USE OF REMOTE SENSING & GIS IN DEVELOPMENT AND MANAGEMENT OF HORTICULTURE IN HIMACHAL PRADESH

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ABSTRACT

Recognizing importance of horticulture in promoting livelihood and employment opportunity and bringing prosperity to the state of Himachal Pradesh, the Govt. of India has extended National Horticulture Technology Mission Programme to Himachal Pradesh. The objective of Mission is to develop horticulture based farming system that is economically viable and ecologically sustainable using all the modern tools and techniques available .The space technology including remote sensing, Global Positioning System (GPS) and Geographical Information System (GIS) are the advanced tools that aid in gathering and updating information and develop scientific management plans. Updated and accurate database is pre-requisite for systematic planning of horticulture sector be it area expansion, increase in productivity or creating post- harvest handling facilities. With this aim, a study was carried out to generate blockwise database on apple plantation inapple growing districts of Himachal Pradesh. Remote sensing data from the Indian Remote Sensing satellites like IRSP6 has been used along with other international sensors to generate apple orchard maps, orchard conditions in term of density, terrain parameters like elevation, slope, aspect etc. The GIS tools have been used to characterize the orchard distribution pattern in relation to terrain parameters. The final outputs are in digital form amenable to produce maps at different scales as well as statistics as required by a user.

1. INTRODUCTION

Horticulture crops play significant role in the food and nutritional security of the country. The importance of these crops compounds in hilly and undulating terrains, like Himachal Pradesh where traditional agricultural activities catering to field crops is not economically remunerative and sustainable, while the climate in general is suitable for growing temperate and subtropical fruits. This scenario offers a vast potential for horticultural crops that is yet to be realized. To achieve this, the Government of India has launched the Technology Mission for Integrated Development of Horticulture (Anon, 2000). The systematic and scientific approach is the backbone of this Mission. Better management of the existing orchards/plantations and bringing more area under these crops is one of the methods envisaged under this project. Thus, a holistic approach for apple orchard development plan has been envisaged by the state. This calls for a baseline database of the existing apple orchards in the state. This work has been undertaken to generate such information using advanced techniques like satellite remote sensing, Geographic Information System (GIS) and Global Positioning System (GPS). A number of studies have been carried out in field of horticulture, aiming at identification of crop, area estimation, condition assessment etc. using satellite data(SAC, 2001; SAC, 2003)

2. METHODOLOGY

2.1 Data used

2.1.1 Ancillary / Collateral Data

The important collateral data used in this study included administrative boundary of the state, district and blocks, location of settlements, drainage/rivers etc. and area and production statistics of apple and other important fruit crops of the state.

2.1.2 Ground Truth Data

Ground truth plan was made based on stratification of the image data, variation in crop signatures, etc. The information and location were noted with the help of maps, image print outs and Global Positioning System.

2.1.3 Remote Sensing Data

Indian Remote Sensing Advanced Wide Field Sensor (IRS AWiFS) and Indian Remote Sensing P6 Linear Image Self Scanning Sensor(IRSP6 LISS III) are basic remote sensing data used in this study. Temporal IRS AWiFS ((spatial resolution is 55m) data were used to select optimum dates for its identification of apple orchards. IRS LISS III data (spatial resolution is 23 m) were used to map the orchards.

2.1.4 Terrain data

Terrain parameters are derived using digital terrain model data. For this, the NASA Shuttle Radar Topographic Mission (SRTM) that provides Digital Elevation Data (DEM) for over 80% of the globe is used. The SRTM DEM has a resolution of 90m at the equator. The vertical error of the DEM's is reported to be less than 15m.

2.2 Mapping of orchards

2.2.1 Selection of optimum data

The Ancillary information on the crop phenology / calendar and the local vegetation dynamics as well as temporal data of coarse resolution sensors like AWiFS that corresponds to different growth stages was used to select optimum period for selecting optimum bio-window for apple orchard delineation. It is observed that May end data was most suitable for identifying apple orchards and derive vegetation vigor variation within the orchards. IRS P6 LISS III data were used for block level mapping of orchards.

2.2.2 Geo-referencing, Image stacking and Database

Since, satellite data from many sources with different spatial resolution was used, UTM projection system with WGS84 (earth model) was used as referencing scheme. One date from the set of LISS III data was considered to be the master image and was geo-referenced using GCP's (Ground Control Points) from 1:50,000 Survey of India toposheets. The data of other dates were registered to the master image using image-image GCP's. The image-image registration was done with sub-pixel (<0.5 RMSE with second order polynomial) accuracy. The digitized district and block boundaries were overlaid on the image database. The ground truth data on orchards collected using GPS and maps were overlaid on images with attributes on orchard characters. The digital forest map at 1:50, 000 scale of FSI was used to identify the forest classes.

2.2.3 Classification

A two- step classification approach has been used to map the apple area. In the first step, a non - vegetation classes has been masked using Normalized Difference Vegetation Index (NDVI) thresholding. The exact values of NDVI for thresholding can be known with the help of satellite data and ground information.

$$NDVI = (NIR – R) / (NIR + R)$$

After masking non – vegetated area, unsupervised classification technique (ISO data clustering), is used to carry out preliminary orchard inventory. The known ground truth sites were used to assign clusters to orchard classes. Thus, a preliminary mask of orchard area was created. This was used for detailed ground truth data classification.

