District-wise forest area variation in Sri Lanka from 1992 to 2001 for supporting the National Physical Planning Policy

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ABSTRACT:

Sri Lanka does not have a prior experience in preparing a National Physical Planning for its integrated development. The National Physical Planning Department has not only setup a GIS Laboratory to cater to National Physical Planning of Sri Lanka, but it also ventured into acquiring a full Landsat 7 ETM+ coverage of the Island for 1999-2001 in the purpose of updating the island-wide Land Use Mapping. Being a humid tropical country, the large extent of close canopy forest, being mainly primary forest, is the second most important natural resource asset (after water) to be considered for the future development of the Island.
Closed Canopy forest mapping was undertaken by the staff of the GIS laboratory on the purpose of deriving district-wise information of forest cover changes over the last 20 years. The method used for classification of the forest land cover was a semi-automated update of previously available map, by means of region growing tools available in GIS/RS typical software.
A set of 3 Districts of fast decreasing forest cover and of 5 Districts of substantial increase of forest cover have been identified out of 25 districts of Sri Lanka in the period of 1992-2001. District changes highlight planning policies options of critical importance for the implementation of the National Policy at District level.

1. INTRODUCTION

Sri Lanka doesn't have prior experience in preparing a National Physical Planning. In 1997 the Presidential Task Force on Housing & Urban Development recommended that there should be a National Spatial Development Plan for Sri Lanka based on which all development should take place in a planned manner. At the end, the National Physical Planning Department (NPPD) was set up under the Town & Country Planning amendment Act no.2000, dated 7th July 2000 (NPPD, 2002).
National Structure Planning is known as the integrated planning and implementation of the physical, social, economical and environmental aspects of the area. The plan will formulate the spatial guidelines for utilization of land and its targeted economic growth through the provision of infrastructure network and services. It will guide the development in a sustainable manner by rationalizing the use of land for each activity without disturbing the eco-system of the country.
When formulating a national spatial development plan to the country, it is of paramount importance to put deep consideration on present land use pattern. Sri Lanka has a total extent of 6.5 million of hectares. Non-developed areas are especially forest, reservations, slope lands & hilly areas. Out of this forest cover is the most considerable feature & it plays vital role within eco-system of the country, beside its

large eco-tourism potential.

Sri Lanka was at one time rich in tropical forests, which provided the local people with many of their needs. A part of their forest cover however has been lost due to the spread of plantation agriculture in the latter half of the nineteenth century. In the twentieth century main actors of deforestation are settlements, agricultural development projects and planned resettlement programs of the government and illegal settlements.

Today Sri Lanka's forest cover amounts to approximately 2.1 million hectares representing 32 % of the total land area. Of this extent 2.04 million hectares represent natural forest and 0.7 million hectares planted forest (NPPD, 2002). Of the area under natural forests, 1.58 million hectares are close canopy forest covering 23.9% of the land area and 4.6 million hectares sparse forest covering 7.0% of the land area. The natural forests are very unevenly distributed with 86% being concentrated in the dry zone and intermediate zones. These two zones carry 85% of the closed canopy forests in the country and 90% of the sparse and open forest. (Silva, 2001)

National Physical Planning is implemented at the Province level, by the development of specific Physical Planning schemes, known as Regional Planning. This Planning is developed jointly between the National Physical Planning Department, the Provincial Councils and the local authorities' representatives. Sri Lanka's Administration implementation network is based on Districts, while planning is based on Provinces. Therefore, the analysis of forest area changes should be performed at the District level, supplementing the Provincial level with information at the adequate planning scale. This paper intends to show the work of the Information and Scientific Research Unit of NPPD and to provide analysis for decision-making purposes.

2. METHODS

2.1. Satellite Images

The images used in this study were Landsat 7 ETM + data from the day-time (mid-morning), having a spatial resolution of 15-30-60m (according to the band) at satellite nadir, ordered through RadarSat International© by way of an International Tender Notice.

Acquisition Dates	Path/Row	Acquisition Dates	Path/Row
24 September 1999	142/53 141/54	10 February 2001	141/54 141/55
04 November 1999	141/53 141/54	10 February 2001	141/55 141/56
23 January 2000	142/53	14 March 2001	142/54
21 October 2000	142/54	14 March 2001	140/55
28 October 2000	142/55	06 April 2001	140/56
15 December 2000		26 May 2001	
15 December 2000		26 May 2001	

Table 1. Details of original Satellite Images used in this study.

