CS-116

THE STUDY OF THE EFFECT OF TRANSFORMATIONS FOR LANDUSE CLASSIFICATION IN DEHRADUN

SATISH CHANDRA

DIRECTOR

STUDY GROUP

ANIL KUMAR

NATIONAL INSTITUTE OF HYDROLOGY

JAL VIGYAN BHAWAN

ROORKEE - 2476 67

INDIA

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SUMMARY

The utility of satellite data for multiple earth resources applications is the beginning to unfold the informationin in the areas, such as agriculture, landuse, water resources, forestry and other allied subjects. The potential of these data for landuse studies had started in recent years and there is notable increase in the acceptance and utilization of Landsat and IRS data for landuse mapping. The latest IRS sensors contain new designs like the LISS II and the special cameras which allows the improvement of computational uses for image and pattern analysis.

The purpose of this report is to apply the recent digital image processing technique for preparing the landuse classifiaction map. In view of the rapid development in image processing, pattern recognition, artificial intelligence and data base systems applicable to integrated (RS+GIS) remote sensing data processing. With these advancement in image processing techniques, so many new technique is coming out and it is very difficult to say what would be the effect of a particular transformation for any particular study. Therefore, two frame one in plane and another in hilly areas, to see the effect of various transformations have been selected. Only those transformations have been explained, whom results are found to be significant in this study.

This is not possible to differentiate among the various landuse classes from the available channel of a remote sensing satellite. Therefore, additional images will be created by applying the various image processing technique and the same training and checking sample set will be used with the newly created images by various transformations. The classification had

been done by running the Box classifier and Maximum likelyhood classifier and the confusion matrix had been prepared by running the confmat program in the ILWIS software.

This report will be useful for the people who need an insight into the actual working of remote sensing data processing for direct involvement in their work environment, i.e. research scientist and teaching staff at university level.

Satish Chandra
(SATISH CHANDRA)
DIRECTOR

CONTENTS

	PAGE
LIST OF FIGURES	i
LIST OF TABLES	ii
SUMMARY	iii
1. INTRODUCTION	1
1.1 Objective	1
1.2 Project Area	2
1.3 Landuse	3
2. DATA USED	3
2.1 Equipment	4
3. PROCEDURE	4
4. CLASSES	6
5. DESCRIPTION ABOUT VARIOUS TRANSFORMATIONS	7
6. CONCLUSIONS	9
REFERENCES	12

LIST OF FIGURES

Figure1: Landuse map around Dehradun of Nov. 1972

Figure2: Showing the difference between city and irrigated area by various transformations by, visual interpretation.

Figure 3: Showing the difference between River 2, Landuse and Waterlogged area by various transformations, by visual interpretation.

Figure4: Shows the effect of various transformations in hilly area.

Figure 5: False colcur composit (4,5,7) around Dehradun.

LIST OF TABLES

Table 1.1: Confusion matrix with band 4,5,6 and 7 Images.

Table 1.2: Confusion matrix with PC1, PC2 and PC3 Images.

Table 1.3: Confusion matrix with b47, b57, b45 Images.

Table 1.4: Confusion matrix with b4n, b5n, b7n Images.

Table 1.5: Confusion matrix with m1 and m2 Images.

Table 2.1: Confusion matrix with band 4,5,6 and 7 Images.

Table 2.2: Confusion matrix with PC1, PC2 and PC3 Images.

Table 2.3: Confusion matrix with b47, b57 and b45 Images.

Table 2.4: Confusion matrix with b4n, b5n and b7n Images.

Table 2.5: Confusion matrix with m1 and m2 Images.

1.0 INTRODUCTION

The systematic earth orbital observations began in the year 1960 with the launch of (TIROS-1), the first meteorological satellite. Latter on the first Landsat (ERTS-1) was launched in 1972 carrying in addition to other equipment, a four channel multispectral scanner scanning the earth surface in four separate spectral bands.

The utility of satellite data for multiple earth resources applications is the beginning to unfold in the areas, such as agriculture, landuse, water resources , forestry and other allied subjects. The potential of these data for vegetation oriented landuse pattern analysis has started in recent years and there is notable increase in the acceptance and utilization of Landsat and IRS data for landuse mapping. The latest Landsat sensors contain new designs like the Thematic mapper and the special cameras which allows the improvement of computational uses for image and pattern analysis.

