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LANDUSE MAPPING OF TAWI CATCHMENT USING SATELLITE DATA

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PREFACE

Landuse and landcover are the most important surface characteristics of a catchment .Various aspects of hydrologic studies can be undertaken if information on landuse and landcover are available for a catchment.Various hydrologic processes such as interception,infiltration ,evapotranspiration,soil moisture and ground water recharge are influenced by landuse /landcover characteristics of a catchment.

The National institute of Hydrology engages in constituting studies and research in the area of hydrology. At the regional centre of Institute at Jammu ,remote sensing application in hydrological studies are also undertaken.For the present study Tawi catchment upto Jammu has been chosen for preparation of landuse map using satellite data.This area has been chosen as a number of irrigation projects are being developed in the area and for carrying out hydrologic modelling of the catchment.Visual as well as digital analysis have been carried for the preparation of landuse map. Digital analysis has been carried out on ERDAS system available at the Institute.

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ABSTRACT

Landuse and landcover exerts considerable influence in determining various hydrologic phenomena such as infilteration overland flow,evaporation and interception.Various aspects of hydrologic studies can be undertaken if information on landuse/landcover are available for a catchment. In the present study a landuse .In the present study a landuse map of Tawi catchment upto Jammu has been prepared by visual interpretation and digital analysis of CCT data.

The Tawi catchment considered for the present study extends from 32° 35′ to 33°15′ north latitude and 74° 45′ to 75° 45′ east longitude.The Tawi river,,one of the tributary of the Chenab river,originates from Kalikundi glacier.The area is covered in one frame of IRS-1A ,LISS-I data path and row no. 32/44. The various categories of landuse in the area recognised by visual interpretation and digital processing are :vegetation,Barren,Degraded,Snow,Built-up. Results obtained through both the techniques are quite similar.In digital image analysis result obtained from supervised classification are better than unsupervised classification. The difference between the results of visual and digital processing has been minor.

1.0 INTRODUCTION

Information on the rate of change in the use of land resources is essential for their proper planning and management. Land use includes every kind of vegetation and non agriculture uses viz, water surfaces and impervious surfaces etc. The term land cover relates to the type of feature present on the surface of the earth. Urban buildings, lakes, glacial ice etc. are all examples of landcover types.

The landuse change have a direct bearing on the hydrologic cycle. The effects of landuse on the processes of hydrologic cycle are realised from the point the precipitation reaches the earth surface. Various hydrological processes such as interception, infiltration, evapotranspiration, soil moisture, run-off and ground water recharge are influenced by landuse/landcover characteristics of a catchment.

The type of landuse thus plays an important role in the hydrologic cycle and the effects of landuse alterations are reflected in the various hydrological processes. The traditional methods of monitoring changes in the landuse and drainage pattern are field methods and large scale aerial photography, which is time consuming and expensive. Moreover such techniques are valuable where environmental changes are localized to small sites and conveniently situated with respect to access. Further ground survey methods become tedious in mountainous regions as compared to mapping in plains. It is also difficult to get real time information through conventional means since landuse are dynamic features over space and time. Satellite imagery provide up-to-

date landuse and drainage pattern information, at desired scales at reasonably low cost and better accuracy. It is generally agreed that valuable landuse maps can be produced from satellite data at 1:50,000 and 1:250,000 scales at low cost. The informations as bare rock, forest, shrubs, grass lands, agriculture, residential, wet land etc. can be obtained from the satellite imageries and aerial photograph. Remote Sensing technique offers some main advantages as described below:-

i) collection of relevant data at a faster speed.
ii) Multidate data availability
iii) Synoptic viewing of areas.
iv) Multispectral scanning
v) Repetitive and real time information.
vi) Quick response and continuous data collection.
vii) In case of disasters and natural hazards, availability of quick and point data.
viii) Quick processing of data

Due to these advantages remote sensing data provide an unique platform to study the land and water resources of a particular area in its totality and as an entity.

