JSc- EUSL(2008) **Vol.5 No.1, p 19-31**

ISSN 1391-586X: ©2008 Published by Eastern University, Sri Lanka.

Assessment of landuse changes in the Batticaloa district (2000 -2003/2005) for the preparation of a (spatial) zonation plan to aid in decision making for development

K.Partheepan[1], M. Manobavan[2] and N.D.K.Dayawansa[3]

[1] United Nations Organization for Humanitarian Affairs (UNOCHA), Batticaloa, Sri Lanka
[2] Environmental Information Systems Laboratory, Dept. of Biol. Sc., Faculty of Applied Science, Vavuniya Campus of the University of Jaffna.
[3] Department of Agriculture Engineering, faculty of Agriculture, University of Peradeniya

---

Abstract

The land cover or landuse over the eastern region, such as the Ampara, Batticaloa districts in Sri Lanka, has rapidly changed in the last twenty years (mainly as a consequence of the unpredictable socio-political system). Land cover change induced by anthropogenic factors as such is a detrimental force to the ecological stability of the localities. As such, estimating the spatial extents of land cover change or transformation and inferring the patterns (inherent) are of paramount importance when it comes to soundly managing the natural resources (and consequently planning for sustainable development) in the said districts. In this respect, detection of Landuse changes becomes essentially (and only) possible by the data generated by space-borne sensors. The objective of this study is to detect the landuse changes in the Batticaloa district between years July 2000 and May 2003 using space borne information and maps based on a local survey. As such, Landsat images data was analyzed using GIS and remote sensing tools in synergy for this study. Parallely, land use maps based on a local survey and statistical data were also used for comparision. Results indicate the severity of the changes in the landcover types and emphasise on the need for the establishment of a sound zonation plan as a mitigatory measure. This paper also presents an initial framework for an effective zonation plan (or map) on the spatial domain to aid in development focused decision making based on the results obtained on the land use changes at local scale. Arguably, this research paper can be considered unique as it is by and large the first ever attempt (in a scientific manner) to apply GIS and remote sensing tools for landuse mapping in the Batticaloa district.

Key word: Land use, GIS, Remote sensing, Landsat, Vegetation

---

1. Introduction

The land cover or landuse over the Eastern Region of Sri Lanka, such as the Batticaloa, and Ampara districts, was rapidly changed in the past twenty years. For example, the cultivated lands of inner Batticaloa autonomous region decreased from 1978 to 1990, while they increased as settlement region from 1990 to 1999 (Source: Ampara and Batticaloa Statistical handbooks). This region has been subjected to desertification related processes, induced by unsuitable land use, such as overcultivation, overgrazing of livestock, and excessive gathering of fuel wood and due to civil war displacements and resettlements. Hence landuse management in an effective manner is essentially important at local to regional scales in the Batticaloa district.

It is stressed that to explore suitable land use management or assessment, it is essential to monitor the environmental changes continuously over time. In this respect, the space-borne sensors deployed on the Landsat generation of satellites as part of the NASA's mission for effectively understanding the Earth system is of immense importance as it provides sufficient spatio-(temporal) data to accomplish the task of monitoring environmental changes (i.e. landcover change) from very local to regional (and even to continental) scales. Since the launch of Landsat satellite in July 1971, the techniques to detect the global changes of vegetation and land cover have been developed. There are many studies about the relationships between global changes of Normalized Difference Vegetation Index (NDVI) and climate factor, such as temperature, rainfall, and radiation [1],[2]. To detect environmental changes, [3] and [4] adopted five indicators obtained by Landsat data, as per categorizing under surface condition/s and showed that the signal of environmental changes could be extracted by using the techniques regardless of spatial scale [6]. However, there are few (or no studies to the knowledge of the authors) studies to detect the environmental change by human activity in local scale in Batticaloa district. The objective of this study is to detect the environmental changes of between 2000 to 2005 by satellites and maps based on the local survey in Batticaloa Region of Sri Lanka.

Study area

Batticaloa is situated in the eastern coast of Sri Lanka, between 8°75' and 10°01' North latitude and between 79°5' and 81°5' East longitude (Figure 1). It comprises of 14 Divisional Secretariat divisions with a total geographical area of 2633 square kilometers. Batticaloa shares a boundary with Pollonaruwa district in the North West and West, Indian Ocean in the East and Ampara district in the South and South East. It has an approximately 120 km long coastline.