This report is the result of the final project in partial fulfilment of the requirement for the "Digital Image Processing and Pattern recognition" course done at ITC,Enschede, The Netherlands.

The purpose of this course is to impart the techniques on "Digital Image Processing" through lectures and practical. The aim of this case study was to apply the know how attained during the course through lectures and practical in developing a landuse classification map of an area around, Dehradun, India.

1.1 Objective

The main objective of this case study was to obtain the landuse information in the form of a landuse map by applying various transformations. Because all the information related to any problem have to be extracted from the available channel. Some time it is not possible to differentiate among the various classes due to limitation of spatial, spectral and radiometric resolution of remote sensing satellites. Therefore, more images will be created by applying various transformation and the results will be analysed visually and digitally. Because, It is very difficult to say what would be the result of a particular transformation for landuse classification.

The second objective initially was to monitor the changes in landuse in the proposed study area, which could not become possible due to damage of CCT contain the required data.

1.2 Study area

The himalaya mountains chain is about 2500 Kms long and 240-400 Km wide rising from the low lying Indian plains to well over 8000 m has a complex physiography. Situated between latitude N 27^{o}-37^{o} and longitude E 73^{o}-97^{o}, this arc shaped mountains mass cutting across many latitude covers. The entire territories of Nepal and Bhutan and completely or partly the five states of India, namely; Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, west Bengal hills, Sikkm and Arunachal Pradesh are coming in this range. This Himalyan range run from west to east, starting from Naga parbat in the west to its eastern limits in Arunachal Pradesh.

The case study area is around Dehradun. Dehradun city is situated nearly 30^{o}N latitude and 78^{o}E longitude between Aravalli hills and Himalayan mountains in the North West part of India. The centre of latitude and longitude of the image is 30.04^{o}N and 78.09^{o}E and the image covers 185×185 km. This area is selected because it has a variety of landforms, landcover and soil types and changes in landuse area also rapid.

1.3 Landuse

The himalaya range have large variations in topography, elevation and location and this results in great contrasting landuse and climates from region to region. Not withstanding these local and regional variations in climate, the entire himalyas experiences a general weather and climatic pattern dictated by the monsoon phenomenon of Asia.

It is well known that the climatic and topographical conditions are the determining factors for landuse in a certain area, besides other factors. Climatically the temperature varies from $8^{o}C$ in winter to $40^{o}C$ in summer and topographically, Dehradun is situated in a valley.

2.0 DATA USED

Following data have been used for the case study

-----Landsat 4 MSS with bands 4,5,6 and 7 from 14th November 1972 was used.

-----No toposheet was available of this area.

Details of Landsat MSS data

Band	Wavelength(μm)	
4	0.5-0.6	Spatial resolution = 80m
5	0.6-0.7	Radiometric resolution
6	0.7-0.8	= 6 bits
7	0.8-0.9	

2.1 Equipment

The following equipment\system\software have been used for this study;

(i) Ramtek

The Ramtek system was used to make the skew and scene element size correction and for transfering the data from CCT to ILWIS format.

(ii) Ilwis

The processing of digital data was carried out on an IBM PC-AT using the Ilwis software package version 1.21.1 along with the peripherals viz: NEC Multisync II high resolution (480×640) colour monitor.

(iii) Tektronix inkjet plotter

3.0 PROCEDURE

The original image was on CCT and was converted to ILWIS format on the Ramtek system of the IPL at ITC. The files were copied onto floppy discs in the IPL, so that further work could be done on the IBM PC-AT with ILWIS package.

The main intention of this case study is to study the effect of various transformations for the landuse classification by visual and digital interpretation technique in the proposed area. Because it was predicted that the usefulness of some transformations would be dependent on the characteristics of the area under considerations. Therefore, two windows corresponding to (750×750 element) and (300×300 element) were selected in the plain and hill areas respectively.

Firstly, Histogram calculation were made for all the four bands of Landsat 4 MSS after determining the amount of haze and it was concluded that only band four required haze correction in this case.

