Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (42) No. (2) April, 2020

Evaluation of Change Detection Methods by using Landsat Images

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ملخص البحث:

الهدف الرئيسي من هذا البحث هو تقييم تقنيات الكشف عن التغير (Change detection techniques) لرصد تغيرات الغطاء الأرضي التي حدثت بين عامي 2016 و2017 في منطقة الدراسة الواقعة في محافظة القاهرة – مصر. مساحة منطقة الدراسة 77.35 كم ^{2}. بيانات الصورة هي صورتان تغطيان منطقة الدراسة وكلاهما من القمر الصناعي Landsat_8 OLI/TIRS مع درجة وضوح مكانية منخفضة 30 م *30 م. البيانات المرجعية هي صورتان تغطيان منطقة الدراسة وكلاهما من القمر الصناعي Nanosat مع درجة وضوح مكانية عالية 3م * 3م. وقد تم تصنيف منطقة الدراسة إلى طرق ورمال وصخور وتربة عارية ومسارات ومباني باستخدام طريقة التصنيف Maximum Likelihood Classifier. الهدف فحص فعالية كل تقنية فيما يتعلق بالكشف عن المناطق المتغيرة والغير متغيرة والتمييز بينهما. التقنيات التي ستقيم هي Principle Component Analysis وIndependent Component Analysis. تم إجراء التقييمات لنتائج هذه التقنيات لتحديد أنسب طريقة للكشف عن التغير التي توفر أعلى دقة لتحديد طبيعة ومدى تغيرات الغطاء الأرضي. أوضحت النتائج أن تقنية independent component analysis قدمت أعلى دقة بينما تقنية Principle Component Analysis أعطت أقل دقة.

الكلمات المفتاحية: تقنيات رصد التغير، تقنية تحليل المكون المستقل، تقنية تحليل المكون الرئيسي.

ABSRACT

The aim of the research is to know the accuracy of Change detection techniques to know the different land cover changes that occurred between 2016 and 2017 in the study area located in Cairo Governorate. 77.350 km^2 it is the actual studied area. Two Images were obtained from the Landsat_8 OLI / TIRS satellite covering the studied area and pixel size 30m * 30m. Two images were obtained from the Nanosat satellite covering the studied area and pixel size 3 m * 3 m. The studied area consists of roads, sand, rocks, bare soil, routes and buildings. two change detection techniques namely; Independent Component Analysis and Principal Component Analysis were applied. The objective is extended to examine the effectiveness of each change detection technique regarding not only the ability to differentiate changed from unchanged areas, but also the ability to classify the changed areas according to the "from-to" identifiers. Quantitative evaluations for the results of these techniques were performed to determine the most appropriate change detection technique which will provide the highest accuracy for identifying the nature and extent of land-cover changes in the study area. The results indicated that the independent component analysis change detection technique provided the highest accuracy while the principal component analysis technique gave the least accuracy.

KEWORDS: Independent component analysis; Principal component analysis.

1. Introduction

Remote sensing is the ability to measure, study, analyze, collect, interpret, and analyze target characteristics and get results without any direct contact by taking pictures and visual of the target using satellites.

Change detection is the process of detecting changes in areas and detecting obvious or unclear differences by observing the study area at different times by remote sensing technology [1].

In this study, two techniques of change detection techniques will be evaluated to know the extent of the changes between 2016 and 2017 that occurred in the study area located in Cairo, Egypt, as shown in Figure 1 and Figure 2.

These techniques are:

(1) Independent Component Analysis (ICA).

(2) Principle Component Analysis (PCA).

Quantitative evaluations for the results of these techniques were performed to determine the most appropriate change detection technique which will provide the highest accuracy for identifying the nature and extent of land-cover changes in New Administrative Capital. In this study, several image-processing steps were performed by ENVI and ERDAS programs. [2] [1].

2. Study area and data sets

2.1 Study area

77,350 sq. km is the area studied its length, width and coordinates, as shown in Figure 2.

