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Evaluation of Land Use Maps Using Remote Sensing and GIS

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Abstract

Land use map considered as one of the most essential problems for planning and managing schemes to come across the increase in demands for basic human requirements and prosperity of the ever increasing population. Remote sensing is an important tool for the creation of land use maps by the use of image classification techniques. GIS is a tool that is helpful for conducting image classification through modeling. The aim of this study was to evaluate the land use map produced from classification of available Landsat images using modern techniques. The present study was accompanied in the Gold Triangle region, Egypt. The Landsat 8 images used in the classification process were taken in 2015 for land use mapping. Firstly, supervised classification was performed based on signature samples covered the area of interest. Then, accuracy assessment was done using ground truth of random points distributed all over the image produced from classification process. The total resultant accuracy of the image classification was 86 % and the Kappa coefficient was 0.82. This means there was 82 % agreement for the classified image by chance alone.

Key words: Land use, Remote Sensing, GIS, Classification, Accuracy Assessment

INTRODUCTION

All times, land is considered one of the most important resources in economy development around the world. The mode of society and economy development affects greatly realistic uses of land resources. Land use information is crucial for spatial planning process and environmental protection studies. Remote sensing imagery can be used as a data source to access to the urban land use information and becomes essential technology. Moreover, land use classification is necessary because its products can be useful in modeling, specifically in the environmental applications, another example when dealing with climate change and strategies developments. Classification of satellite images can be done with the integration of Geographic Information System (GIS) technique. Open source data of Landsat images granted the opportunity to use it in classification. Also, spatial resolution of Landsat images, 30 meters resolution, forced us to do accuracy assessment of the output of classification. Earlier, accuracy valuation was not the first priority in image classification studies. However, because of the enhanced chances for error caused by digital imagery, accuracy evaluation has become a very serious process. Validation of results is an important step in the processing operations of remote sensing data due to imperfect atmosphere during the observation time. The global accuracy of the resulting classified image identifies the percentage by which each of the image pixels is categorized against the definite land cover conditions attained from their matching ground reality data. Creator's accuracy detects the errors of omission, which is a measure of the real world land cover types can be represented. Operator's accuracy amounts the errors of commission, which characterizes the probability of a categorized pixel matching the land cover type of its corresponding real world location. The overall, producer and user accuracy are obtained from an error matrix describing the relation between classified data and its corresponding ground truth. The error matrix is the main in the accuracy assessment of the classification process. The main objective of this research was to produce land use map from the classification of Landsat images using Geospatial Information System (GIS) techniques. Also, accuracy assessment of the classified data was one of the goals of the paper to discover how well the classification processes was undertaken.

Data Collection:

The Golden Triangle is located in the eastern desert region of Egypt. The shaded part of Figure 1 shows the study area. The area extends between latitudes 24˚58'19" N and 26˚55'17" N and longitudes 31˚47'53" E and 34˚54'40"E. The total study area is 38600 km^2.It has valuable importance and play a pivotal role in the overall development process taking place in this region. It connects province of Qena located at the Nile River with the Red Sea province located in the Red Sea. The Safaga - Qena Road located in the area and considered to be the most important crossroads that serve day passenger traffic coming from the provinces ofQena, Assiut, Sohagand Luxor to the cities of the Red Sea and vice versa. It also serves as a tourist movement which departs daily from the cities of Hurghada, Safaga and Quesir and go to visit the archaeological sites in Qena, Luxor and Aswan.

The sources of data includes images from free Landsat 8 satellite. Landsat 8 (OLI/TIRS) imagerycontains9 spectral band groups with a 30 m spatial for 1 to 7 and 9 bands. Novel band 1 (Ultra blue) is valuable for coastline and aerosol studies. New band nine (9) is suitable for cirrus cloud recognition. Band 8resolution (panchromatic) is fifteen (15) meters. Thermal bands 10 and 11 are beneficial in providing more accurate surface temperatures and are captured at 100 meters. Estimated scene width is 170 km north-south by 183 km east-west.The total coverage area by 9 scenes as shown in Figure 2.