After haze correction, destriping was done by applying the six sensor-histogram matching (Destrl) program for all the four bands. These destriped and haze corrected images were used for further analysis.

All MSS bands (4,5,6 and 7) were used for the analysis inspite it is known that band 6 and 7 are highly correlated, because the main intention was to study the effect of various transformations in developing a landuse classification map.A false colour composite was made by assigning Red, Green and blue for band 7,5 and 4 respectively for displaying and sampling. The training and checking samples map was made by sampling the window of the false colour composite. Using all the four bands a landuse classification map was obtained by running the Box classifier with a multiplication factor 2.5. A confusion matrix was prepared by running the cross and the confmat program from the ILWIS software.

Afterwards principal component transformation was done by running the principal component program and PC_1, PC_2 and PC_3 were obtained.

Further Ratioing, Sum normalisation and MMI transformations were done by using the MCalc calculation program in "Spatial modelling Module" in ILWIS package.

The same training sample map was used for the classification of the images obtained by applying the various transformation.

The images obtained after the transformations were used for creating landuse classifications using the same training samples map. This procedure was repeated for all the images resulting by applying various transformations on the original bands.

Again the Box classifier was used with a multiplication factor of 2.5 and confusion matrices were prepared by running the confmat program to analyse the classification results. Also this process was repeated for all the images resulting by various transformations and each time the same checking samples map was used.

4.0 CLASSES

Following classes were selected which exist in the frame (750x750) corresponding to plain area:

(i) Sal forest;
(ii) Mix forest;
(iii) Tea Garden;
(iv) Landuse;
(v) River1
(vi) River2
(vii) Water;
(viii) Irrigated field;
(ix) Water logged area,
(x) City;

Only three classes exist in the frame (300x300) corresponding to hilly area; i.e. in Himalaya mountains.

(i) Oak and Pine;
(ii) Deciduous forest;
(iii) Grassi rock;

Training and checking samples were provided by Prof. Meijerink and some of the classes were created to see the difference in spertral behaviour. It is proposed to stud' the difference of spectral behaviour of sal forest, mix forest and tea garden because in band 4,5,6 and 7 they behave spectrally same. Further, water logged area, irrigated areas and city behave spectrally same in all the four bands.

5.0 DESCRIPTION ABOUT VARIOUS TRANSFORMATION

The transformation which were used to study the change in spectral behaviour of the proposed classes are explained briefly;

(i) Principal Component Transformation:

It has been shown that all the spectral information in the four bands of a Landsat MSS image can be very well represented by two dimensional or, at the most, three dimensional data because channels are highly correlated (Mather p. 206). In the more common applications, such as landuse mapping, all such information has equal potential significance and colour composite picture production systems are frequently designed to display all the available information. principal component analysis, a powerful method of analyzing correlated multidimensional data, can be used in such systems to facilitate the visual interpretation of a mass data having uniform a priori significance, by reducing redundancy, i,e correlation between channels (Byrne,1980) Information which appears in more that one channel is treated as being of no less potential value than any other. The procedure incidentally renders it susceptible to presentation with a three channel optical system.

(ii) Ratioing

It is a most commonly used transformation in which the pixel value in one spectral channel is divided by the corresponding pixel value in second spectral channel. There are two reasons to do so. One is that certain aspects of the shape of spectral reflectance curves of different earth cover types can be brought out by ratioing. The Second undesirable effect on the recorded radiance, such as the effect of variable illumination resulting from the variation in topography can be reduced (Mather,p. 189).

Ratioing of spectral bands will not have any meaningful interpretation because we are working in a domain of Photon counts. Basically ratioing is a trick which provides the user a wide range of possible outcomes with a range from 0 to infinity (Bakx.p.24,L.N. 1991).

B45=(b4/b5)*40; B47 = (B4/B7)* 40; B57 = (B5/B7)*40;

Here, 4,5,6 and 7 are Landsat MSS bands and 40 is a compensation factor. The compensation factor is needed because the result of the ratio can be smaller than one.

