Different Resolution Merging Methods For Environmental Areas Extraction

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Abstract

The usage of remote sensing techniques in managing and monitoring the environmental areas is increasing due to the improvement of the sensors used in the observation satellites around the earth. Resolution merge process is used to combine high resolution one band image with another one that have low resolution multi bands image to produce one image that is high in both spatial and spectral resolution.

In this work different merging methods were tested to evaluate their enhancement capabilities to extract different environmental areas; Principle component analysis (PCA), Brovey, modified (Intensity, Hue ,Saturation) method and High Pass Filter methods were tested and subjected to visual and statistical comparison for evaluation.

Both visual and statistical comparison showed that High Pass Filter method have highest visual enhancement and highly maintained the quantitative information of the original image, Modified (Intensity, Hue, Saturation) method showed good visual and statistical results in comparison with PCA and Brovey method which had the lower results respectively.

Keywords: Environmental Areas, Resolution merge, High Pass Filter method, PCA, Visual inspection and statistical comparison.

استخدام طرق مختلفة في دمج الصور الفضائية لأستخلاص المناطق البيئية

هشام عبدمناف عطا

الخلاصة

إن استخدام تقنيات التحسس النائي في ادارة ومراقبة المناطق البيئية المختلفة في ازدياد مستمر وذلك بسبب التحديث الحاصل في المتحسسات المستخدمة في انظمة المراقبة الفضائية حول الأرض. تستخدم عملية دمج الصور بين صورتين، الأولى تكون ذات قدرة تمييزية عالية ومتكونة من حزمة موجية واحدة، اما الثانية فهي اقلقدرة تمييزية نسبياً من الأولى ولكنها متعددة الحزم الموجية، لينتج لنا صورة واحدة تحتوي علىقدرة تمييز عالية ومتعددة الأطياف.

في هذا العمل، تم اختبار مجموعة من طرق دمج الصور لمعرفة قابلياتها على تعزيز القدرة في استخلاص وتحديد المناطق البيئية المختلفة، وهذه الطرق هي تحليل المركب الرئيسي، بروفي، طريقة (الكثافة، الدرجة، التشبع) المعدلة، مرشح الترددات العالية تم اختبارها من حيث التباين الظاهري ومن خلال المقارنة الأحصائية لمجموعه من المعاملات.

اوضح اختبار التباين الظاهري و الأختبارات الأحصائية ان طريقة مرشح الترددات العالية لديها اعلى تباين لحدود المناطق البيئية كما وانها حافظت بشكل كبير على المعلومات الكمية الأحصائية للصورة الأصلية، تليها طريقة طريقة (الكثافة، الدرجة، التشبع) المعدلة والتي اظهرت تحسين ظاهري ونتائج احصائية جيدة مقارنة بطريقة تحليل المركب الرئيسي وبروفي الذين اظهروا اقل النتائج على التوالي.

الكلمات الرئيسية

المناطق البيئية، دمج الصور، طريقة مرشح الترددات العالية، تحليل المركبات الأساسية، أختبار التباين الظاهري والمقارنة الأحصائية .

Introduction

The Remote sensing technologies is a valuable tool for Environmental purposes it have been used for decades for land changes detection and for different areas monitoring from environmentally side of view (Marcus Borengasser, 2008).

The early attempts to resolution merging or enhancement were related to merging the bands (4, 6, 7) which have a 240 m resolution with the fifth band which have a 80 m resolution for the Landsat MSS (Nikolakopoulos, 2004).

The reason beyond resolution merge process is to increase the interpretability of the high spectral resolution (multi bands) images with the aid of the high spatial resolution images, which will enhance the recognition of the exact limits of objects and shapes, maintaining as much as possible the spectral signature of these objects and shapes (Steven M. and De Jong, 2005).

After the merging process, the resulted images must be tested against the original images, the evaluation includes in most cases a statistical and visual interpretation comparison between the images (Is. Parcharidis, 2000).

The objective of this work is to compare the efficiency of four different techniques of merging high spatial resolution image with multispectral image in improving the extraction and identification of different environmental areas.

Area Of Study

The study area lies in the south of Basrah governorate, in the southern part of Iraq. This area includes Um-Qasser, the border city between Iraq and Kuwait and One of the largest Iraqi harbors which surrounded by Desert, crop and palm fields and lies in the mouth of Al-Zubair estuary (Khawr Az-zubair), the area includes as well the northern part of Bubian island. The diversity of environmental areas of this location is what makes it suitable for this research.

