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An Empirical Investigation on Thematic Accuracy of Landuse/Landcover Classification Using Fused Images

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Abstract: The satellite images at different spectral and spatial resolutions with the aid of image processing techniques can improve the quality of information. Especially image fusion is very helpful to extract the spatial information from two images of different resolution images of same area. An operation of image analysis such as image classification on fused images provides better results in comparison of original data. The comparisons of various fusion techniques have been discussed and their accuracies have been evaluated on their respected classifications. By using the digital image classification techniques such as supervised and unsupervised classification methods, the study reveals that all the fused images have higher information than the original images. In this study to demonstrate the enhancement and accuracy assessment of fused image over the Multispectral images using ERDAS Imagine 9.1 Software.

Keywords: ***Image Fusion Techniques, PCA, Modified IHS, Accuracy Assessment***

1. INTRODUCTION

The term "image fusion" covers multiple techniques used to combine the geometric detail of a high-resolution Panchromatic image and the color information of a low resolution multispectral image to produce a final image with the highest possible spatial information content while still preserving good spectral information quality. Fusion of multi-sensor image data has become a widely acceptable process because of the complementary nature of various data sets. While High spatial resolution dataset's are necessary for an extraction and accurate description of shapes, features and structures. Hence merging of these two types of data, to get multi-spectral images with high spatial resolution, is beneficial for various applications like vegetation, land-use, precision farming and urban studies. During the last twenty years, many methods such as IHS, Modified IHS, PCA, Pansharp, Wavelet, LMM, LMVM, Brovey, and Multiplicative fusion techniques have been developed producing good quality fused images.

Image fusion is performed at three different processing levels according to the stage at which the fusion takes place Pixel, Feature and Decision level. It is clear that the most effective solution for providing high-spatial-resolution and high-spectral-resolution remote sensing images is to develop effective image fusion techniques. The principal interest of fusing multi-resolution image data is to create composite images of enhanced interpretability. The images should have the highest possible spatial information content while still preserving good spectral information quality.

In order to quantitatively measure the quality of the fused images, we have made the following controls. First, we have examined the visual qualitative result. Then, we examined the correlation between the original MS and the fused images and all the statistical parameters of the histograms of the various frequency bands. Finally, we performed a supervised and unsupervised classification, and we compared the result images.

The main objectives of this project includes,

- To generate the hybrid images using LISS-IV and CARTOSAT image with spatial resolution;
- To perform the quality assessment and analysis by using image enhancement techniques;
- To classify the hybrid images using digital image classification techniques; and
- Comparison of the classification result to identify the best classification technique for Landuse/Landcover.

2. STUDY AREA

The present study area Byadgi taluk, Haveri district, Karnataka extends from North latitudes 14°48′00″-14°79′00" and East longitudes 75°28′00"- 75°58'00". Byadgi taluk was earlier in Dharwad district. During the year 1997-98, Dharwad district was divided and Haveri was made a new district having 7 taluks. For administrative purposes district has been made into two sub divisions - Haveri sub-division consists of Haveri, Byadgi , Hirekerur & Ranebennur and Savanur sub-division consists of Savanur, Shigon & Hangal taluks. The area of the taluk is 436Sq.Kms. Railway line of 15Kms broad gauge runs in the taluk with 2 railway stations. Taluk has 13Kms of National Highway and 32.70Kms of State Highway, 126.70Kms of major district roads, 96.45Kms village roads.

