Photonirvachak

Springer

J. Indian Soc. Remote Sens. (December 2008) 36:387–392

SHORT NOTE

Mapping of Apple Orchards using Remote Sensing Techniques in Cold Desert of Himachal Pradesh, India

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Received: 12 October 2006 / Accepted: 23 May 2008

Keywords Apple · Cold desert · Cash crop · Remote sensing · Indian Himalaya

Abstract The present study was conducted to map Apple orchards in dry alpine Spiti region of Indian Himalaya using LISS III satellite image. The barren terrain with sparse woody vegetation helped in classification of apple orchards with 91.3 % accuracy. The orchards were found in 154.6 ha of the study area and are anticipated to expand owing to its economic importance.

Introduction

The horticulture in India contributes significantly to Indian economy. In terms of fruit production, India stands second in the world producing 46.9 million tones fruits per year (Anonymous, 2004). Apple is one of the major components of it and is an important commercial crop of India. Along with neighbouring states of Jammu and Kashmir and Uttarakhand, Himachal Pradesh (H.P.) accounts for almost entire apple production of India. Shimla district of H.P. is the major apple producing area with 31213 ha under apple plantations (Anonymous, 1995), while it is also grown in other districts like Kullu, Chamba, Kinnaur and Mandi. Attractive margin on profit from apple production has caused replacement of many traditional crops (Saxena *et al.*, 2005), as evident from many new areas being developed as apple orchards. The Spiti valley of Lahaul-Spiti district is one such example, which is a cold desert area having peas, potato, etc. grown as cash crops. Dry scrubs and herbs dominate the area, while few tree species like *Juniperus macropoda* and *Betula utilis* are visible at scattered locations. Plantations of Salix, Populus and Robinia species have also been brought up in the valley under the Desert Development Program (DDP) launched by

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government of India (http://planningcommission.nic.in). Occurrence of apple orchards in such desert areas is a unique phenomena (Fig. 1).

Fig. 1 Apple orchard in the Spiti valley of Himachal Pradesh.

In this context, base line information on occurrence of apple orchards is imperative for understanding survival and growth patterns of apple plantation for future planning. Such information recording process has become more efficient and reliable with the advent of satellite remote sensing, which provides an opportunity for making accurate, timely and cost-effective resource evaluation (Heller and Ulliman, 1983). Realizing the importance of apple orchards, studies have been conducted in H.P. (Kimothi *et al*., 1997; Vedwan and Rhoades, 2001), which indicate that apple plantation in hilly region can be successfully mapped using satellite remote sensing. The present study thus aims to generate latest information on status of apple orchards in the Spiti valley of H.P. using satellite remote sensing techniques.

The study was carried out in Spiti valley of Himachal Pradesh, which is a sub-division of Lahaul-Spiti district. Located in western Himalayan region in India (Fig. 2), it is an integral part of Indian cold deserts. It lies between 31°42' to 32°58' N latitude and 77°21' to 78°35' E longitude and occupies an area of 5,582 km^2. It is bounded by Tibet in the north-east, Kinnaur in south-east, Kullu in west and Ladakh in north, with an average elevation of 4000 m. The area is famous for fossil-rich rocks, lakes and monasteries. Spiti River, which originates from Kunzum pass and Pin River originating from Bhava pass are the perennial sources of water in the valley. Gete (4270 m) and Kibber (4205 m) are amongst the villages in the valley located at highest elevations in world (Anonymous, 1991), which are linked with roads.

Being a part of cold deserts, the study area is characterized by harsh climatic conditions i.e. dry and cold weather, heavy snowfall, low temperature, which some times goes down to as low as –45°C and low annual rainfall (Kapadia, 1996). Due to extreme climatic situations the valley remains cut-off from the rest of the country for 6–7 months. Spiti harbours most of the commercially important medicinal and aromatic plants widely spread between sub-alpine to

Fig. 2 The study area.

dry alpine zones. The local people of the area belong to Buddhist community and they mostly grow crops like mustard, buckwheat, barley, wheat and other high yielding cash crops like green pea and potato. Besides this, apple is emerging as a new cash crop, which is gaining importance due to its high economic value and from government support for its commercialization. Apple is considered an important source to increase the economy of farmers of this tribal area. Therefore, traditional agricultural crops and arable land has now been replaced by apple orchards in lower Spiti area adjoining Kinnaur region.