Methodology

LandSat7 ETM+ Images took in 27th of January 2002 is used in this work. Two images have been used, the first one with (4, 3, 2) bands with a 30 meter resolution displayed in **Figure1**, The second image is panchromatic band with resolution 15 meters, displayed in **Figure 2**.

The results of this work were achieved by using ERDAS Imagine 9.3 software. In the beginning all the images were accurately corrected and geo-referenced, in order to start the merging process.

The merging process was done with four different methods:

1- Principal Component Analysis

Some of the merging methods can be used with only three bands, the Principle component analysis can be used with more than three bands which is one of the main advantages of this method (Zhijun Wang, 2005).

The PCA highly maintain the original scene radiometry in the output file, this advantage come with longer time for processing; also this method tend to keep the data range in the output file same as the multispectral file (ERDAS Field Guide, 2008) .

This method uses the equation below for remapping the fused images

$$\begin{bmatrix} DN^{h}_{MS1} \\ DN^{h}_{MS2} \\ \cdots \\ DN^{h}_{MSn} \end{bmatrix} = \begin{bmatrix} DN^{l}_{MS1} \\ DN^{l}_{MS2} \\ \cdots \\ DN^{l}_{MSn} \end{bmatrix} + (DN^{h'}_{PAN} - DN^{l}_{PAN}) \begin{bmatrix} v11 \\ v21 \\ \cdots \\ vn1 \end{bmatrix}$$

Where

$$DN^{l}_{PAN} = PC1 \text{ and } DN^{h'}_{PAN} \text{ is } DN^{h}_{PAN}$$

(Zhijun Wang, 2005)

2- High Pass Filter Method

In this method, the injection of high frequency information (spatial details) extracted by the high pass filter from the High resolution Panchromatic image into the multi band low resolution image, which will produce a fused image with sharp high frequency characteristics (Haixia liu and Xia Zhang, 2009).The model used in this method is

$$DN^{h}_{MS} = DN^{l}_{MS} + \left(DN^{h}_{PAN} - DN^{l}_{PAN}\right)$$

Where $DN^{l}_{PAN} = DN^{h}_{PAN} * h_0$ and h0 is low pass filter such as boxcar filter. (Zhijun Wang, 2005)

3- Brovey Method

This method uses a direct intensity modulation; it was developed to increase the visual contrast in the ends of the image histogram. The limitation of this method is only three bands can be used in

each merging process (Jian Guo Liu, 2009) as represented in the equation below

$[DN_{B1} / DN_{B1} + DN_{B2} + DN_{B3}] \times [DN_{high\ res.\ image}] = DN_{B1\_new}$
$[DN_{B2} / DN_{B1} + DN_{B2} + DN_{B3}] \times [DN_{high\ res.\ image}] = DN_{B2\_new}$
$[DN_{B3} / DN_{B1} + DN_{B2} + DN_{B3}] \times [DN_{high\ res.\ image}] = DN_{B3\_new}$
(ERDAS Field Guide, 2008)

4- Modified IHS (Intensity, Hue, Saturation) method

The modified IHS have an improvement over the traditional IHS method when working in merging images that have relatively high differences in spectral response (Siddiqui, 2003) .
This method like the Brovey method can be used with three bands only in each merging process as represented in this equation

$$\begin{bmatrix} DN^{h}_{MS1} \\ DN^{h}_{MS2} \\ DN^{h}_{MS3} \end{bmatrix} = \begin{bmatrix} DN^{l}_{MS1} \\ DN^{l}_{MS2} \\ DN^{l}_{MS3} \end{bmatrix} + \left(DN^{h'}_{PAN} - DN^{l}_{PAN}\right) \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

Where

$$DN^{l}_{PAN} = (1/3)(DN^{l}_{MS1} + DN^{l}_{MS2} + DN^{l}_{MS3})$$

And $DN^{h'}_{PAN}$ is DN^{h}_{PAN} (Zhijun Wang, 2005).
In all methods the merging process used the cubic convolution as the resampling method.
The merged images were put in comparison from two stand of view;
1- The visual inspection
2- Statistics

Visual Inspection

In order to evaluate the visual enhancement of each method, general and specific comparisons for the images have been done.

