

Assessing post-apartheid settlement growth patterns, using remote sensing and GIS: A case study of Cape Town metropolitan area

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INTRODUCTION

Post-1994 South Africa was characterised by a significant migration of people from rural areas to urban areas in search of better living conditions. This, together with an amalgamation of cities and townships into large metropolitan areas, created numerous challenges in spatial development planning, infrastructure provision and service delivery.

In Cape Town, the exponential growth of formal or informal settlements inside and/or outside the metropolitan area has compounded the need to monitor and evaluate the city's spatial development trends. A change detection analysis on satellite imagery was proposed to provide a clear indication of the land cover and/or land use changes in the Cape Town metropolitan area.

LAND COVER CHANGE

Land cover change shows how the land has been managed; the monitoring of land cover has been made possible by availability of satellite imagery since the commissioning of Landsat satellite in the early 1970s. To conduct change detection, a comparison of two or more satellite images (acquired at different dates) can be used to evaluate the spectral and temporal changes that have occurred between them.

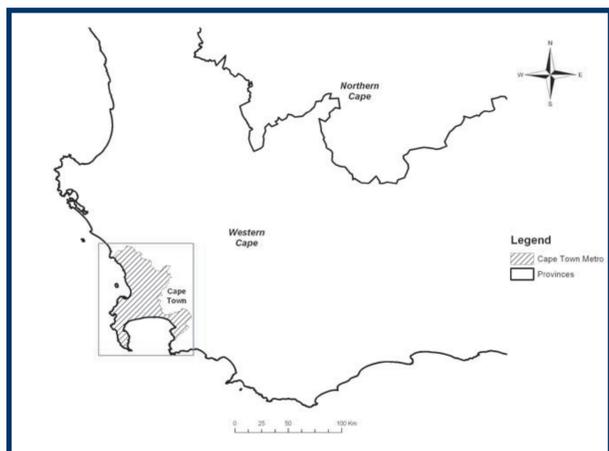


Figure 1: Map showing the Cape Town metropolitan area.

STUDY AREA

The Cape metropolitan area is in the southern most tip of the African continent and spans an area of approximately 2 175 km². The area is facing a number of environmental challenges as a result of the population growth, with acute needs for infrastructure, housing and other corresponding resources.

METHODOLOGY

Change detection is a technique used in remote sensing to determine the changes in a particular object of study between two or more time periods. This poster outlines the use of post-classification technique for detecting land cover change.

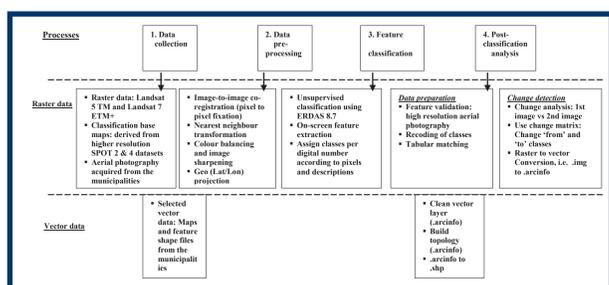


Figure 2: Change detection process.



Figure 3: The co-registered Landsat ETM+ scene of the Cape metropolitan area.

Data pre-processing

The raster images of Landsat 5 TM and Landsat 7 ETM+ (Fig. 3) were subjected to an image-to-image co-registration (i.e. pixel-to-pixel fixation) and resampled using a nearest neighbour resampling method to avoid any significant loss of pixel information. The accuracy of the rectification process was evaluated against the root mean squared error benchmark of 0.5.

Feature classification

Arbitrary classes based on the National Landcover classification criteria, occurred as defined below.

- **Industrial areas:** non-residential areas of major heavy and light industrial-related infrastructure
- **Commercial areas:** non-residential areas for conducting commerce and other mercantile businesses in the central business district of major towns
- **Residential structures:** formal built-up areas, subdivided according to high and low residential areas
- **Informal housing:** unstructured non-permanent settlement types established on an *ad hoc* basis. Typically, high-density buildings
- **Open space:** areas with no land use activity attached to their existence.

Feature classification involved the use of unsupervised classification on the Landsat 5 TM and Landsat 7 ETM+ images to produce 30 classes according to pixel values. Subsequently, these 30 classes were recoded to fit into the five classes mentioned above. (Fig. 5).

Post-classification analysis

Post-classification is a technique in change detection, in which different images from different dates are independently classified and involves data preparation and change detection. These images are later combined to create a new classified image that indicates the changes in land use from one date to another.



Figure 4: An example of two classes (low and high density residential areas) on a Landsat ETM+ panchromatic image.

