RS-based regional crop identification and mapping: A case study of Barwala sub-branch of Western Yamuna Canal in Haryana (India)

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Information on spatial land use is the main input in strategic and tactical plan-making by all agricultural participants in countries like India with agriculture at the mainstay of the economy. In addition, accurately evaluation of the management of crops in a spatio-temporal context, information on cropping systems is also required, but such information on a regional scale are scarcely available. The spectrum of multiannual patterns of land use on cultivable land, however, remains unknown. The paper thus focuses on the mapping of the cropping systems that are actually practiced in Hisar District of Haryana (India). The objective of this research was to use satellite data and Remote Sensing (RS) techniques to identify the cropping pattern of Barwala sub-branch of Sirsa branch of the Western Yamuna Canal in Haryana. To identify classes of interest, handheld GPS was used to collect ground-truth information. Mask of mixed classes was developed to reclassify an image under the mask. Moreover, appropriate classification of images and application of logical combinations helped in generating cropping pattern maps and statistics. Results revealed that major crops identified in the study area were cotton, rice and pearl-millet in Kharif season, which accounts for about 70% of total cultivated area. In the case of Rabi season, wheat and mustard were observed as the major crops covering approximately 57% of total area. RS technology is currently capable of providing cropping pattern with 90% accuracy. The results of the current study could be useful in the land use and efficient water management in the canal command areas in the water-scarce southern Haryana, India. Some crops like guar, pearl-millet, horticultural crops, etc. were also identified during this period but the major crops that were identified during Kharif season were Rice and Cotton.

Keywords: Classification, Cropping pattern, Landsat 8, ISODATA, Remote sensing

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Agriculture is a rush job of human beings and a dominant factor in economics and sustainable development of every country and information on agricultural resources are necessity for a country like India[1] where agriculture is considered to be the backbone of the Indian economy. Agriculture pays about one-third of national income and 70% of the population[2]. Hence, it is an important sector from both the economy and food production point of view. Reliable, precise and timely data on crop area and estimates of production are essential pillars in the strategic and tactical decision-making of all agricultural participants, such as farmers, processors, resource managers, marketers, finance and lastly in the formulation of government policies. Moreover, regional crop area estimates and yields are required to manage huge agricultural land, determine food prices and trade policies. Crops in fields represent solid evidence and require vast field programs to collect yield data, which is labour-intensive, and also expensive[1,3,4]. The goal of every farmer is to produce cost-efficient food for a large-scale or regional agriculture agency[5]. In recent years, the spatial distribution pattern and location aspects of land use and land cover can be studied more accurately by using RS (RS) and GIS techniques. It has emerged in recent times as an essential instrument for tracking and managing natural resources. In order to obtain brief and repetitive observations on crop spectral behavior and growing environment, RS is used with space-borne sensors, i.e., soil and atmosphere[6]. Pre- and post-seasonal crops should be examined when choosing a crop for a season. RS imagery had been used to determine crop types, area and predict yield[7],

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during the seasonal cycle, the spectral signature for vegetation changes entirely, i.e., maturity, green-up, senescence and dormancy[8,9]. Crop discrimination based on RS and area estimation, including a single date approach based on maximum likelihood classification as well as a hierarchical / growth profile for crop classification[10,11]. In 1996 a project on Crop Acreage and Production Estimation (CAPE) under RS Applications Mission (RSAM) with a boosted scope was formed. A wholly directed effort has been made under this program to develop methodology applicable over large areas[12]. Therefore, various techniques of discriminating crops and mapping different types of crops based on vegetation phenology. Several studies were carried out using various RS methods and time series data were analyzed at different resolutions and found highly economic in terms of time and expenditure. Therefore, taking into account the above issues, this study deals with the regional crop identification and mapping of the Barwala Sub-branch command area in Haryana (India) using RS. The main focus of this study was on the identification of crops for irrigation management using temporal Landsat-8 data for the year (2015-16). In recent years, by using RS and GIS techniques, the spatial distribution pattern and location aspects of land use and land cover can be studied more accurately[13,14]. It has appeared as an effective method for observing and managing natural resources.

