can initiate corrosion in the condensation zone because of volatile decomposition products[13].

Resin fouling can be minimized by a thorough study of water quality. Routine microbiological analysis of the source water is required to avoid major complications due to bacterial fouling. In conditions wherein there is high bacterial population in the source water, effective biocidal treatment is necessary to prevent microbial fouling. Since one of the sources of nutrients for bacteria was found to be the thick algal mats growing in the flocculator of the water system, their growth should be prevented. This can be done by regular aquatic weed/algae control measures[14].

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B. ANUPKUMAR
T. S. RAO*
K. K. SATPATHY

Water and Steam Chemistry Laboratory,
Bhabha Atomic Research Centre Facilities,
Kalpakkam 603 102, India
**For correspondence*
(e-mail: subbarao@igcar.ernet.in)

Mapping of *Hippophae rhamnoides* Linn. in the adjoining areas of Kaza in Lahul and Spiti using remote sensing and GIS

Vegetation mapping in the hostile and inaccessible mountainous terrains of the Himalaya has always posed great challenge to foresters. Nevertheless, a number of researchers have undertaken such arduous mapping expeditions in the past and prepared excellent vegetation maps of these hilly terrains. However, there always existed conflicts regarding the accuracy of distribution and boundaries of such maps. This is not surprising because many of the conditions to prepare the maps were fulfilled through extrapolation and/or interpolation, as the rugged terrain forbids physical examination of every outcrop. It is in this context that the potential of remote sensing is appreciated. The greatest advantage of the satellite image is the synoptic view it provides, which gives a regional and integrated perspective of and interrelations between various land features such as vegetation cover, drainage pattern, etc. which can be better perceived on the image than on the ground[1]. This is of greater relevance in the inaccessible and difficult terrains of the Himalaya, especially in the cold barren desertic conditions of the Greater and Trans-Himalayan regions where the rocks are directly exposed to the satellite sensors.

Hippophae rhamnoides Linn. is a varying-sized shrub, with shoot often modified into spines. It is a popular plant nowadays as its berries yield isoharmnitol, while the leaves contain flavones. Plants contain steroids, terpenoids, alkaloids and sugars, fruits are rich in vitamin-C and seeds yield fatty oil. Polyphenols, quercetin and isorhamnetin have also been found. In Siberia, the plant is used for the treatment of tumours and in sun-burn preventing preparations; as emollient in the prevention of wrinkles near the eye region and in other cosmetic preparations. In China, various parts/products of the plant are utilized in medicines, skin creams, oils, jams, jellies, squashes, wines, etc.

The genus *Hippophae* is distributed in the region from Pakistan to Himachal Pradesh and Central Asia between 2100 and 3600 m on riversides. It is most commonly found at Keylong, Pooh division and Baspa valley in Kinnaur between 2800 and 4200 m and Shego, Attargu, Kumling, Rangrik, etc. in Spiti[2] (Figure 1). The shrub exhibits the following characteristic features: leaves lanceolate-linear, obtuse, with peltate and stellate scales on the lower surface. Male flowers in clusters at the bases of the shoot; petals free, suborbicular. Female flowers pedicellate in clusters 2–4; petals 3–4 mm long, united. Utricles subglobose, succulent, red or orange coloured (Figure 2). Seeds are solitary, unequally bilobed, light black and stony.

Recently the market of *Hippophae* is expanding as the traders and pharmaceutical industries in India have set their eyes on the Western Himalayas, towards the expansion of their business plans. People are thinking in terms of increasing the number of *Hippophae* plantations to have a better yield of the plant parts. The importance of the plant and its products has raised the price of its fruit from Rs 10 to Rs 15–20 per kg.