Digital processing of the CCT data has the added capability of examining a large quantity of data and objectively classifying it quickly according to the guide lines established by pattern recognition algorithms and by analyst.This processing of spectral data based on pattern recognition technique either utilize unsupervised classification or supervised classification.It has been observed that computer aided classification gives fairly

accurate results where ground features are spectrally seperable.When there is a mixing of spectral responses the accuracy detoriates.

2.0 REVIEW

A number of studies have been conducted to map the landuse using aerial photographs and satellite imagery. Extensive landuse studies have been carried out by various agencies like NRSA, SAC, CSRE, IIRS and others in one or the other part of the country. It has been seen that both digital and visual analyses have capabilities of identifying different categories of land use/landcover.

Anderson, Baker (1971,79) proposed a classification scheme for landuse at scale ranging from 1:250,000 to 1:100,000 . The scheme has following categories of landuse (i) Agriculture (ii) Grazing land (iii) Forestry (iv) Mining and quarrying (v) Urban activity (vi) Transportations communication and utilities (vii) Recreational. (viii) Low activity areas (ix) water bodies. Anderson also gave modified schemes, which could be used at a scale of 1:250,000 to 1: 100,000 with little ground truth. Anderson etal (1972) suggested a landuse classification system in which remote sensing data was used.This system is used in majority of the countries in the world.

In the international symposium on remote sensing for observation and inventory of earth resources and endangered environment held at Feiburg, Miller and William (1978) gave the opinion that the greatest potential for the sustained application of landsat imagery is in monitoring the areas where landuse and landcover is subjected to rapid iterations by either natural or manmade activities. Preparation of sampling designs to test the landuse map accuracy was carried out by Hay(1979) using Landsat

data.

Sita Ram etal (1982) used aerial photographs on scale 1:60,000 for examining landscape characteristics, drainage pattern and present landuse on analysis of photo elements viz tone, texture, pattern, size and shape and their correlation with ground truth data.

K.P. Sharma et al. (1984) prepared a landuse and landcover maps for Dehradun - Roorkee region using visual interpretation technique. Area of each landuse/landcover category was determined for the year Dec. 1972 and April 1977.

Seshagiri etal (1985) have used different techniques of airphoto interpretation and remote sensing in the evaluation of land resources for working out development plans for Mahaboobnagar of 1:20,000 scale and Landsat data of 4,5 & 7 bands and also colour composition in 1:250,000 scales have been used for this study. The data acquired through conventional field work at rapid reconnaissance survey level is taken as a base for comparison.

Gupta and Rao (1985) reported that in a semi-arid tract of Rajasthan as many as 21 landuse, and soil classes could be recog nised in a linear stretched FCC. The study could also bring out the newly forested areas.Natrajan et al (1986) used landsat imagery of 1:250,000 scale (band 5&7) and 1:1 m (FCC) for delineating the physiographic units covering 1611 sq kms. in Mewat area of Haryana. The overlays of landuse and landforms delineated from band 5 and water bodies, old channels and water logged areas delineated from band 7, were used to prepare a generalized soil and landuse map on 1:250,000. The FCC imagery at

1:100,0000 scale was used for comparison and to help in delineating the physiographic boundaries.

M.C porwal etal (1988) prepared a forest composition cover type map using Landsat TM FCC on 1:250,000 scale. Landsat TM FCC have been visually interpreted for delineation of forest cover type identified on the basis of tone/colour, texture pattern and correlated with geographical location.

D.R.Singh etal (1988) carried out visual as well as digital analysis for a part of landsat scene (path and row 157/039). The study covered 344.89 sq. km of Paonta Sahib area, a part of Doon valley, representing different types of physiography, soils, landuse and varied crops as well as natural vegetation. on the basis of this study it was included that maximum likelihood classification was more accurate for mapping of various landuse/landcover classes as compared to minimum distance and parallelepiped classifier programs.

Inderjeet Singh (1989), carried out study on forest cover type and landuse classes in Ranikhet tehsil of U.P. This study highlights the potential of remote sensing techeniuqe for monitoring the changes in forest cover and landuse classes.

S K Pathan etal (1991) have carried out urban landuse mapping of forest cover and landuse classes of Ahemedabad city and its environs. In this study visual and digital both techniques were applied. Spatial distribution of various urban uses and the space devoted to each urban landuse has been broughtout.