Study Area

The command area of the Barwala Sub-branch forms part of the Indo-Genetic alluvial plain of Hisar district. Its expanse is spread through Barwala tehsil and some adjoining area. Barwala sub-branch command area is situated between 29°10'0" to 29°33'0" N latitudes and 75°34'0" to 76°13'0" E longitudes. It occupies an area of 89481.6 hectares. Fig. 1 indicates the location of the study area.

Data used

The basic data source for crop identification is Landsat 8 data, which is ideal with optimal spatial and temporal resolution. The sensor provides spatial resolution data of 30 m in 11 bands with a 16-day revisit capability. Its repetitive cycle and multi-date data were used to derive cropping patterns of Kharif and Rabi season.

Methodology

Erdas Imagine, Geomatica and ArcGIS software was used for digital image analysis. The complete numbering approach was used to identify the crops in the study area for 2015-16. Fig. 2 shows the steps
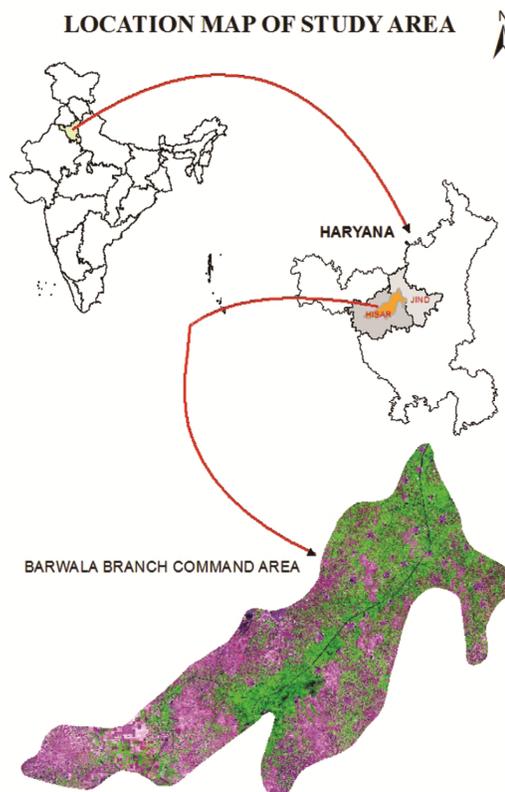

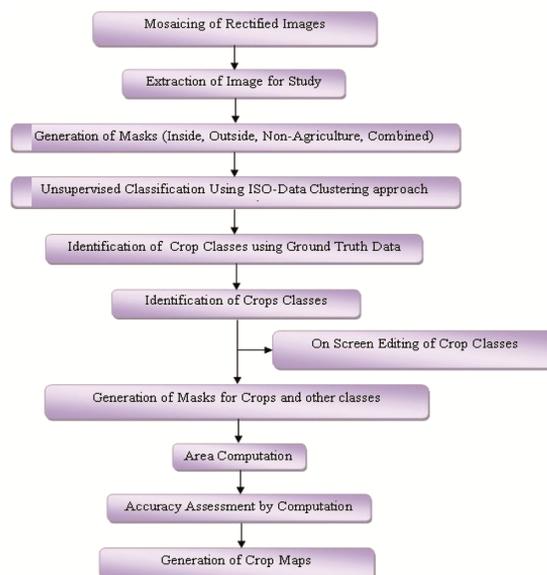Fig. 1 — Location Map of Study area

Fig. 2 — Methodology flow chart of digital analysis

applied in digital analysis. Using a full enumeration approach, the digital analysis was performed using geo-referenced images. Incomplete numeration approaches showed the boundary of the study area on the images, a mask that was generated and put on the geo-referenced image. Using unsupervised classification approach, all the image elements (pixels) were extracted for any further classification. ISO-Data Clustering classifier was used. Map of plants were generated utilizing classified images.

