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Remote Sensing of Horticultural Plantations in Kumarsain Tehsil in Shimla District, Himachal Pradesh

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ABSTRACT

The favourable agroclimatic conditions for orchards especially apples have increased the acreages in Himachal Pradesh (HP) which has significantly contributed in the growth of state economy. Realizing the importance of horticulture in HP and its changing scenario of the land use/land cover, a study was conducted to identify and map apple and almond plantations in the Kumarsain tehsil of Shimla district using Remote Sensing (RS) techniques. IRS-1B LISS-II False Colour Composite (FCC) diapositives of October 27, March 30 and April 20, 1992 were visually analysed for mapping apple and almond plantations. The results indicate that IRS LISS-II data of April 20 on 1:50,000 scale was found very useful for identification and mapping of apple and almond plantations in this region. Accuracy of interpretation was also tested on sample basis assuming a binomial distribution for the probability of success/failure of sample points. The overall interpretation accuracy assessed based on 40 sample points was found to be 87 per cent at 90 per cent confidence limits.

Introduction

Horticultural crops encompassing a large variety of fruits, vegetables, flowers, plantations and spice crops, medicinal and aromatic plants, roots and tuber crops, etc. cover slightly more than 7 per cent of the gross cropped area of Himachal Pradesh but contribute more than 18 per cent to the gross value of the agricultural output of the country (Kaul, 1993). Himachal Pradesh is basically an agro-ecosystem where 90 per cent of the population is rural and dependent on agriculture, horticulture, silviculture and animal husbandry. Typical geographical feature

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coupled with favourable agroclimatic conditions have helped in changing the cropping pattern in favour of horticultural and vegetable crops.

Mapping and identification of various land use features and horticultural plantations in the Himalayan region using RS satellite data becomes more complex because of shadow casting due to rough terrain, difficulty in getting cloud free data, large diversity in vegetation composition based on altitude and co-existence of apple plantations with forest. Moreover, well demarcated horticultural plantation maps are not available and there is encroachment of horticultural plantation in the forest area. Remote Sensing, in such inaccessible terrain offers an unique opportunity to map and monitor horticultural plantations in cost and time effective manner. A large number of studies have been carried out for preharvest estimate of major agricultural crops using Remote Sensing (RS) techniques (Navalgund *et al.*, 1991). However, efforts in identification, mapping and area estimation of major horticultural crops have been very few even though they manifest broad zonal distribution. Realizing the importance of horticultural plantations, which are one of the most important cash crops of India, a study for identification and mapping horticultural plantations (Apple and Almond) using RS techniques was initiated. This paper deals with detailed methodology adopted for delineation and mapping of horticultural plantations using visual analysis of IRS LISS-II data.

Study Area and Data Used

Kumarsain sub-tehsil is one of the leading apple growing valley in Shimla district of Himachal Pradesh and occupies the place of pride not only in the state but also in the country. The geographical area of this tehsil is 232.55 km^2 and lies between 77°20' to 77°32' N longitude and 31°13' to 31°22' E latitude (Fig. 1). The altitude of this area varies from 300 m to more than 2800 m. The average annual rainfall is around 1028 mm and occasional snow fall in upper reaches during the months of winter. The wide range of altitude, temperature, precipitation and topography has resulted in varied and rich flora ranging from sub-tropical chir pine *(Pinus roxbhurghii)* to Himalayan moist temperate forest of ban oak *(Quercus dilatata, Quecus incana)*, Burans *(Rhododendron arboreum)* and mixed dominated forest of conifer like Kail *(Pinus wallichiana)*, Deodar *(Cedrus deodara)*, Tosh *(Abies pindrow)* and Rai *(Picea smithiana)*. Such agroclimatic condition prevailing in the area is very much conducive for growing apple orchards and other temperate fruits. It was late Shri Satyanand Stroke formerly an American Missionary named as Samuel Stroke who pioneered the cultivation of delicious varieties of apples in Kotgarh region, date back in 1920. The initiative taken by him and thereafter followed by others altogether changed the economic complexion of the people of the area. The main commercial varieties of apple grown in the area are Royal delicious, Rich-a-red, Red delicious, Golden delicious etc. Other fruit trees grown in the area are Pears, Peaches, Apricot, Plum, Almond, Citrus and Cherry.

i) Satellite data: IRS-LISS II diapositive FCC and geocoded FCC prints on 1:50,000 scale (October 27, March 30 and April 20, 1992)

ii) Survey of India Topographical maps on 1:50,000 scale (53 E/7, E/8 and E/11)

iii) Forest working plan maps of Kumarsain range

iv) Ground truth data on location, site characteristics, growth stages and cultural practices of horticultural plantations.