In **Figure 3** the original and the merged images were put together for the general inspection.

The spatial resolution is clearly improved for the resulted images in compare with the original multi bands image. All the images highly preserved the color composite of the original multi band image, although the Brovey image were darker than others.

Figure 4 illustrates the comparison for the coastal area. The coastal area appears highly distinguishable in the HPF image, the high brightness of the shore line in the IHS image give it some advantage over the PCA and Brovey images which had less capability of extraction for the coastal area respectively.

Figure 5 shows the agricultural zone, the same results as the coastal area were obtained; the visual enhancement was higher in HPF and IHS than PCA and the Brovey which has the least enhancement; the same result appeared in desert and urban zones as well.

Statistical Comparison

The statistical parameters comparison is used to identify the effect of different merging techniques on the original image in quantitative terms.

Table1 shows the statistical information (Min, Max, Mean, Median, Mode and Standard deviation) for the images participated in this work.

The first parameter for comparison is Mean, which describes the central location of the data or where the DN histogram curve is positioned horizontally. **Figure 6** illustrate a graphical comparison among the four techniques and the original multi band image. The figure shows that Brovey method image have a lower mean values than other images, HPF and IHS images a very close values to the original multi band image and the PCA image was less closer to the original image, this means that the Brovey image is expected to be darker than other images which approve the result obtained from the visual inspection.

The other tested parameter was the standard deviation, shows how much variation or exists from the mean value. The importance of standard deviation is expressing the brightness values variation of the image.

Figure 7 representing the standard deviation of the merged and original images.

In this figure we notice that the Brovey image has less standard deviation than the original image, this resulted in less brightness contrast and less environmental boundaries definition. PCA has standard deviation values higher than Brovey but less than original image. The IHS scored higher values than the original image except the third

Band and the HPF have approximately the same values of the original image.

Conclusion

In this work, four merging methods were tested for their suitability for different environmental areas extraction. Visual enhancement and statistical comparison took place for the evaluation process.

In General, all the methods enhance the image spatial resolution. The visual inspection showed that the HPF and Modified IHS methods had better image quality, although HPF method preserved the natural colors of the original multi spectral image more than other images.

The statistical comparison showed that HPF method maintained the quantitative information of the original image, Modified IHS method showed good statistical results in comparison with PCA and Brovey method, which had the lower results respectively.

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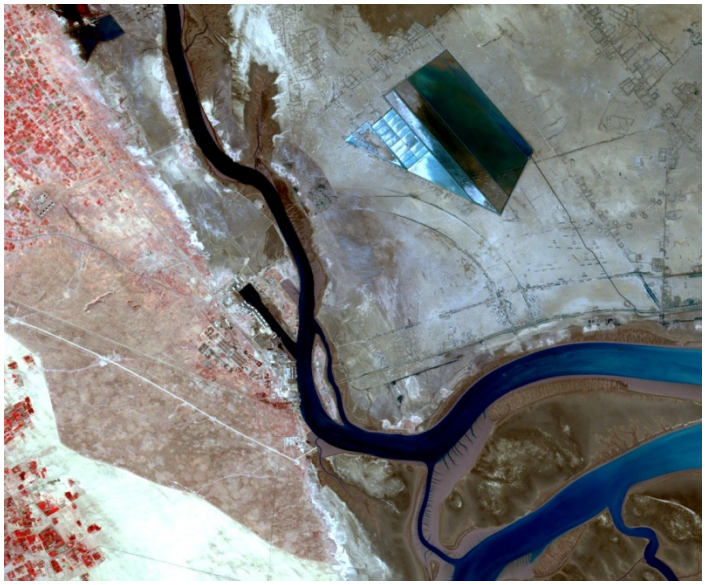

Figure 1 A 4, 3, 2 RGB image with 30 meter resolution for the study area, nearly in the middle of the image is Um-Qasser city.