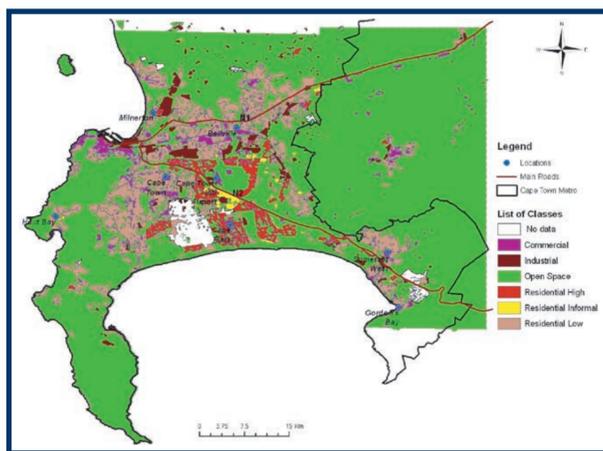


Figure 5: A classified Landsat image of Cape Town indicating land use classes for 2002.

A comprehensive grid for each study area was used to apportion the classified Landsat images to enable the user to verify and clean the classes by moving from one grid to another.

These classified Landsat images were compared to create a new change image, which indicated the change 'from' and 'to' that occurred.

RESULTS AND DISCUSSIONS

The results from a change detection analysis between 1994 and 2002 indicated that a significant change in spatial growth has taken place in the Cape metropolitan area (Fig. 6). A sizeable spatial growth occurred towards the south, the west and north-west directions of the city of Cape Town. Further spatial growth is evident in the vicinity of the Somerset West mountain slopes and Gordons Bay in a southerly direction of Cape Town. Concentrated (infill) spatial development is mostly located in the Cape Flats areas in the south of Cape Town International Airport.

Table 1: Land use change classes and their areas (in hectares and percentages)

Change class	Area (in Ha)	% Change
Open space to commercial	781.55	11.32
Open space to industrial	913.44	13.23
Open space to residential high	671.39	9.72
Open space to residential low	3935.81	57.01
Open space to residential informal	601.83	8.72

Earth observation satellite change detection conducted over a period of time has revealed fundamental land use changes in the Cape metropolitan area since 1994.

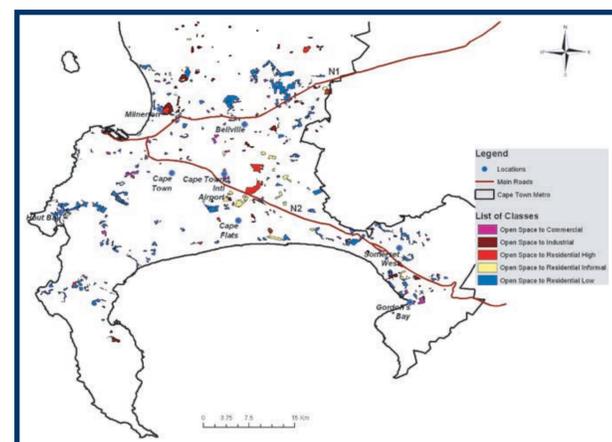


Figure 6: Change detection analysis map showing the change 'from' and 'to' classes for the Cape Town Metropolitan Area.

The quantitative results of the land use change (Table 1) indicated that most changes that occurred in *Open Space to Residential Low* (57,01 %) were in the areas of Hout Bay, Bellville, Somerset West and Milnerton (Fig. 6). The land use classes of *Open Space to Industrial* (13,23 %) and *Open Space to Commercial* (11,32 %) were found in the areas of Milnerton, Bellville and Gordons Bay. Other land use classes of *Open Space to Residential High* (9,72%) and *Open Space to Residential Informal* (8,72 %) were more evident on both sides of the N2 highway in the vicinity of Cape Town International Airport and Cape Flats. The results indicated that change detection analysis can give a rapid appraisal of the land cover and land use in large metropolitan areas. The limitations of using images with low resolution and inadequate spectral characteristics (e.g. Landsat images) were evident when delineating land use classes that are spectrally close to each other.

CONCLUSION

The study has demonstrated the feasibility of using multi-temporal, large coverage satellite imagery to detect land use changes in metropolitan areas, such as the Cape metropolitan area over a period of twelve years. The use of high resolution SPOT imagery and aerial photography were critical in eliminating the uncertainties experienced in the feature classification of medium resolution Landsat imagery.

This change detection study provides beneficial insight into the amount and type of change that occurred in the Cape metropolitan area and can serve as a point of departure for the development of the spatial development framework and provincial spatial development strategy. The results highlighted the extent of spatial growth and land use change in and around the Cape metropolitan area, thus enabling decision makers to appraise the impact and develop sustainable land use management practices. This study can also be used as a model to be applied in other metropolitan areas encountering urbanisation and significant changes in their land use.

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