Abstract

The increasing global population is exerting pressure on natural resources to fulfil the increased human needs and demands. An efficient utilisation and management of the natural resources has become more important than ever to meet these enlarged demands. Crop products are one of the most important natural resources available to us. In-season assessment of crop area estimates helps planners and decision makers to efficiently manage the crop products. There has been tremendous improvement in in-season assessment of crop acreage estimation, during last couple of decades. Remote Sensing (RS) is an important tool that provide near real time data which can be used for crop area estimation. RS data with different specifications (spatial, temporal, spectral resolutions, active/passive etc.) are typically used for crop area estimation at different scales. Non-availability of frequent high spatial resolution optical RS data is an issue that affects an early estimation of crop area estimation over large areas. Typically, high spatial resolution (low temporal frequency) RS data is used for single crop area estimation over small regions. Similarly, frequently available (low spatial resolution) optical RS data is used for multiple crop area estimation over large regions. While estimating small area crop acreages, frequently available low spatial resolution data are not used; less frequently available high spatial resolution data are overlooked for large area crop acreage estimation. Hence, an early estimation of small area crop acreage estimation is not done and crop acreage estimation over large area suffers due to crop field discrimination ambiguity. This situation may improve if we develop techniques of integrating the information derived from high spatial resolution data as well as high temporal resolution data at different scales. Currently there is no operational RS based system in India for an early estimation of Rabi crop area which is an important information needed by agriculture management agencies at multiple levels.

This thesis presents a methodology of an early estimation of Rabi crop area at two levels (district and state) using multi-source Remote Sensing data. The sub-studies presented in the thesis use RS data in different formats and spatial resolutions from different sources. The RS data from three satellite based sensors i.e. Terra MODIS (MODerate resolution Imaging Spectroradiometer), Resourcesat-2 AWiFS (Advance Wide Field Sensor), and Resourcesat-2 LISS-III (Linear Imaging Scanning Sensor – III) have been used. High degree of non-

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uniformity or dissimilarity among the multi-source data with respect to their characteristics creates difficulty in their synergistic utilization. To use the data available from multiple sources with such non-uniformities, it needs to be normalised for the dissimilar characteristics. Haze Optimised Transformation (HOT) and Harmonic ANalysis of Time Series (HANTS) have been used for relative radiometric normalisation in spatial and temporal domains, respectively. Maximum Likelihood Classification (MLC), K-means and ISODATA (Iterative Self-Organising Data Analysis Technique) clustering have been employed for classifying the RS data into land-cover classes. Error Matrix based classification accuracy assessment in terms of User's Accuracy, Producer's Accuracy, Overall Accuracy, Kappa Coefficient, and comparison of the estimated values with reference values have been carried out.

The synergistic use of single date Resourcesat-2 LISS-III data and multi-date AWiFS data up to 22 November 2011 yielded an early estimation of Rabi sown area of 58.9 '000 ha for Mehsana district of Gujarat state, India (small area study). The overall classification accuracy was 96.5% with Kappa Coefficient value of 0.954. Multi-date AWiFS and Multi-date MODIS data up to mid-December 2011 over Gujarat along with multi-year MODIS derived a-priori crop history image were used for an early estimation of Rabi crop area at state level (large area study). The multi-source data analysis estimated the Rabi crop sown area of 1.125 Mha. Comparison with the reference data shows that the estimate is close to the actual crop sown area by first fortnight of December. To demonstrate the feasibility of moderate spatial resolution data for regional scale crop area monitoring, multi-date MODIS data from 2002-03 to 2011-12 over Gujarat state were analysed. The study showed that the average rate of increase in the total area under Rabi crop was found to be 8.6%. The rate of increase in Rabi crop area was tested for statistical significance and found significant at 90% confidence level with t statistics of the rate = 2.10.

This methodology has potential to be extended for operational use from district to national levels. It also presents an approach for multi-year monitoring of Rabi crop area at regional scale using moderate resolution Remote Sensing data. The research presented in the thesis involves management and analysis of Multi-source / Multi-sensor Remote Sensing (MRS) data. The management challenges of using MRS data are identified and resolved. It details the methodologies developed for integrating MRS data derived information for early estimation of Rabi crop sown area. It shows how the information derived from previous years Remote

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Sensing (RS) data can support the current year's early estimation. The integrated use of MRS data provides timely information which otherwise cannot be extracted from any single dataset used in the study. The approach has been used to early estimate Rabi sown area of Mehsana district and Gujarat State for 2011-12 season. The research concludes that the information embedded in multi-source RS data can be integrated for making an early estimation of Rabi crop sown area at multiple levels. The methodology developed and demonstrated for district and state levels can be extended to national level.