(iii) Sum Normalisation

Sum normalisation is used to make the input data independent of the influence of external factors such as sun angle or relief. Basically, the addition or summation of input data known as representation of this influence. The ratio between the individual input bands and this sum, results in intensity independent data. If the results are displayed they appear as flat.

B4n = (B4/Int)* (90/0.58); B5n = (B5/Int)*(90/0.58);
B7n = (B7/Int)*(90/).58);
Int = (B4+B5+B7); and (90/0.58) is a compensation factor.

The results of normalisation is always within the interval 0 to 1, therefore it should be multiplied with a compensation factor.

(iv) MMI Transformation

It is already known that the influence of intensity on actual colour can be removed by sum normalisation. The effect of Sum normalisation on the data is mapping the data onto a triangle spanned by maximum Red, Green and Blue. For all points within this triangle the total intensity is equal to the single colour maximum intensity. Although saturation and Hue can be used to describe every point within the triangle, a mathematically simpler method is using two orthogonal axes. An obvious choice is to have the origin of the two orthogonal axes at point where the intensity axis crosses the triangle plane. The two axes are coded M1 and M2 and M1 is going from origin to Red and M2 is orthogonal to M1 thus, parallel to the line from Green to Blue. m1 and m2 are sum normalised data:

m1: = 0.82*B7n - 0.41*B5n- 0.41*B4n + 127;
m2: = 0.71*B5n - 0.71*B4n +127;
and 127 is a compensation factor.

6.0 CONCLUSIONS

The main intention of this study was to improve the landuse classification and to improve the visual interpretation of the image by applying the transformations which have been explained in earlier paragraphs.

(i) By principal component transformation in the plain areas there is no improvement for the differentiation between irrigated field, water logged area and city classes. On the other hand class city is classified as class River1; (Tab.-1.3). But by visual interpretation water logged area can be detected more clearly from the surrounding class (Fig.3 -(C)).

But the principal component transformation in hilly area results a flat image corresponding to PC2 (Fig.-4(c)). So all the three classes can be visually differentiated. This statement gets support from the results of the confusion matrices, which maintain the overall accuracy (Tab.-2.3).

(ii) By ratioing among the band 4,5 and 7, it can be seen that there is no pixel, which can be classified as water because after ratioing the pixel value increased beyond 255. So there is no improvement in classification result (Tab.-1.3). But by the visual interpretation city and irrigated area can be clearly delineated by ratioing between band 4 and 7 (Fig.-2(d)).

But in hilly area there is no improvement in classification result (Tab. 2.3) or for visual interpretation (Fig.-4(d)).

(iii) By sum normalisation there is no improvement in classification result because city is classified as irrigated field, tea garden and river1 (Tab.-1.4). But by visual interpretation city and irrigated area (Fig.-2(e)), river bed and surrounding soil (Fig.-3(e)) can be delineated. But in hilly area it results nearly a flat image (Fig.-4(e)).

(iv) By MMI transformation, there is no improvement either for visual interpretation (Fig.-2(f),and (Fig.-3(f)) or from classification point of views(Tab.-1.5),and (Tab.- 2.5).

(v) It can be concluded that the effectiveness of the principal component transformations depends on the type of terrain.

(vi) It is necessary to mention that the figures in the confusion matrices are not too significant because I had only a limited number of checking samples set at my disposal,so there is statistical noise.

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Table 1.0

Table 1.1 Confusion matrix with band 4,5,6 and 7 Images.

	1	2	3	4	5	6	7	8	9	10	uncl	
1	20	0	0	0	0	0	0	0	1	0	0	0.95
2	0	14	0	0	0	0	0	0	0	0	4	0.78
3	0	0	21	0	0	0	0	0	0	0	5	0.81
4	0	0	0	17	0	1	0	0	0	0	0	0.94
5	0	0	0	0	29	0	0	0	0	0	7	0.81
6	0	0	0	1	0	15	0	0	0	0	1	0.88
7	0	0	0	0	0	0	17	0	0	0	2	0.89
8	0	0	0	0	0	0	0	1	6	10	2	0.05
9	0	0	0	0	0	0	0	0	3	17	0	0.15
10	0	0	0	0	0	0	0	0	0	18	1	0.95
REL	1.00	1.00	1.00	0.94	1.00	0.94	1.00	1.00	0.30	0.40		

Average Accuracy = 72.15%

Average reliability = 85.82%

Overall accuracy = 72.77%

Table 1.2 Confusion matrix with PC1, PC2 and PC3 Images.