The Himachal Himalaya form a giant arcade geographical landmark with varied topographical features and widely varying altitudes and climates. There is a pronounced latitudinal succession of vegetation types with the tropical forest at the base, leading to the eternal snow on the peaks in Lahul and Spiti. There is a steppe-like vegetation, with *Artemisia*, *Caragana*, *Hippophae*, *Ephedra* and *Arenaria*. During the last few years, natives of Tabo, Pooh, Mane and Kaza have taken interest in growing moist trees such as *Salix* sp. and some plants of poplar, willow, walnut and apricot. On the mountain slopes we find juniper, wild roses, artemisias, furze, cratagus, etc. The wild ferns, e.g. Karu and Khamad are found growing along the 'nallahs' and valleys and are locally used as condiments[3].

Himachal Pradesh is a hilly state with diverse physiographic, orographic and demographic mosaic. The climatic set-up is so complex that some regions are hot tropical, while the others are dry (cool) temperate. At Spiti, the annual snowfall is 72 cm and the annual rainfall is 5 mm. The temperature fluctuates between 30.5 and – 19.5°C. Cloudy days in one year account to near about 60. Beyond the lush green glens lies the vast alpine desert that occupies an area of not less than 10,000 km^2. The mountainous terrain extends from Baralacha Pass (5333 m) in Lahul and Spiti to Kanan village of the Pooh sub-division in Kinnaur district. There is absolutely no sign of vegetation in a stretch of about 80 km, extending from Baralacha to Kunzum Pass and Losar village in Spiti. This stretch of cold desert is an integral part of Chandra valley of Lahul.

The traverse made by the Spiti river shows an intricate fabric of valleys and spurs, with very precipitous sides jutting out in every direction from the main ranges between which are located narrow ravines. The inhospitable terrain represents a barren and bewildering landscape. Lithologically, rocks are composed of diverse coloured sandstones, shales, limestone, etc. with numerous dead organisms, indicating the existence of vast sea (Tethys Sea) in the past. Barring a few patches of green along the Chandrabagha and Spiti rivers, the entire terrain is devoid of vegetation. Some of the higher valleys are covered with alpine pastures[4]. The altitude of the ranges varies from 6100 to 7000 m and many U-shaped glaciated valleys are present in them.

Ground truth is essential in any remote sensing study. It is the collection of ground information for its correlation with signature resulting in calibration of the thematic units[5]. As the desired level of detail sought from remotely-sensed data is increased, the amount and quality of the ground truth must also be increased. Intensive ground truthing and accurate measurements taken on the ground are the keystones, which lead to the better prediction of absolute results. During the field visit to Lahul and Spiti in the third week of October 2000, detailed ground truthing was carried out which led to the stratification of *Hippophae* vegetation cover.

Hard-copy outputs of the IRS 1C LISS-III data were used for the study.

Figure 1. Growth of *Hippophae rhamnoides* in the riverbeds of Spiti.

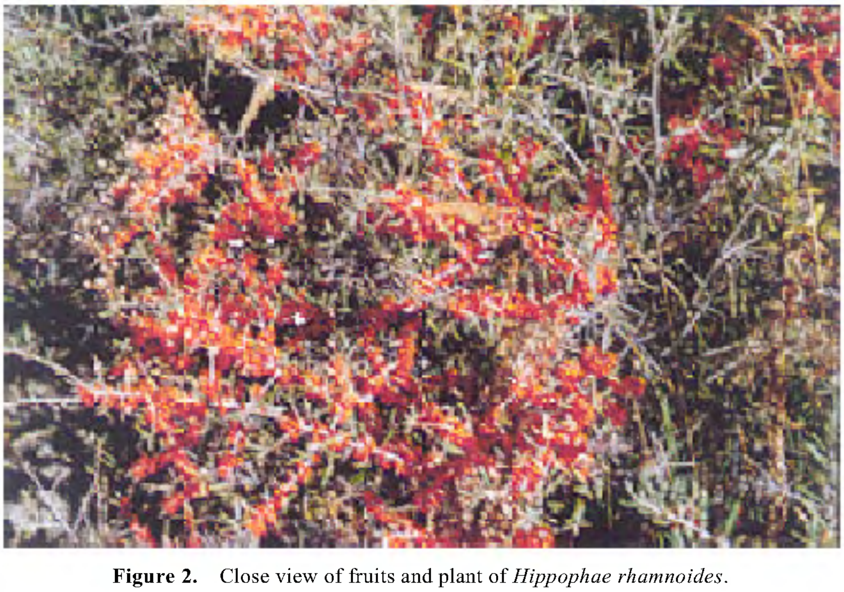

Figure 2. Close view of fruits and plant of *Hippophae rhamnoides*.