Methodology

IRS LISS-II images of March 30, April 20 and October 27, 1992 were scanned to differentiate horticultural plantations from forest

and other land use/land covers. This comparison has helped in understanding the dynamics of seasonal changes in the horticultural area and selection of optimum season satellite data for mapping of horticultural plantations. It was observed that IRS LISS-II data of April 20, was found more appropriate for identification and discrimination of horticultural plantations (apple and almond). During this period the sun elevation is high and shadow effect is found to be minimum. Besides this the local time of IRS data acquisition is around 1045 hrs. which has minimum local shadow effects.

Ground truth (GT) survey was conducted in May, 1994. For GT data collection, horticultural plantations map on 1:50,000 scale, based on preliminary visual interpretation was prepared and random numbers were generated and plotted on this map. In selecting the point, accessibility and geographical position were also considered. After reaching the sample points, field details were translated on ground truth map and enlarged FCC prints (1:50,000 scale). Various site characteristics and cultural practices of apple and almond were recorded for each site. Total 40 points were verified in apple and almond orchards. Other information regarding the type of vegetation, other land use/land cover and agricultural practices were also collected.

Based on ground truth information and preliminary interpretation of IRS LISS-II data at 1:50,000 scale, a final interpretation key was prepared (Table 1) in order to delineate the apple and almond plantations. Different growth stages coupled with different canopy structure has helped to categorize the apple plantations into three categories.

IRS LISS-II imagery of April 20, has been used for final mapping using visual interpretation along with Survey of India map at 1:50,000 scale. Image characteristics like tone, texture, pattern, size and location etc. have been used to delineate horticultural plantation with other associated land covers. The distribution of horticultural plantations is governed by the altitude. It was observed that normally apples are grown above 1500 m altitude and below this altitude, almond plantations were observed. Therefore, a contour line at 1500 m, altitude in addition to ground truth information were considered to stratify the apple and almond plantations. Based on this information the area has been divided into three strata:

Table 1. Interpretation key for mapping horticultural plantations using IRS LISS-II FCC.

Category	*Tone*	*Texture*	*Pattern*	*Size*	*Location*
1. Apple Plantations					
Mature/Dense	Brownish red/reddish	Course to mottled	Patchy/ regular	Small to medium	Above 1500 m altitude outside forest areas
Middle aged	Reddish	Medium	-do-	-do-	As above but some time found in forest areas
Young	Light reddish	Smooth fine	-do-	Small	-do-
2. Almond Plantations					
	Light red to yellowish	Fine/medium	Patchy	Small	Occurring below 1500 m altitude along Satluj river