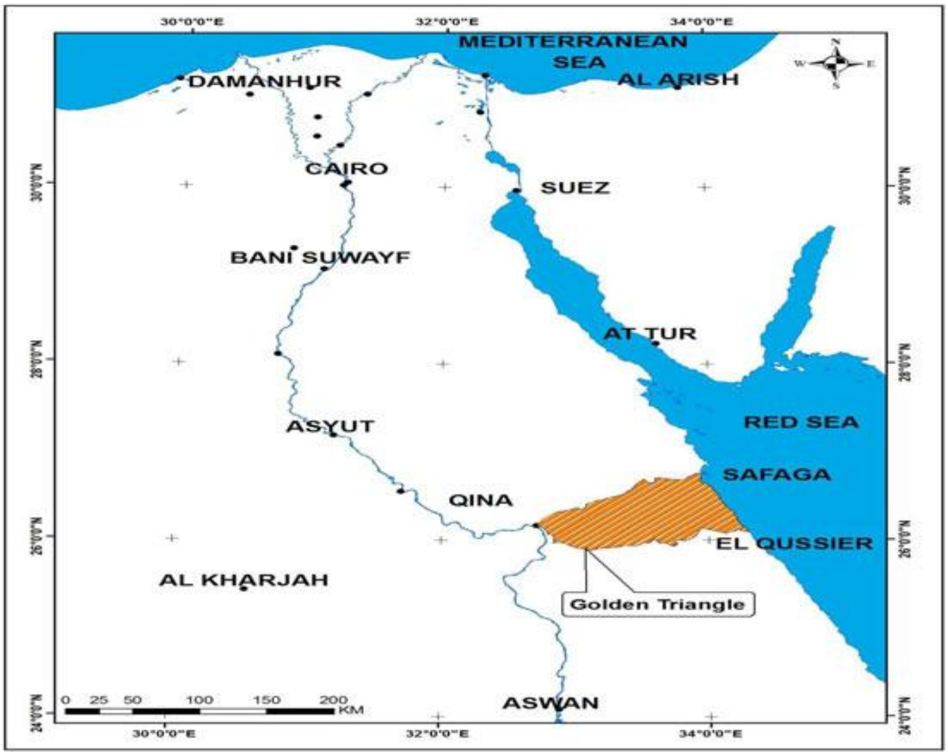

Fig. 1: Study area

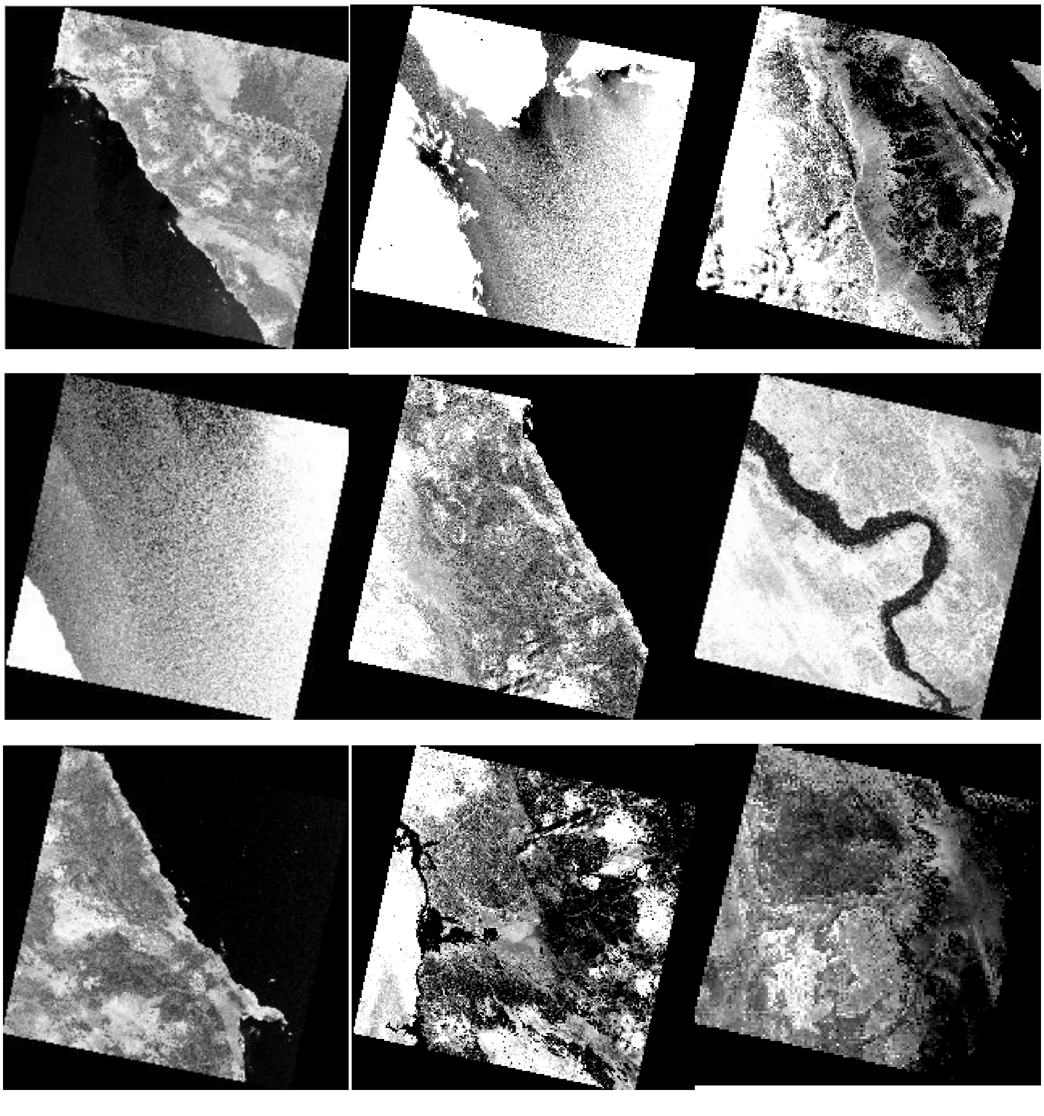

Fig. 2: Landsat scens covered the study area.

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Data Preprocessing And Classification:

Classification process were done using nine scenes of Landsat satellite images covering the study area. They were provided by the United States Geological Survey (USGS) Earth Explorer. The horizontal datum is WGS 1984 and the coordinate system was the Universal Transverse Mercator (UTM Zone 36 North). Some preprocessing options for the images were done before classification. Every image scene contains eight bands with a 30 meters spatial resolution (Bands 1 to 7 and 9) which staked together to create a single raster dataset from these multiple bands. After staking bands, the panchromatic band (Band 8) of resolution 15 meters was used to create pan-sharpened dataset for each scene. Panchromatic refining utilizes a high-resolution panchromatic image to combine with a low resolution multi-band raster data to yield a multi-band raster dataset with the resolution of the panchromatic raster. Afterwards, a mosaic was created from combination of pan-sharpened images by mosaicking them together using overlapped areas between each successive images. Then, from the mosaic dataset the image data of the study area was obtained by cropping the mosaic using a polygon shape for the area of interest.

Image classification process states to the mission of grabbing information classes from a multi-band raster image. The raster product of image classification can be used to generate thematic maps. It comprises of two methods: supervised and unsupervised classification. In this paper, only supervised classification method was used. The main goal of supervised classification is to allocate each pixel in the study area to a known class. It uses the spectral signatures obtained from training samples to classify an image. The input to classification is a signature file comprising the multivariate statistics of each class. The result of each classification is a map that divides the study area into known categories which correspond to training samples. With the ArcGIS Spatial Analyst extension, supervised classification were done as shown in Figure 3 which demonstrates the sequential steps of image classification workflow.

From Figure 3 after preprocessing operations discussed earlier, the first step in supervised classification is to collect training samples to identify classes and calculate their signatures. This is done using on-screen digitizing of features represent different classes depending upon those areas obviously recognized in all sources of images. More training areas were selected to represent each particular class. In this study area, there were five classes: Agriculture lands, Built-up areas, Mountainous areas, Sandy lands and Wet lands. Afterwards, the collected training samples were evaluated to avoid interference between the spectral characteristics of different samples. Then a signature file can be created after determining the exercise samples are illustrative of the desired classes and are distinct from one another. The supervised classification was applied after defining the signature file. Filtering and generalization process were applied to remove isolated pixels, or noise, from the classified image. The final result of supervised classification was as shown in Figure 4.

