent of the total annual rainfall comes from the northeast monsoon, whereas the southwest monsoon accounts for 35 per cent (Vaani *et al.*, 2018). Since more than 80 per cent of the state's arable lands depend on rainfall for their seasonal crop production, it is more vulnerable to agricultural drought when the monsoon fails.

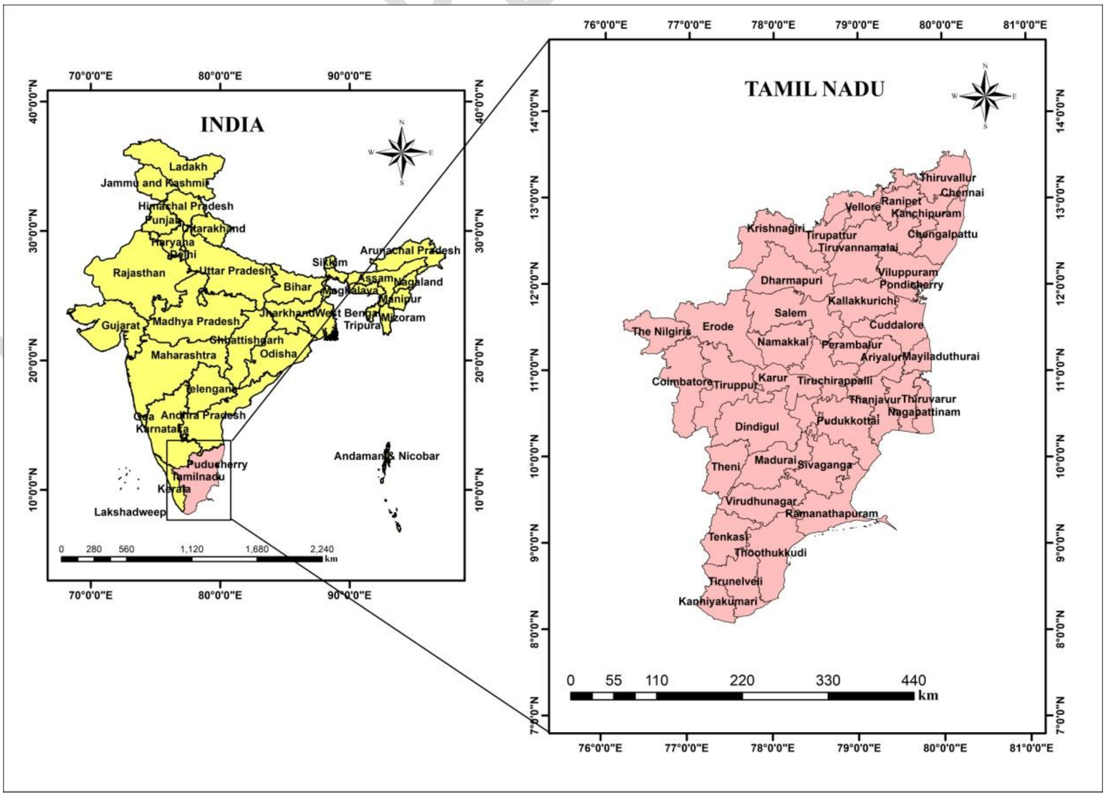

Figure 1. Study area map – Tamil Nadu

MATERIALS

Description of satellite data

Product name	MOD13Q1
Platform	Terra
Instrument	MODIS
Processing level	Level 3
Spatial resolution	250 meter
Temporal resolution	16 days
Archive Sets	6, 61
Spatial extent	Global
Coordinate system	sinusoidal

Product description

The MOD13Q1 product provides two vegetation layers, namely, Normalized Difference Vegetation Index (NDVI), which is referred to as the continuity index to the existing National Oceanic and Atmospheric Administration-Advanced Very High-Resolution Radiometer (NOAA-AVHRR) derived NDVI and Enhanced Vegetation Index (EVI), which has better sensitivity across high biomass zones. The algorithm selects the best possible pixel value from all 16-day acquisitions. Low clouds, a low view angle, and the maximum NDVI/EVI value were utilized as criteria. The HDF file will include MODIS reflectance bands 1 (red), 2 (near-infrared), 3 (blue), and 7 (mid-infrared), as well as four observation layers, vegetation layers and two quality layers.