The physical feature of the Batticaloa District is generally flat land the elevation not exceeds 7.62 metre. It consists of undulating plains and alluvial flats are watered by rivers from the mountain zone of Uva and Central Provinces. Batticaloa District is singularly unfortunate in being the only Dry Zone District which does not have any perennial river flowing through it.

The annual rainfall varies from 834mm to 2890mm (100 Years averge) distribution of which has slight variation throughout of the district. The northwestern part of the district is dry, with less than 800mm of annual rainfall. As a result, these fluctuating rainfalls are very often subjected to drought. Most of the rain (78% of the annual total) falls during the period of October to January and is both inter monsoon and North East Monsoon types. October to January, when the northeast monsoon prevails. The temperature ranges from 25°C to 32°C. Average Annual rainfall is 1687.4 mm, average annual mean maximum temperature is 31.07°C the average annual mean minimum temperature is 24.31°C. (Source; Meteorological Department, Batticaloa)

Figure 1: Batticaloa District Map

2. Materials and Methods

2.1 Landsat images used and description

The Landsat series initiated the era of Earth observation from space for non-military purposes. Landsat-type data are now collected by satellite systems built by other countries and commercial enterprises, but Landsat data are the standard for Earth observations, and Landsat is the only system of its type with the mission to collect, archive, and distribute data of all the Earth's land surface.

Thus, for an accurate assessment of the occurrence extent and changes it is necessary to get a correct picture of the spatial and temporal distribution of a number of meteorological, hydrological, socioeconimical and surface variables. Space observation having this potential has made a significant contribution in this field. The satellite sensors that have the capability to retrieve surface parameters with high spatial and temporal resolutions over large areas have provided a comprehensive view of the situation. Many landover studies have made an extensive use of the Landsat derived data, as it monitors earth surface changes continuously, freely accessible and it is widely recognized around the world. In this study we use Landsat imagery obtained in 2000 and 2003 for the Batticaloa district (Figure 3).

Figure 3: Batticaloa Landsat images year 2000 and 2003

2.2 Analysis of remotely sensed images

From remotely sensed Landsat data, after duly geo-referencing, all the bands were used to obtain land use classes by adopting supervised classification using ERDAS Imagine software[1]. Since the study, area has a mixed cropping pattern; only croplands are identified in general. Water and moistened water body are also very distinctly identified. Barren land has a limited ability to support life, and therefore it is also easily identifiable. The rocky out crops and vegetation cover are mixed up. The water tank is the only class identifiable under water category since some rivers also exist in the study area. Ground truth was obtained from the UN sources based on the data collated by them at specific locations during field visits made in the years 2004/2005 and using known GPS points. The accuracy of classification for all the images is found between 89 to 97%. Land with or without scrubs and degraded was considered as grazing and barren land by the author.

As such, the 2000 and 2003 Landsat images were analyzed and NDVI values were derived and supervised-classified images were produced by using GPS points. Five classes were obtained and land cover classes were analyzed. To extract the area through characteristic land use change, the trend of vegetation cover is obtained from 2000 to 2003. In the Batticaloa area extracted by above mentioned, landuse or cover change based on the 2 land use maps was compared with the changing trend of each indicator. Please see Figure 2 for a summary of the schematic diagram of research methodology adopted for this project.

Figure 2: Schematic diagram of Research Methodology

2.3 Production of a reference land cover / Environmental zonation map

A zonation map depicts division of land surfaces into zones of variety degree of stability based on estimated significance factors, which are important in a climate driven factors. Various different methods of zonation are discussed in [7] and [8].

In this project by using GIS software – thematic (raster or vector) layers were created for zonation with the help of various relavnt departmental data sources (proposed and planned). This method determines the relative effect (RE) of each unit such as surface geology, water table, climatic conditions, land use and land cover by calculating the ratio of the unit portion in coverage. The zonation plan was developed with reference to the most recent Sri Lankan

[1] ERDAS Imagine is the most commonly used software for the spatial analysis and modeling of digital data gathered by remote sensing instruments in the field of environmental science.