The IRS 1C LISS-III sensor provides data in four bands: two bands in visible (green: 0.52–0.59 and red: 0.62–0.68[7] microns), one band in near infrared (NIR: 0.77–0.86 microns) with a spatial resolution of 23.5 m and one in short-wave infrared (SWIR: 1.55–1.70 microns) with spatial resolution of 70.5 m. The data used in this study include IRS 1C LISS-III dated 25 June 1999. Apart from this, Survey of India topographic map was used as the reference map. The area shown in Figure 3 is the extracted portion of the satellite hard-copy data on 1 : 50,000. The IRS 1C LISS-III data have been visually studied to understand the regional set-up and the landform and land-cover pattern of the area. The subscene of 76 km^2 area covering Keuling, Seko, Lara and Lidang regions was extracted from the hard-copy satellite data.

Visual interpretation techniques coupled with extensive ground-check method and sampling were adopted to tap as much spectral variation as possible. Location was recorded using GPS[6]. The different vegetation communities present, as well as the presence of environmental conditions caused the spectral variation. However, the spectral signature of the *Hippophae* sp. does not remain the same round the year, as it follows the phenological gradient. But the season and month under consideration, best enable us to delineate *Hippophae* as it is in its fruiting stage, thereby separating it from its close associate *Salix* sp. (Figure 4). The methodology followed for information extraction from satellite image is described next.

IRS 1C LISS-III False Colour Composite (FCC) was taken to the study area and reconnaissance survey of entire area was made to correlate image characteristics and ground features. Spectral signatures of different land features were studied to prepare an interpretation key (Table 1). The final map was prepared from visual interpretation of FCC on the basis of image recognition elements (shape, size, tone, texture, association, etc.)[7]. Area of interest of 76 km^2 was extracted from the full scene on 1 : 50,000 and was scanned from the satellite data for further analysis. Arcview software was used for GIS-based inputs. SOI toposheet no. 52 L/04 was used as a reference. It was found that 0.915 km^2 of area is dominated by *Hippophae rhamnoides*. Suitable colours were assigned to different classes and a colour-coded map was obtained. After that, proper legending was done and the final classified image was prepared[7] (Figure 5).

This study has been carried out as part of an ongoing project on biodiversity characterization at landscape level using remote sensing and GIS in Himachal Pradesh, sponsored by Department of Space and Department of Biotechnology, Government of India. While the team was working in the field to collect ground truth with the hard-copy satellite data, it was observed that *Hippophae*-bearing river-beds could be delineated and mapped. Therefore, an attempt was made to correlate the image tone and texture of diffe-