Ground data

Accurate above-ground land use and land cover information are required for training, mapping, accuracy assessment and interpretation of all remote sensing outcomes. If the random or systematic sampling is difficult because of the large area and limited resources, a stratified sample can be used across the homogeneous agricultural area (Biradar and Xiao, 2011). The global positioning system (GPS) was used to record the accurate locations of the ground data points and 345 points were collected across the TN. At every point, information regarding rainfed / irrigated crop and crop phases besides cropping patterns were gathered. In addition, these points were digitalized for further analysis.

METHODOLOGY

Presently, numerous data sets are freely available online (Panigrahy *et al.*, 2010). MODIS13Q1 data product from 1 January 2020 to 31 December 2021 was downloaded from the Earthdata website (www.earthdata.nasa.gov), which has various products and spectral bands, namely NDVI, EVI, Red, NIR (Near-infrared), Blue and MIR (Middle infrared). Entire Tamil Nadu is covered by two tiles viz., h25v07 and h25v08. The normalized reflectance variation between NIR and visible red bands is NDVI. Initially, HDF-EOS format and sinusoidal projection of MODIS data were downloaded. Then, the MRT tool was utilized for mosaicking, reprojection and converting image files to Geotiff format with GCS (Geographic Coordinate System) WGS-84 of the study area. The processed MRT data was used to extract NDVI. The maximum NDVI was derived utilizing the cell statistics tool and NDVI for each ground truth points was extracted using extract by multi-value point in ArcMap. Finally, the graph of the rainfed cropping season was generated. The detailed methodology was given in Figure 2.

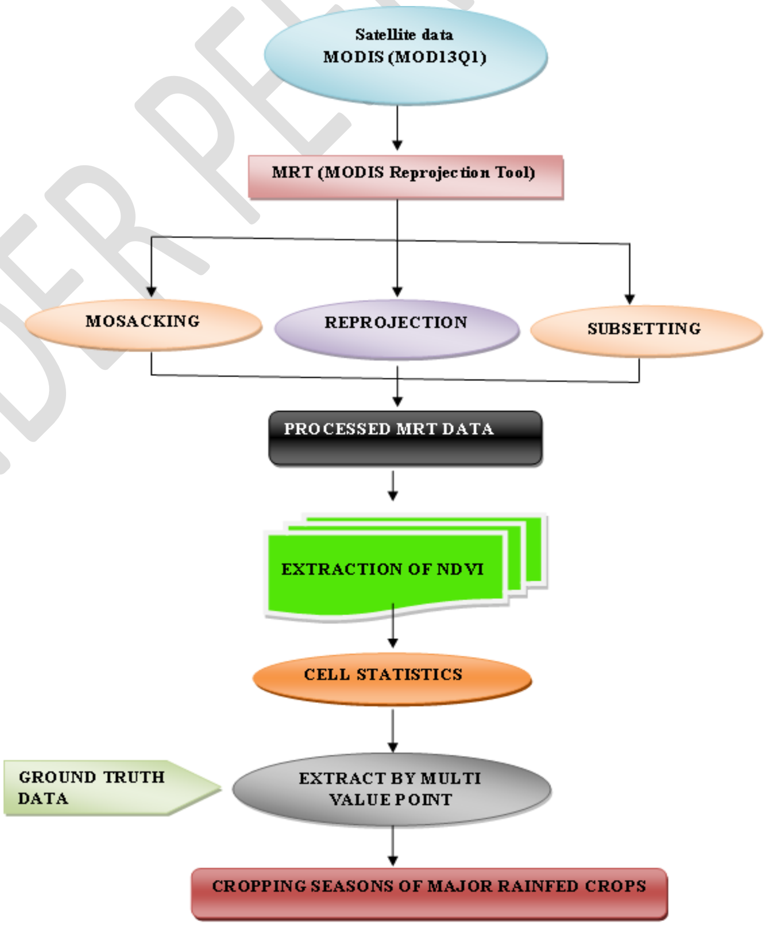

Figure.2. Methodology for cropping season identification in major rainfed crops of Tamil Nadu