Government proposal for ' *Nagenahira Navodaya*[2]" which prescribes that certain villages will be developed and will be urbanized. Those villages were identified and a 3Km point buffer was created and used as urban area in 2020 then from the Forest Department proposal for the (forthcoming) next 10 -15 years (they estimated forest plantation in Batticaloa in certain areas - this is also included in this zonation plan as a thematic layer). Further, present forest cover is announced/declared/designated as reserved forest so chena cultivation and further societal destructions (of the unplanned and illegal mode) will be banned. Grass and cultivatable land should remain same and are left as it is in this zonation plan.

For environmental concern - as the Central Environmental Authority (CEA), Batticaloa, and NECDEP (North East Coastal Community Development Project) suggest a wetland layer (mangrove plantations and presently mangroved areas) and coastal protection layer (Casuarinas plantation) are also included in this zonation plan for Batticaloa. As such all the above detailed factors were applied in the production of a and zonation map for Batticaloa for the year 2020. Consequently, this zonation plan can be envisioned as the spatial representation of the visualized state of the Batticalioa district as per the strategies recommended by all the proposals by the governmental and non-governmental socurces with regards to its sustainable development. In other words, this zonation plan can be considered as is the spatial model forecast for a sustainably developed Batticaloa district in the future (i.e. by 2020).

3. Results and discussions

3.1 Land use change

Figure 3and 4 show the Comparison between the 2000s and the later 2003s. It indicates that the land use has been changed significantly in this area. In western part in the district, large unused land changed to cultivated land. In north part of the area, grassland changed to cultivated land. Figure 4 shows the composition of the area of land use types in 2000s and later 2003s. The cultivated land increased by 35.8%. and grassland decreased by 8.9%. The change must indicate that large area of unused land turned into grassland.

Figure 4: Land use maps of years 2000 and 2003

Figure 5: Composition of land use types, for the 2000s and late 2003.

[2] Development of the (liberated) East as proposed by H.E. Mahinda Rajapakse (President of Sri Lanka) in 2007.

3.2 Comparison of land use data and plans for development

This section details the findings when the extracted land cover classes from analysis of 2000 and 2003 Landsat imagery were compared with statistical data for 2005 and beyond. Cultivated area was dramatically increased from 2000 to 2005 by 41.9%. This increase was due to the prevailed calm situation in the district as a result of peace process. Normally in Batticaloa district, 70-80 % of area (including paddy and high land) had no proper access due to conflicts- but during 2002-2006 [9] periods, it was the time of the peace process, and people had access to their land and to cultivate crops. As a result, cultivated area was increased dramatically. Also they cleaned some clear forest and involved in Chena cultivation as well. This can be the reason for reduced forest cover area. In 2005, rainfall was low and peoples have abandoned their Chena cultivation so again that Chena cultivation. These Chena lands have become grassland and shrub in year 2005.

Figure 6: Land use classes and area covered trend in 2000 2003, and 2005

By using the trends inferred in the image analysis (and etc.), zonation layers were identified through a synergistic approach combining GIS and remote sensing. In these regards, Landsat data for 2000 and 2003 were analysed and land use classes were extracted and compared with real world data and statistical data of 2005. By using MCE (multi criteria evaluation) techniques, on these information a land cover zonation map for the year 2020 was predicated/ generated (Figure 7) as illustrated in the methodology section.

Figure 7: Zonation Map for Batticaloa District in year 2020

4. Conclusion

The risk of landcover change and the consequences that it would enforce on population dynamics, agriculture and cultivation, and, the environmental management systems of Batticaloa has been analyzed on the spatial domain using GIS in this report. Hence, the aim of this paper is to provide an overview link between the theoretical and experimental aspects of this paper and to provide a summary of the key findings regarding the analaysis of remotelysensed digital data to detect landcover change/s in the Batticaloa district.

As stated earlier, in the Batticaloa district, there is a need for quantifying, monitoring and reporting the impacts of landcover change and is of critical importance politically, economically and environmentally. Currently, there is no systematic and timely approach for landuse change assessment and reporting in this district. This is attributed to the natural, and physical lacks of the existing ground relevant data in the region that prevent the development of ground-data based on drought assessment systems. Alternatively, the remotely sensed data should allocate such system for the entire district to be developed.