Figure 2 The panchromatic image with 15 meter resolution of the study area

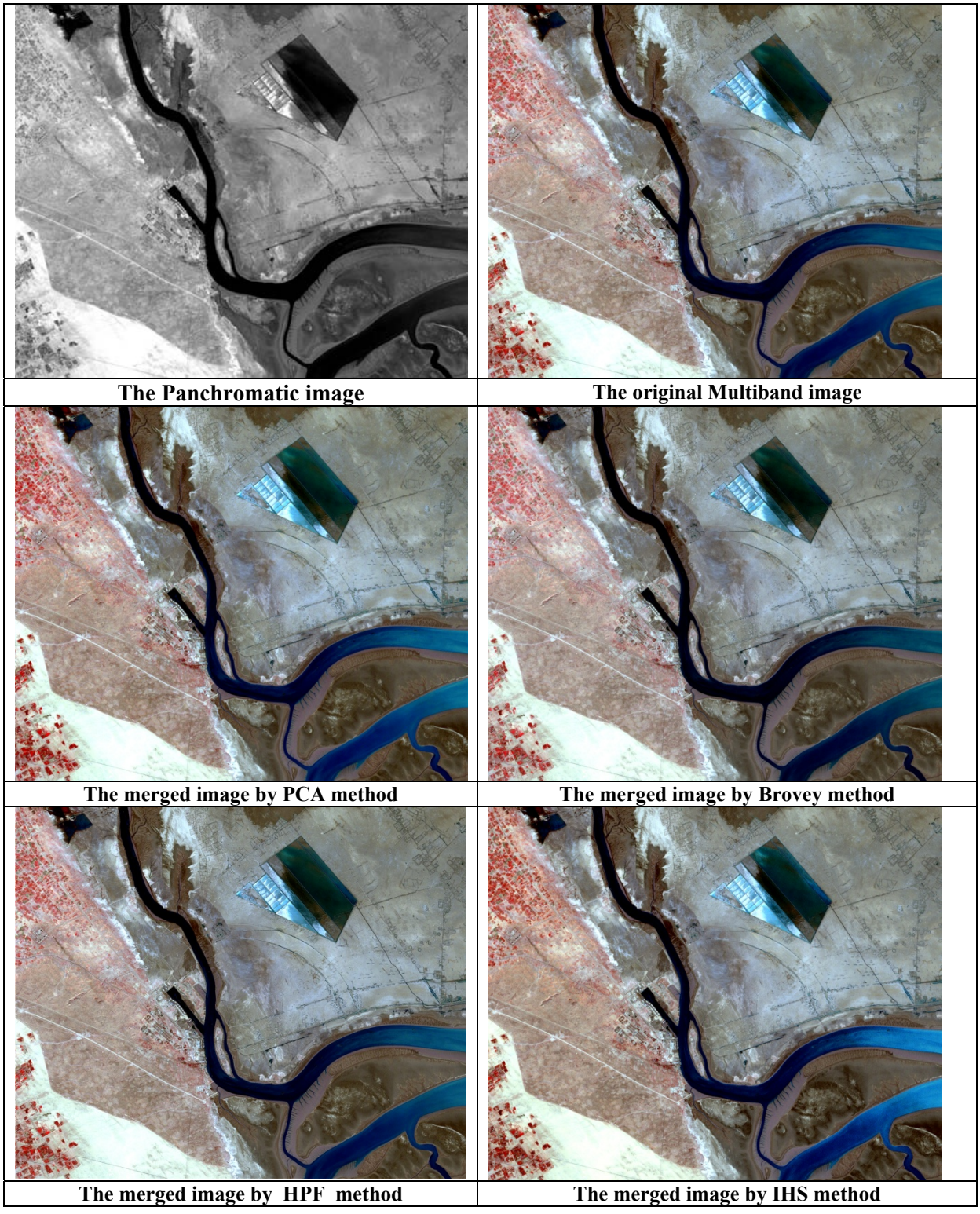

Figure 3 The original (panchromatic and multi bands) and the different methods merged images.

