MAPPING OF *EUCALYPTUS* PLANTATIONS THROUGH TEMPORAL SATELLITE DATA IN CHINA

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ABSTRACTS: *Eucalyptus* plantations play a major role in the China's ecological, social, economic and other aspects and presently China is the second largest producer of Eucalyptus in the world next to Brazil. It was introduced as an ornamental tree during 1890 but later it became a commercial crop. During 1960s large number of Eucalyptus timber were used for railway sleepers and it was also used as shelter belt for rubber trees. It becomes one of the important national resources of commercial timber once the production reached to 5 million m^3/yr. Through *Eucalyptus* oil, it brought about 20% of foreign exchange. In the present study, it was aimed to estimate the *Eucalyptus* growing area in the southern Guangdong in China in terms of aerial extent and changes between 1991 and 2001 using Landsat TM and ETM+ data. Object based classification technique and subsequent temporal change detection analysis were followed to identify the changes between the periods. In the present study, the total area was divided into three classes viz., plantation area with trees, plantation area without trees and others. Object oriented classification was found to be more accurate in the present study. Overall increase of about 23.62 km^2 was noted between 1991 and 2001 in the plantation area. With reference to the present study area, the growth of *Eucalyptus* growing area was 7.4% in the 10 year periods. From this study it is clear that the area under *Eucalyptus* cultivation is growing considerably year by year in China. However, elaborate study must be conducted considering larger areas to accurately predict the growth of *Eucalyptus* growing areas.

KEY WORDS: China, Eucalyptus, Mapping, Change detection, Remote sensing

1. INTRODUCTION

Eucalyptus plantations play a major role in the China's ecological, social, economic and other aspects. China has the second largest planting of *Eucalyptus* in the world next to Brazil. As *Eucalyptus* plantations are proven to bring highly positive effects on the environment the total area under this plantation are more than 460,000 ha in China (Zhong Weihua, 1993). In China the *Eucalyptus* was first introduced in 1890 as an ornamental tree in parks and houses. Large scale establishment of *Eucalyptus* plantations came after the foundation of the People's Republic of China.

In China, the economic and social progress was much improved after the introduction of *Eucalyptus*. It improved the living standard of people in one hand and also contributes to improving ecological conditions (Bai Jiayu *et al.* 1990). As the annual production of *Eucalyptus* reached to 5 million m^3/yr, it became one of the important national resources of commercial timber (Qi Shuxiong, 1989). The *Eucalyptus* wood was used for many purposes including paper industries and man-made fiber industries. More than 2000 ton of eucalypt oil is produced by China, which is 20% of the total earning of foreign exchange (Song Yongfang 1990).

Monitoring of plantations and its growth in terms of aerial extent in different periods is important for its management. Mapping the aerial extent of forests and woodlands through conventional ground survey methods is time consuming (Tiwari *et al.* 1996, Soares *et al.* (1998)). Satellite data are widely used to estimate the aerial extent of woodlands in many parts of the world as it offers an inexpensive means of deriving complete spatial coverage of environmental information for large areas in a consistent and regularly up-datable manner (Muldavin *et al.* 2001).

Mapping of vegetation through satellite images has been done by visual interpretation (Beaubren 1986) computer-aided digital classification (Jensen 2000), hybrid classification (Hoffer 1986, Behera *et al.* 2000), onscreen visual interpretation (Jayakumar *et al.* 2002), or expert classification (Ramachandran *et al.* 2007). Satellite remote sensing techniques with reasonably high spatial and temporal resolution could be used as potential tools for monitoring changes (Lillesand & Kiefer 1978, Jayakumar *et al.* 2000). In fact, remotely sensed data has been applied by many investigators in order to illustrate forest changes over time (Sader & Joyce 1988, Iverson *et al.* 1989, Green & Sussman 1990, Hall *et al.* 1991). All the above studies used either pixel based classification or ratio based classification of forest and plantations. In recent times, object-based classification and change detection gains much importance

(Desclee *et al.* 2006). According to this method similar contiguous pixels are grouped into objects (Coppin and Walter, 2004,) and the main advantage of object-based method is the integration of contextual information (Flanders *et al.* 2003). In the present study it was aimed to delineate and map the *Eucalyptus* plantations in part of the Southern Guangdong, and to estimate the changes in aerial extent in different periods in a decade between 1991 and 2001 using Landsat satellite data.

2. STUDY AREA

The study area is located in the China at the southern end called Guangdong (Fig 1). Geographically it is situated between 21° 13' 00" to 21° 00' 31" N and 109° 40' 07" to 110° 32' 24" E.