The original images were delivered to the Information and Scientific Research Unit in the form of 14 original images. Only nine images are necessary to cover all Sri Lanka, however, the cloud cover made necessary to have supplementary images of the same areas. A second set came along, consisting of 4 CDROM units having 12 tiles at 30m spatial resolution. The tiles are having a band combination of 5, 4, 3, pan-fused by a Brovey Transform then resampled back to 30m. A third set was the original pan-fused images at 15m spatial resolution (40 CDROM units).

2.2. Previous Forest mapping

Earlier forest mapping documents are found in Andrews (1961) and the Survey Department of Sri Lanka (1981a and 1981b). The creation of forest inventory report in 1982/85 was undertaken by Forest Department of Sri Lanka (FAO/GOSL, 1986), assisted by the United Nations development Program the food and Agriculture Organization of the United Nations & donor Governments. The main object of this project was to prepare a Master Plan and Investment program for the forestry sector of Sri Lanka. Eventually it was also used to identify problems which are constraints to immediate development of Sri Lanka. Aerial Photographs, satellite imagery as well as Field inventory of forest Department were used to review forest cover of 1983. The unavailable forest map of the 1982-1983 Forest Department study was instead replaced (Fig. 3.) by its district-wise equivalent found in the main report (FAO/GOSL, 1986), and then used for analysis of temporal changes at district level. Legg and Jewell (1995) reported the use of remote sensing along with a large quantity of GIS based map information to compile and classify a forest map of Sri Lanka. The procedure included the use of Landsat 5TM imagery in 3, 4, 5 band combination, with few systematic processing. The classification was essentially born out of Computer assisted vectorization (called sometimes on-screen digitization) over the pre-arranged data combination. A specific work-chain hovering between satellite imagery and GIS-based cross-checking of classes' validity was set up and gave very good results. The authors mention (non-statistically calculated) accuracy of classification in the range superior to 90% overall, while the closed canopy forest class would range above 95% accuracy.

2.3. Computer Assisted Photo-Interpretation for Forest mapping of 1999-2001 dataset

Close canopy forest mapping over Sri Lanka was performed by semi-automated computer photo interpretation. The application of this method in this study featured a remote sensing analyst following the areas previously mapped by Forest Department and using a region growing tool, this tool is assisting in mapping homogeneous areas automatically by propagating a choice of pixels from the analyst. It has been also used recently in Sri Lanka by Mutuwatte and Chemin (2002). For this study, seed radius was varying from 5 to 15 pixels, with inclusion of island polygons most of the time. Exclusion of island polygons was used when the area of forest was particularly large; thus creating accordingly large islands that had their own different land use characteristics other than close canopy forest. The simple software used was not providing other parameterization of the region growing tools as some more sophisticated software would. Eventually, it still did a very satisfactory assessment of the convoluted fringes of forest areas island-wide, especially because of the good spectral contrast of the land cover boundaries. Field surveys undergone in January 2002 are confirming the results for the Central zone of Sri Lanka, even if the sampling rate is not significant island-wide, it has shown very good convergence with remote sensing analysis at a local level. Further field checking are now possible in the Northern and Eastern parts of Sri Lanka, enabling some stronger validations.

3. RESULTS

On the subject of forest land use changes between 1983-1992, Silva (2001), states that perhaps the most significant changes in land use in recent years have taken place within the forestry sector. Due to the rapidly increasing demand for land for settlement and economic activities, there is a constant struggle going on between forestry and other uses, and in this struggle, forestry invariably emerges as the loser. As a result, forest lands are being constantly turned over to other uses. Since the state owns most of the forestlands, forests have been cleared periodically to provide lands to "peasant" farmers and landless persons under Village Expansion Schemes, Major Settlements Schemes and the Mahaweli Development Programme. The extent of these programmes between 1983 and 1992 amounted to approximately 6,000, 22,000 and 29, 000 hectares respectively (Silva, 2001 quoting the Land Commissioner's Department).