Through spatial models and remote sensed images with high resolution, it is possible to process various scenarios and to predict potential influences and developments. This paper produces findings based on the integration of multi-thematic information and relevant statistical data - using remote sensing techniques to establish landcover change patterns in the Batticaloa district as follows:

1. In the temporal analysis of the land cover change, it is seen that the district's cultivated area has dramatically increased from 2000 to 2005 by 41.9%. – this may due to the peace process prevailing in the country at that time.

2. Forest land was cleaned and Chena cultivation was done during 2003 to 2005 after that this land was abandoned, and now this land has become covered with grass and shrubs.

3. With reference to the **Zonation Map** (for year 2020) – this zonation map was produced with reference of land cover changes, the development proposal by the Government of Sri Lanka and, the environmental conservation proposals of relevant departments.

4. The findings of this project can be of use in the planning and development activities by the sectoral departments of the GOSL; and, also in the development projects of the non-governmental agencies.

References

[1] Nemani, R.R. and Running, S. W., (1997), Land cover characterization using red, near-IR, and thermal-IR data from NOAA/AVHRR, *Ecological Applications*, **7**, 79-90.

[2] Yu, F., Price, K. P., Ellis, J., and Shi, P. (2003), Response of seasonal vegetation development to climatic variations in eastern central Asia, *Remote Sensing of Environment*, **87**, 42-54.

[3] Kondoh, A., Tateishi, K., Runtunuwu, E., and Park, J. (2002), Relating vegetation activity to climatic variation and atmospheric CO2 content, *J.Japan Soc. Hydrol. & Water Resour*., **15** (2), 128-138.

[4] Kondoh, A., (2004), Vegetation and land cover change detection by global remote sensing and its causal analysis, *J.Japan Soc. Hydrol. & Water Resour*., **17** (5), 459-467.

[5] Partheepan, K. and Jeyakumar, P. (2005). *Time Series Modeling Methodology to Forecast Climatic Data in the Batticaloa District* Water Professionals' Day 2005 - Proceedings PGIA, Sri Lanka.

[6] Manobavan, M.and Saebi, N. *"Influences of International Climate Mecha nisms at Regional Levels: A case study in Sri lanka"* in 'AgriEast - Journal of Agricultral Sciences, Sri Lanka', 4(1391-5886) Faculty of Agriculture, Eastern University, Sri Lanka, Chenkalady, April, pp. 13-20. (**2005**)

[7] Manobavan, M. (2005) *Natural Resource Management priorities and relevant strategies for the Batticaloa Special Management Area*. Strategic paper for the management of the Batticaloa Lagoon Special Management Area approved by the Special Management Area Committee for Batticaloa under the North East Coastal Community Development Project.

[8] Manobavan, M. (January 2006) *Interim Special Management Area Plan for Batticaloa (Version 4)* submitted to the Asian Development Bank via Project Head Office (Trincomalee) of the NECCDEP in January 2006.

[9] SLMM and Batticaloa situations: http://www.satp.org/satporgtp/countries/shrilanka/document/papers/memorandum2002.htm www.**slmm**.lk/ (07.09.2007)

Figures:

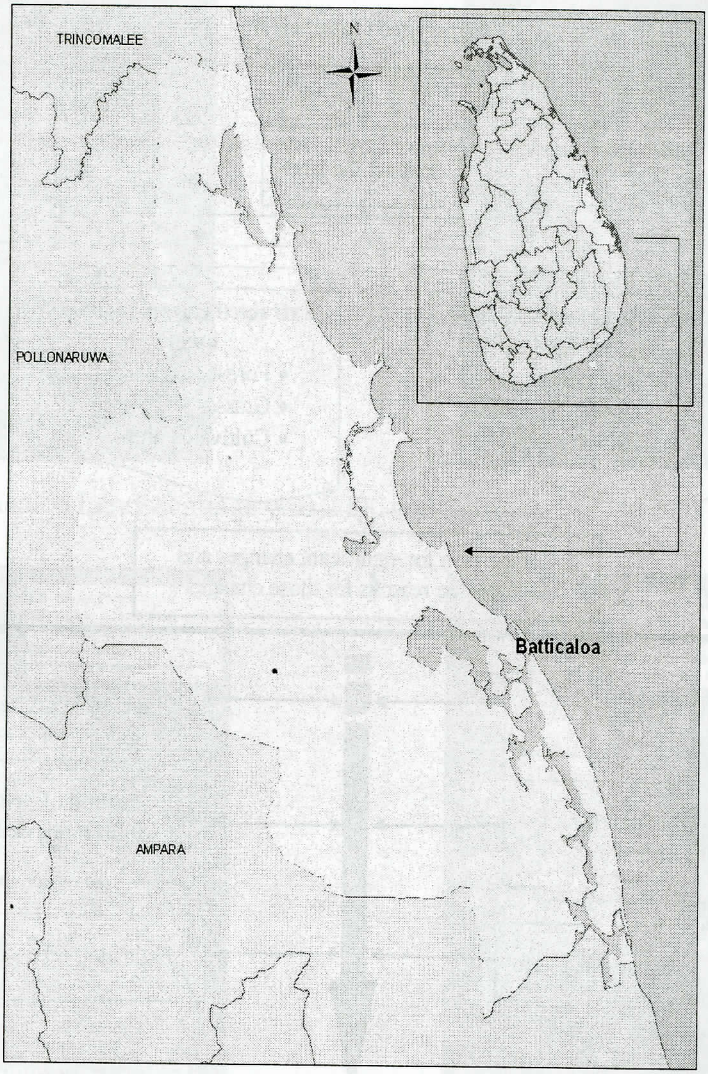

Figure 1: Batticaloa District Map

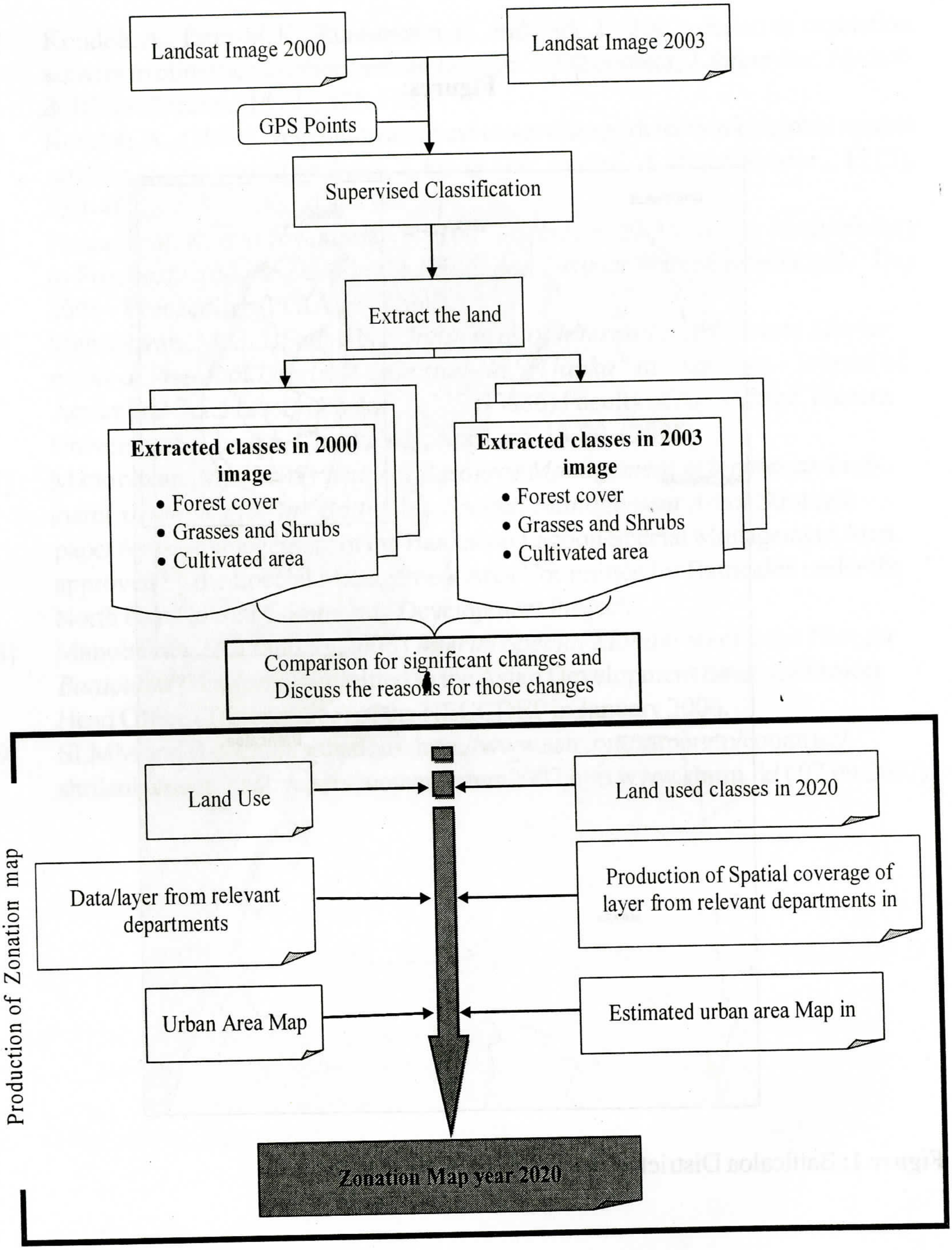

Figure 2: Schematic diagram of Research Methodology