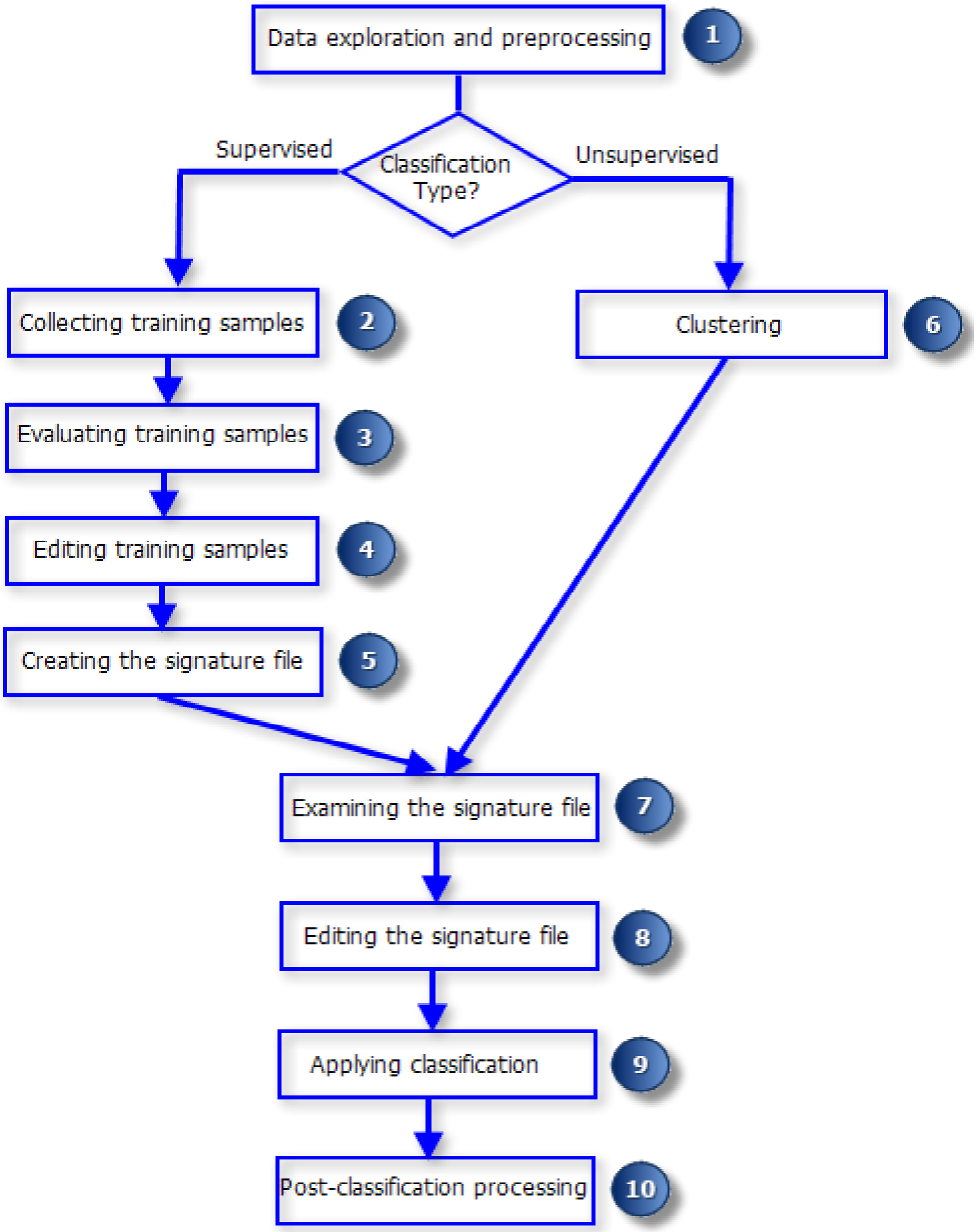

Fig. 3: Image classification workflow in the ArcGIS Spatial Analyst extension.