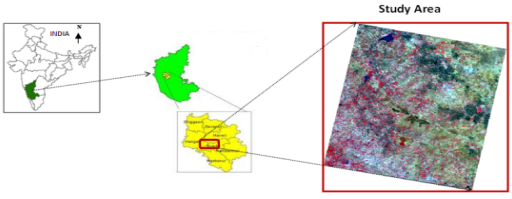


Figure1. Study area

3. METHODOLOGY

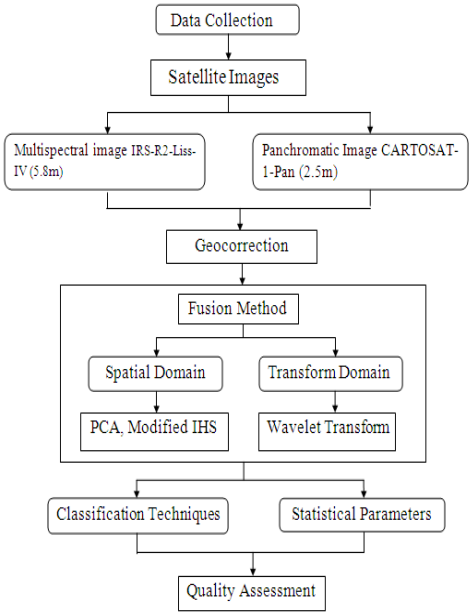
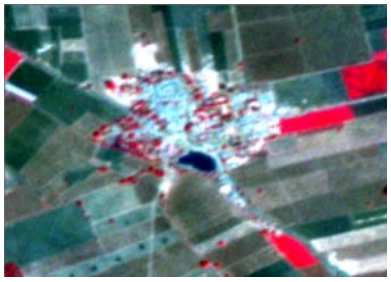


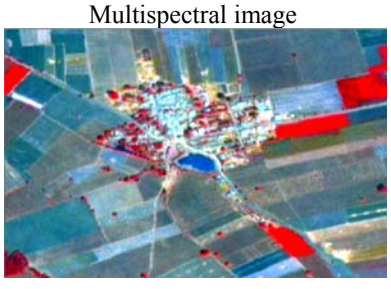
Figure2. Schematic diagram of Methodology

3.1 PCA (Principle Component Analysis) Fusion Method

The PCA transform converts intercorrelated MS bands into a new set of uncorrelated components. The first component also resembles a PAN image. It is, therefore, replaced by a high-resolution PAN for the fusion. The PAN image is fused into the low-resolution MS bands by performing a reverse PCA transform. It also preserves the original colors in all the possible combinations.



Multispectral image



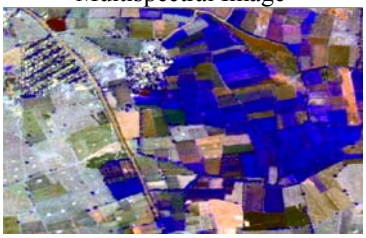
Hybrid image by PCA method

Figure3. Multispectral and Hybrid image by PCA method image

3.2 Modified IHS Fusion Method

The intensity component is replaced by the PAN image, the hue and saturation bands are resampled to the high-resolution pixel size using a nearest neighbor. The Modified IHS image is the best representation of natural and man-made features. The modified IHS transform also improves the resolution of the fused image.

Multispectral Image

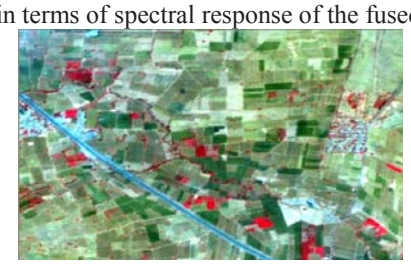


Hybrid image by Modified IHS method

Figure4. Multispectral and Hybrid image by Modified IHS method image

3.3 Wavelet-PCA fusion method

Principal component analysis has been performed prior to wavelet analysis and the fusion has taken place on the first principal component. Then the inverse principal component transformation has been applied producing the four fused bands. This method is supposed to produce fused images with less spectral distortion. Wavelet PCA fusion methods perform very well in terms of spectral response of the fused products.