	1	2	3	4	5	6	7	8	9	10	uncl	ACC
1	20	0	0	0	0	0	0	0	0	0	1	0.95
2	0	14	0	0	0	0	0	0	0	0	4	0.78
3	2	0	20	0	0	0	0	0	0	0	4	0.77
4	0	0	0	17	0	1	0	0	0	0	0	0.94
5	0	0	0	0	31	0	0	0	0	2	3	0.86
6	0	0	0	2	0	13	0	0	0	0	2	0.76
7	0	0	0	0	0	0	17	0	0	0	2	0.89
8	1	0	0	0	0	0	0	2	16	0	0	0.11
9	0	0	0	0	0	0	0	0	20	0	0	1.00
10	0	0	0	0	0	0	0	8	11	0	0	0.00
REL	0.87	1.00	1.00	0.89	1.00	0.93	1.00	0.20	0.43	0.00		

Average Accuracy = 70.70%

Average reliability = 73.18%

Overall accuracy = 72.30%

Table 1.3 Confusion matrix with b47, b57, b45 Images.

	1	2	3	4	5	6	7	8	9	10	uncl	ACC
1	20	0	0	0	0	0	0	0	1	0	0	0.95
2	5	10	0	0	0	0	0	0	3	0	0	0.56
3	21	0	5	0	0	0	0	0	0	0	0	0.19
4	0	0	0	16	0	2	0	0	0	0	0	0.89
5	0	0	0	0	24	4	0	2	1	2	3	0.67
6	0	0	0	0	0	16	0	1	0	0	0	0.94
7	0	0	0	0	0	0	0	0	0	0	19	0.00
8	0	0	0	0	0	2	0	1	14	1	1	0.05
9	0	0	0	0	0	0	0	1	19	0	0	0.95
10	0	0	0	1	6	3	0	2	6	1	0	0.05
REL	0.43	1.00	1.00	0.94	0.80	0.59	?	0.14	0.43	0.25		

Average Accuracy = 52.52%

Average reliability = 62.15%

Overall accuracy = 52.58%

Table 1.4 Confusion matrix with b4n, b5n, b7n Images.

	1	2	3	4	5	6	7	8	9	10	uncl	ACC
1	14	6	0	0	0	0	0	0	1	0	0	0.67
2	0	18	0	0	0	0	0	0	0	0	0	1.00
3	12	6	5	0	0	0	0	0	0	0	3	0.19
4	0	0	0	16	0	2	0	0	0	0	0	0.89
5	0	0	0	0	30	3	0	0	1	1	1	0.83
6	0	0	0	0	0	17	0	0	0	0	0	1.00
7	0	0	0	0	0	0	19	0	0	0	0	1.00
8	0	2	0	1	1	2	0	0	11	1	1	0.00
9	0	0	0	0	1	0	0	0	19	0	0	0.95
10	0	0	0	1	9	3	0	0	6	0	0	0.00
REL	0.54	0.56	1.00	0.89	0.73	0.63	1.00	?	0.50	0.00		

Average Accuracy = 65.31%

Average reliability = 65.01%

Overall accuracy = 64.79%

Table 1.5 Confusion matrix with m1 and m2 Images.

	1	2	3	4	5	6	7	8	9	10	uncl	ACC
1	13	7	0	0	0	0	0	0	1	0	0	0.62
2	0	17	0	0	0	0	0	0	1	0	0	0.94
3	14	6	3	0	0	0	0	0	0	0	3	0.12
4	0	0	0	14	0	4	0	0	0	0	0	0.78
5	0	0	0	0	30	4	0	1	1	0	0	0.83
6	0	0	0	0	0	17	0	0	0	0	0	1.00
7	0	0	0	0	0	0	19	0	0	0	0	1.00
8	0	2	0	1	2	2	0	0	12	0	0	0.00
9	0	0	0	0	1	0	0	0	19	0	0	0.95
10	0	0	0	1	7	4	0	0	6	1	0	0.05
REL	0.48	0.53	1.00	0.88	0.75	0.55	1.00	0.00	0.47	1.00		

Average Accuracy = 62.93%

Average reliability = 66.61%

Overall accuracy = 62.44%

Table 2.0

Table 2.1 Confusion matrix with band 4,5,6 and 7 Images.