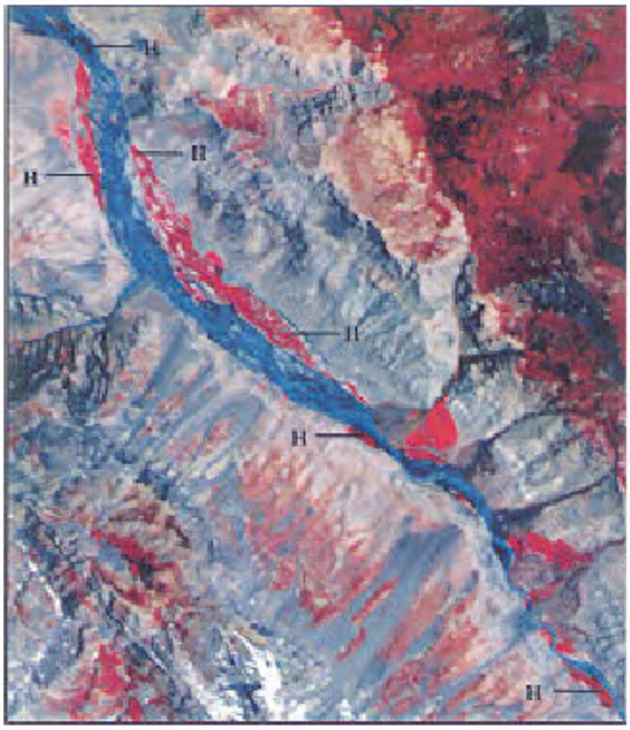

Figure 3. IRS IC LISS-III False Colour Composite (FCC) showing *Hippophae rhamnoides* (H) (Spiti river near Lara) dominating areas adjoining Kaza in Lahul and Spiti district.

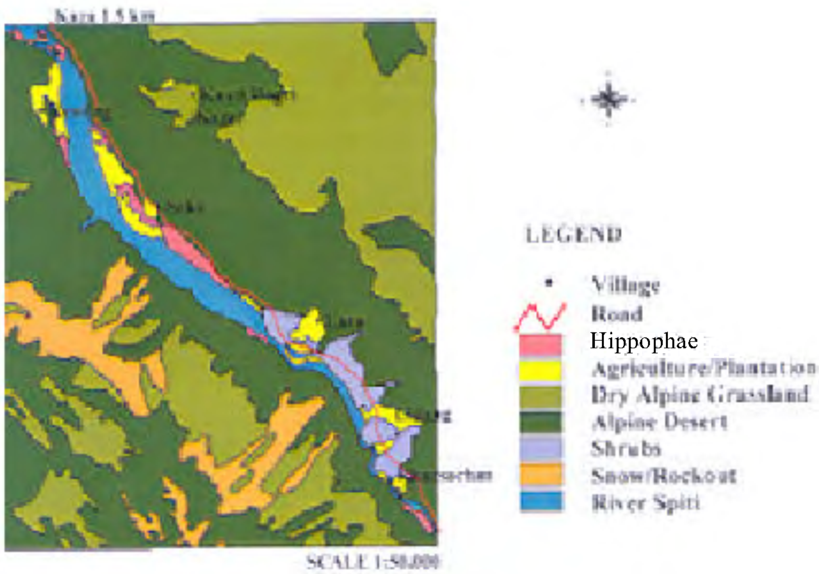

Figure 4. Classified image of Kaza and adjoining areas showing distribution of *Hippophae rhamnoides*.

rent vegetation, lithological and landform subunits bearing this species in various proportions. The *Hippophae*-bearing riverbeds were first located on ground and then efforts were made to classify and map them. This work incorporates the essence of great deal of extensive ground truthing done on the field[8]. Moreover, it should be feasible to map similar areas elsewhere using remote sensing and GIS. The use of GIS in this case was limited to digitization for classifying the satellite data. Use of GPS proved to be of paramount importance in identifying the exact locations of the *Hippophae*-bearing riverbeds.

Such a study on the inventory of *Hippophae* vegetation could prove a boon to researchers, planners, foresters and conservationists, as these open new frontiers towards the identification and mapping of economically important species and subsequently to follow conservation practices. The focus of this study has been to determine the extent to which IRS 1C/1D data can be used to delineate the *Hippophae* and to map the vegetational variations within and around them[9]. It has been observed that the high-altitude cloudless skies and the arid and less-vegetated environment provide the best possible conditions for the use of satellite data for mapping purposes in a place like Lahul and Spiti Valley, where the lithological subunits of land mass are exposed to the satellite sensors. The high-resolution IRS 1C/1D data are remarkably useful for studying remote, inaccessible regions such as Kaza and Rangrik, where field studies are logistically arduous and expensive. Considering the rich plant potential, it is recommended that the