V.K.Choubey (1990) has carried out hydrological landuse mapping of Malaprabha and Ghatprabha catchments of Krishna basin.Based on the study ,the recommended landuse for both catchments taken into account the suitability of soils,its erosion status,the availability of ground water potential and the existing landuse practices in the area.

A.K.Bhar et al (1987) prepared a landuse map of upper Yamuna catchment using remotely sensed data.Six landuse categories of hydrologic importance deciphered from the imagery.In order to minimise the effect of sun shadow in digital processing ,the 2 MSS2/MSS4 band ratio image file found to be workable though could not eliminate the same completely.

V.K.Choubey et al (1989) carried out study on landuse of Sabarmati basin using multi band landsat imagery.Seven landuse categories were identified from the imagery.

3.0 STATEMENT OF THE PROBLEM

Purposeful and effective application of land management require the collection and organization of much information regarding characteristics and use capabilities of land. The purpose of developing a landuse map is to present available data in a simple and practical way for applications to landuse planning and to indicate the most intensive, profitable and safe way to which the land could be put to use.

A collative use of topographical maps and IRS-1 A imageries has been made in the present study. Topographical maps of the area have acted as guide maps. The Tawi catchment has been chosen for the present study as a number of irrigation projects are being developed in the area.Landuse/Landcover of the catchment is required for various hydrological studies . This study was carried out using visual and digital processing.

4. DESCRIPTION OF THE STUDY AREA

The river Tawi is one of the main tributaries of the river chenab. It rises form the lapse of Himalayan glacier at a place named Kalikundi and adjoining area, situated on the south west of Bhaderwah in the Doda distt.The Tawi catchment which has been chosen for the present study extends from $32^{\circ}35' - 33^{\circ}15'$ north latitude and $74^{\circ}45' - 75^{\circ}45'$ east longitude. The catchment upto Jammu is considered for this study.The basin shape in the upper part is elongated while broad in the lower part. The upper portion of the basin is characterised by rugged mountainous topography , whereas lower basin consists of low hills and aggradational plain. The average height of the basin is about 2200 m above mean sea level.The slope of the basin is from east to west in the upper part , while north east to south west in the lower part.The catchment of Tawi river upto Jammu is about 1900 sq. kms falls mostly within the districts of Jammu,Udhampur and a small portion of Doda in Jammu region of J&K state.

Climatically the region is exposed to extra tropical type of climate in the upper part and monsoon type in the lower part . Annual precipitation is about 100 cm. over the plain (Jammu).From here it increases rapidly towards north east with increasing elevation till the Pirpanjal is reached where it exceeds 150 cm. According to district wise distribution annual rainfall varies from 90 to 100 cm over Jammu distt. , from 140 to 190 cm over Udhampur and from 90 to 140 cm over Doda distt. By and large middle portion of the Tawi catchment records heaviest rainfall over the catchment. Geologically Western Himalayas described

as lying within moving belts of earth's crest.Tawi catchment mainly consists of shivaliks,murree and granite intrusions.Tawi catchment has three meso geomorphic regions:kaplas granite zone from kaplas range to panjal thrust with maximum elevation of 4000 m., thrust zone from panjal thrust to Udhampur thrust with elevation of 700 m. to 1900 m. and shivalik zone lying between Udhampur thrust and Jammu.Most of this region consists of hilly as well as plain areas. Only a small portion of Tawi catchment at its origin from the Kalikundi glacier is snowfed.

5.0 AVAILABILITY OF DATA

The study area is covered under two frames of IRS-IA,LISS-II imageries and one frame of LISS-I. The imageries which were used for the present study are given below :-

Table:1 IRS data used in the analysis

S.No.	Path/Row	Date	Satellite	Bands	FCC
1.	032/44 A2	Dec.,1989	IRS-1A LII	2,3,4	FCC
2.	032/44 B2	Dec.,1989	IRS-1A LII	2,3,4	FCC
3.	032/44	Dec.,1989	IRS-1A LI	1,3,4	CCT

A base map of the study area showing drainage pattern was prepared using Survey of India topographic maps at 1:250,000 scale (fig.1) The toposheets used are 43 K,L,O and P.