	1	2	3	uncl	ACC
1	15	0	0	0	1.00
2	1	18	0	5	0.75
3	0	0	19	3	0.86
REL	0.94	1.00	1.00		

Average Accuracy = 87.12%

Average Reliability = 97.92%

Overall Accuracy = 85.25%

Table 2.2 Confusion matrix with PC1, PC2 and PC3 Images.

	1	2	3	uncl	ACC
1	14	0	0	1	0.93
2	2	21	1	0	0.88
3	0	0	17	5	0.77
REL	0.88	1.00	0.94		

Average Accuracy = 86.04%

Average Reliability = 93.98%

Overall Accuracy = 85.25%

Table 2.3 Confusion matrix with b47, b57 and b45 Images.

	1	2	3	uncl	ACC
1	12	3	0	0	0.80
2	0	20	0	4	0.83
3	0	0	18	4	0.82
REL	1.00	0.87	1.00		

Average Accuracy = 81.72%

Average Reliability = 95.65%

Overall Accuracy = 81.97%

Table 2.4 Confusion matrix with b4n, b5n and b7n Images.

	1	2	3	uncl	ACC
1	4	11	0	0	0.27
2	0	19	0	5	0.79
3	0	0	17	5	0.77
REL	1.00	0.63	1.00		

Average Accuracy = 61.04%

Average Reliability = 87.78%

Overall Accuracy = 65.57%

Table 2.5 Confusion matrix with m1 and m2 Images.

	1	2	3	uncl	ACC
1	4	11	0	0	0.27
2	0	23	0	1	0.96
3	0	0	17	5	0.77
REL	1.00	0.68	1.00		

Average Accuracy = 66.59%

Average Reliability = 89.22%

Overall Accuracy = 72.13%

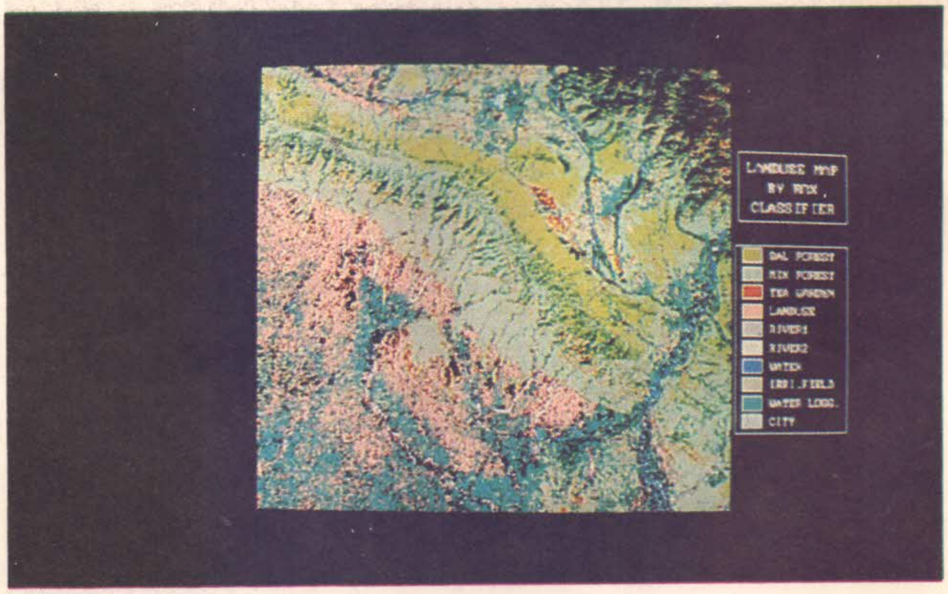

Figure 1: Landuse map around Dehradun.