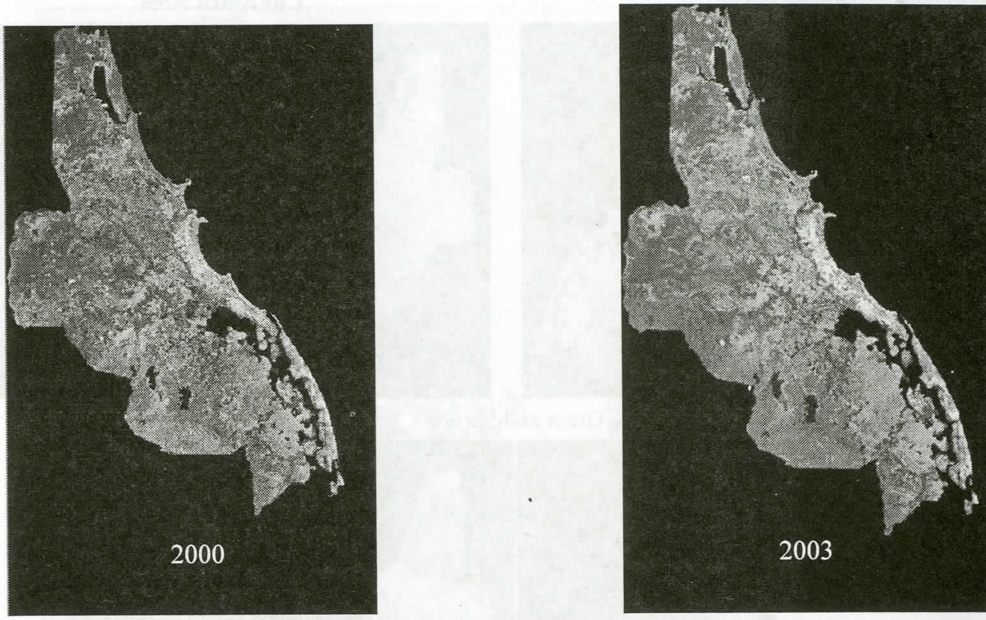

Figure 3: Batticaloa Landsat image year 2000 and 2003

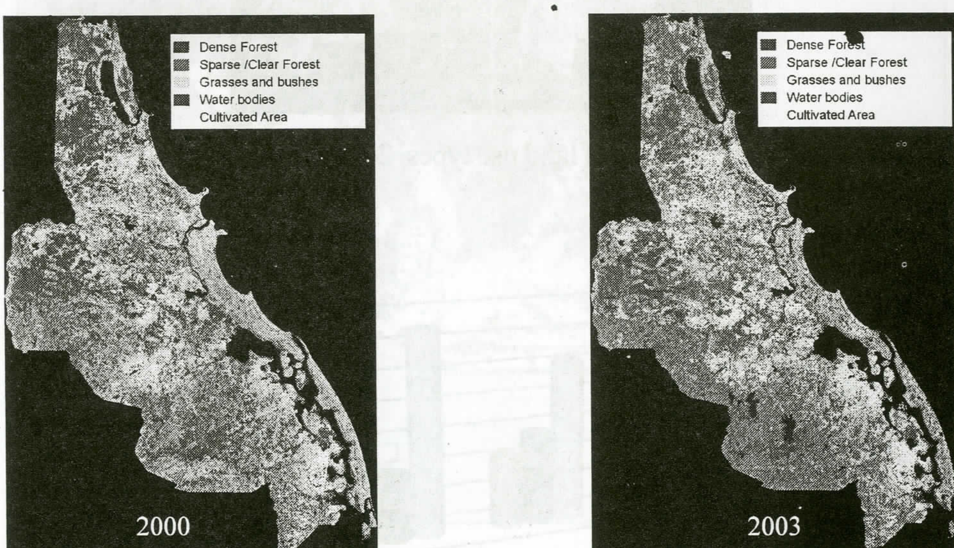