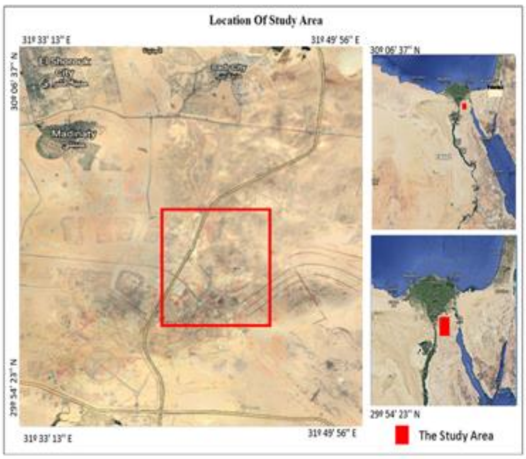


Figure (1): Study Area Location.

in light of the vast urban development that is taking place today, permanent monitoring of cities is very important to contribute to making important decisions and also to know the extent of the changes that occur for different types of land cover in our modern time.

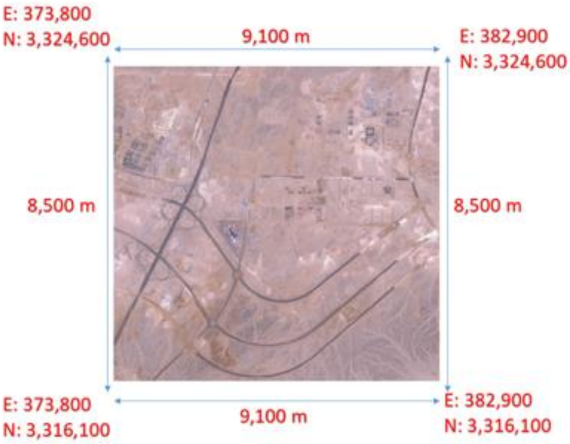


Figure (2): the Coordinates and Dimensions of The study area.

2.2. Reference data

Two images were obtained from the Nanosat satellite covering the studied area and pixel size 3 m * 3 m, as shown in figure (3).

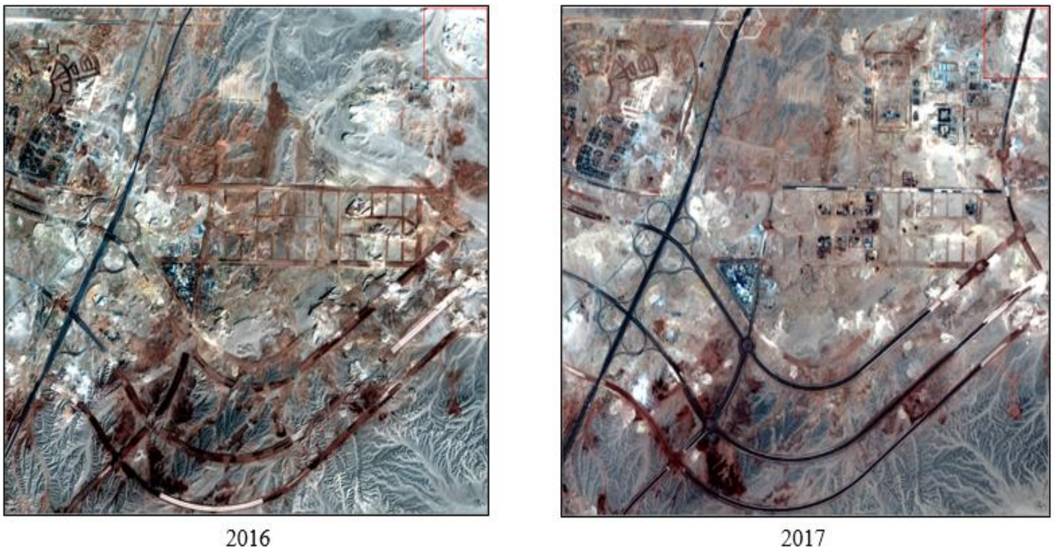
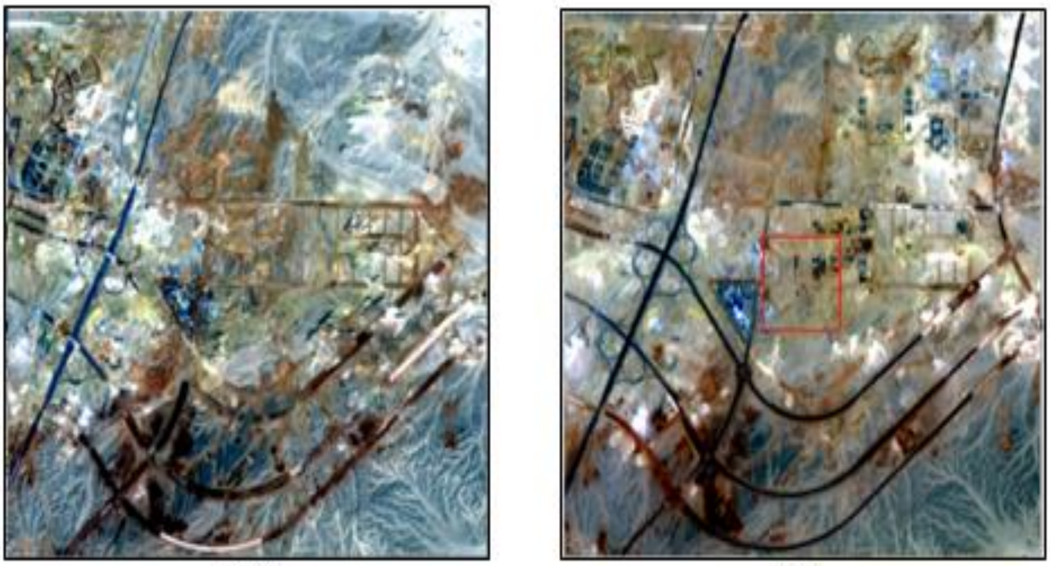


