ABSTRACT

Agriculture is the basis to make available food for rapid increasing population growth in India. Rapid population growth in India has led to expansion in the croplands. This is due to the need to grow more food for the growing food demand of the burgeoning population. These expansions negatively impact the sub-region's ecosystem with implications for the water and soil quality, biodiversity and climate. The accurate and up-to-date information on agricultural land use is required for the appropriate monitoring of the changes in croplands and assess its impact on the ecosystem and other environmental processes. The excessive cloud cover, small agricultural fields and a heterogeneous landscape are the major issues for mapping the spatial distribution of crops in India. Therefore, this study investigated the possibilities to improve the agricultural crop mapping by utilizing optical satellite images with high spatial resolution. Synthetic Aperture Radar (SAR) systems resolve the limitations of the cloud cover for the crop classification, monitoring of crop growth and for the retrieval of soil moisture.

A number of algorithms have been employed for crop classification using various remote sensing data. Some of the classification algorithms have their specific problems which limits their applicability. In the present research work, some alternative classification algorithms were used for the different crop classification and compared their performance. Images of the Linear Imaging Self-Scanner (LISS-IV), Landsat 8-OLI (Operational Land Imager) and Radar Imaging Satellite (RISAT-1) for the year 2013 and Sentinel-1A SAR data of 2015 and 2016 were acquired of Varanasi district, India. In addition, ground reference data for the year 2013, 2015 and 2016 were

collected by the field visits in study areas of Varanasi. The research was carried out in three main stages.

In the first stage, the relative performance of the support vector machine (SVM), artificial neural network (ANN), random forest (RF) and maximum likelihood (ML) classification algorithms was evaluated by using LISS-IV, Landsat-8 OLI and RISAT-1 data-sets for the classification of different crops. Before the performance analysis of the classification algorithms, the separability analysis was conducted to find the separation between the crop classes. In comparison to the Transformed divergence (TD) and Jefferies Matusita (J-M) methods, the TD method provided high separation between the crops. The classification accuracy results were also analysed statistically using Z-test and $\chi 2$-test. The overall better performance was found using SVM algorithm in comparison to the ANN, RF and ML algorithms. However, the performances of ANN, RF and ML were also found good.

The performance of ANN algorithm was analysed using LISS-IV and Landsat-8 OLI data-sets at different learning parameters such as learning rate, momentum term and root mean square error (RMSE) values. The accuracy results were higher using LISS-IV data in comparison to the Landsat-8 OLI data in the present study. However, the LISS-IV data didn't show the consistency in the classification accuracies except using learning rates 0.003 and 0.01. The consistent accuracy results were found using Landsat-8 OLI data in comparison to LISS-IV data excluding some results. The present study indicates that the classification performance depends on several parameters such as data type, scale of data, training sample size and type of classification algorithm employed.

In the second stage, support vector regression (SVR), random forest regression (RFR), artificial neural network regression (ANNR) and linear regression (LR) were

applied for the estimation of winter wheat crop parameters using Sentinel-1A SAR data. Five wheat crop growth parameters such as leaf area index (LAI), fresh biomass (FB), dry biomass (DB), vegetation water content (VWC) and plant height (PH) were estimated using VV polarization at C-band. RFR achieved relatively more accurate results in comparison to SVR, ANNR and LR algorithms. Apart from regression algorithms approach, water cloud model (WCM) was used for the estimation of LAI and leaf water area index (LWAI) of corn crop using Sentinel-1A SAR data. The retrieval values of LAI and LWAI were found close to the observed values by the inversion of WCM.

Finally, in the last stage, SVR, RFR and ANNR algorithms were evaluated for the retrieval of the soil moisture covered by the wheat, barley and corn crops. The performance of the SVR and RFR were found better in comparison to ANNR algorithm using Sentinel-1A SAR data at VV polarization for almost all three type of crop covered soil moisture. At VH polarization, the results were found lower in comparison to VV polarization for soil moisture retrieval using the Sentinel-1A satellite data.