GIS and Remote Sensing for Mapping and Monitoring Land Cover Changes in Mubi Metropolis

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Abstract
This study evaluates land use/cover changes and urban expansion in Mubi metropolis, Adamawa State Nigeria, between 2009 and 2015 using satellite images. Spatial and temporal dynamics of land use/cover changes were quantified using two Landsat images, a supervised classification algorithm and the post-classification change detection technique in GIS. Accuracy of the Landsat-derived land use/cover maps ranged from 85 to 90%. The analysis revealed that substantial growth of built-up areas in Mubi over the study period resulted significant decrease in the area of vegetation, water bodies, and bare lands. Urban land expansion has been largely driven by population growth and economic development. Rapid urban expansion through clearing of vegetation resulted in a wide range of environmental impacts, including habitat quality. As reliable and current data are lacking for Mubi, the land use maps produced in this study will contribute to both the development of sustainable urban land use planning decisions and also for forecasting possible future changes in growth patterns.

Key wards - Change detection, GIS, Land use and land cover, Mapping, Monitoring, Mubi metropolis, Remote Sensing, Urban expansion

INTRODUCTION

Change detection is the process of identifying differences in the state of a phenomenon by observing it at different time (Singh 1989). According to Meyer (1991), every parcel of land on the earth surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the earth surface. The use to which we put land could be grazing, agriculture, urban development and mining among others, while land cover categories could be cropland, forest, pasture, road, or urban areas. Meyer et al, (1994) added that changes in land cover have important implications for range of issues such as biosphere-atmosphere interactions, species and genetic diversity associated with endangered habitats, water and sediment flow, and sustainable use of natural resources in the development process of human society.

A change in land cover by land use pattern driven by a variety of social cause, result in radiation budgets, trace gas emission and other processes that both affect climate and biosphere Reinbsome et al., (1990).

Ecosystem may also initiate modifications upon land cover. Globally, land cover today is already altered principally by direct human use, through agriculture, forest harvesting, urban and sub-urban constructions. There are also incident impacts on land cover from other human activities such as forest and lakes damaged by acid rain from fossil fuel combustion and crops near cities, which damage atmospheric ozone layer, resulting from automobile exhaust Meyer (1995). Hence to use optimally, it is not only land use cover, but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of natural actors which shape the landscape.

Aim and Objectives

The aim of this study is to produce a map of Mubi metropolis showing changes in Build-up Area, Open land, Water Bodies, and Vegetation Cover.

The above aim can be achieved from the following objectives:

- To obtain the Landsat images of 2009, 2015.
- To create land use/ land cover classification scheme
- To determine the trend, nature, location and magnitude of land use / land cover changes.
- To generate data on land consumption rate and land observation coefficient.
- To forecast the future pattern of land use in the study area.

Justification Why the Topic is Worthy of Investigation

Mubi metropolis has witnessed remarkable expansion in population and developmental activities such as buildings and road construction. This has therefore resulted to increase in land modification and alteration in the status of its land use/ land cover over time. These changes remain undetermined due to lack of detailed and comprehensive information as provided by remote sensing and GIS to evaluate this status. For this reason Geographical Information Systems (GIS) and Remote Sensing (RS) will be employed with the view of detecting the land consumption rate and also make attempt to find out possible changes that might have occurred. This could be of great importance particularly to planners, to have basic information for developmental planning purposes. Shosheng and kutiel (1994), suggest that such information is of value to resource management and agencies that plan and predict future changes. This study is therefore a necessity.

Remote Sensing as a Tool for Change Detection

The science and art of obtaining information about a phenomenon acquired by a device that is not in contact with the phenomenon is termed Remote Sensing (RS) Lillesand and Kiefer, (1987). It provides a large variety and amount of data about the earth surface for detailed analysis and change detection with the help of various spaceborne and airborne sensors. RS have been proven to be a very useful tool for Landuse Landover (LULC) change detection Matinfar, et al., (2007).

A large number of change detection techniques have been developed since the advent of the orbital system Lillestrand (1972). Weismiller *et al.,* (1977) have used various RS techniques for evaluating change detection for coastal zone environments. In 1980, Byrne, Crapper and Mayo have shown that Landsat multispectral data can be used to identify LULC changes very effectively. Change detection and monitoring involve the use of several multi-date images to evaluate the differences in LULC, due to various environmental conditions and human actions between the acquisition dates of images.