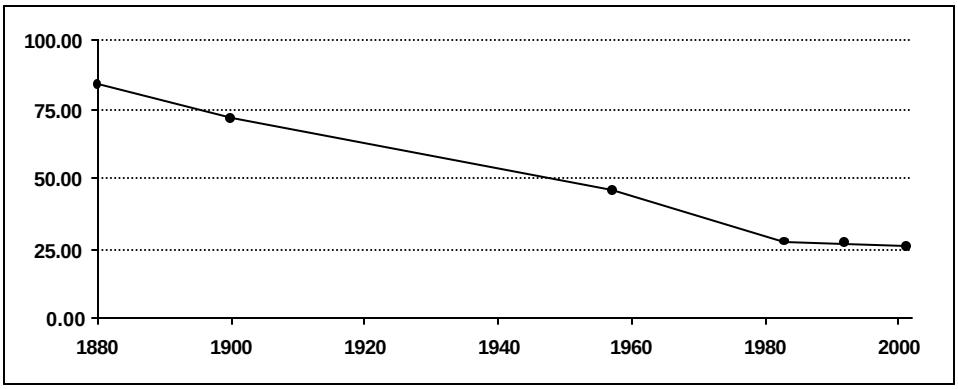
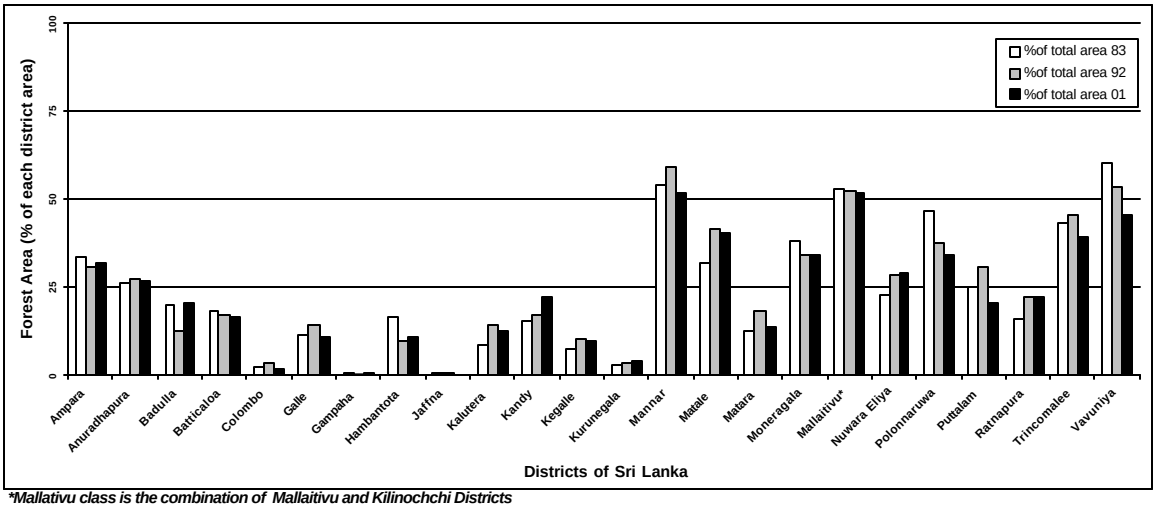


Figure 1. Variation (%) of close canopy forest area in Sri Lanka (expanded from Legg and Jewell, 1995).

Dense forest have also been affected by encroachments, as it is supposed that ground demarcation, weak enforcement of rules and regulations, are the main reasons for this (Silva, 2001). The extent of the encroachment is not clearly known, however, the Forest Department reports that approximately 2,500 hectares of forestland have been encroached upon in forest reserves between 1991 and 1996 (Conservator of Forests, 1996). Some simple extrapolation over the full dataset from 1880 (Fig. 1.) would predict a full deforestation after 350 years, while an extrapolation from the last 20 years data would forecast a complete deforestation of the island after 1000 years. The importance of such scenarios results on the general trends of forest reduction is vital for setting up the enforcement priorities over sensitive/protected areas especially located in the Southern and North Central Sri Lanka (Fig. 4.). It is clear that the situation over the last 20 years has to be kept as much as possible within the same trends in the coming 30 years that the National Physical Planning Policy (NPPD, 2002 ; Abeykoon et al., 2002) is addressing.