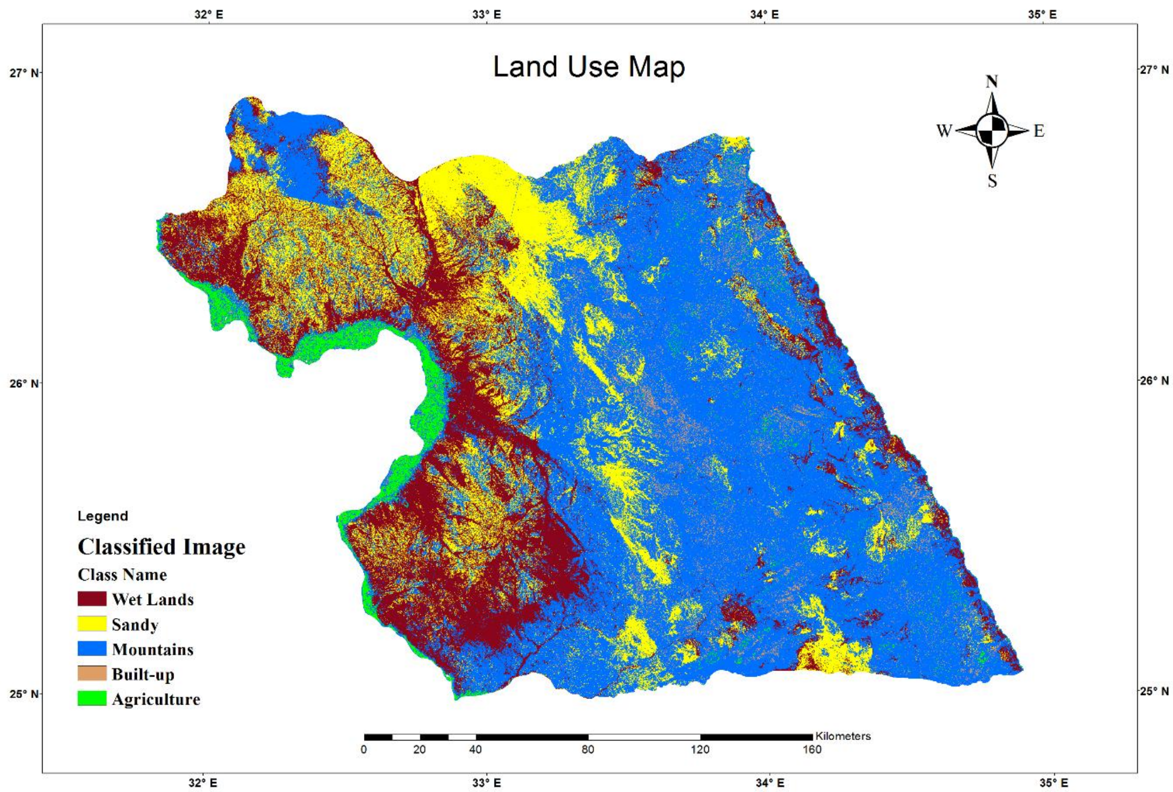

Fig. 4: Classified map of the study area.

Accuracy Assessment Of Classified Image:

The classified imaged (Land Use map) resulted from supervised classification must be assessed in order to ensure the accuracy of results. The objective of the accuracy evaluation is to quantify the effectiveness of pixel samples in the correct land use classes. Figure 5 illustrates a schematic work flow for Land use accuracy assessment.