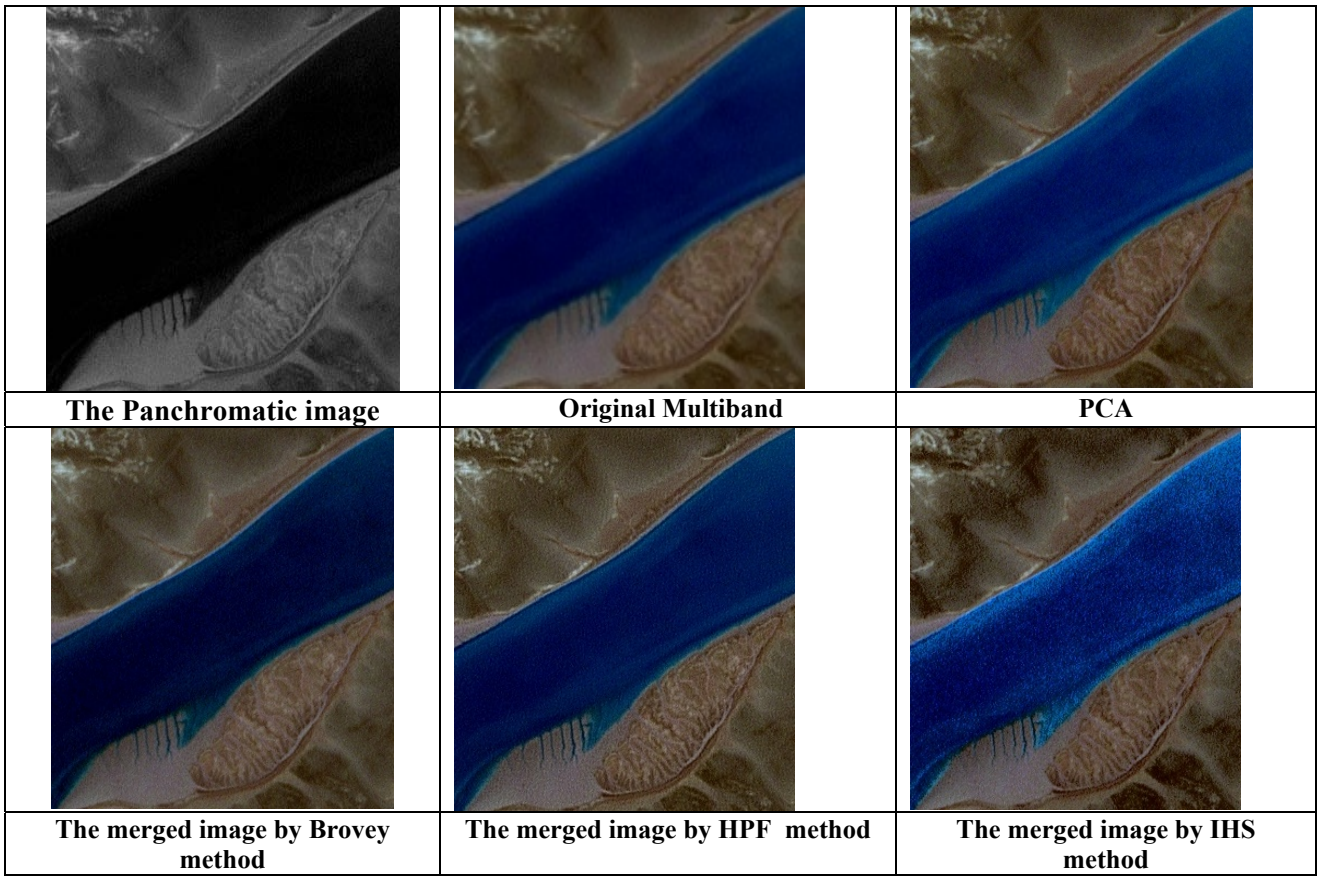

Figure 4 Sub scenes of the original and resulted images, to compare the coastal zone extraction.