The IRS 1D LISS III satellite image (Path 096, Row 048) of October 23, 2002 (Fig. 3) acquired from National Remote Sensing Centre (NRSC), Hyderabad had been used for the present study. As the minimum size of the apple orchards encountered in the study area was more than 3 hectare, LISS III image of 23.5 m spatial resolution was found to be suitable for mapping of apple orchard (Ajai, 2002). In addition, toposheets on 1:50,000 scales procured from Survey of India (SOI), Dehradun, were used for geo-referencing the satellite images. The classification of apple orchards was done using digital image processing in Erdas Imagine 8.6 software.

Initially, a reconnaissance survey of the study area was carried out to record training sites of apple orchards. The geographical co-ordinates of orchards were also recorded using GPS handset. The satellite image of the study area was geometrically corrected with reference to SOI toposheets. The image-to-image registration with 2nd degree of polynomial transformation resulted in root mean square error of less than one pixel. The image of the study area (Fig. 3) was clipped by overlaying district boundary over the georeferenced image. The satellite image was classified in to two broad classes, first containing vegetation (apple orchards, agriculture, grassland, scrubland and tree plantation), and the second containing non-vegetation classes (barren slopes, stony/rocky area, habitations, etc.). The classification was done by 'ISODATA' algorithm (ERDAS, 2001) of unsupervised classification. The

vegetation pixels were identified based on the colour, as they appear in shades of red in a colour infrared composite image. Pixels displaying colour other than red were grouped as non-vegetation class. The masking operation (Singh *et al*., 2002) was performed using vegetation class so as to get image corresponding to vegetation pixels. The image, thus obtained, was later used for vegetation classification (Kumar *et al*., 2007), which also included apple orchards, using signatures generated from training sites obtained during reconnaissance survey. The spectral signatures of apple orchards were distinct from other vegetation classes as herbs and shrubs dominate area. The continuous and homogenous agriculture fields surrounding the apple orchard showed orange tone in the image. The smooth texture of agriculture field in the image, in comparison to rough texture of orchards, also helped in its separation from apple orchards. The spectral separability of apple orchards was less only from tree plantations. But here also tree plantations appeared in darker tone in comparison to apple orchards. Besides, they also differed in their colour as plantations showed dark red colour, while apple appeared in light red to pinkish colour. The absence of woody vegetations in a cold desert area, like Spiti, facilitates the apple classification process. The barren terrain conditions and unique geological settings further serves as an added advantage.

The final classified map (Fig. 4) thus obtained represents distribution of apple orchards in the valley. The ground truthing was done to verify the classification from the ground condition. The random points were generated for apple orchard and were cross checked on the ground. The accuracy assessment performed on the above classification showed overall accuracy of 91.3%. The misclassified pixels were then masked and replaced with their accurate classes by local editing of pixels with aid of field check data.

From the present study, it is revealed that apple orchards occupy 154.6 ha of Spiti valley. It was observed that the distribution of apple orchards is confined to a small area mainly located within Tabo and Sumdo. Besides this, Lari, Sumra, Chandigarh, Hurling, etc. are some other localities in the valley, where apple orchards exist. The distribution pattern indicates that starting from Tabo apple plantations occupy sizeable area of agriculture, which is almost replaced by apple in Hurling. These orchards were found in association with habitations along the bank of Spiti river. Though a very less area is occupied by apple orchards in the study area in comparison to other apple producing areas in the