Figure (3): Reference data of the study area (High Resolution Images).

2.3. Image data

Two Images were obtained from the Landsat_8 OLI / TIRS satellite covering the studied area and pixel size 30m * 30m, as shown in figure (4).



2016 2017

Figure (4): Image data of the study area (Low Resolution Images).

3. Reference Change Detection Result

To complete the supervised classification for an image in the ENVI software, an image ROI file must first be created, as shown in figure (5).

Figure (5): ROI File for Image of Nano Sat for the year 2016 shows Six Classes.

The studied area consists of roads, sand, rocks, bare soil, routes and buildings.

In our study, we will perform the supervised classification for image in the ENVI program using the Maximum Likelihood method as shown in the figure (6).

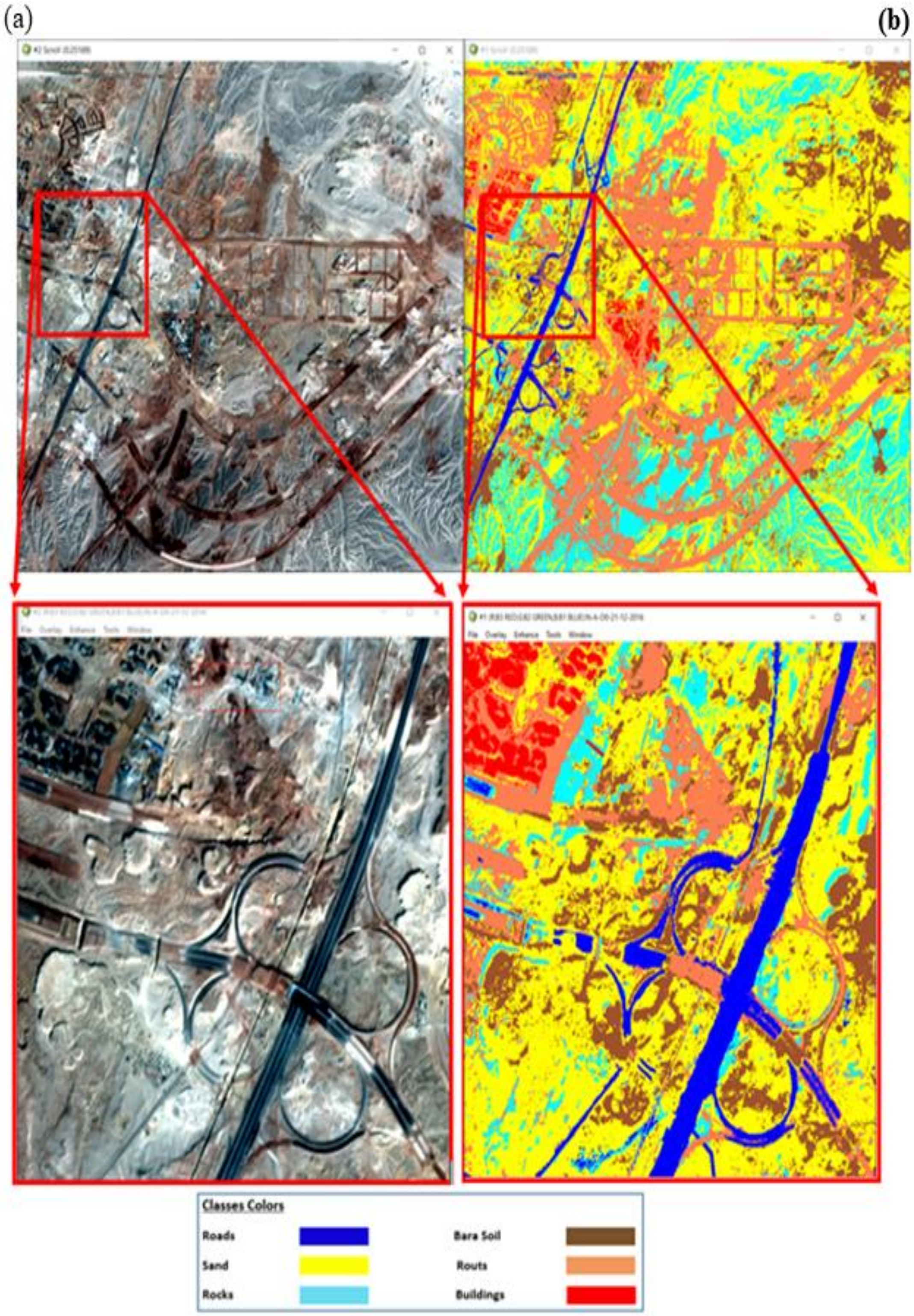


Figure (6): (a) Nanosat Image for the year 2016

(b) Classification of Nanosat image for the year 2016

Supervised Classification for image of NanSat for the year 2017, as sohwn in figure (7).