Results

A perusal of data (Table 1), indicated that there were significant differences in the area among different crops. The cotton crop was significantly higher than other crops which were found to occur in 42531.12 ha and occupies around 47.53% area of the total cultivated area. Similarly, rice during Kharif cropping season secured second highest value (4700.25 ha) while lowest was observed in case of pearl-millet which accounts only 4095.90 ha of the total area and represents only 4.58% of the total cultivated land. The area under fallow land was 16.70% whereas other crops hold only 18.42% share and constitute about 16485.21 ha area. Total non-agriculture area for Kharif season was 7.25% of the total area of the study area. Spatial distribution maps of Kharif crops in the study area are depicted in Fig. 3,

which were derived from multi-date RS data. Cotton cropping is evenly spread through the study area except in southern and south-western part where the concentration of pearl millet and fallow land is more. Rice crop is located along the main canal in the southern part of the study area. It indicates that the study area is extensively cultivated. Spatial distribution of crops and associated categories is depicted in Fig. 4.

A significant difference was observed in Rabi cropping season as shown in Table 2 and Fig. 5. Mustard is the second highest crop grown in this area after wheat in Rabi cropping season and covers about 23383.1ha and occupies 26.13% area of total cultivated area. Wheat is the highest growing crop represents 45.43% area which accounts for 40651.3 ha area of total cultivated area. Rabi crops in the study area are depicted in Fig. 6, which are derived from multi-date RS data. Wheat cropping is evenly distributed through the study area except in southern and south-western part where the concentration of mustard and other crops is more. Other Crops including vegetables, fodder, and gram etc. combinedly occupied an area of 9866.4 ha whereas the fallow land area of 9089.6 ha (10.16 % of total area) is demarcated during classification, which is less compared to Kharif season fallow land. It indicated that the study area is extensively cultivated. Spatial

Table 1 — Kharif season cropping pattern in study area

Crops/Category	Area (ha.)	% of Total Area
Cotton	42531.12	47.53
Rice	4700.25	5.25
Pearl millet	4095.90	4.58
Other Crops	16485.21	18.42
Fallow Land	15177.69	16.70
Non-Agriculture	6491.43	7.25
Total	89481.60	100

Table 2 — Rabi season cropping pattern in Study Area

Crops/Category	Area (ha.)	% of Total Area
Wheat	40651.29	45.43
Mustard	23383.08	26.13
Other Crops	9866.43	11.03
Fallow Land	9089.55	10.16
Non-Agriculture	6491.43	7.25
Total	89481.6	100

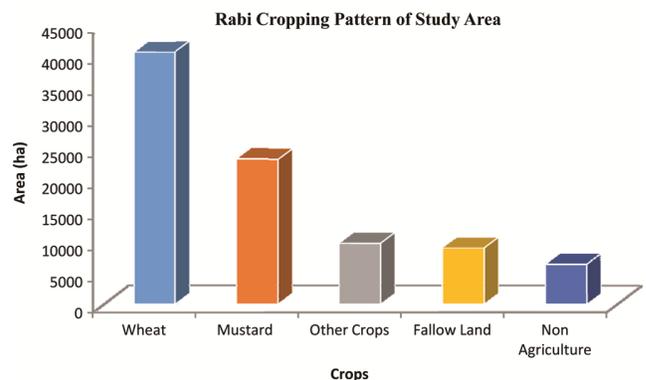Fig. 3 — Kharif cropping pattern of Barwala Sub-Branch Canal Command Area (2015)