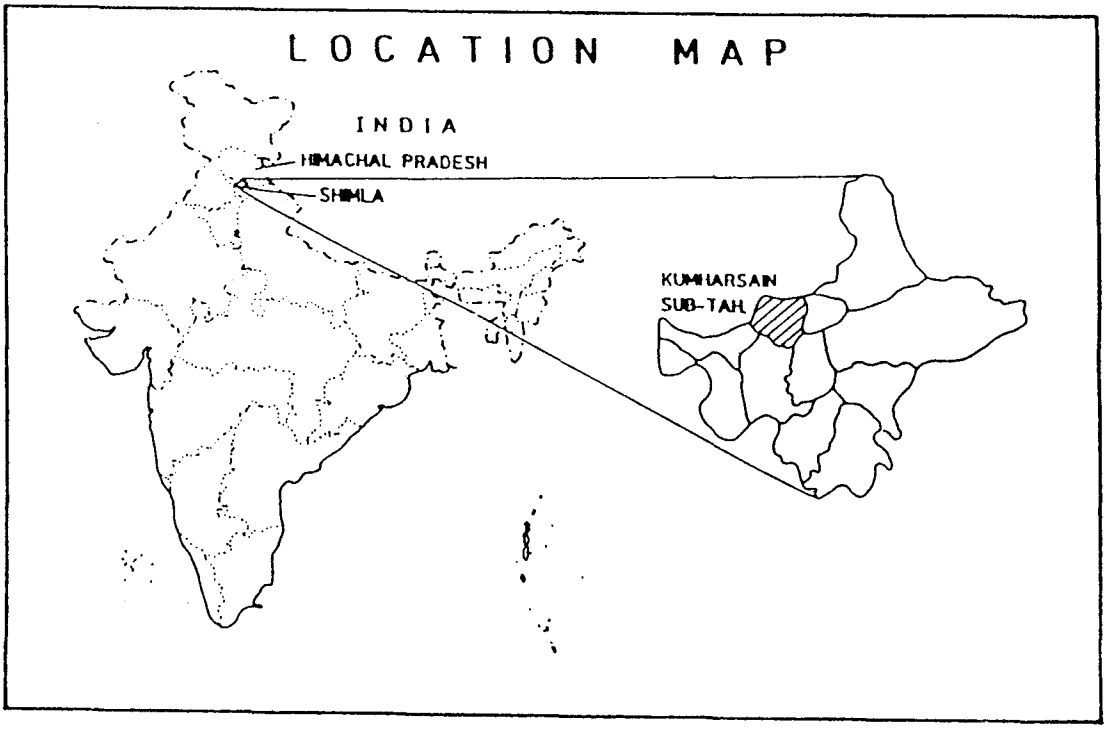

Fig. 1. Location map of study area.

(i) The apple plantations (areas between 1500 to 2500 m altitude)

(ii) The almond plantations (areas below 1500 m altitude) and

(iii) Non-horticultural areas (consisting of forest, agriculture, grassland, wasteland etc.)

Horticultural plantation map on 1:50,000 scale was finalised by incorporating necessary correction/modification using ground truth and final interpretation key. The classes as well as their boundaries were refined. Area under different horticultural plantations was estimated by millimeter dot grid overlay.

Results and Discussion

Optimum Season for Mapping Horticultural Plantations

Vegetation identification and discrimination is based on the fact that each vegetation type has a unique spectral signature. The spectral response of the vegetation canopy is influenced by (i) leaf area and per cent crown cover, (ii) different growth stages, (iii) canopy architecture, (iv) difference in cultural practices, (iv) stress condition, and (v) soil/water background are an important influencing factor. Identification and discrimination of horticultural plantation needs multi-season satellite data as used in the present

study. This is due to the fact that the canopy density of horticultural plantations (apple, almond) varies in this locality from season to season within the year. Since apple and almond trees are deciduous in nature, leaf shading starts with the ripening of fruit in the monsoon and is completely devoid of leaves up to March. Flowering and fruiting start by the end of March.

Almond plantations look dull orange-red, smooth to coarse in texture on LISS-II FCC. The almond plantations were always observed on lower elevations below 1500 m altitude along the Satluj river. Other non-horticultural areas predominantly forest, agriculture, grassland, wastelands etc. appear in different tone and texture on IRS LISS-II FCC.

Forest area which is dominated by conifers like Chil, Kail, Deodar, Rai etc. show different physiognomy and structure like straight bole, needle shaped dark green leaf, and conical structure of the crown. These conifers are distributed in contiguous homogeneous patches and on the contrary retain most of the foliage throughout the year because of their evergreen nature except Chil forest in lower altitude. Agricultural crops in this area also indicate different cropping pattern.