Extraction of vegetation indices

Chlorophyll pigments absorb much of the incident blue and red radiation in plants. Healthy vegetation reflects more in the NIR region and a little more in green, giving it a green appearance. Crops often lose chlorophyll content before harvest, resulting in reduced green reflectance and lower near-infrared reflectance. Green and near-infrared reflectance decline may indicate the existence of crop stress. NDVI is useful for vegetation health because it compares reflected near-infrared to red wavelength radiation.

$$NDVI = \frac{\rho NIR \ - \rho RED}{\rho NIR - \ \rho RED}$$

Here, ρ NIR in the near-infrared band reflectance, and ρ RED is the red band reflectance. Because of their high reflectance of near-infrared and low reflectance of red, healthy plants have a high NDVI value. In the remotely sensed image, crop areas with constant vigorous development should seem consistently bright, while stressed crops appear dark (Prajesh *et al.*, 2019; Biradar and Xiao, 2011).

RESULTS AND DISCUSSION

The spatial map of Tamil Nadu NDVI is derived from the MODIS product (MOD13Q1) in 2021 (Figure.3). Each image depicts crop coverage of that month, and the increase in greenness shows an increase in crop cover. The NDVI suggests that most crops are grown between June and December. Then the NDVI for each ground truth point is determined by utilizing monthly NDVI to derive the Tamil Nadu crop growing season graph. Figure.4 represents the different growing months of major rainfed crops such as rainfed rice, maize, sorghum, chilli, black gram, ground nut, moth bean, cotton and pearl millet. In most of the rainfed areas of Tamil Nadu single crop is grown yearly after which field is maintained as fallow. But in some parts of Tamil Nadu, like Vilupuram, Thiruvannamalai and Vellore, double cropping (Moth bean-Groundnut) is followed with the help of supplemental irrigation. The growing season in these areas mainly depends on the monsoon.

The growing period of major crops grown in rainfed areas of Tamil Nadu

Based on increasing trend of NDVI, the crop growing season was identified. The rainfed maize growing season started in June, and the trend attained its maximum which after maturity, starts decreasing in September and October because of the loss of greenness. This trend was majorly seen in the districts of Perambalur, Ariyalur, Salem, Erode,Viruthunagar, etc. The growing season of rainfed rice starts during the first fortnight of September and shows steep increasing trend upto mid-October, after which, it declines gradually. Ramanathapuram, Viruthunagar and parts of Kanyakumari are the districts where rainfed rice was cultivated. The cotton-growing season started during July, with an increasing trend seen upto the second fortnight of August and decreasing trend upto February. The major rainfed cotton-growing areas are Perambalur, Ariyalur, Cuddalore, Ramanathapuram, etc.

Groundnut, black gram and moth bean growing period starts in July and ends in September. Again it begins in October and ends in February. The regions where groundnut was grown as rainfed crops are Vilupuram, Thiruvannamalai, Trichy, etc. Rainfed sorghum sowing started in October, and then a gradual increase in NDVI was seen upto November. In December the trend attains a plateau and then gradual decreases upto second fortnight of February. This trend was seen in Dindigul, Coimbatore, Tiruchirapalli, Salem, Ramanathapuram, Karur and Tirupur.