Figure 4: Land use map of year 2000 and 2003

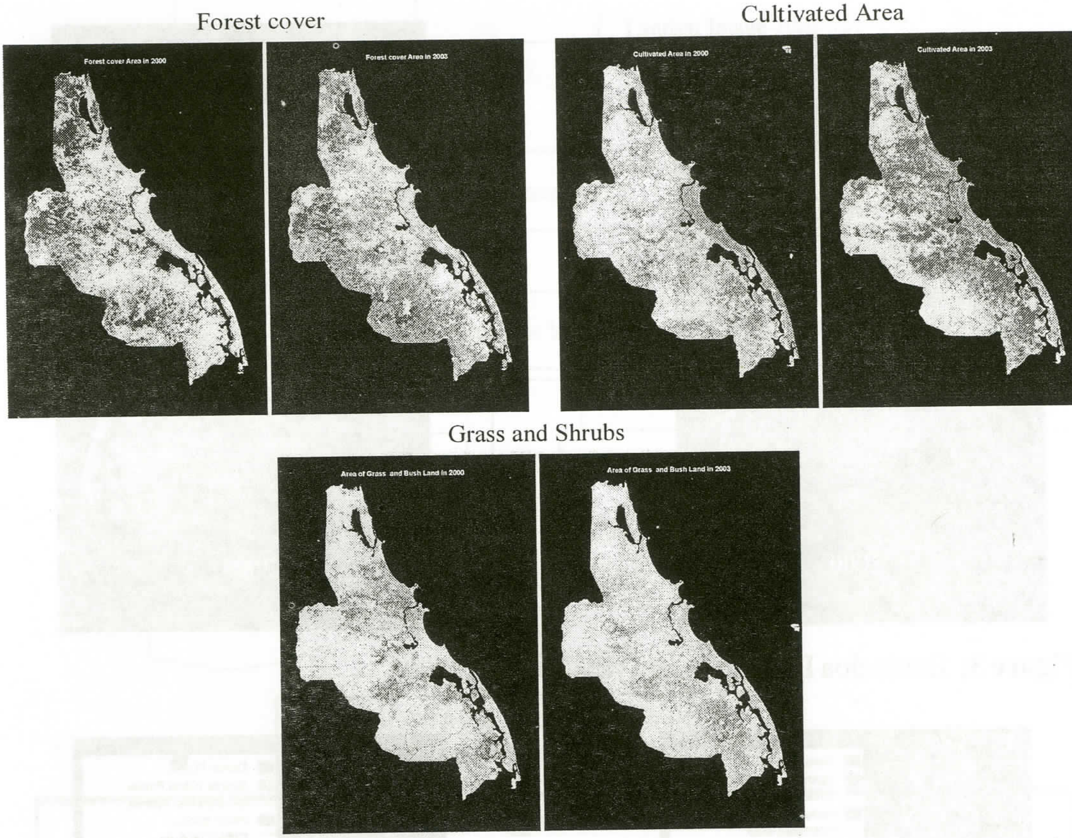

Figure 5: Composition of land use types, 2000s and late 2003.