With the availability of historical RS data, the reduction in data cost and increased resolution from satellite platforms, RS technology appears poised to make an even greater impact on monitoring land-cover and land-use change Rogan and Chen (2004). In general, change detection of LULC involves the interpretation and analysis of multi-temporal and multi-source satellite images to identify temporal phenomenon or changes through certain period of time.

Study Area

Mubi metropolis, Fig.1, is located in the north-eastern part of Adamawa state of Nigeria. It lies between latitude 10^0 16” 08’ N and longitude 13^0 16” 14’ E and falls on the topographic map sheet of UBA 156 NE with area coverage of 1321.80 m^2. Mubi has an altitude of 572 m above mean sea level, with average temperature of 23.9^0c annually. Federal Republic of Nigeria official gazette (2009) provides that Mubi metropolis has a total population of 128,900. Mubi shares boundary with Michika on the Northeast, Hong on the West, Maiha on the South and Cameroun on the East.

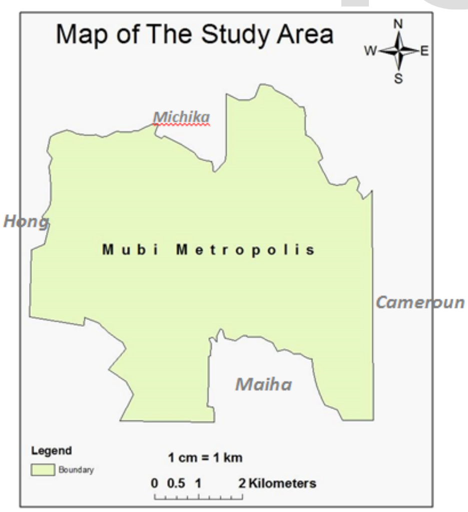

Fig.1. Study area.

Methodology

Conventional ground method of land use mapping is labour intense, time consuming and is done relatively frequently. These maps soon become out-dated with the passage of time, particularly in a rapid changing environment. In recent years satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use/land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, the techniques are perhaps the only method of obtaining the required data on a cost and time effective basis (Singh 1989).

A remote sensing device records response based on many characteristics of land surface, including natural and manmade features. According to Arvind and Nathanwat (2006), land use/land cover study in Hangana State in India, showed that majority of land use are for agricultural purposes. Adeniyi and Omojo (1999) in their land use/ land cover change evaluation in Sokoto Rima Basin of North-Western Nigeria based on archival of Remote sensing-GIS techniques, used aerial photographs, land sat MSS, SPOTXS/ Panchromatic image and topographic map sheets to study changes in the two dams (Sokoto and Guronyo), between 1962 and 1986. The work reveals that land use / land cover of both areas was unchanged before the construction, while settlement alone covered most part of the area after construction.

This methodology shows step by step design involving the identification of data needed for the study, acquisition, processing, result presentation and display. This is expected to show change in land cover/ land use in the study area.

Four classes of land use were utilised in the classification process, table 1.

Table 1: Land use/Cover classes

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	Land use feature/Class	Description
1	Vegetation	orchard, crop fields, fallow land etc
2	Bare soil	exposed soils, unused lands, rock, sand etc
3	Water	rivers, ponds, creeks, dams etc]
4	Built-up areas	industrial, commercial residential, services, transport etc

Instrument/Equipment Used:

Hardware:-

A Laptop computer, Scanner and printer

Software

The four software used for the research include:

i. ArcGIS 10.2

ii. Erdars Imagine 2014

iii. Microsoft word 2010

iv. Microsoft Excel 2010

Data Acquisition

The data acquired and the methodology flow chart is shown below

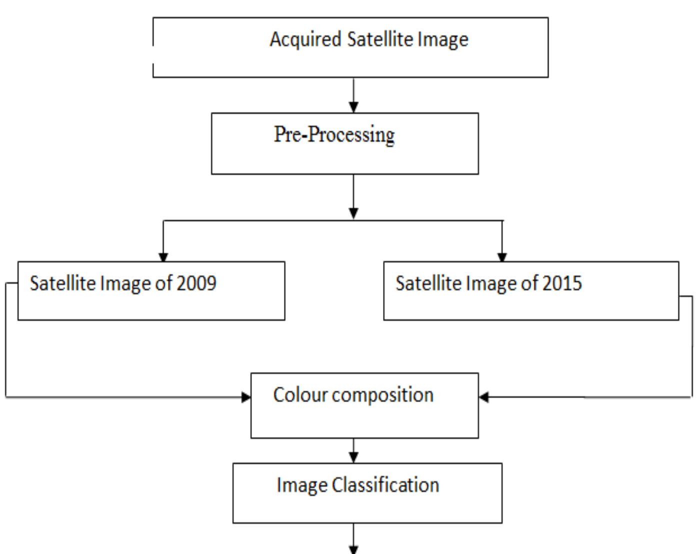

Fig.2. Schematic procedures for obtaining land change information

Satellite imagery used was Land sat image of 2009 and 2015. The Land sat image was acquired from the Global Land Cover Facility (GLCF).

The satellite image was acquired and processed using the map tool in ERDAS IMAGINE 2014. The images were mosaic together to form the basics of the study area. Earth science data interface (ESDI) Colour Composition.The colour composite of the image were combined using data management tools in ERDAS IMAGINE 2014. Through the raster processing and band combination, the image Band 4, 3, 2 were used for the earth surface analysis. The creation of the colour composite, which displayed the primary colours (Red, Green and Blue), has enhanced the colour interpretation of the reflection.

Image Pre – Processing:

Pre-processing refers to the functions which are frequently performed to improve geometric and radiometric qualities of the images. This is done to correct the errors during scanning, transmitting and recording of the data by remote sensing platform.

At this stage the scene of satellite image was prepared and the subset of the study area, to enable detail information on the satellite image to be identified which minimizes errors during post processing.

The land cover classification was used to identify the

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changes in build-up area, vegetation cover, open land, water bodies. This was achieved through the use ERDAS IMAGINE 2014. The steps involve: (i) radiometric correction which is to compensate for the effects of atmosphere (ii) geometric correction i.e. registration of the image to make it usable with other maps.

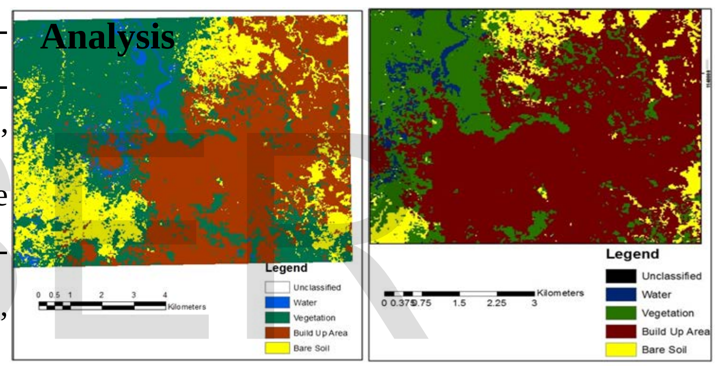
Image Classification

Image classification is to automatically categorize all pixels in an image into land cover classes. Normally, multispectral data were used to perform the classification and the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. To emphasize spectrally, oriented classification procedures for land cover mapping used *Supervised Classification.* The image analyst "supervises" the pixel categorization process by specifying, to the computer algorithm, numerical descriptors of the various land cover types present in the scene. To do this, representative sample sites of known cover type, called *training area*, are used to compile a numerical "interpretation key" that describes the spectral attributes for each feature type of interest. Each pixel in the data set is then compared numerically to each category in the interpretation key and assigned with the name of the category it "resembles". The data obtained were then classified using maximum likelihood.

Maximum likelihood means, whole area spectral value/spectral signature is trained to be in particular class, and any area with spectral value close to trained class, is likely to be in that class. For example, if an area with spectral value of 25 is trained as water body, any area within the spectral value of 23 to 30, likely belongs to the class.

The satellite images of 2009 and 2015 were then classified using Supervised Classification in ERDAS IMAGINE 2014, into four (4) different classes (Build-up area, Water Bodies, bare surface and Vegetation cover), and a Training Set raster which identifies representative sample areas for each of the desired output classes was set. The process determines the statistical properties of each of the training classes, and then uses these properties to classify the entire image, shown in figure 5.

Analysis



2009 2015

Fig.5. Classification of Mubi Land use / Land cover.

Two main methods of data analysis were adopted in this study.

(i) Calculation of the Area in hectares of the resulting land use/land cover types for each year (2009 and 2015) and subsequently comparing the results.

(ii) Maximum Likelihood Classification

The comparison of the land use land cover statistics, assisted in identifying the percentage of change, trend and rate of change between 2009 and 2015.