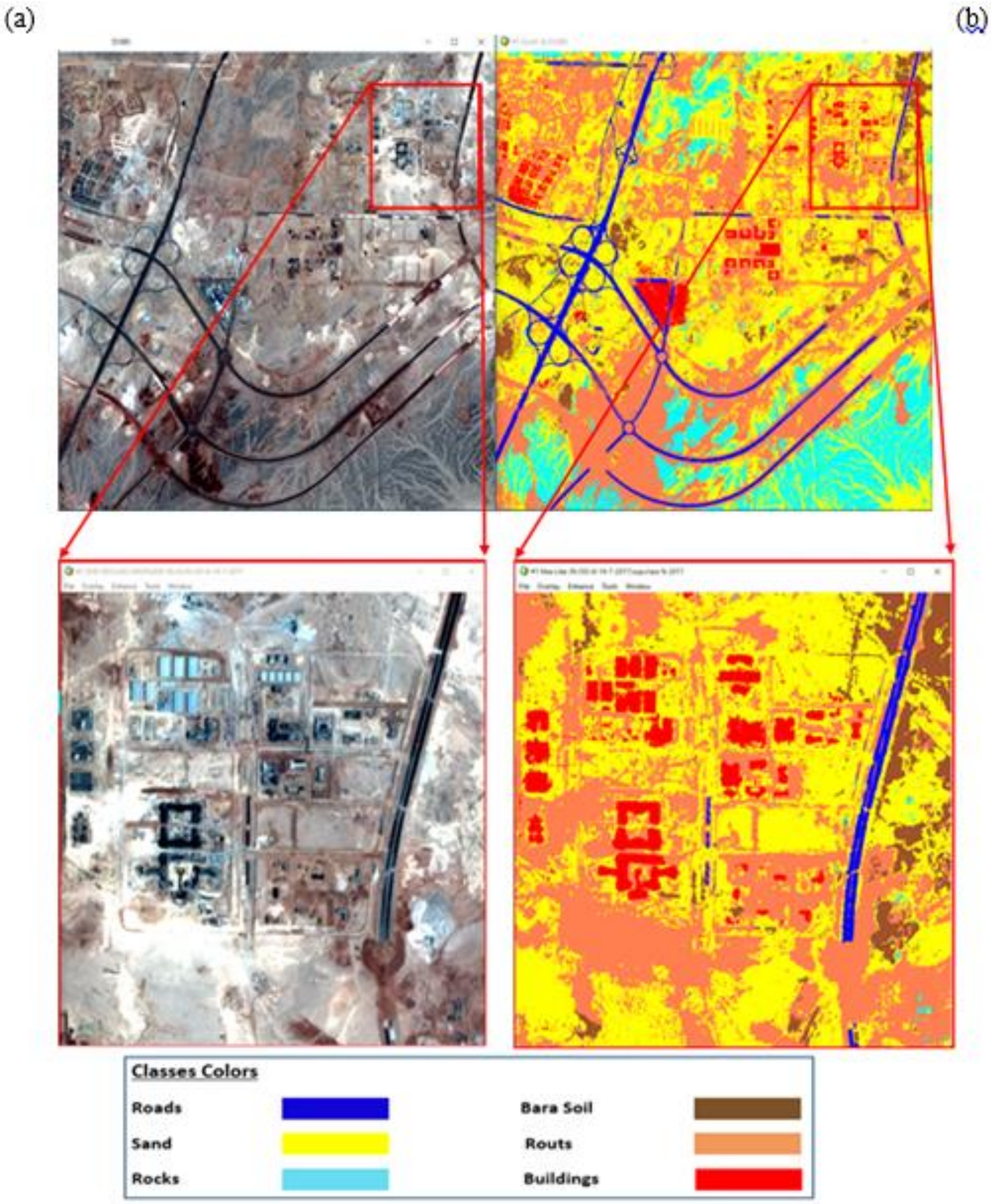


Figure (7): (a) Nanosat Image for the year 2017

(b) Classification of Nanosat image for the year 2017

The following table (1) shows the result of change detection for reference images between 2016 and 2017.

Table (1): Reference Change Detection Result (km²).						
Classes	**Road**	**Sand**	**Rock**	**Bare Soil**	**Route**	**Buildings**
2016	1.21	33.31	12.53	9.97	19.79	0.96
2017	2.73	34.84	10.32	4.29	24.28	1.29
Unchanged	0.72	22.14	6.19	1.66	12.97	0.6
Gained	2.01	12.7	4.13	2.63	11.31	0.69
Lost	0.49	11.17	6.34	8.31	6.82	0.36

4. Change Detection Techniques

4.1 Independent Component Analysis (ICA)

Use independent components (IC) analysis on multispectral or hyperspectral datasets to transform a set of mixed, random signals into components that are mutually independent. The applications of IC transformation in remote sensing include dimension reduction, extracting characteristics of the image, anomaly and target detection, feature separation, classification, end member extraction and noise reduction [5] [6].

4.1.1 ICA Error Matrices of Classified Change Detection Result

Table (2) illustrate the error matrix of change detection result for the Post Classification technique.

Table (2): ICA Error Matrix of the classified change image.

Pixels	Reference Data								
Classified Data	Classes	No change	Road	Sand	Rocks	Bare Soil	Routees	Buildings	Row Total
	No Change	2930756	90574	855511	283169	129995	686684	34981	5011670
	Road	125548	96107	10815	29931	2568	9125	1254	275348
	Sand	700452	4588	467706	10377	9048	49000	2175	1243346
	Rocks	207196	21228	5762	116330	983	6861	5113	363473
	Bare Soil	213681	3251	13907	1891	144581	11928	1611	390850
	Routees	702859	5002	54937	14318	3922	490618	7660	1279316
	Buildings	38832	3597	2194	3668	841	2077	24269	75478
	Column Total	4919324	224347	1410832	459684	291938	1256293	77063	8639481

ICA overall accuracy of the classified change image is 49.400 % and the Kappa coefficient is 0.184.

