shown in Fig. 7 by converting color image into grey image. Median filtering is less sensitive and it does not reduce the sharpness of the image. It can be observed that median filter removes noise better, with less blurring of edges.

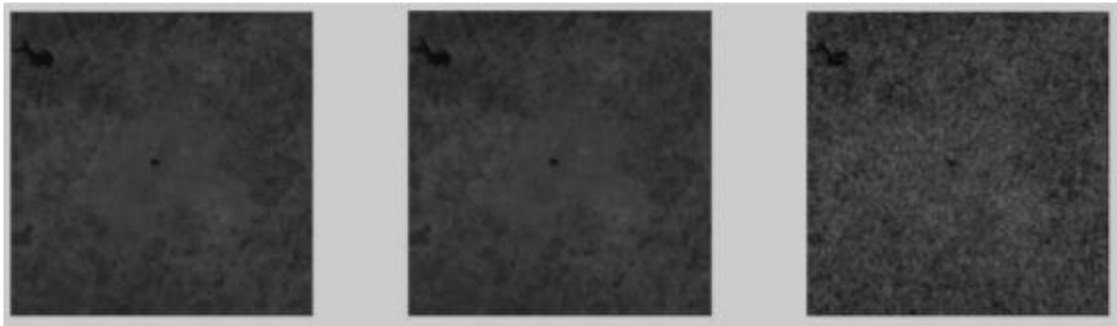

Fig. 7 a. Input image, b. Input image with added noise and c. Median filtered Image

3. Haze reduction: Atmospheric haze effects are like very fine particles, smoke, dust and liquid droplets suspended in the air limit the visibility and reduces contrast. Removing haze can significantly increase the visibility of the scene and correct the color shift [23]. Adaptive median filter identify pixels which are likely to be contaminated by noise [24] with edge preservation and noise suppression. Haze reduction enables to reduce overall haze in an input image. For LISS III images, Haze reduction based on the point spread convolution, generates a component that correlates with haze. This component is removed and the image is transformed back into RGB space. This method increases brightness, vegetation greenness, and surface moisture (wetness) as shown in Fig. 8. Bright areas like sand and barren land appear in red in color. Vegetation appears in green or cyan in color, fallow fields appear brownish in color and water bodies appear bright blue in color.

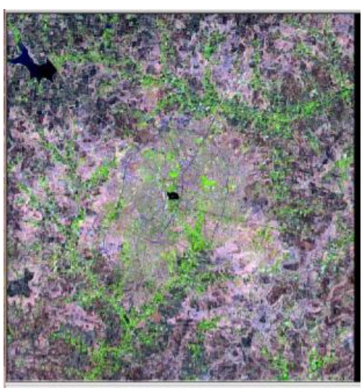

Fig. 8 Enhancement by Haze reduction

F. Principal Component Analysis

The Principal Component Analysis is a multispectral transformation method appeals directly to the vector nature of the multi-spectral image. It includes the principal component analysis transformation [25]. PCA reduces image dimensionality by defining new, four uncorrelated bands with orthogonal variables [26]. It provides maximum visual separability of image features thus maximum features appear in first principal component. It reduces the dimensionality by linear projection of data along the directions of maximal variance. Principal Component Analysis extracts the most important information from the image, compresses the size, simplify the description of the input image. Pixels of an image (X_1, X_2..X_n) given by n-dimensional vector x = $[X_1, X_2, ...X_n]^T$. If the image A was of size M*N with four bands, Then, total K = M $*$ N, 3-D vectors were generated. This was transformed into a vector y according to equation 4.

$$y = A(x - m_x) \qquad (4)$$

The vector mx in equation 4 is the vector of mean values of all input variables. Correlation matrix, Eigen vectors and Eigen values were generated from the PCA. The Resultant first principal component image is shown in Fig. 9 below.

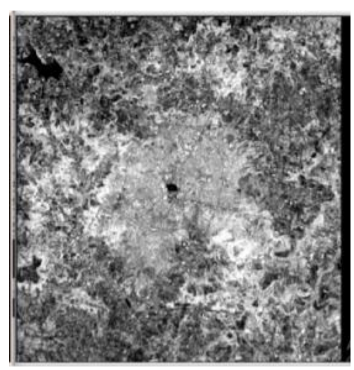

Fig. 9 Enhancement by Principal Component Analysis

IV. COMPARATIVE ANALYSIS

Decorrection Stretch, shown in Fig. 2 reflects very bright colors. Excluding water and vegetation, but it was difficult to differentiate between the features. Anisotropic Diffusion [27] shown in Fig. 3 smooth's all the features, but it was difficult to determine the edges. Partial Differential Equation method as shown in Fig. 4 smooths out noise and conserves detail like edges. The output image is denoised and visually more appealing. Histogram Equalization as shown in Fig.5 develops darker shades of colors, but water and rocky lands were non-differentiable. Filtering methods like mean filters gives averaging effect suppresses the edges leading to blurring of an image, as shown in Fig 6 and Median Filter reduces the impact of salt and pepper noise with minimum blurring as shown in Fig 7. Haze reduction generates better output but gives blocky effect in the enhanced image as shown in Fig. 8. Principal Component Analysis method is an automatic and effective method to reduce the dimensionality but water and rocky lands are not much discriminable, as shown in .The first PC is the linear combination with maximal variance [28]. Compared to all the method implemented in the study, output generated by Partial Differential Method is visually better, removes the effect of noise, conserves edges and at the same time resultant image, as shown in Fig. 4 image feature images approximate the input image.

V. CONCLUSION

Enhancement is a preliminary step for any image processing technique to increase image quality needed as an input for further analysis. Enhancement results in improved visibility of the image by enhancing the contrast and simultaneous noise reduction. Main aim of the study was to make the multi-spectral image visually acceptable for display. LISS III images are low resolution images and differentiation of the feature at first look is difficult. A better enhancement technique is required to represent an input image in an appealing way. In this direction, various image enhancement techniques were tested on IRS-1C LISS III images. An assessment was made to find better enhancement techniques for LISS III images. Decorrelation stretch, Anisotropic Diffusion, Partial Differential Equation method, Histogram Equalization, Filtering and Principal Component Analysis were implemented on study image. It was observed visually, from the results obtained, that multi-spectral image enhancement by Partial Differential Equation overcomes the effect of noise and enables the user to identify the available features visually easily. However, the current work is still preliminary and yet promising. This study gives directions on research using low resolution multi-spectral IRS-1C LISS III image enhancement techniques for future research.

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