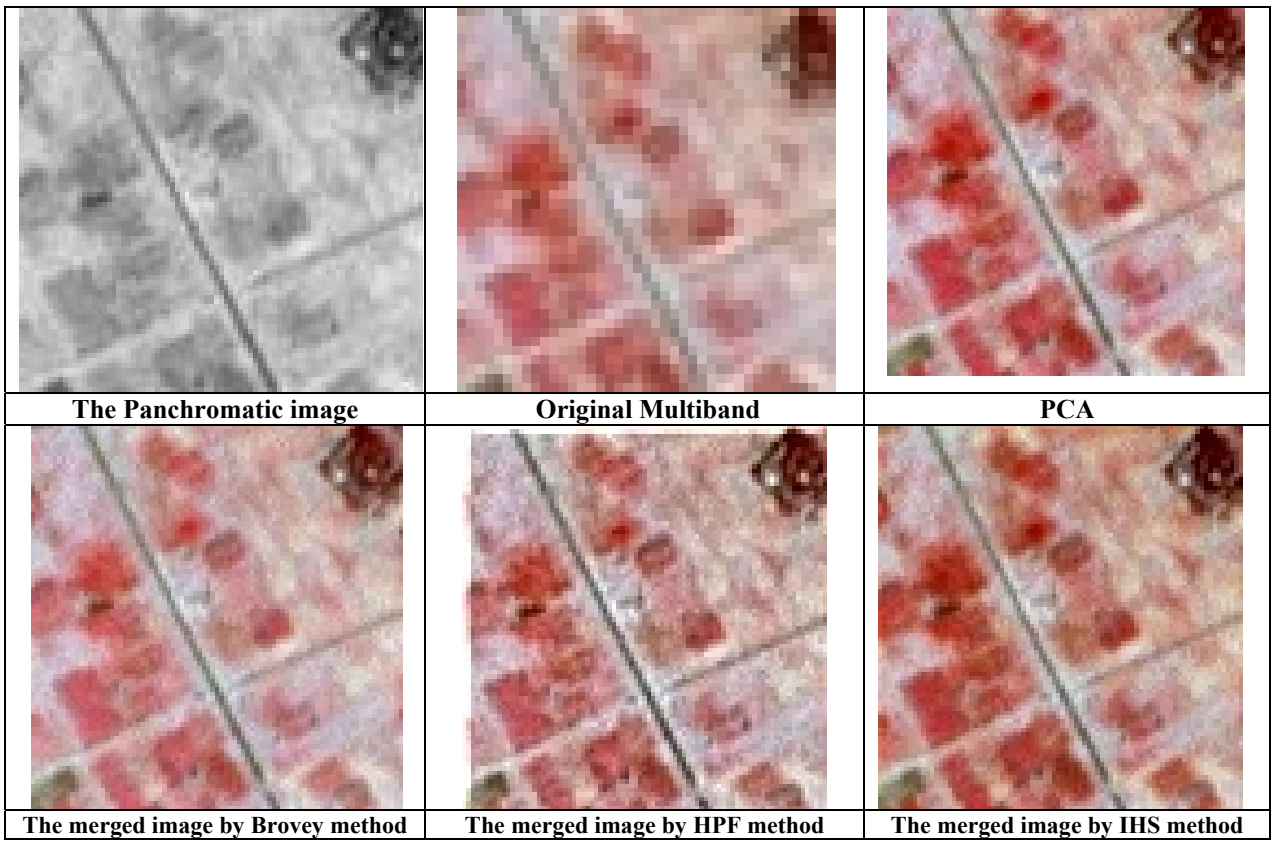

Figure 5 Sub scenes of the original and resulted images, to compare the agricultural zone extraction.

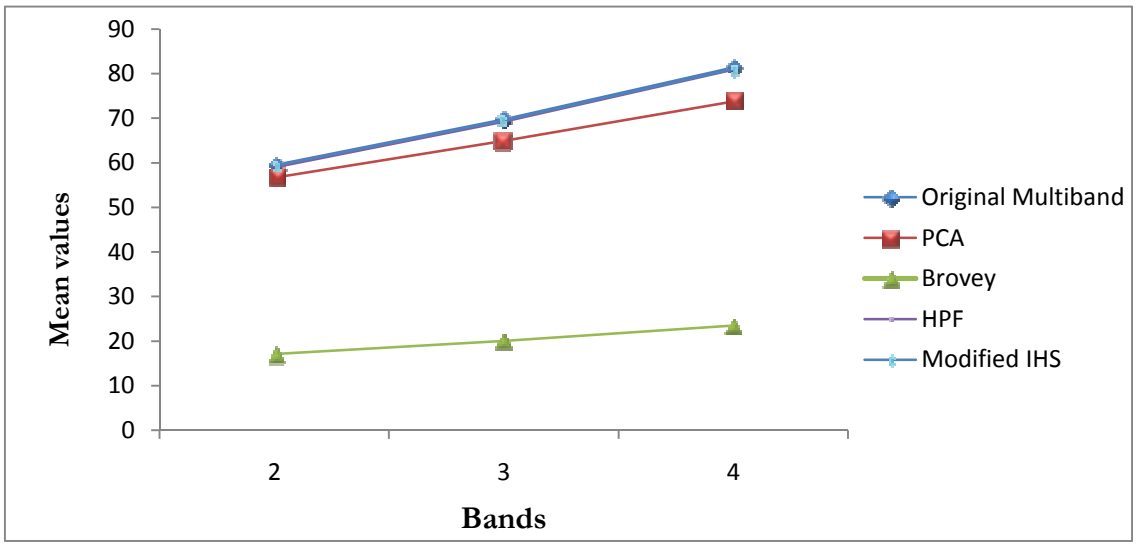

Figure 6 A graphical comparisons among the four techniques and the original multi band image