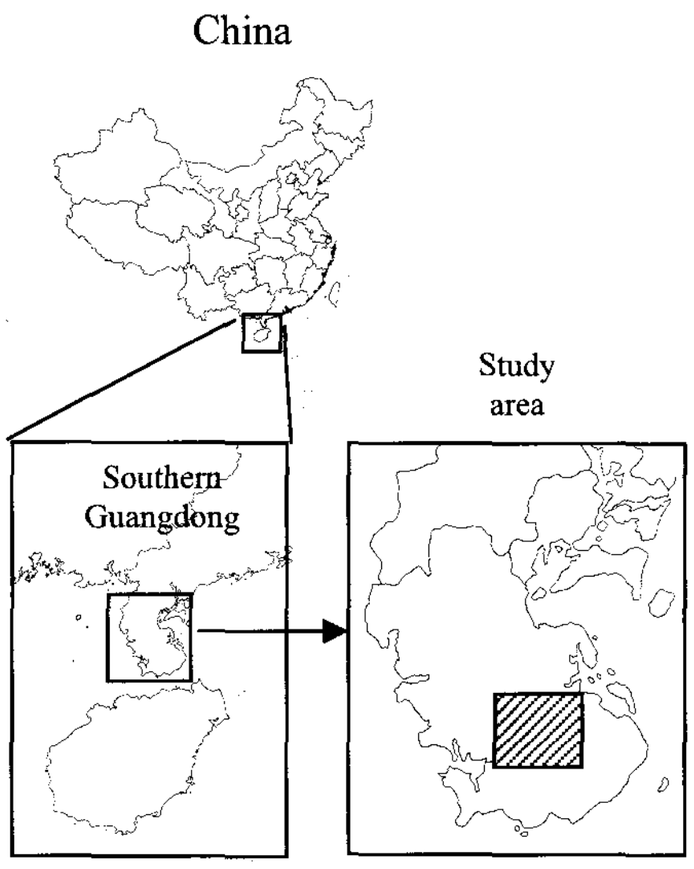

Figure 1. Location map of the study area

3. MATERIALS AND METHODS

Landsat Thematic Mapper (TM) satellite data for the year 1991 and Landsat Enhanced Thematic Mapper (ETM) data for the year 2001 of Path 124 and row 46 were used (Fig 2). For image processing and classification Definiens Professional eCognition version 5.0 software was used.

Radiometrically and Geometrically corrected Landsat satellite data of the aforementioned periods were used for classification and further analysis. In the present study, only the *Eucalyptus* plantation area was taken into account. Therefore there were only three classes viz., *Eucalyptus* plantation areas with trees, *Eucalyptus* plantation area without trees and others. Segmentation was carried out with various parameters to select optimum segment size for classification. Most published works found that more meaningful objects were extracted with a higher weight for the color criterion (Laliberte *et al.* 2004). In the present study, the color criterion was assigned a weight of 0.9 and the shape received the remaining weight of 0.1 (compactness 0.9 and smoothness 0.1).

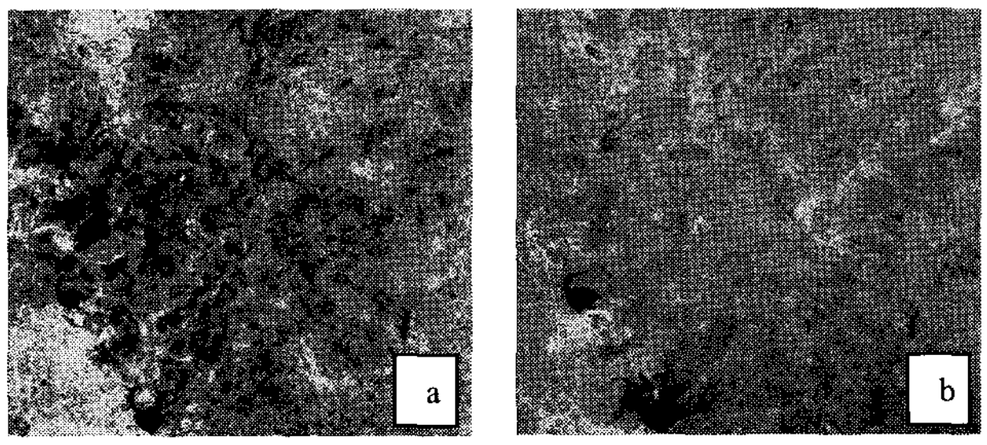

Figure 2. a. Landsat Thematic Mapper (TM) 1991, b, Landsat ETM$^+$ 2001.