Based on these observations, the study revealed that during the April month maximum contrast between the horticultural area (apple and almond), forests, agriculture and other land use categories was observed on the FCC of IRS LISS-II. On IRS FCC, apple growing area appears light red to brownish red tone. The texture varies from smooth fine to course mottled, depending upon the canopy cover and maturity of the plantations (Table 1). These plantations are in general patchy and regular in shape and small to medium in size. The subtle tone texture differences in apple plantations may be because of its different growth, canopy architecture and different cultural practices. This has helped to further classify apple plantations into three sub-classes namely mature/dense, middle aged and young/sparse. All the apple plantations were found distributed between 1500 m to 2500 m altitude. Considering these factors the apple and almond plantations with their different sub-classes were mapped on 1:50,000 scale. The spatial distribution of apple and almond plantations is shown in Figure 2.

Area Estimation

Mapping has been carried out at 1:50,000 scale which has enabled the identification of apple and almond area and their location up to village level more accurately. The smallest mapping unit taken as 3 × 3 mm which is equivalent to 150 × 150 m (2.25 ha) on ground. Acreage under different categories was calculated from the map and presented in Table 2.

Table 2. Acreage estimates of horticultural plantations in Kumarsain Tehsil based on IRS LISS-II data.

Horticultural Plantation	*Area (ha)*	*Per cent of total area of Tehsil**
Apple		
Mature/dense	1780	7.7
Middle aged	1176	5.1
Young/sparse	708	3.0
Total	3664	15.8
Almond	452	1.9
Grand Total	4116	17.7