Table 1. Interpretation key

Landcover/landuse	Tone	Texture	Shape	Associated physiography	Phenology
Hippophae	Reddish	Coarse	Irregular	In riverbed	Green
Salix sp. (plantation)	Brownish-red	Coarse	Irregular	In and along riverbed	Green
Agriculture	Dark orange	Smooth	Irregular	Near river	Ploughed fields
Dry alpine grassland	Reddish-orange	Coarse	Irregular	Higher elevation	Dirty green
Alpine desert	Greyish-blue	Smooth	Irregular	High elevation	*
Shrub	Light grey	Smooth	Irregular	Along riverside	Green
Rockout	Blue	Coarse	Irregular	Low–high	*
River	Blue	Smooth	Irregular	Low–high	*
Snow	White	Smooth	Irregular	High	*

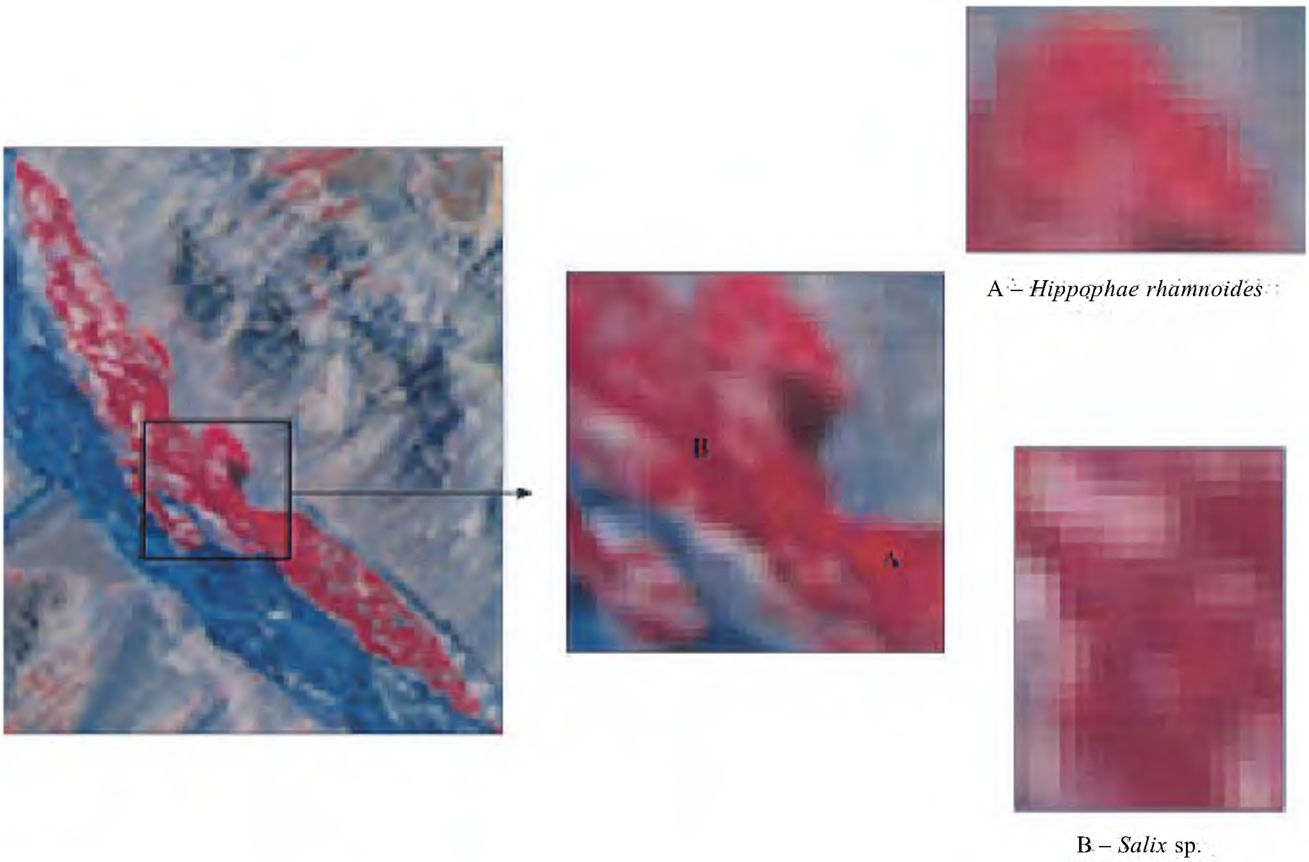

Figure 5. Images showing spectral variation between (A) *Hippophae rhamnoides* and (B) adjoining *Salix* sp.