4.1.2 ICA Error Matrix of Change / Unchanged Result

Table (3) illustrate The Change/ Unchanged error matrix.

Table (3) : ICA change/unchanged error matrix.

(Pixels)	Reference Data			
Classified data	Class	No Change	Change	Total
	No Change	2930756	2080914	5011670
	Change	1988568	1639243	3627811
	Total	4919324	3720157	8639481

ICA overall accuracy of the change/ unchanged image is 52.90% and the Kappa coefficient is 0.0365.

4.2 Principle Component Analysis (PCA)

Assume that multi-temporal data are highly correlated and change information can be highlighted in the new components. This method is based on the Eigen vector of the variance or the covariance matrix of the merged data set. This technique is a multivariate analysis technique which is used to reduce the spectral components to the lesser number of principal components which are the reason behind the occurrence of most of the variance in the original multispectral images. For the reduction of spectral components, often linear transformation is used. Linear transformation is performed on the multi-date images and is combined so as to obtain a single dataset . PCA Advantage is reduces data redundancy between bands and emphasizes different information in the derived components [3]. PCA Disadvantage is PCA is scene dependent, thus, the change detection results between different dates are often difficult to interpret and label [3].

4.2.1 PCA Error Matrices of Classified Change Detection Result

Table (4) illustrate the error matrix of change detection result for Principle Component Analysis.

Table (4) : PCA Error Matrix of the classified change image.									
Pixels	Reference Data								
	Classes	No change	Road	Sand	Rocks	Bare Soil	Routees	Building	Row Total
Classified Data	No Change	2855786	85641	854849	283248	126639	683876	34592	4924631
	Road	125770	93208	10158	27732	2558	9030	1243	269699
	Sand	707980	4900	462034	9741	7750	47896	2185	1242486
	Rocks	240773	25182	6964	118399	1056	7065	5113	404552
	Bare Soil	222335	3322	14619	2007	149156	12159	1611	405209
	Routees	719271	5258	59079	13397	3878	493862	4051	1298796
	Buildings	47409	6836	3129	5160	901	2405	28268	94108
	Column Total	4919324	224347	1410832	459684	291938	1256293	77063	8639481

PCA overall accuracy of the classified change image is 48.700 % and the Kappa coefficient is 0.178.

4.2.2 PCA Error Matrix of Change / Unchanged Result

Table (5) illustrate The Change/ Unchanged error matrix.

Table (5): PCA change/unchanged error matrix.				
(Pixels)	Reference Data			
	Class	No change	Change	Total
Classified data	No Change	2855786	2068845	4924631
	Change	2063538	1651312	3714850
	Total	4919324	3720157	8639481

ICA overall accuracy of the change/ unchanged image is 52.169% and the Kappa coefficient is 0.0244

5. Analysis of the Results

Table (6) summarizes the overall accuracy and the KHAT calculated from each change/unchanged and classified change error matrices due to applying the three change detection techniques.

Table (6): Overall accuracy and the KAHT value of the three change detection techniques.				
Technique	Change / unchanged		Classification	
	Overall Accuracy %	KAHT	Overall Accuracy %	KAHT
Independent Component	52.169	0.024	48.700	0.178
Principle Component	52.900	0.0365	49.400	0.184

The results indicated that the independent component analysis change detection technique provided the highest accuracy while the principal component analysis technique gave the least accuracy.

6. Conclusions

1. The results indicated that the independent component analysis change detection technique provided the highest accuracy while the principal component analysis technique gave the least accuracy.

2. For each change detection technique, the overall accuracy of the resulted change/unchanged image is higher than that of the classified change image. This is due to the errors induced by the "from-to" classification process.

7. References

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