Multispectral Image

Hybrid image by Wavelet PCA method

Figure5. Multispectral and Hybrid image by Wavelet PCA method image

3.4 Wavelet-IHS fusion method

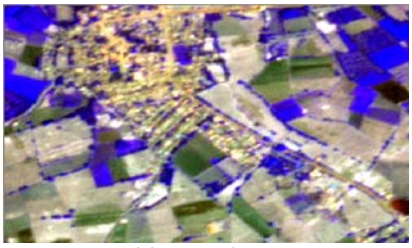
The Wavelet IHS fusion method preserves the spatial information of the LISS- IV data and the color information of the Multispectral image. The color of the fusion result is very close to that of the original MS image, and the fusion image looks as clear as the multispectral data. The wavelet IHS fusion method can preserve the color information much better while maintaining competitive spatial information. The wavelet IHS fusion image is much closer to the multispectral image. The wavelet-IHS fusion method utilizes the merit of the IHS fusion in smoothly integrating spatial resolution information and the merit of the wavelet fusion in preserving color information.

3.5 Edge Enhancement

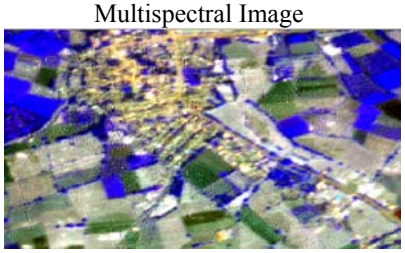
Edge enhancement delineates these edges and makes the shapes and details comprising the image more conspicuous and perhaps easier to analyze. Wavelets are an efficient and practical way to represent edges and image information at multiple spatial scales. Image features at a given scale, such as houses or roads, can be directly enhanced by filtering the wavelet coefficients. Wavelets may be a more useful image representation than pixels. Hence, we consider PCA dimensionality reduction of wavelet coefficients in order to maximize edge information in the reduced dimensionality set of image.

3.6 Evaluation of statistical parameters

For evaluating image fusion quality, we have selected statistical parameters are min, max, mode, median, mean and standard deviation. The statistical parameters have been displayed in Table 1. The mean, standard deviation in Table 1 are, in general, not high, but still indicate that the mean, standard deviation of the wavelet-IHS method are significantly closed to the multispectral image than the other methods.



Multispectral Image



Fused image by Wavelet IHS method

Figure6. Multispectral and Fused image by Wavelet IHS method image

PCA Fused image

Edge Enhancement Technique by using PCA Fused image

Figure7. Multispectral and Fused image by Edge enhancement Technique

Table1: Statistical information of the Panchromatic, Multispectral and fused images

Image	Layer	Min	Max	Mean	Median	Mode	Standard Deviation
Panchromatic Image	1	6	311	100.316	98.93	98.93	12.984
Multiband Image	1	91	306	118.322	117	116	9.528
	2	72	370	126.513	126.71	127.88	17.678
	3	56	423	179.825	180.72	180.72	24.668
Modified HIS	1	65	366	178.467	177.88	177.88	19.770
	2	48	323	126.340	126.42	119.97	19.161
	3	61	275	118.190	118	115	12.619
PCA	1	1	210	59.528	60	59	10.217
	2	1	223	62.871	65	64	16.633
	3	1	245	89.106	89	88	25.870
Wavelet PCA Fusion Method	1	1	324	115.843	115.82	115.82	15.594
	2	1	357	123.989	124.77	124.77	22.773
	3	1	372	179.707	179.25	183.6	22.250
Wavelet IHS Fusion Method	1	17	333	117.278	116.98	116.98	9.870
	2	11	351	125.827	125.22	127.88	17.470
	3	78	467	180.243	179.81	182.85	22.386

4. Result And Discussion

The fused image outputs were evaluated based on three characteristic, i.e. statistically, visually and by comparing classification accuracy. The visual expressions of various merged products were also studied. The study could help to grade the suitability of various merging methods for Landuse/Landcover mapping and extraction. The wavelet based methods with combination of IHS and Principal component analysis gave the best optimal result. In image recognition, the wavelet based fusion methods are most suitable because the spectral and structural characteristics of Landuse/Landcover features can be identified more accurately for visual interpretation and feature extraction.