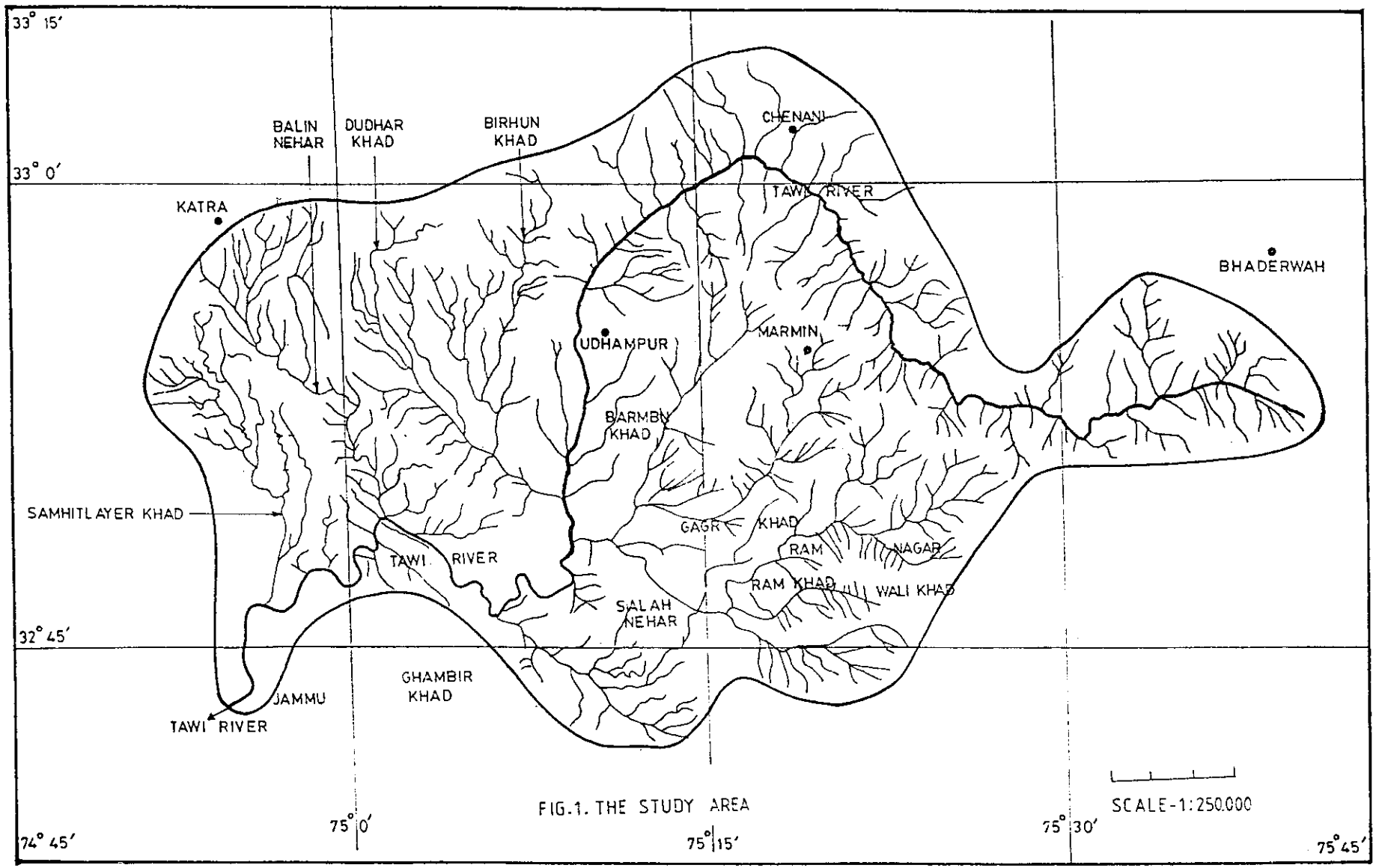

FIG.1. THE STUDY AREA

6.0 METHODOLOGY

In the present study visual as well as digital analyses have been carried out for the area using data available. The FCC of bands 2,3 and 4 were used for visual interpretation. In this techniques with the help of light table 2 X prints of IRS-IA LISS-II were analyzed. Six landuse categories were demarcated on the map. These categories are vegetation, degraded, barren,sand, snow and built up.