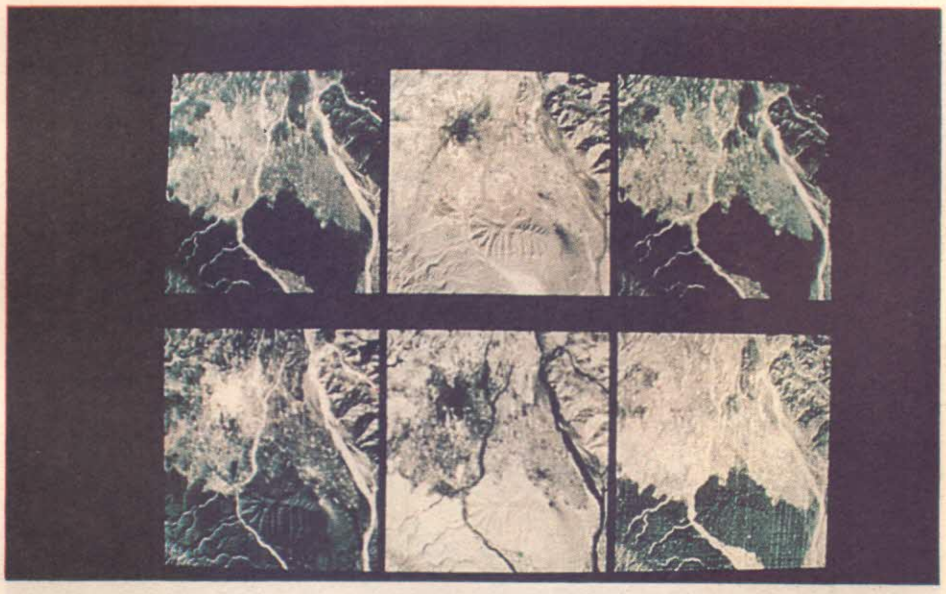

Figure 2: (a) Landsat MSS band 4 Image (b) Landsat MSS band 7 Image (c)Principal component 1 (d)b47 Image (e)b7n Image (f)m2 Image, shows the difference between city and irrigated area.

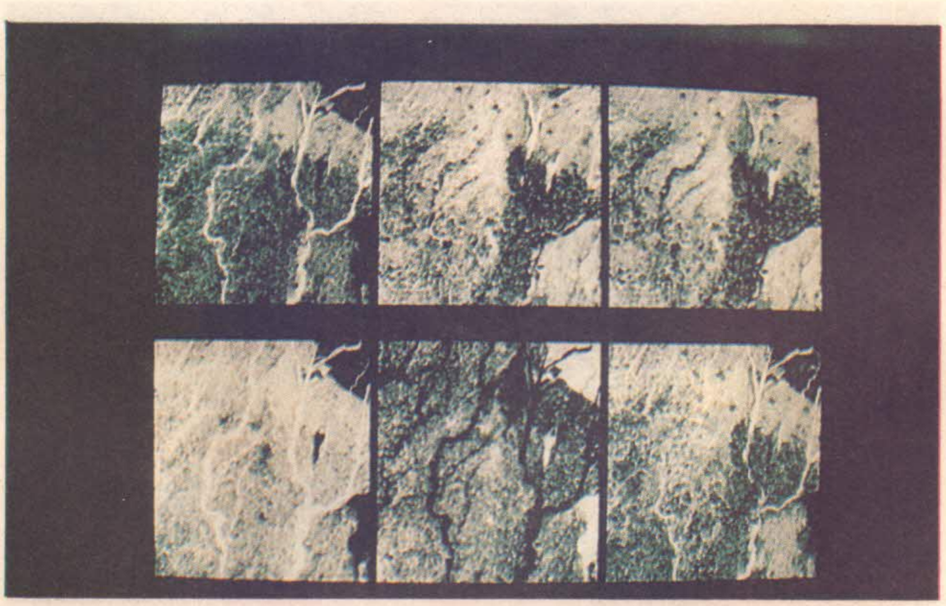

Figure 3: (a) Landsat MSS band 4 Image (b) Landsat MSS band 7 Image (c)Principal component 1 (d)b57 Image (e)b7n Image (f)m2 Image, shows the difference between River2, Landuse and water logged area.