Accuracy Assessment

The accuracy assessment comparison of supervised and unsupervised classification is done and level of accuracy has been calculated and compared. The comparison of total accuracy and kappa accuracy for both the classifications shows that wavelet IHS fused method is the most appropriate for fusion and having the higher level of accuracy in classification as shown in Table 3 and 4. Higher kappa values have been obtained in wavelet based method. Overall accuracy can be arranged in following order Wave IHS > Wavelet PCA > Modified IHS > Multispectral > PCA.

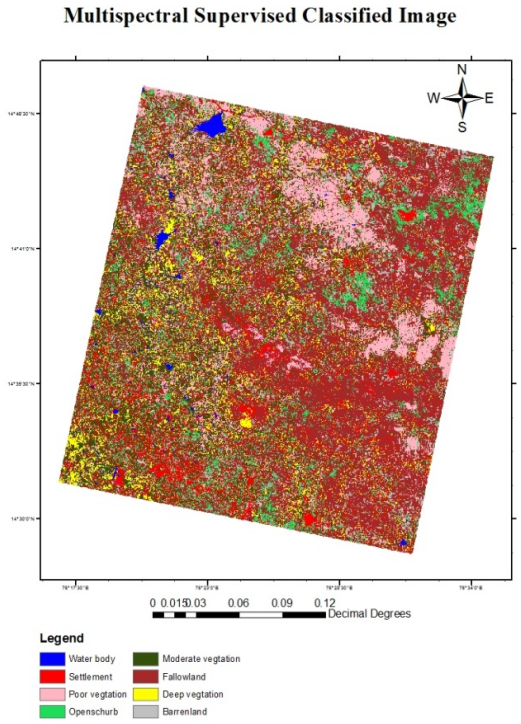


Figure8. Multispectral Supervised Classified Image

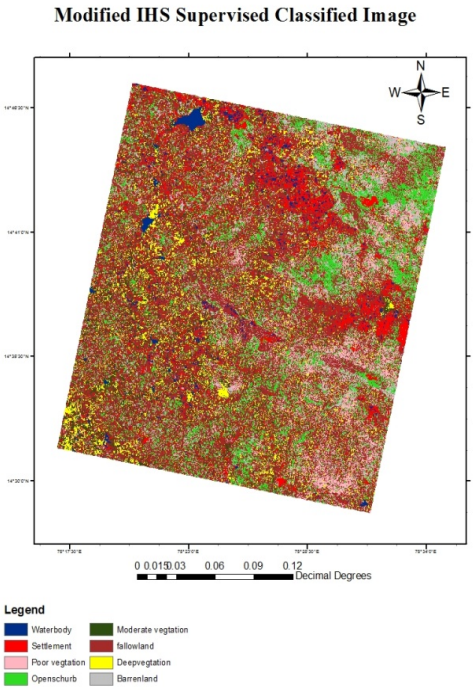


Figure9. Modified IHS Supervised Classified Image

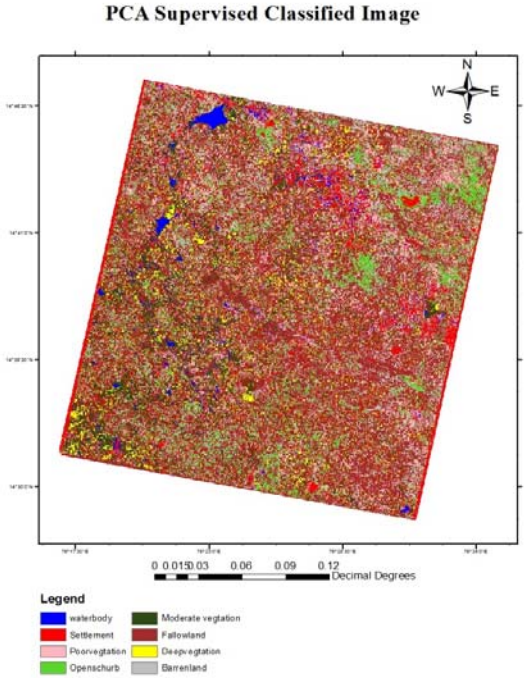


Figure10. PCA Supervised Classified Image

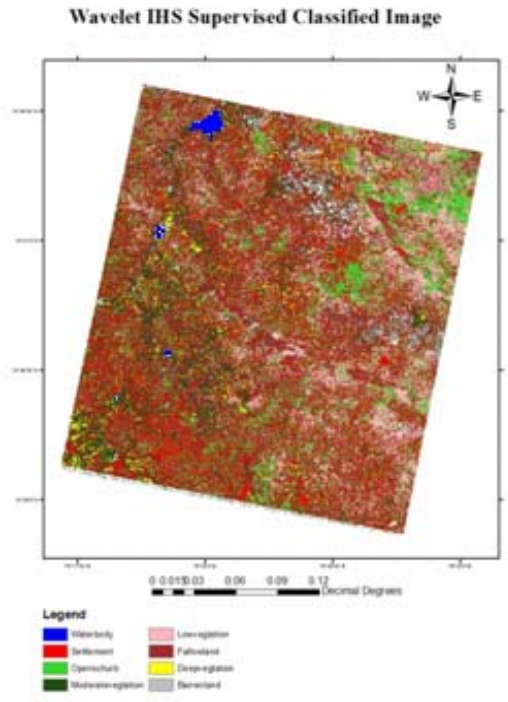


Figure11. Wavelet IHS Supervised Classified Image

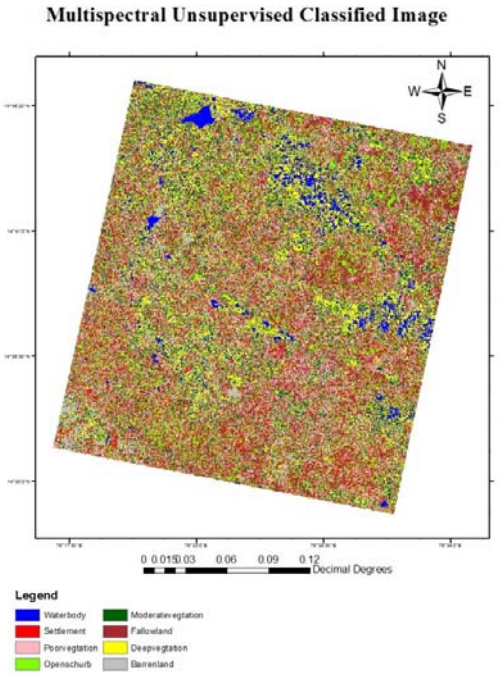


Figure13. Multispectral Unsupervised Classified Image