Digital analysis of the area has been carried out using Earth Resources data Analysis System (ERDAS).This system is a PC based system having image processing and basic GIS utilities. ERDAS-7.5 soft ware contains a variety of modules that can be used independently or combined ERDAS programs with in each module are accessible through a series of menus.This system can be installed on a variety of hardwares and operating systems.IMAGRAPH display device which can display upto 1024 * 1024 pixels display resolution with 32 bit image depth,out of which 24 bits as image planes (3*8 bit colour guns i.e. red ,green and blue), 4 bits as overlay plane and 4 bits as blank overlay which is useful to toggle the overlay. Digital Image Processing has some advantages and they are as follows:

i) Utilization of entire dynamic radiometric range of sensor data (i) integration and simultaneous utilization of different spectral bands data for classification purposes. Digital format provides a convenient way to transmit, store, retrieve and use image data. Further digital data can be subjected to different processing algorithms keeping the original data intact.For the present study area comprising the Tawi catchment has been

extracted from the CCT data of Dec.,1989.From this extracted boundary of the Tawi catchment was digitized .Then with the help of digitized map Tawi catchment has been extracted.The following processes has been carried out for Tawi catchment.

The multi spectral image data is usually strongly correlated from one band to the other. Principal component Analysis (PC) is a statistical technique used to produce uncorrelated set of bands from given set of bands. This transformation compresses whole of the information contained in the original multiband data set into fewer new channels or component and making the correlation zero. Principal component transformations are used for spectral pattern recognition as well as image enhancement.

One of the most widely used and accepted application of pattern recognition techniques to digital image processing has been the assignment of picture elements (pixels) to various categories through multispectral classification. This technique convert raw satellite digital data into meaningful information which will be useful for quantitative analysis of remote sensing data. Pattern recognition techniques are used for computer aided demarcation of land use; but the efficacy of these techniques depend upon the spectral contrast between various features. Pattern recognition techniques are broadly divided into two types : supervised and unsupervised.

In the supervised classification ,the identity and location of some of the land cover types must be known a priori through a combination of field work,analysis of aerial photographs and personal experience. The analysis is attempted after locating specific sites in remotely sensed data that represent homogenous

examples of the known landcover sites. These homogenous areas are commonly termed as training sites because,their spectral characteristics are used to train the classification algorithm for landcover mapping of remainder image. Multivariate image parameters (means,standard deviations ,covariance matrices and correlation matrices etc.) are calculated for each training sites,which are further used for classifying the pixels ,within and outside training area to assign the class of which it has the highest likelyhood ,there are three well established algorithms such as minimum distance to mean,parrellopiped and maximum liklehood .

In unsupervised classification a computer algorithm is employed which locates and groups the naturally occurring concentrations of similar features from any given heterogeneous sample of pixels.This approach is preferred when ground truth is lacking, or surface features within the scene are not well defined.Normally this procedure is a two pass method. In first pass ,the program reads the data set and sequentially builds the clusters. A mean vector is associated with every cluter.While ,in second pass the whole process is repeated on a pixel to pixel basis,assigning it to a class based on minimum distance to means algorithm.

7.0 ANALYSIS AND RESULTS

Visual image interpretation and Digital image processing have been carried out for the study area.

7.1 Visual Image Interpretation

Using the elements of image interpretation, the various categories of Land use/landcover were identified. The information from toposheets and other available map provided limited ground truth.The characteristics features of the different class used as keys in interpretation are given in table 2. Table 2 : Signature of various landuse categories on satellite images

S.No.	Category	Colour in FCC
1.	Vegetation/forest	Red
2.	Barren with sparse Vegetation	Yellow to light brown
3.	Sandy/gravely river bed	Light bluish to white
4.	Snow	white
5.	Shadow	black
6.	Degraded	bluish

The landuse/landcover information in the form of map is shown in fig.2. The classes which have been demarcated are built up area, forest, degraded, snow, sand and barren.Percentages of the area covered by these classes are given in table no.3. The landuse map of the catchment reveals the following general trend of landuse distributions.