*23255 ha

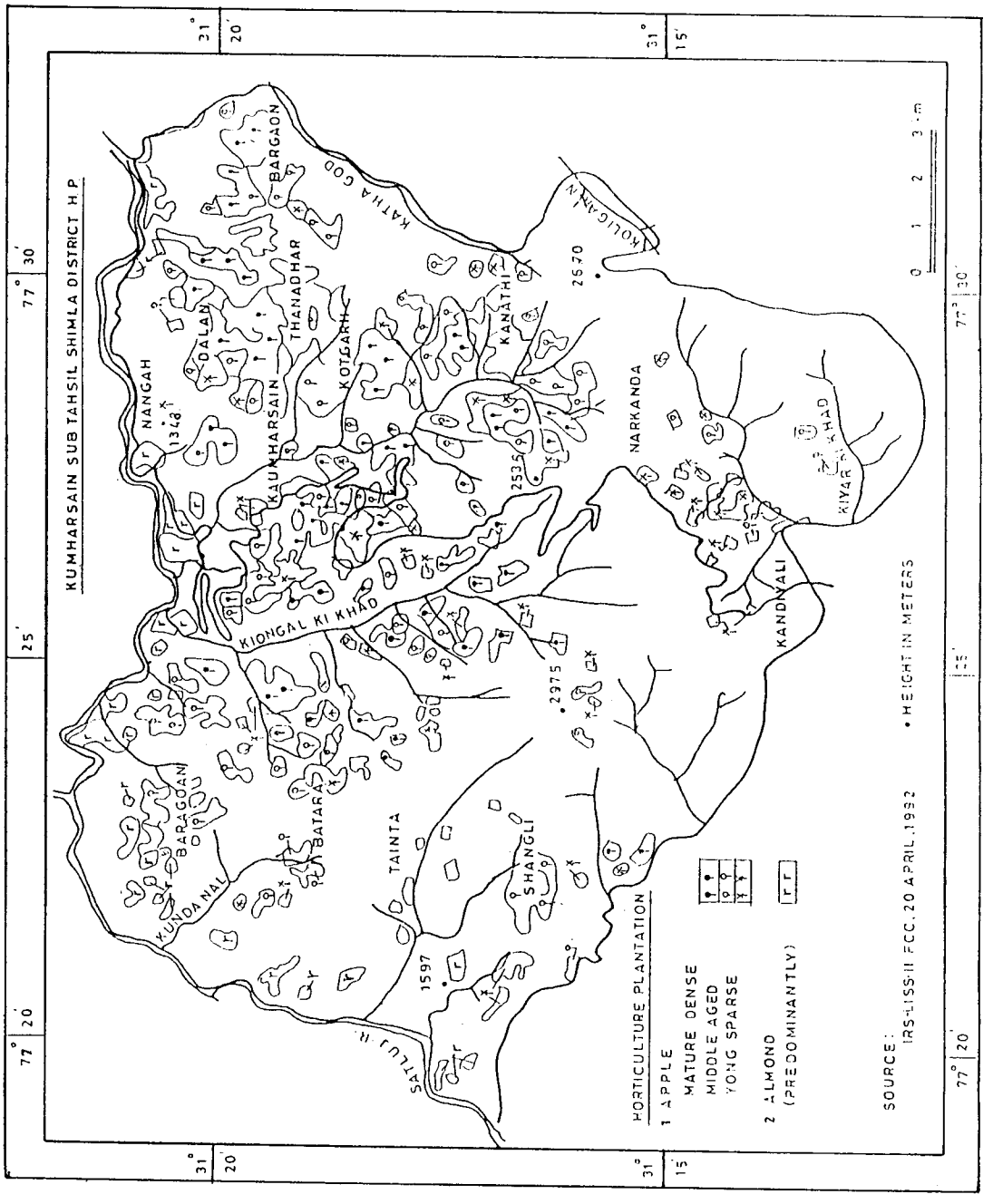

Fig. 2. Spatial distribution of Apple and Almond plantations in the study area.

The major observations are as follows:

(i) Horticultural area predominantly apple and almond occupies nearly 17.7 per cent of land of Kumarsain sub-tehsil (23255 ha). Apple are distributed between 1500 to 2500 m altitudes, where as almond area are found in lower altitudes along the Satluj river.

(ii) The estimated acreage under Apple is 3664 ha i.e. 15.8 per cent of the total study area. Mature plantations shared maximum acreage (1780 ha) followed by middle aged (1176 ha) and sparse/young plantations (708 ha).

(iii) Sparse/young plantations are scattered almost all over the valley whereas maximum concentration of mature plantations was observed around Kotgarh village.

(iv) Almond acreage (452 ha) is distributed in lower altitudes.

However, estimated acreages may have some variation, due to undulating terrain, since actual area under such plantations is not available at present. Therefore, no comparison has been attempted.

Interpretation Accuracy Assessment

Horticultural plantations map on 1:50,000 scale based on preliminary visual interpretation was prepared for interpretation accuracy assessment. Doubtful areas were identified from the preliminary interpretation. For ground verification random numbers were generated and plotted on the map. In selecting the point, accessibility and geographical position were also considered. In order to know the accuracy of the prepared map, interpretation accuracy have been assessed after field verification. The results are tabulated in the form of confusion matrix (Table 3). The overall interpretation accuracy assessed on 40 sample points was found to be 87 per cent at 90 per cent confidence limits. The interpretation accuracy is tested on sample basis assuming a binomial distribution for the probability of success/failure of sample points (Arnoff, 1982). Except two sample points, one each in apple (middle aged) and almond, all other points were found to be correctly interpreted.

Conclusion

The study provides an avenue for a comprehensive and detailed mapping in the other apple growing areas in the Himalayan region for which very little information is available either with the horticultural department or forest department. The results of visual interpretation of IRS LISS-II FCC on 1:50,000 scale suggests that the apple plantations in hilly region can be successfully identified and mapped using April month data with an accuracy of 87 per cent at 90 per cent confidence level. The horticultural plantations which are smaller than one ha in size can be successfully delineated at 1:25,000 using IRS-1C LISS-III and PAN data. This will help more accurate acreage estimation under such plantations.

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Table 3. Confusion matrix for accuracy assessment of horticultural plantations.

Class	*AM/D*	*AMA*	*AY/S*	*AL*	*Total*	*Omission per cent*	*Accuracy per cent*
AM/D	12	0	0	0	12	0.0	100.0
AMA	1	10	0	0	11	9.0	90.9
AY/S	0	0	8	0	8	0.0	100.0
AL	0	0	1	8	9	11.1	88.8
TOTAL	13	10	9	8	40		
Commission %	8.3	0	12.5	0			

AM/D = Apple mature/dense plantations, AMA = Apple middle aged plantations
AY/S = Almond plantations predominantly, AL = Almond plantations
Total sample points = 40, Number of failures = 2
Overall classification accuracy = 87 per cent at 90 per cent confidence level

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