Final classification was carried out using the maximum likelihood supervised classification using known ground truth data. Efforts were made to use as many class variations so as to reduce the number of unclassified pixels and achieve at least 90 per cent classification accuracy.

2.2.4 Density/Vigor Categorization

NDVI (Normalized Difference Vegetation Index) was computed for orchard classes from NIR and Red bands using the following relationship.

$$NDVI = (NIR - R)/ (NIR + R)$$

Where, NIR and R are DN (Digital Number) values in Near Infrared and Red bands, respectively.

2.2.5 Characterization of Growing Environment

Some of the horticultural crops like apple orchards are concentrated in hilly terrain of higher elevations due to the physiological requirement of cool temperature of the crop. Thus, slope, aspect and elevation are some of the deciding factors for orchard condition and productivity. Incorporation of this information also improves the classification accuracy through logical decision rules. Digital Elevation Model (DEM) generated was used as a image channel and orchards were further characterized on the basis of slope, elevation and aspect of orchards, using logical modeling. The final orchard area has been calculated after labeling all the classes and merging them into major classes based on density or some logical merging. The acreage under each class was estimated, and their class accuracy can be assessed. Orchard maps were generated and hard copies were taken at desired Scale.

3. RESULTS AND DISCUSSION

3.1 Area

Total orchard area mapped in the various apple growing districts in Himachal Pradesh amounted to 950.54Sq. Km. with 211.37Sq. Km,376.30Sq. Km,145.20Sq. Km,104.52 Sq. Km,90.76 Sq. Km and22.37 Sq. Km area in Shimla, Kullu,Mandi, Kinnaur, Chamba and Sirmaur districts respectively. Shimla district with a share of about 40% is highest ranking apple growing district (Table-1).

Table-1 Apple area in Himachal Pradesh and its apple growing districts

S. No.	District	Apple Area (Sq. Km)
1.	Kullu	211.37
2.	Shimla	376.30
3.	Mandi	145.20
4.	Kinnaur	104.52
5.	Chamba	90.76
6.	Sirmaur	22.37
	Total	**950.54**

3.2 Density

Most of apple plantation (81%) in Himachal Pradesh belonged to dense or moderately dense category. Kullu district has highest percent of dense category(26%) orchard area (Table 2)

Table 2 Area under different categories of apple in Himachal Pradesh and its apple growing districts

S. No.	District	Area under different categories of apple (Sq. Km)		
		Sparse	Moderately dense	Dense
1.	Kullu	6.48	148.14	56.75
2.	Shimla	96.59	209.74	69.96
3.	Mandi	42.29	94.52	8.31
4.	Kinnaur	38.62	48.00	17.89
5.	Chamba	11.29	44.75	35.11
6.	Sirmaur	-	8.36	14.07
	Total	**195.29**	**570.28**	**202.12**

Elevation

Elevation range 1500-2500m supports majority of apple plantation in Shimla, Kullu,Mandi, Chamba and Sirmaurdistricts while Elevation range 2000-3000m hosted most of apple plantation in Kinnaur district as shown in table3.

Table 3 Apple area in relation to Elevation in Himachal Pradesh and its apple growing districts

S. No	District	Applearea(Sq Km) in elevation range					
		<1500m	**1500-2000m**	**2000-2500m**	**2500-3000m**	**>3000m**	**2000-3000m**
1.	Kullu	5.20	43.27	75.02	54.36	33.11	129.39
2.	Shimla	17.57	101.87	19.53	49.96	10.89	29.71
3.	Mandi	35.22	55.46	36.20	36.20	16.96	91.66
4.	Kinnaur	0.25	10.32	27.60	41.72	24.61	69.33
5.	Chamba	2.96	16.01	28.31	28.75	14.70	57.06
6.	Sirmaur	2.22	10.41	6.71	0.56	0.06	17.12
	Total	**63.45**	**237.37**	**369.16**	**211.57**	**100.35**	**661.76**

3.3 Aspect

More than Sixty seven percent apples in Himachal Pradeshgrowon hills having North-East and South East Slopes. District wise distribution is shown in table 4.

Table 4 Apple area in relation to aspect in Himachal Pradesh and its apple growing districts

S.No	District	Apple area(Sq Km) in relation to aspect				
		North-East (NE)	**South-East (SE)**	**South-West (SW)**	**North-West (NW)**	**NE+SE**
1.	Kullu	68.46	67.24	41.43	32.03	135.71
2.	Shimla	127.11	133.05	57.78	54.66	260.16
3.	Mandi	27.43	26.20	15.69	10.21	100.18
4.	Kinnaur	32.49	38.88	20.48	11.73	71.38
5.	Chamba	24.79	38.24	21.77	4.70	63.04
6.	Sirmaur	7.29	7.32	4.41	3.22	14.62
	Total	**287.60**	**310.96**	**161.85.4**	**116.58**	**645.11**

3.4 Slope

More than half of apple orchards (52.5%) in Himachal Pradeshare located on slopes, 21-40^0.District wise distribution is shown in table 5.