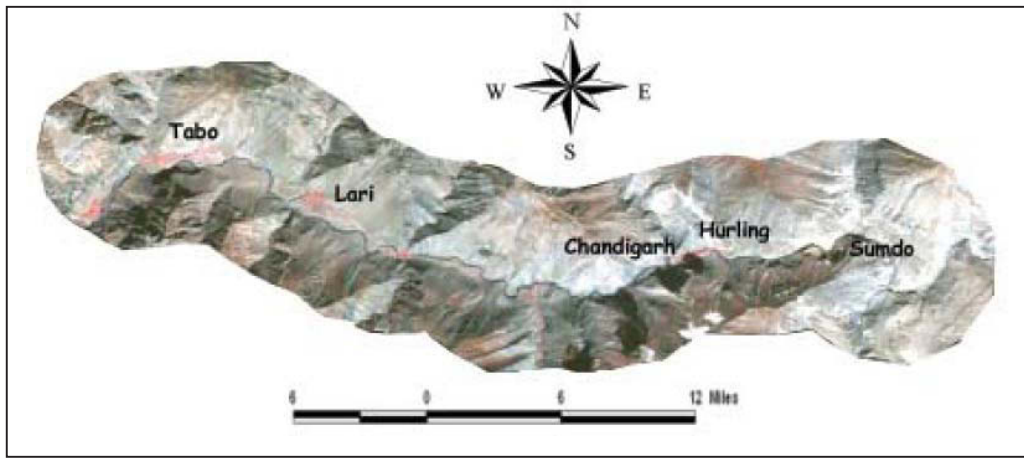

Fig. 3 IRS 1D LISS III image of the Spiti valley (H.P.).

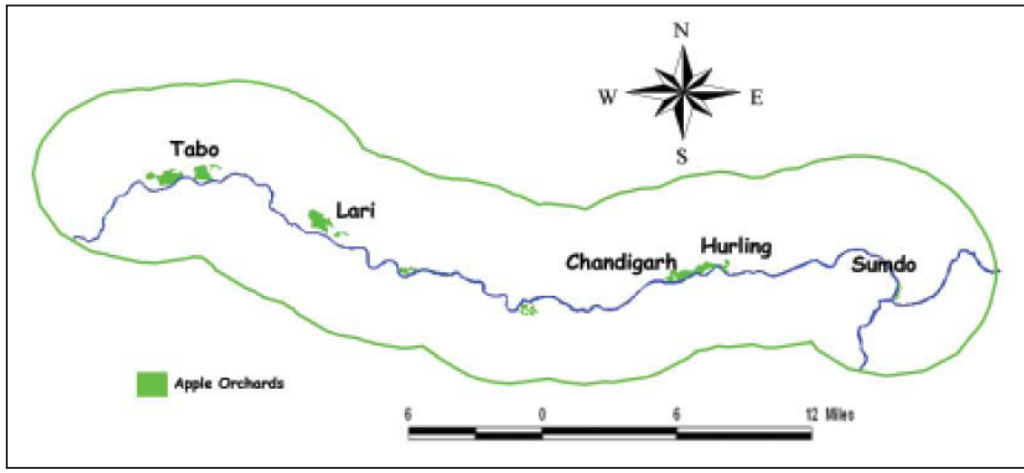

Fig. 4 Classified image showing distribution of Apple orchards in the Spiti valley (H.P.).

state, but these apple orchards are comparatively younger (Anonymous, 1991). The existence of such orchards in dry alpine conditions is unique but quite significant. These orchards are likely to be expanded to other localities in the study area and may emerge as new apple destination of the state. The presence of such orchards along with other tree plantations will not only help in improving ecology of the region but it will also augment economy of the regional community.

Acknowledgements The authors express their gratitude to P. S. Ahuja, Director, IHBT, Palampur for the support and facilities given. The authors gratefully acknowledge S. K. Uniyal and S. Rajkumar, Scientists, IHBT, Palampur for their valuable suggestions. Thanks are also due to National Bioresource Development Board (NBDB), Department of Biotechnology, Government of India, for providing financial support. This is IHBT communication number 0671.

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