This was achieved by first developing a table showing the area in hectares, and secondly the percentage change for each year (2009 and 2015) measured

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against each Land use /land cover type.

The Satellite image was analysed through the following methods:

i. Imageries were imported into ERDAS IMAGINE 2014. These imageries were already available in the organization main frame computer. The image was imported via Geogateway where they were grouped into Map list and eventually sub mapped.
ii. Interpretation and digitizing: the various land use classes were identified using spectral colour with a combination of direct land available in a pixels value, where some picture element were picked for land use classification, interpretation, hence digitizing was simultaneously carried out by ERDAS IMAGINE 2014.
iii. The calculated total area of each class was input in Microsoft excel where graphs and charts were produced.
iv. Categorization of the various change types was formulated and area extent for each type was automatically calculated by the computer. To compare these set of data, they were converted to percentage and used as an absolute data during presentation. The **magnitude of change** was calculated using the formula:

    C = B-A

    Where C is the magnitude of change, B is the base year 2015, A is the reference year 2009.

Percentage of change E

E = C X 100 / Base year

Annual Rate of change D

D = Magnitude of change / Period from the year

Land Use/Cover Classification

Figures 3, 4 and 5 depicts the land use maps generated from the various data sets using the supervised maximum likelihood classification. With the aim of the study being to determine the extent and pattern of change using two reference years of 2009 and 2015, Mubi Metropolis has undergone a rapid population growth evident from the rate of conversion and modification of urban land use and cover. Population statistics of the town is on the increase. This has led to unplanned and illegal erection of structures to accommodate the teeming influx of people especially after the insurgency that took place in 2014.

Table 2: 2009 land cover's statistics

Class Name	Area (ha) 2009	Percentage Cover
Built- Up Area	144624	29.0
Bare soil	160877	32.0
Vegetation	112848	22.0
Water Body	88553	17.0
Total	**506902**	**100%**

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Table 3: 2015 land cover's statistics

Class Name	Area (ha) 2015	Percentage Cover
Built- Up Area	489435	65.0
Bare soil	139103	18.0
Vegetation	41800	6.0
Water Body	81994	11.0
Total	**752332**	**100%**

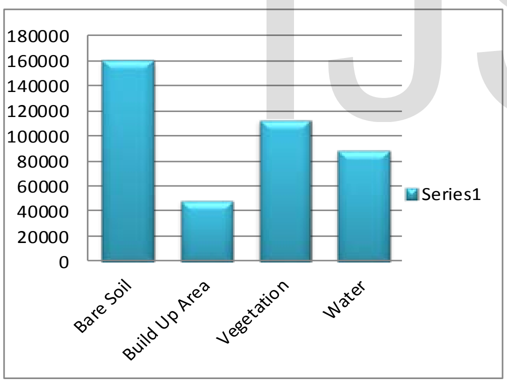

Fig.6. 2009 Land cover Change

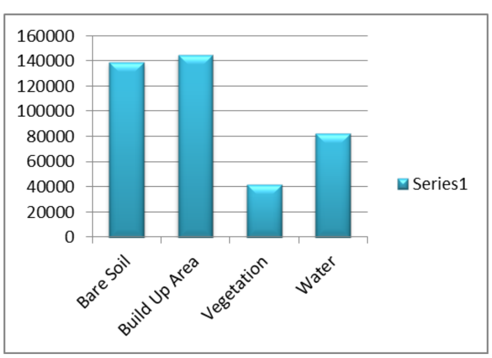

Fig.7. 2015 Land cover Change

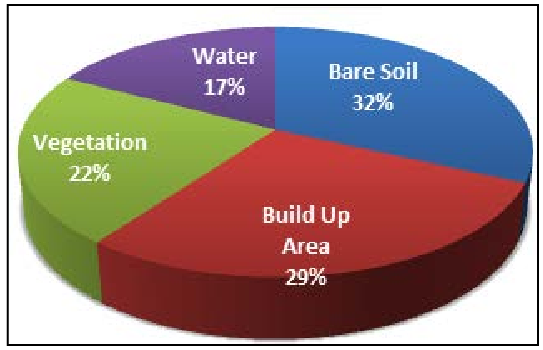

Fig.8. Extends of area in 2009 (Ha)