survey of the plant wealth be conducted and priority be given to areas which are especially rich in genetic diversity. The survey, however, should not be merely taxonomic, but a dynamic one carried out by multidisciplinary field parties with the objectives of identifying the contributions which the proper exploitation of plant wealth can make to medicine, agriculture, forestry and other allied fields[10]. Stress should also be laid to survey the less-known wild plants, which the tribal people use to supplement their diet, especially during the long winters or in times of stress[11]. Information on distribution and structure of medicinally important plants obtained from interpretations of the IRS 1C/1D images in conjunction with ground data is being used to strengthen the ongoing studies of the economically important plant species.

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P. S. Roy*
M. C. Porwal
Lalit Sharma

Forestry and Ecology Division,
Indian Institute of Remote Sensing (NRSA),
Dehra Dun 248 001, India
**For correspondence*
(e-mail: dean@iirs.gov.in)

Inheritance of protein markers detecting polymorphism among rice genotypes with contrasting host response to green leafhopper

Green leafhopper (GLH) [*Nephotettix virescens* (Distant)] is one of the most destructive insect pests of rice throughout south and south-east Asia. It damages the crop as a pest by direct feeding and as a vector of rice tungro virus causing yield losses even up to 100% during tungro epidemics[1]. Host plant resistance is widely recognized as the reliable strategy to contain this pest, given the fact that diverse sources of resistance are available. Eight genes conferring resistance to GLH have so far been identified[2,3]. An attempt earlier by the authors to relate resistance–susceptibility of rice varieties to GLH with protein markers revealed the presence of the polypeptides of molecular weight 46.8, 42.7 and 33.9 kD together to be associated with susceptibility and their absence with resistance[4]. Although these polymorphic polypeptides could be used for detection of hybridity in GLH resistance breeding programme, understanding the mode of inheritance is necessary for using them as reliable markers in the selection process. Keeping this in view, a cross between the susceptible variety T(N)1 and resistant variety IET 15120, which differs distinctly in the expression of the three polypeptides was made and studied in the F_2 for both phenotypic response to the pest and electrophoretic analysis of seed proteins. Individual F_2 seeds were cut into two halves, of which the one with the embryo was grown into plants for screening against GLH at tillering stage by adopting tiller test method of screening[5], while the other de-embryonated half was used for extraction of seed proteins for electrophoresis.

Total proteins were extracted by suspending seed flour obtained from grinding individual F_2 seeds and the two parents in 50 μl of 0.5 M NaCl (pH 2.4) for 30 min at room temperature with intermittent mixing at an interval of 10 min. The suspension was centrifuged at 12,000 rpm at 10°C for 5 min. An aliquot (25 μl) of the supernatant was uniformly mixed with an equal volume of cracking buffer containing 0.125 M Tris HCl (pH 6.8), 4% SDS, 20% glycerol, 10% 2-mercaptoethanol and 0.01% bromophenol blue followed by denaturation in hot waterbath at 100°C for 1 min. SDS-PAGE of denatured protein samples was carried out[6]. Each sample (25 μl) was loaded in a lane of one-dimensional, 1 mm thick, 12% SDS-polyacrylamide gel and electrophoresed in a buffer containing 0.025 M Tris (pH 8.3), 0.192 M glycine and 0.1% SDS for 9 h at 50 V. The gels were stained in 0.125% Coomassie brilliant blue, destained, photographed and scored.

Phenotypic evaluation of the F_2 population against GLH suggested a single dominant gene to confer susceptibility. The χ^2 test confirmed the segregation ratio of 3S : 1R ($\chi^2 = 2.285$ with $P =$