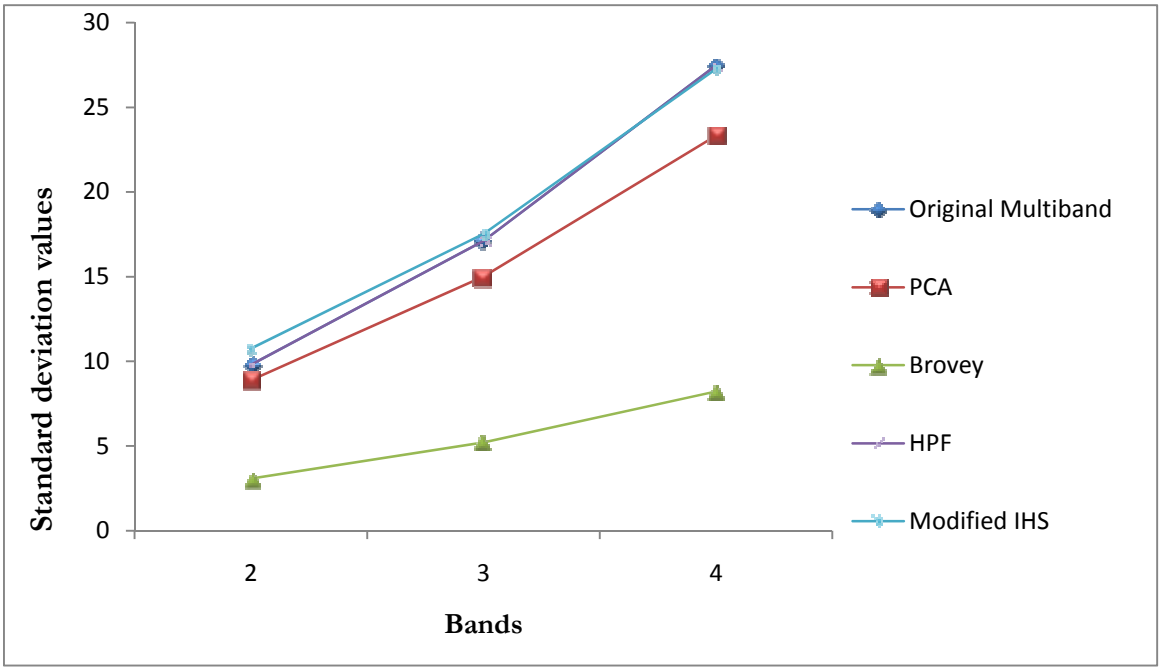

Figure 7 Representation of standard deviation values for the merged and original images.

Table 1 Statistical information of the Panchromatic, Original Multi band and merged images

Image	Band	Min	Max	Mean	Median	Mode	Standard Deviation
Panchromatic		13	141	60.695	63	68	16.068
Original Multiband	2	23	129	59.486	60	61	9.787
	3	18	150	69.734	71	76	17.104
	4	14	165	81.368	84	81	27.450
PCA	2	22	130	56.717	56.594	57.859	8.881
	3	6	158	64.937	65.969	68.938	15.003
	4	12	165	73.794	75.949	74.754	23.323
Brovey	2	5.0801	41.837	17.098	17.284	17.572	3.079
	3	3.8371	50.276	20.085	20.526	22.159	5.216
	4	3.3241	49.296	23.512	24.334	23.437	8.216
HPF	2	18	156	58.985	59	60	9.791
	3	5	208	69.234	71	73	17.107
	4	0	248	80.869	84	82	27.450
Modified IHS	2	16	129	59.360	60	61	10.756
	3	9	150	69.527	71	70	17.526
	4	14	165	81.007	85	95	27.251