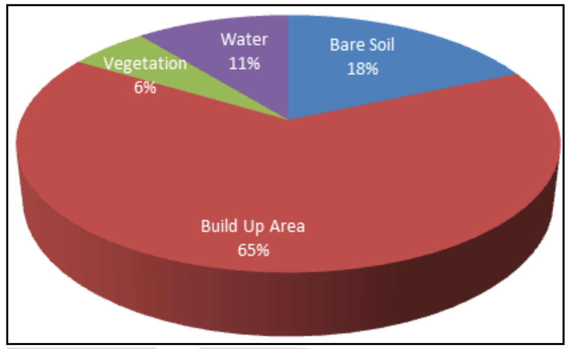

Fig.9. Area extend percentage in 2015 (Ha)

Change Detection

The land use map of 2009 and statistics of the study area (Figure 5 and Table 2) depicts the state of land use. Predominant land use as at 2009 was a combination of bare soil, Water and vegetation lands which occupied 32%, 17% and 22% respectively, figure 8. Built up area, was predominantly around city centre. An enormous and rapid rate of urbanization is evident in the classified image of 2015, with accompanied statistics (Figure 5 and table 3), depicts an increase in built-up area from 144,624 hectares in 2009 to 489,435 hectares in 2015, representing 65% coverage for the year which symbolises 36% increase, figure 9, from the previous reference year (2009). This was as a result of urban growth/expansion and consequently changes in the urban land use dynamics.

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Vegetation and bare soil have retreated from 160,877 hectares and 139,103 hectares in 2009 to 112848 hectares and 41800 hectares in 2015, accounting for a -14% and -6% retreats respectively. It is imperative to note that, Water body has decreased from 88553 hectares in 2009 to 81994 hectares in 2015, accounting for 17% coverage in the year 2009 as against 11% in the base year 2015 (Table 2 and 3).

Table 4: Summary of change (2009 and 2015)

Class/Year	Area Extent 2009 (Ha)	Area Extent 2015 (Ha)	Change	Growth Percentage
Built-Up Land	**144624**	**489435**	344811	36.0
Vegetation	**112848**	**41800**	-71.05	-14.0
Water body	**88553**	**81994**	-6.56	-16.0
Bare soil	**160877**	**139103**	-31.77	-6.0

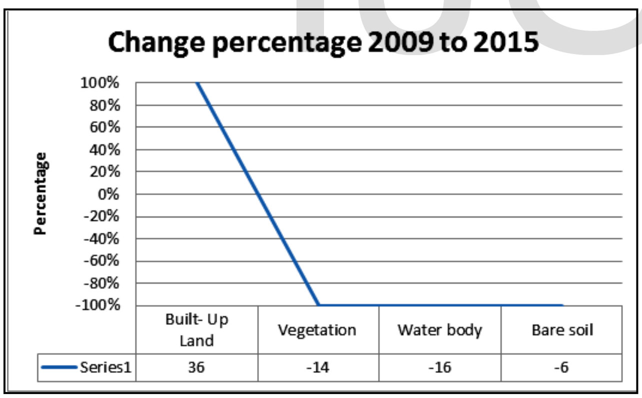

Fig.10. Change percentages 2009 and 2015

Conclusion and Recommendation

Conclusion

The land use map of 2009 and statistics of the study area (Figure 5 and Table 2) depicts the state of land use prior to land change. This suggests that development in Mubi metropolis is in progress. A rapid rate of change is evident in the classified image of 2015, with accompanied statistics (Figure 5 and Table 3) of the study area, with an increase in built-up area from 144624 hectares in 2009 to 489435 hectares in 2015, representing 65% coverage which symbolises 36% increase from the previous reference year (2009). This indicates urbanization expansion and consequently changes in the land use dynamics. Vegetation and bare soil have retreated from 112848 hectares and 160877 hectares in 2009, to 41800 hectares and 139103 hectares in 2015, resulting in decrease of -14% and -6% respectively. Water body decreased from 88553 hectares in 2009 to 81994 hectares in 2015 accounting for -16% coverage.

Recommendations

The findings from this study suggest that the Government Authorities should develop planning unit to monitor the extent of change and ensure timely release of resources to the Local government land management department, to support monitoring change in land use record.

Adamawa state, which is the higher authority, should ensure timely release of resources in order to monitor the land use effectively. There is need for more professionals, particularly in the field of surveying and GIS that will enable proper and further research on the land changes.