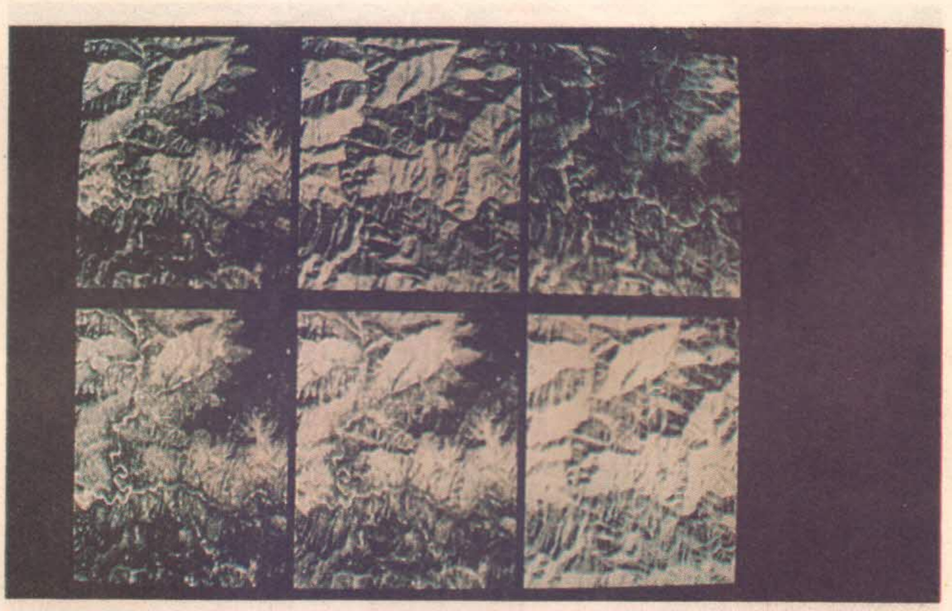

Figure 4: (a) Landsat MSS band 4 Image (b) Landsat MSS band 7 Image (c)Principal component 1 (d)b57 Image (e)b5n Image (f)m2 Image, shows the effect of various transformation in hilly area.

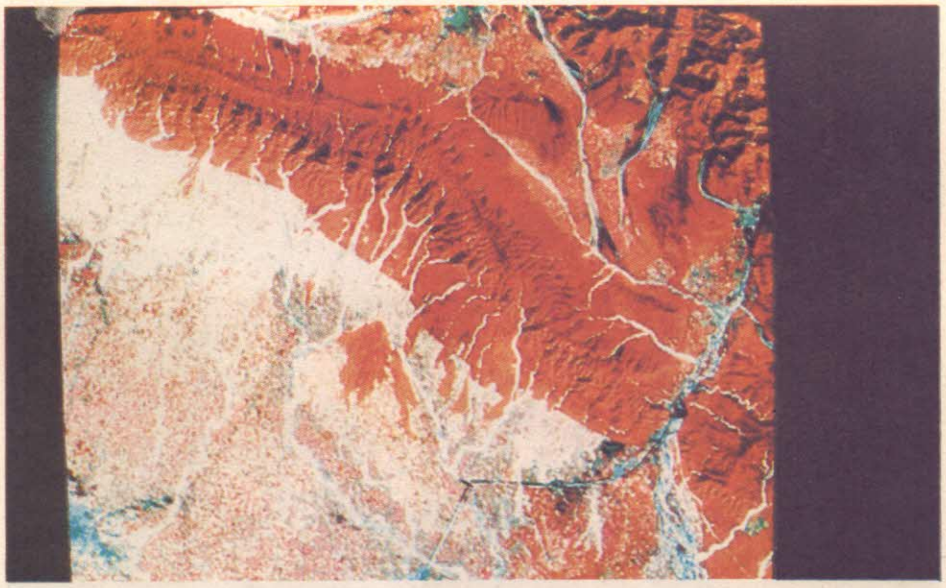

Figure 5: False colour composite (4,5,7) around Dehradun.