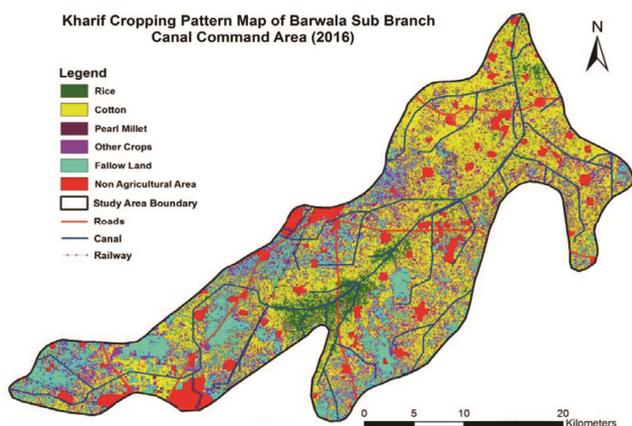Fig. 4 — The area under different crops during Rabi season

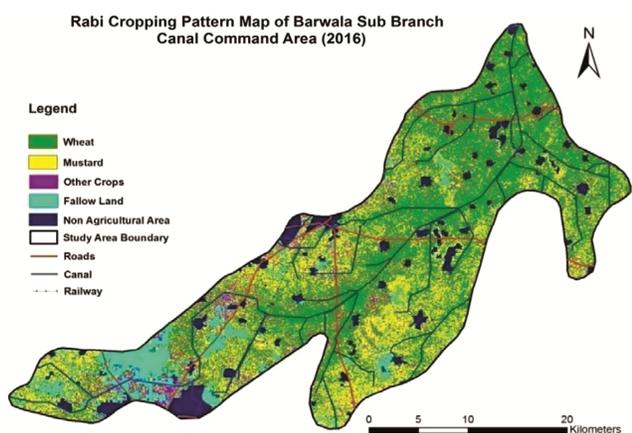Fig. 5 — Area under different crops during Kharif season

Fig. 6 — Rabi cropping pattern of Barwala Sub-Branch Canal Command Area (2016)

distribution of crops and associated categories is depicted in Fig. 4.

Discussion

This research proved the appropriateness of RS techniques for mapping crop types and area for the 2015–2016 using Landsat-8 data. The methodology incorporated multi-temporal satellite imagery and boundaries collected from HARSAC. The methodology showed that Landsat 8 data can be used in the mapping of crops in different areas. It shows that cotton, rice and pearl millet are largely cultivated in the study area during the Kharif season, while the major crops wheat and mustard were identified in the Rabi season. Other crops including vegetables, fodder, guar, gram, etc. were also demarcated in both seasons. Approximately 17% of the total area observed as a fallow land during the Kharif season, whereas 10% of the area is noticed under fallow land during the Rabi season. The reason for fallowing land

is that government land is not used for agricultural purposes. Some portion of the study area is affected by the issue of water scarcity and water logging, which causes the land to fallow. As a consequence, crop area mapping become challenging. But when mapping at field level, the use of Landsat 8 data proved as a valid option. Our findings were in good agreement with other research using different classification techniques and higher-resolution satellite images. We used Landsat 8 multi-temporal images that covered two growing seasons. It is possible to extend maps based on our methodology to estimate the production of all crop types at regional or national level. It indicates that the spectral variability within the field with accurate field boundaries could be lowered. Because of mixed pixels, these limitations eliminated classification errors. Object-based image analysis could be used to detect field boundaries in regions without parcel information.

Conclusion

RS appears as a modern technology for predicting a specific region's crop pattern, which is the most significant aspect of crop production. This research proved the potential for regional level crop type area mapping using unsupervised classification approach applied to multi-temporal 30 m Landsat 8 images for the 2015-16 season. In the Kharif season, major crops identified in the research area are cotton, rice, and pearl millet, whereas in the case of Rabi season, wheat and mustard were noted as the main crops. Identifying the spatial relationship between crops is an advantage of the suggested technique. It will prove to be very helpful in planning and adopting effective crop rotations that will ultimately help in improving farm diversity, soil conditions and fertility status, while achieving the sustainability goal. Its simplicity and ease of use was a distinct advantage of the unsupervised classification. Furthermore, the method can be extended to other fields that are either predetermined by ground data, field knowledge or literature review.

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