Pearl millet was grown as rainfed crops in districts like Villupuram, Thoothukudi and Madurai. The growing season starts in October and ends by February. The rainfed Chilli growing period starts from October and the trend shows a continuous decrease upto April. Mostly Chilli was raised as a mixed crop with sesame and pulses. The major growing districts are Ramanathapuram, Thoothukudi, Sivagangai, Virudhunagar and Tirunelveli.

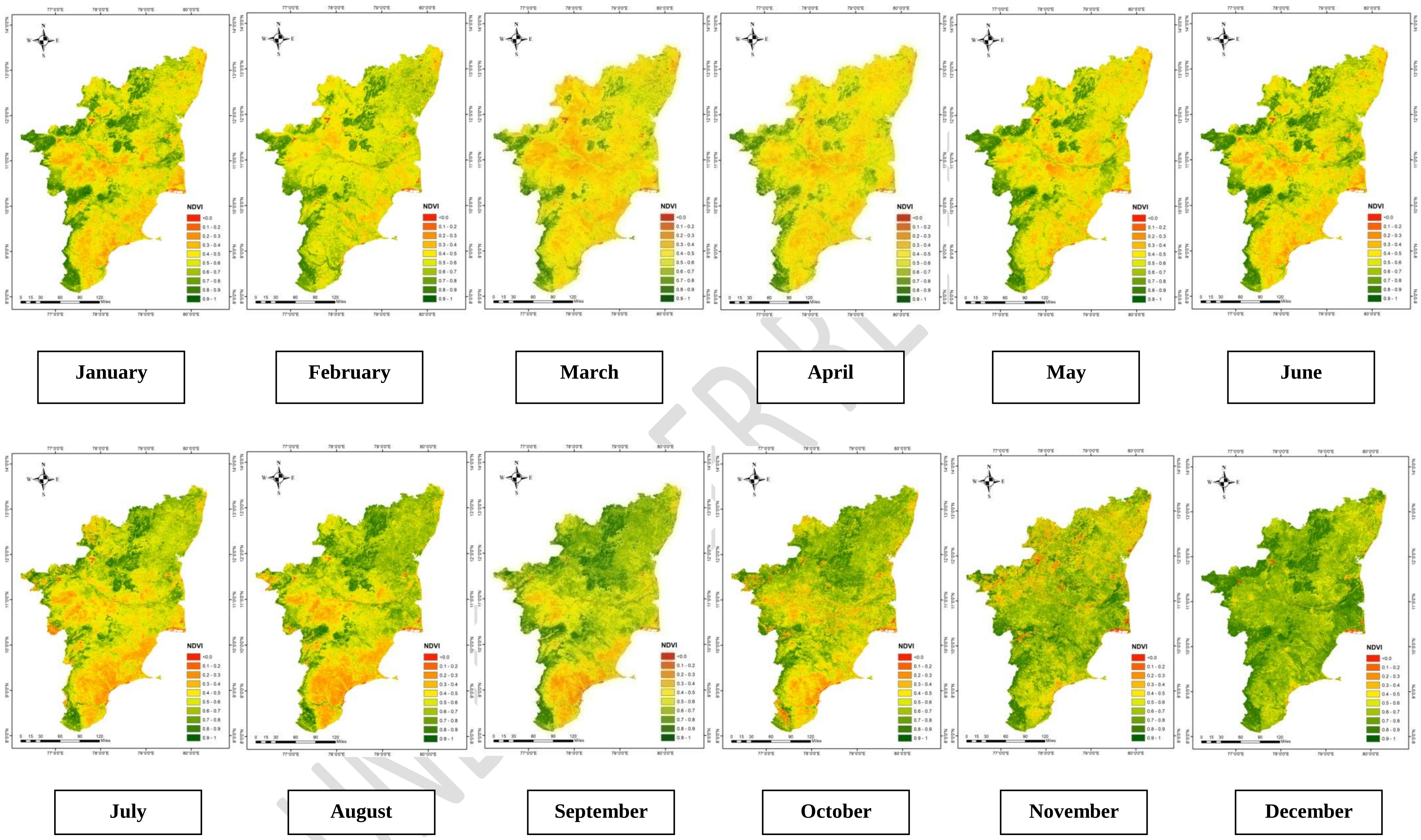

Figure 3. MODIS NDVI product for 12 months showing crop cover phenomena for the year of 2021