(a) A small portion of the catchment at higher reaches of the catchment, at about an altitude of 4000 m., is snow covered.

(b) The ridges and shivaliks have a thick vegetation.

(c) In the middle of the Tawi river the area around is degraded or very less vegetation cover is available.

(d) Some portion of the catchment is not clearly visible due to shadow effect. On the basis of the nearby area we can say the area is under vegetation , and this is also verified with the result of digital processing (7.2).

7.2 Digital processing of CCT Data.

For carrying out digital image processing a subscene covering Tawi catchment has been extracted to identify, delineate and classify various landuse categories.

The Earth Resources Data Analysis System (ERDAS) was used for carrying digital image processing.

Contrast stretched (linear stretching) product has been generated and FCC of bands 1,3, and 4 is shown in fig. 3 . The output product exhibit good contrast between various land uses. Different types of colour composite, could be prepared using the linear stretched data. These images are useful to select the training window for supervised classification.

Principal component analysis has been carried out on the image of the study area. The classes under consideration are clearly differentiable in the contrast stretched image.Various classes are clearly interpretable on FCC of PC1,PC2 and PC 3 compared to FCC of raw data. In this study PRINCE module is used for generating the principal component image and FCC of principal component (PC1,PC2 and PC3) is shown in fig. 4.

Pattern recognition technique like supervised and unsupervised classification were carried on the image for classification of the study area. The ISODATA method for unsupervised classification was used which is an iterative clustering method based on K-means algorithm.The input to this method are the number of classes ,threshold on the minimum distance between two clusters and a threshold in terms of standard deviation within each band fro each class so that a cluster with too much variability is split in two, and a maximum number of clusters which can be merged at any iteration,to avoid overmerging .Using this program 20 spectral classes were generated after a 15 numbers of iterations.The classification of each cluster was displayed and each class evaluated visually. The merging of the similar clusters was done using RECODE program. After this using COLORMOD module different classes were given colours and final output is shown in fig. 5. Various landuse categories classified through the unsupervised classification and percentage of the the area under each category is presented in table no. 3.

In the supervised classification training sets of various classes were fed to computer for use in the classification algorithm. SEED program was used for developing a training set . After this training sets of same classes were merged using SIGMAN program. Later the spectral seperability ellipse were plotted using ELLIPSE program for checking the accuracy of training sets. Finally using the training sets file and maximum likelihood algorithm the area was classified. The result of supervised

classification is shown in fig. 6 and area under each category is presented in table no. 3.

In unsupervised classification two classes sand and built up are not clearly visible and they are merged with other classes.Area under other six classes are quite comparable with supervised classification.

Table no. 3 : Percentage of area covered by each class

Description of each class	Percentage of the area under the class		
	Visual interpretation	Digital processing	
		Supervised	Unsupervised
1. Vegetation	44.15	23.33	29.93
2. Barren	16.69	14.34	12.35
3. Degraded1	24.70	28.84	27.83
4. Degraded2	11.01	15.09	13.71
5. Sand	1.39	1.47	Nil
6. Snow	1.20	1.02	0.99
7. Built-up	0.86	1.09	Nil
8. Shadow	-	14.82	15.17

From the results given in the table above difference in the visual ,supervised and unsupervised analysis is minor.In case of vegetation under visual processing area of shadow is merged in this class due to which its percentage is higher.