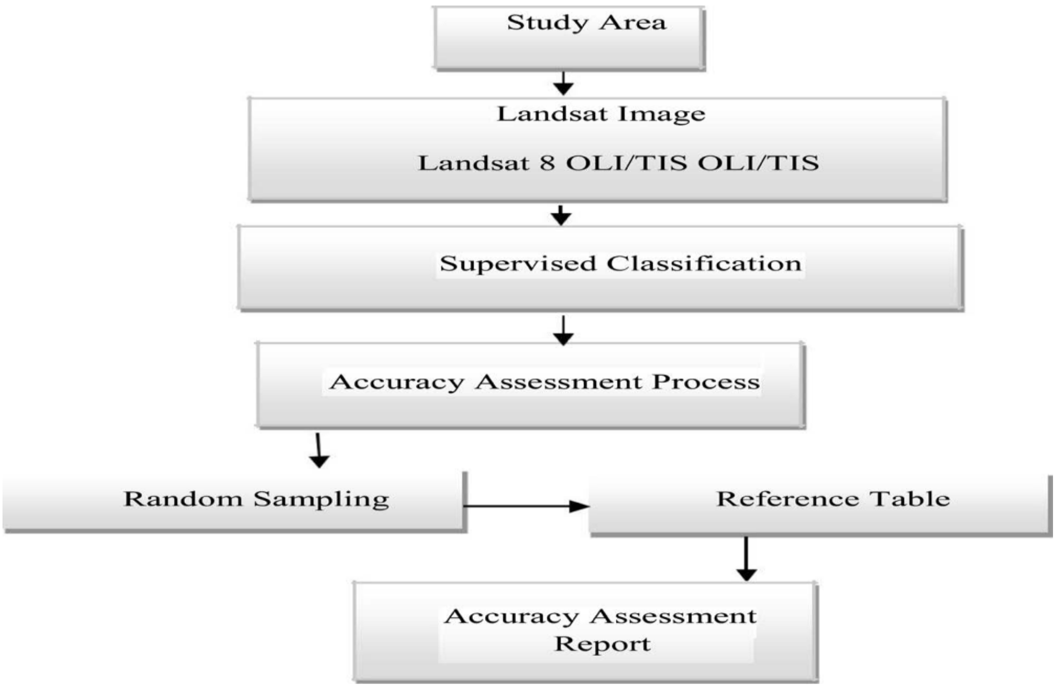

Fig. 5: Schematic work flow for Land use accuracy assessment.

The evaluation of the accuracy of theland use map has been carried out using random points distributed on each class of the classified image and compared with their ground truth from Google Earth.Five hundred (500) points were generated in the classified image of the study area. For instance, Figure 6 shows the classified Agriculture layer with distributed random points on it. Also, the corresponding locations of these random points on Google Earth are displayed in Figure 7. A comparison process between each random point established on the classified image and its corresponding ground truth from Google Earth was done resulting an error matrix. Table 1 shows the error matrix of the accuracy assessment which determines the relationship between the ground truth data and their corresponding classified data. The overall classification accuracy can be obtained by dividing the number of corrected classified random points by the total number of points used in the accuracy assessment. Therefore, the overall accuracy, from Table 1,is 429/500 = 85.8 %.