Reference

[1] W.Acevedo, T.Foresman, et al. “Origins and philosophy of building a temporal database to examine human transformation processes”. ASPRS/ACSM Anual Convention and Exhibition, Baltimore, MD. 1996.
[2] P.O. Adeniyi and A.Omojola, “Landuselandcover change evaluation in Sokoto” – Rima Basin of North

ISSN 2229-5518

Western Nigeria based on Archival of the Environment (AARSE) on Geoinformation Technology Applications for Resource and Environmental Management in Africa. Pp 143-172, 1999.

[3] Anderson, et al. “A Land Use and Land Cover Classification System for Use with Remote Sensing Data”. Geological Survey Professional Paper No. 964, U.S. Government Printing Office, Washington, D.C. p 28, 1976.

[4] C.Arvind, Pandy and M.S.Nathawat, “Land Use Land Cover Mapping Through Digital Image Processing of Satellite Data” – A case study from Panchkula, Ambala and Yamunanagar Districts, Haryana State, India, 2006.

[5] Christaller, Central Place Theory –Wilkipedia Free Encyclopedia, 1933.

[6] Daniel, et al, “A comparison of Landuse and Landcover Change Detection Methods”, ASPRS-ACSM Annual Conference and FIG XXII Congress p.2, 2002.

[7] Fitz and patric-lins. Producing Alaska Interim Land Cover Maps from Landsat Digital and Ancillary Data, in Proceedings of the 11th Annual William T. Pecora Memorial Symposium: Satellite Land Remote Sensing: current programs and a look into the future American Society of Photogrammetric and Remote Sensing, pp. 339 – 347,1987.

[8] T.M.Lillessand and R.W.Kiefer, “ Remote Sensing and Image Interpretation”, 5th edition. John Wiley & sons ,inc, New York, 2004

[9] R.Lillestrand, “ Techniques for Change Detection”, Computers, IEEE Transactions, vol. 21, no 100, pp 654-659, 1972.

[10] H. F. Matinfar, Sarmadian, et al. “Comparisons of Object-Oriented and Pixel-Based Classification of Land use / land cover Types Based on Lansadsat7, EtmSpectralBands”, Case Study: Arid Region of Iran, 2007.

[11] W.B.Meyer, “Past and Present Land-use and Land-cover in the U.S.A.”, Consequences. pp. 24-33, 1995.

[12] A.Moshen, “Environmental Land Use Change Detection and Assessment Using Multi – temporal Satellite Imagery”, Zanjan University, 1999.

[13] J.F.Olorunfemi, “Monitoring Urban Land – Use in Developed Countries –An aerial photographic approach”, Environmental Int.9, pp. 27 – 32,1983.

[14] W.E.Riebsame, W.B.Meyer and B.L. II Turner. “Modelling Land-use and Cover as Part of Global Environmental Change”, Climate Change. Vol. 28.p. 45, 1994.

[15] J.Roganand and D.Chen, “ Remote sensing technology for mapping and monitoring landcover and land-use change”, Progress in Planning, vol. 4 no. 61, pp. 301-325, 2004.

[16] A.Singh, “Digital Change Detection Techniques Using Remotely Sensed Data”. International Journal of Remote Sensing.Vol. 6, No. 10, pp. 989-1003,1989.

[17] M.Shoshany, et al., “ Monitoring Temporal Vegetation Cover Changes in Mediterranean and Arid Ecosystems Using a Remote Sensing Technique”, case study of the Judean Mountain and the Judean Desert. Journal of Arid Environments, vol. 33, pp. 9 – 21. 1994.

[18] Weismiller, R.S.Kristof, et al., “Evaluation of change detection techniques for monitoring coastal zone environments”. Proceedings of the Eleventh International Symposium on Remote Sensing of Environment ERIM, Ann Arbor, MI., 1977.

[19] D.S.Wilkie, and J.T.Finn, “Remote Sensing Imagery for Natural Resources Monitoring”, Columbia University Press, New York. p. 295, 1996.

[20] Y.Xiaomei and L.Q.Y.Ronqing, “ Change Detection Based on Remote Sensing Information Model and its Application to Coastal Line of Yellow River Delta”, Earth Observation Centre, NASDA, China. , 1999.

[21] X.Yang and C.Lo.Using a time series of satellite imagery to detect Land use and land cover changes in the Atlanta, Georgia metropolitan area. International Journal of Remote Sensing, vol.9, no. 239, pp. 1775-1798, 2002.