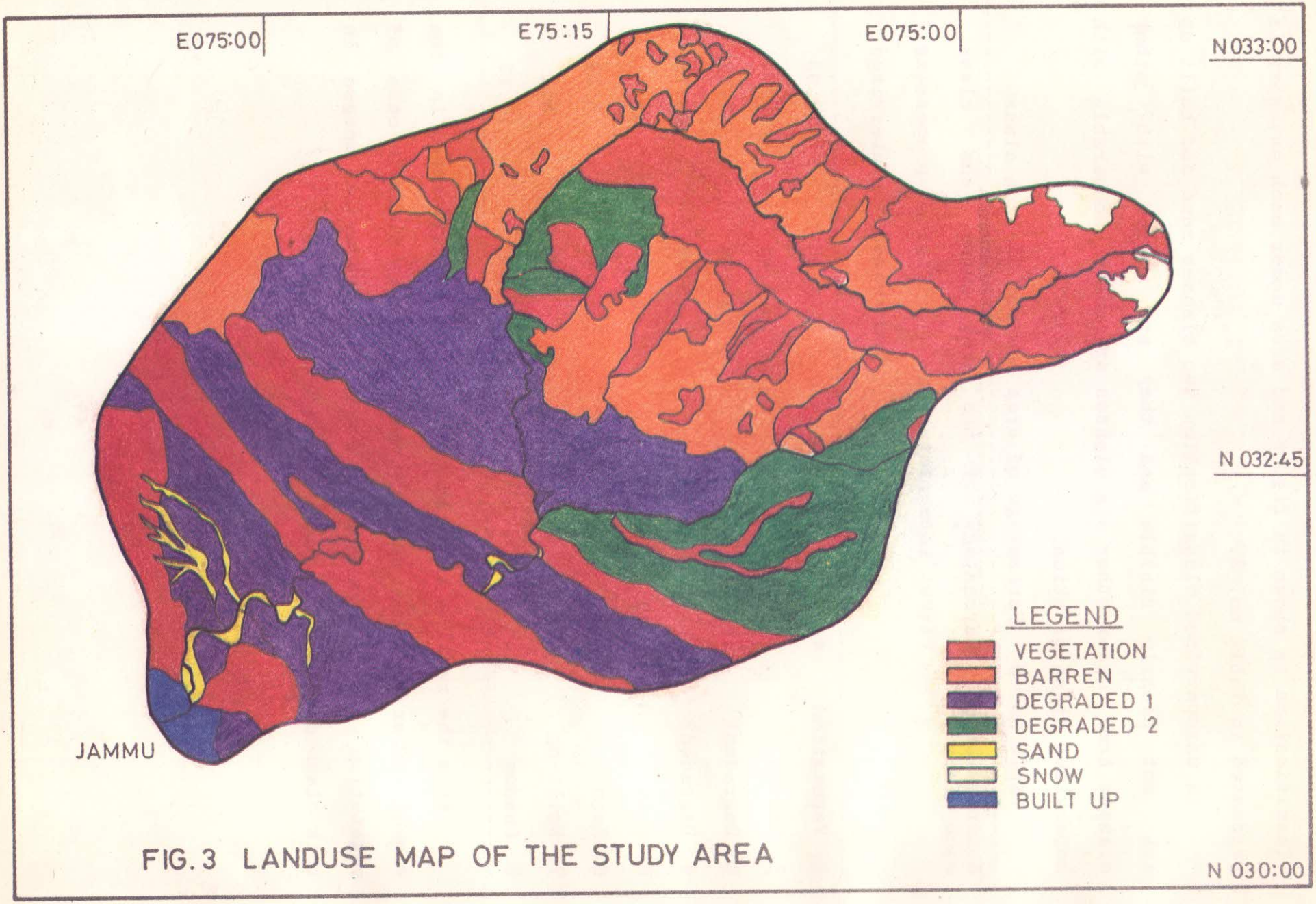

FIG. 3 LANDUSE MAP OF THE STUDY AREA

Fig. 3 FCC of IRS-IA LISS-IA data bands 1,3 & 4

Fig.4 FCC of Principal components (PC1,PC2 and PC3)