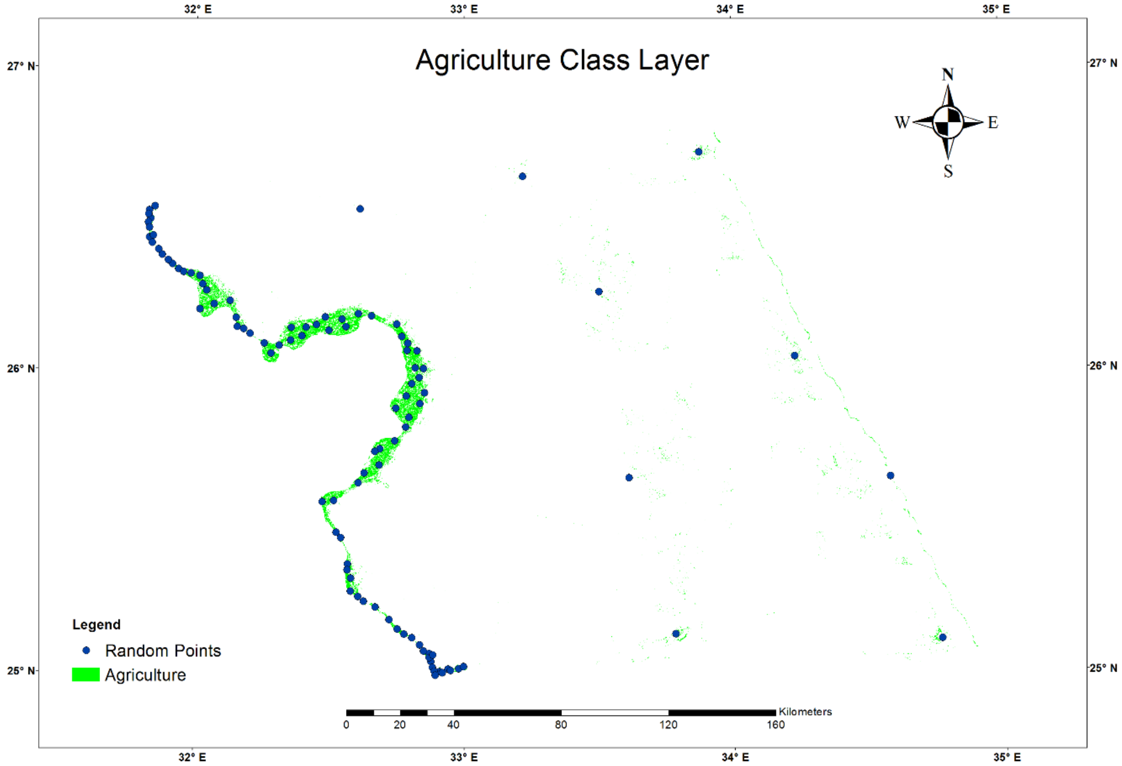

Fig. 6: Classified Agriculture layer with distributed random points.

Fig. 7: The ground truth of random points through Google Earth.

Table 1 Error matrix of the assessment of the classified image.

		Reference Data						User Accuracy
	Classes	Agriculture	Built Up	Wetland	Mountains	Sandy	Total	
Classified Data	Agriculture	91	1	1	5	2	100	91
	Built Up	5	79	2	11	3	100	79
	wetland	1	3	86	6	4	100	86
	Mountains	0	4	5	89	2	100	89
	Sandy	1	6	4	5	84	100	84
	Total	98	93	98	116	95	500	
	Producer Accuracy	92	84	87	76	88		Overall accuracy=86%

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Table 1 shows the error matrix for the supervised classified image with three distinguish parts. Part 1 is the rows of the matrix which represent the categories the image cells have been given in the image. Part 2 is the fields of the matrix display to which classes the pixels is in the validation set belong (ground truth). Part 3 is the diagonal of the matrix which show the pixels that are correctly classified. Pixels that are not in the diagonal assigned to the wrong class and give an indication of the confusion between the different land use classes in the classified image. The last row in Table 1 represents the Producer's accuracy that indicates to how well a certain areacan be classified (omission error). Moreover, the last column is the User's accuracy which denotes the probability apixel class on the map represents thecategory on the ground (commission error).

Additionally, KAPPA analysis is a discrete multivariate technique used in accuracy assessment (Jensen, J.R. 1996) which is a measure of agreement or accuracy between the classified map and the reference data. It is computed as:

$$\hat{K} = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{k}(x_{i+} \times x_{+i})}$$

Where k is the number of rows and columns in error matrix, N is the total number of points used in accuracy assessment,X_{ii} is the observation in row $i$and column i, X_{i+} is the marginal total of row i, and X_{+i} is the marginal total of column i.When Kappa coefficient equal to 1, it means perfect agreement where as a value close to zero means that the agreement is no better than would be expected by chance. In this research the Kappa coefficient was 0.82 which indicates to almost perfect results according to Table 2 that describes the rating criteria of Kappa statistics (Landis, J.R. and Koch, G.G., 1977).

Table 2: Rating criteria of Kappa statistics.

S.No	Kappa statistics	Strength of agreement
1	<0.00	Poor
2	0.00 - 0.20	Slight
3	0.21 - 0.40	Fair
4	0.41 - 0.60	Moderate
5	0.61 - 0.80	Substantial
6	0.81 - 1.00	Almost perfect

Conclusions:

In recent times, remote sensed data is one of the most important sources of images used in producing land use maps. Land use maps can be obtained by classifying of remote sensed images through different methods. The aim of this paper is to use supervised classification method in order to produce land use map and evaluate the classified image against ground truth. Remote sensed images and ArcGIS were used to complete the goal of the research. Firstly, Landsat images were collected for the study area. Secondly, preprocessing operations were done on the collected data such as composite bands of Landsat images, Pan-sharpening, Mosaicking and Clipping the study area from resulted mosaic. All preprocessing operations were done using ArcGIS software. Thirdly, supervised classification was performed to produce land use map for the study area. The image was classified into five classes: Agriculture lands, Built-up areas, Mountainous areas, Sandy lands and Wet lands. Finally, classified image was evaluated using random points distributed on the study area. The overall accuracy of the image classification was 86 % and the Kappa coefficient was 0.82 which indicates that there was 82 % agreement for the classified image.

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