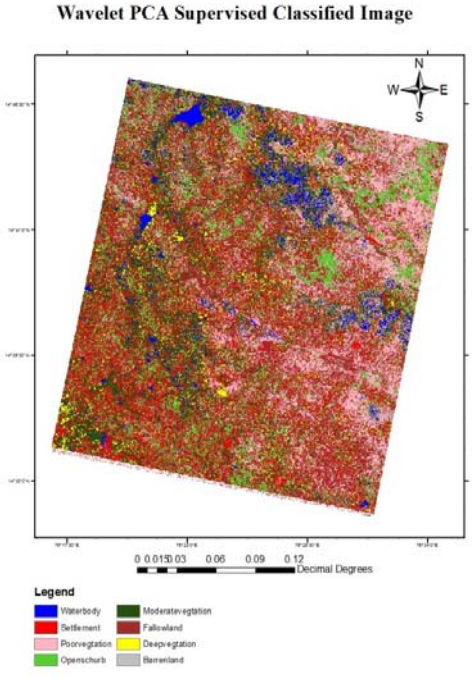


Figure12. Wavelet PCA Supervised Classified Image

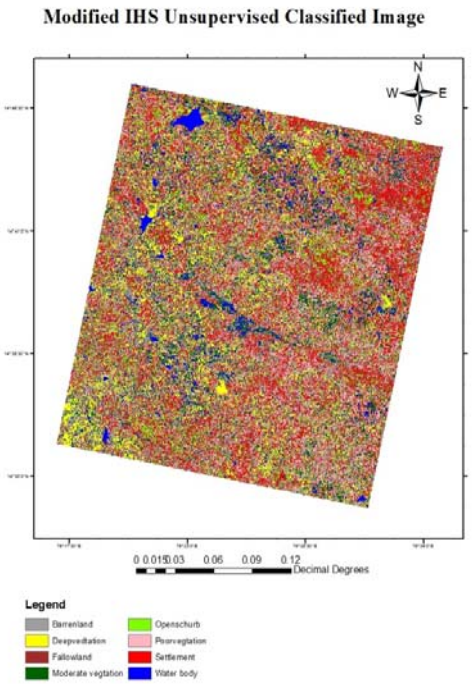


Figure14. Modified IHS Unsupervised Classified Image

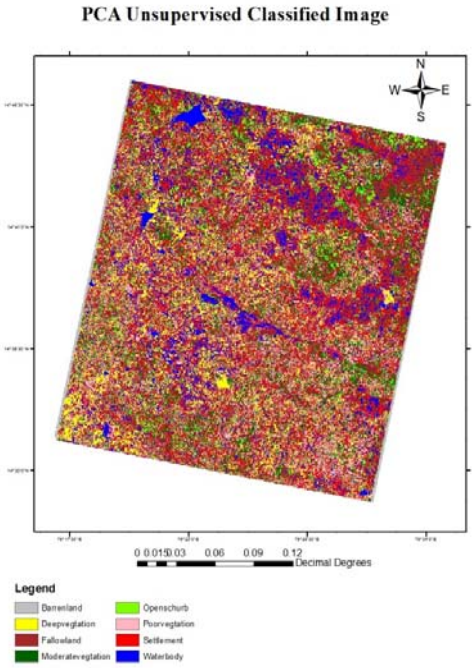


Figure15. PCA Unsupervised Classified Image

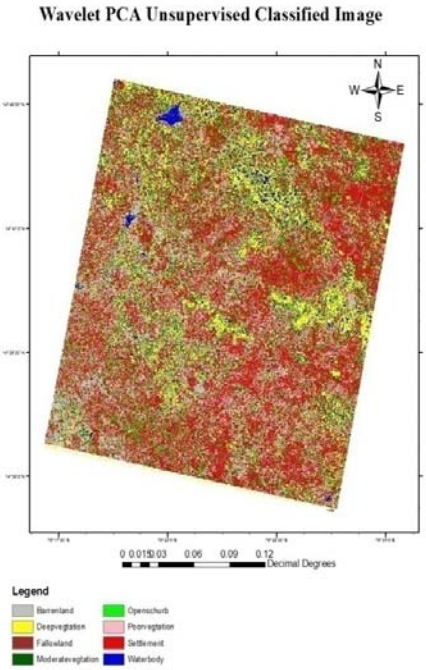


Figure17. Wavelet PCA Unsupervised Classified Image

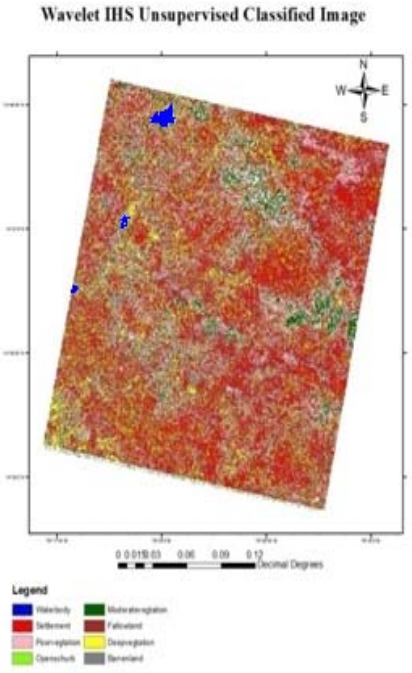


Figure16. Wavelet IHS Unsupervised Classified Image

Table2. Thematic accuracy of Landuse/Landcover classification results

Thematic Accuracy of Classification Results					
	LISS IV	**PCA fused**	**Modified IHS fused**	**Wavelet PCA fused**	**Wavelet IHS fused**
Water body	11.26	14.6	22.8	25.46	25.210
Deep vegetation	72.97	40.93	56.92	33.06	75.06
Moderate vegetation	170.24	112.18	70.92	156.98	180.25
Poor vegetation	145.32	104.33	75.71	152.53	155.32
Barren land	67.40	91.79	54.32	21.76	91.79
Fallow land	413.83	287.64	364.30	249.3	414.44
Settlement	139.78	129.51	85.03	121.45	146.32
Open scrub	93.70	78.83	114.55	97.66	105.62