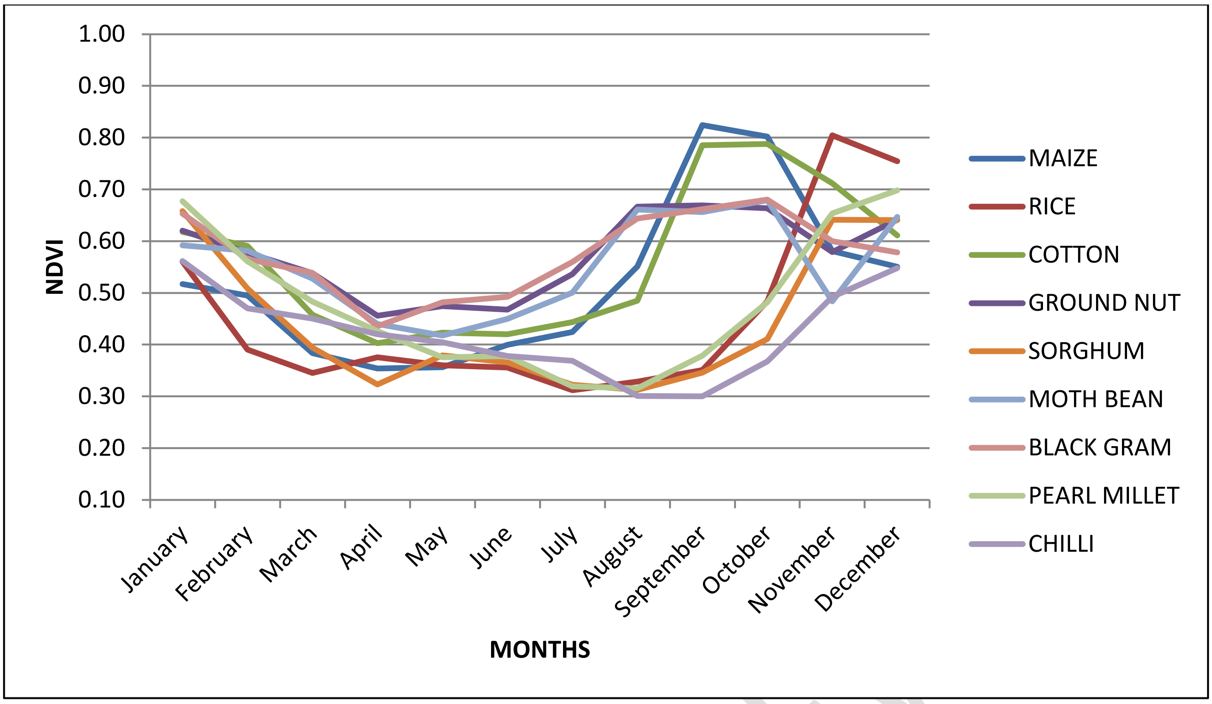

Figure 4. Major rainfed Cropping seasons of Tamil Nadu

CONCLUSION

Rainfed agriculture is an important contributor to Tamil Nadu food grain production. This study reveals that mostly single cropping areas occur in rainfed regions of Tamil Nadu. But in some of the pulse growing areas, double-crop is raised because of the short growing period. The cultivation in these regions mainly depends on the onset of the monsoon. Most of the crops in rainfed areas are sown after withdrawal of monsoon during October to November. The growing period of this region is also short because of aberrant weather conditions. This information is important to take major policy decisions like resource mobilization, market demand, input supply and price fixation. Using this RS technology we can also forecast production, predict end of season and yield of crop.

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