Table 4 Apple area in relation to slope in Himachal Pradesh and its apple growing districts

S. No.	District	Apple area(Sq Km) in relation to slope					
		<10°	**11-20°**	**21-30°**	**31-40°**	**>40°**	**21-40°**
1.	Kullu	12.70	40.42	66.61	56.63	34.99	123.24
2.	Shimla	10.63	39.50	64.84	45.94	20.79	179.47
3.	Mandi	35.22	55.46	36.20	16.96	1.02	91.66
4.	Kinnaur	9.59	21.03	27.51	26.10	20.26	53.62
5.	Chamba	10.84	13.73	22.06	22.32	21.78	44.39
6.	Sirmaur	4.75	4.04	5.44	5.54	3.57	10.99
	Total	**83.77**	**174.21**	**222.68**	**173.47**	**102.44**	**503.39**

The maps showing distribution of apple orchards, apple orchard of different densities and apple orchards in relation to elevation, aspect and slopein Naggar block of Kullu district of Himachal Pradesh are shown in figures 1-5.

Figure 1 Naggar block showing drainage & settlements

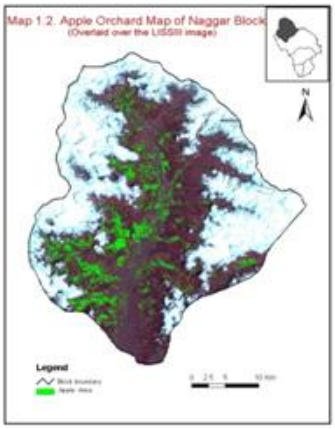

Figure 2Apple orchard map of Naggar block

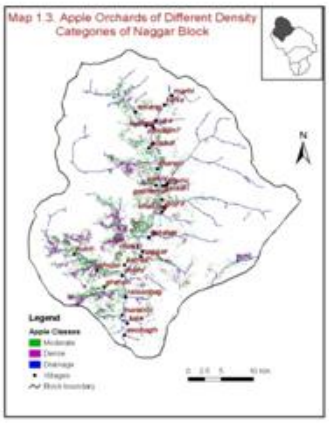

Figure 3 Apple orchard of different densities in Naggar block

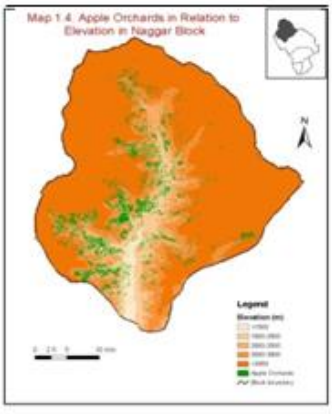

Figure 4 Apple orchards at different elevation range in Naggar block

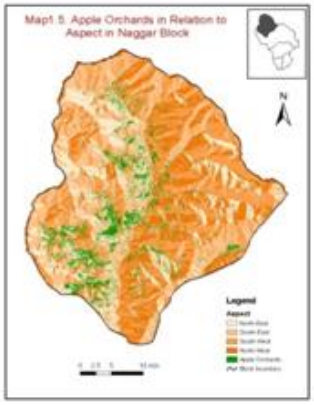

Figure 5 Apple orchards at different aspects in Naggar block

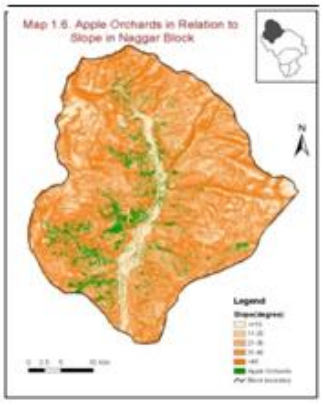

Figure 6 Apple orchards at different slopes in Naggar block

CONCLUSIONS

Apple orchards have been mapped using high resolution remote sensing data from most advance Indian Remote Sensing (IRS)satellite P6. More than ninety percent accuracy has been achieved using remote sensing data acquired during May and following a multistage classification algorithm. Normalized Difference Vegetation Index (NDVI) has been used to categorize orchards into three classes: dense, moderate and low. Accuracy of dense and moderately dense orchards has been matched with field observation with 95% accuracy. The digital elevation model derived using satellite data has been found very convenient to relate the orchards with terrain parameters. The salient results obtained are:

Total orchard area mapped in the various apple growing districts in Himachal Pradesh amounted to 950.54 Sq. Km. Elevation range 1500-2500m and Slope $21\text{-}40^0$ is supporting majority of orchards in Himachal Pradesh..Naggar block in Kullu district has large and contiguous pockets of dense orchards. The terrain parameters indicate that dense orchards lie in elevation range of 1500-2500m.Thus these sites can be used as reference sites to standardize site suitability and management plan of apple orchards. Since the density matched well with the age of the plantations, sites belonging to dense category may be ones need planning for rejuvenation. There is large scope of improving the production through development of sparse orchards.

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