Table3. Accuracy test of supervised classification of fused and Multispectral image

Type	**Multispectral Image**	**PCA Fused Image**	**Modified IHS Fused Image**	**Wavelet PCA Fused Image**	**Wavelet IHS Fused Image**
Total Accuracy (%)	70.83	66.67	75	83.33	87.50
Kappa Accuracy	0.6493	0.6082	0.6807	0.7927	0.8497

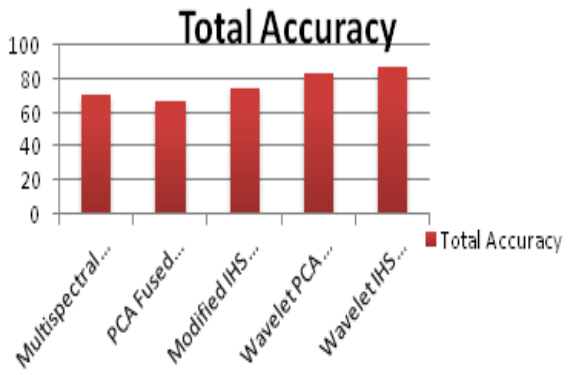


Figure18. Column-chart representing Total Accuracy of Multispectral and different methods of fused image

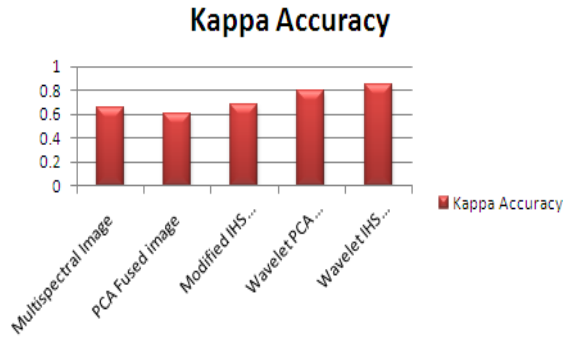


Figure19.Column-chart representing Kappa Accuracy of Multispectral and different methods of fused image

Table 4. Accuracy test of unsupervised classification of fused and Multispectral image

Type	Multispectral Image	PCA Fused Image	Modified IHS Fused Image	Wavelet PCA Fused Image	Wavelet IHS Fused Image
Total Accuracy (%)	45.83	41.67	58.33	62.50	66.67
Kappa Accuracy	0.3620	0.2866	0.5010	0.5462	0.5983

CONCLUSION

This study proves the importance of spatial enhancement techniques and evaluation methods that should be consistent and the necessity of a combined method for a quantitative and qualitative assessment of spatial improvement and spectral preservation. The Wavelet IHS enhancement technique gives best result compare to other enhancement techniques with best representation of natural and man-made features. It is suited for spatial merging of high resolution panchromatic and multispectral images. Therefore it could be used in digital image analysis and visual interpretation. This image processing technique is quiet faster and resulted in better identifying, extracting and mapping of Landuse/Landcover in compare to standard image processing & image classification technique or visual interpretation. Image Fusion provides the way to integrate, disparate and to enhance the information apparent in the images as well as to increase the reliability of the interpretation. The analysis of fused images and multispectral image gives us an idea about the fusion algorithms and their different impacts on original data and their relevance to extract the infrastructure information.

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