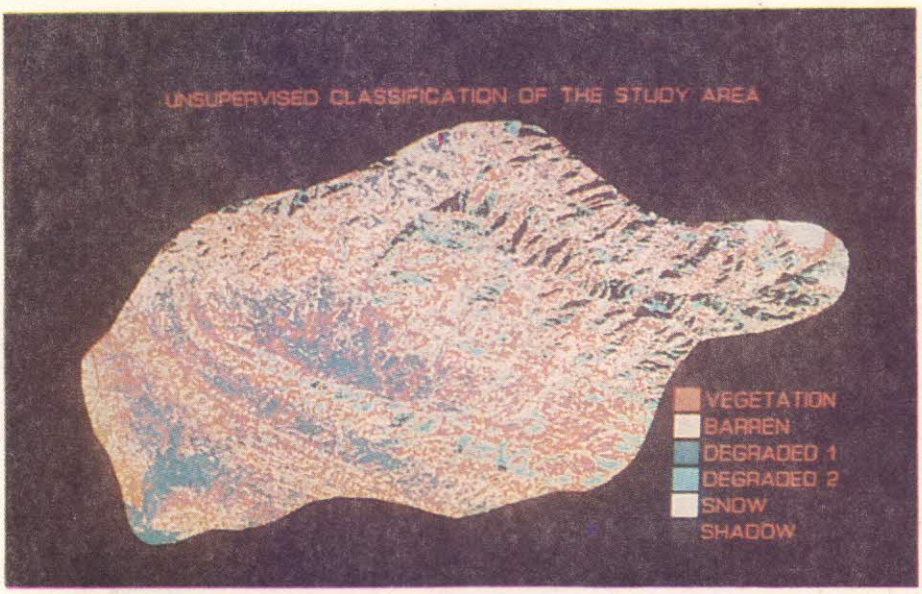

Fig.5 Unsupervised classification of the study area

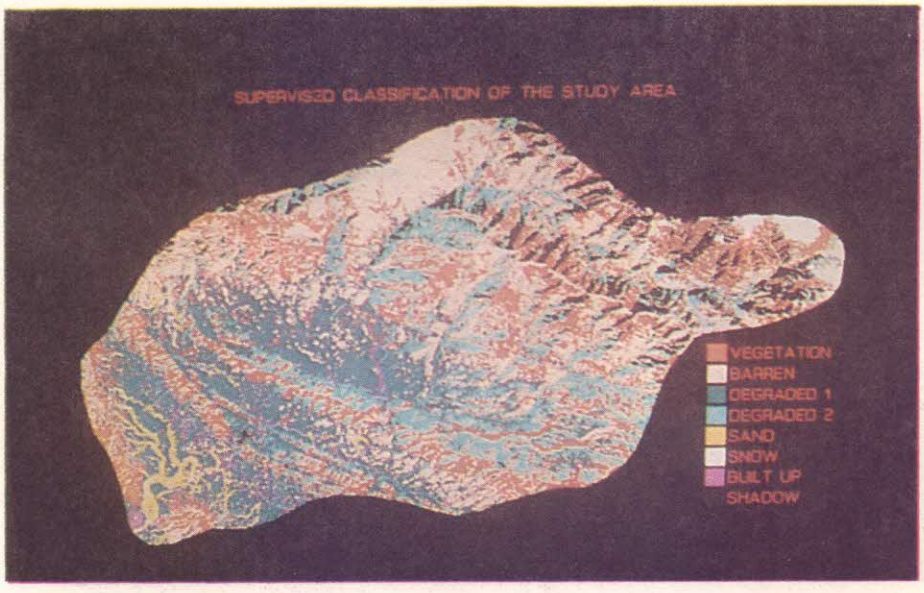

Fig.6 Supervised classification of the study area

8.0 CONCLUSION

The landuse map of the Tawi catchment upto Jammu has been prepared using visual interpretation as well as digital processing. Six landuse categories have been identified from the imagery which are vegetation ,barren,degraded ,built-up,snow and sand. Degraded land constitute the main part in the area. The vegetation is dominant on ridges and in the Shivalik range snow is only prominent in the upper part of the catchment . Supervised classification of CCT data has given better results than unsupervised classifiaction.Precentage of the different classes using visual interpretation and digital analysis are quite comparable. The difference between visual and digital processing has been minor except in the case of vegetation.In case of visual analysis area of shadow is merged with vegetation that is why its area is more in visual analysis.

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