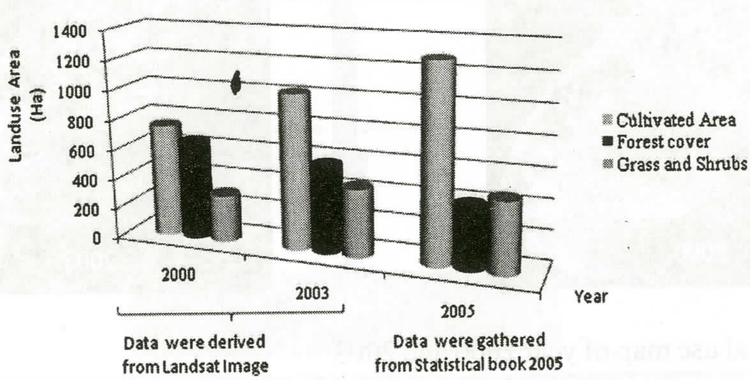

Figure 6: Land use area changing trend from 2000 to 2005 in Batticaloa district

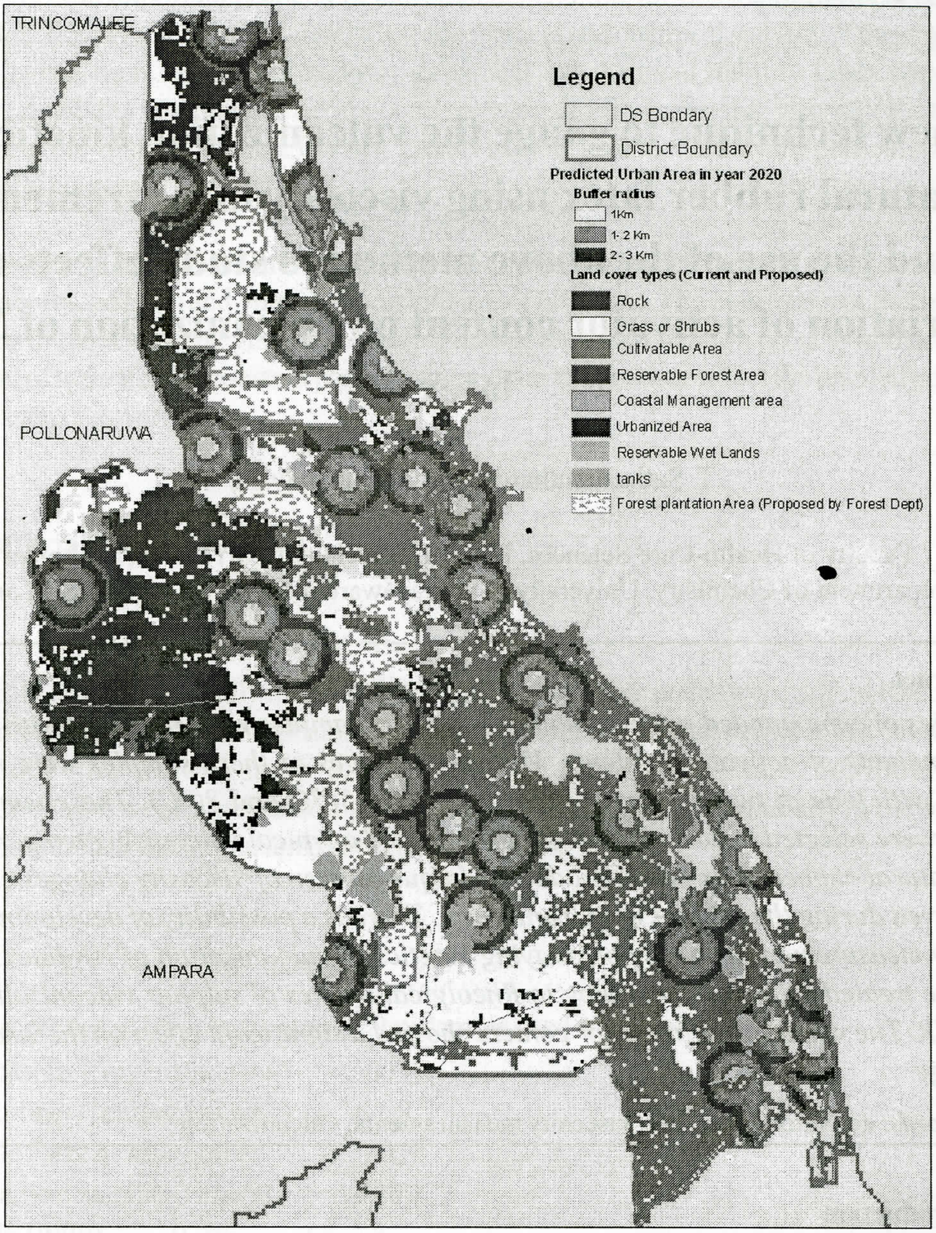

Figure 7: Zonation Map for Batticaloa District in year 2020