4. RESULTS AND DISCUSSION

The change detection analysis in the Southern Guangdong region portrayed very clearly the difference in the *Eucalyptus* plantation between 1991 and 2001. The total area of the present study was 799.97 km^2 (Table 1). In the present study the area was classified into three classes namely, plantation area with *Eucalyptus* trees, plantation area without *Eucalyptus* trees and others.

Table 1. Area under *Eucalyptus* plantation and other categories between 1991 and 2001

Sl No.	Class Name	1991 Area in km^2	2001 Area in km^2
1	Plantation area with tree	312.05	131.02
2	Plantation area without tree	6.16	210.77
	Total	**318.17**	**341.79**
3	Others	481.80	458.18
	Grand Total	**799.97**	**799.97**

4.1. Land use status between 1991 and 2001

The change in the plantation areas between 1991 and 2001 showed elaborate difference (Fig 3). The total increase in the plantation area was about 23.62 km^2 (Table 2). Only 131.02 km^2 area was under plantation with trees category during 2001 (Table 2). About 204.61 km^2 area was harvested totally between these periods. From this study it is clear that the conversion of land into *Eucalyptus* plantation area was progressive between 1991 and 2001.

As a result of this study, it is very clear that the cultivation of *Eucalyptus* plantation in Southern Guangdong region was progressive between 1991 and 2001. In order to fulfill the requirements from various sectors, the growth of *Eucalyptus* growing area was 7.4% between 1991 and 2001. Of course in this study, only a small portion has been analyzed, but if the analysis is done taking into account larger areas, then it is possible to predict the growth scenario of *Eucalyptus* plantation in the entire China.

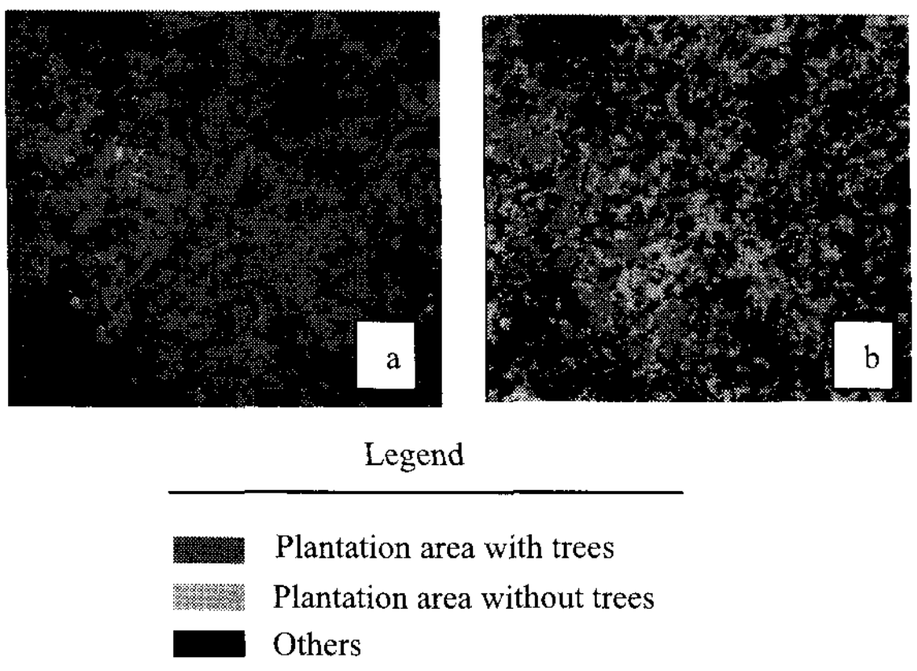

Figure 3. Classified map of the study area, a) 1991, b) 2001.

Table 2. Change detection analysis in the plantation area

Sl No.	Class Name	1991 - 2001 Area in km^2
1	Plantation area with tree	181.03
2	Plantation area without tree	-204.61
	Total	-23.62

5. CONCLUSION

In the present study, a part of southern Guangdong region in China has been classified using satellite data of different periods between 1991 and 2001 employing object based classification technique and multi-temporal image analysis. The Landsat TM and ETM satellite data were found to be useful in delineation of *Eucalyptus* plantation with trees and without trees area than the other land use classes. Object based classification technique was found to be simple and reliable to classify the plantation area as the plantation area was following specific shape and tone. The change detection analysis between these periods clearly portrayed the changes in the plantation and non-plantation areas.

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