**Mallativu class is the combination of Mallaitivu and Kilinochchi Districts*

Figure 2. Percentage forest area in 1983, 1991-91 and 1999-2001 for Sri Lanka's Districts

Kilinochchi District has a large amount of deforestation happening since 1983, it amounts to 53% loss of the total district area. Converging information comes from the 1992 forest mapping of Legg and Jewell (1995). The same authors state that the increase of forest cover in Mallaittivu is more than 50,000 hectares and the large decrease in forest cover in Kilinochchi district are explained by the boundary adjustments between these two districts. The loss in Kilinochchi is almost matched by the increase in Mallaitivu. In Fig. 2., the two districts of Kilinochchi and Mallativu have been merged in order to counter balance these disturbances. The cumulative balance is almost equal in both dates. Districts of Kandy, Matale, Nuwara Eliya, Ratnapura and somehow Ampara sustain a steady increase of close canopy forest area over the three dates. Steady decrease arises in Batticaloa and especially Polonnaruwa and Vavuniya. The district of Polonnaruwa is under agricultural development, explaining such reduction of

close canopy forest. Vavuniya district is under large immigration flux, corroborated by rural settlement patterns and agricultural land development.

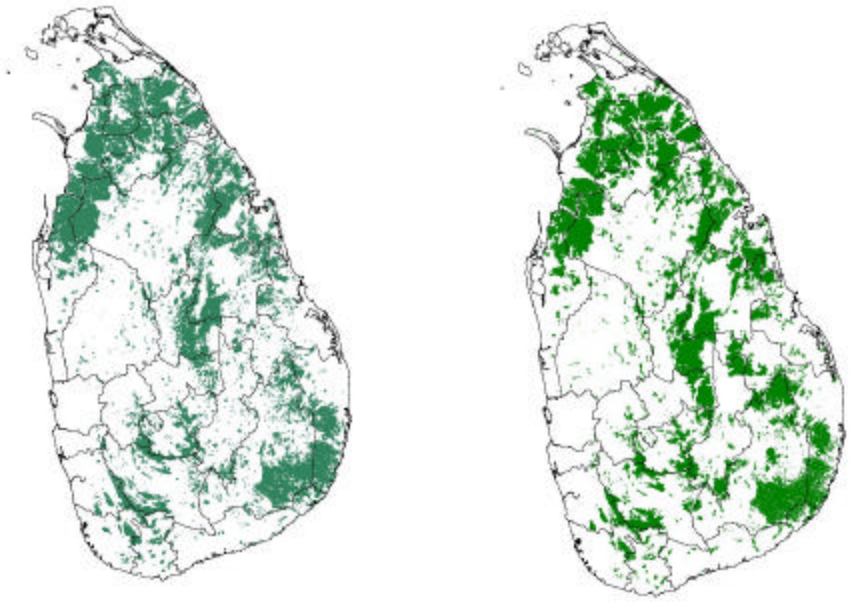


Figure 3. District forest cover of Sri Lanka in 1991-92 and 1999-2001.

Vavuniya, Polonnaruwa and Hambantota Districts are having respectively a forest area fall of 14.9, 12.1 and 5.7% of their district total area (Fig. 2.). This has to be mitigated by their actual forest cover per district of 45.8, 34.4 and 10.9%. This is eventually giving Hambantota as the most critical district under active deforestation, while the two others, Vavuniya and Polonnaruwa, are still having half and one-third of forest cover, even after such loss of forest in the last 20 years that amounts to large areas (respectively 29,405 and 41,989 hectares). Matale, Kandy, Ratnapura and Nuwara Eliya districts (Fig. 2.) are having respectively 8.5, 7.3, 6.3 and 6.2% of positive change in their forest cover. Their actual percentage in 2001 is respectively 40.7, 22.5, 22.4 and 29.3% of their total district area.

It should be noted that the Forest Department was not able to provide any copy of their forest classification map of 1983. It seems that only the districts statistics are still available, explaining that district forest extents have been symbolized by pie-charts. A digital/printed map of forest in 1983 would have permitted the authors to clarify the deforestation repartition of Kilinochchi and Mullaitivu as mentioned above. Patterns of area variations (Fig. 3.) maybe noticed between 1992 and 2001 in the Northern part of Moneragala district and in the Eastern part of the Kandy district where an increase in close canopy forest area has been assessed. In the Northern part of the Puttalam district, there is a reduction of the area assessed between 1992 and 2001.

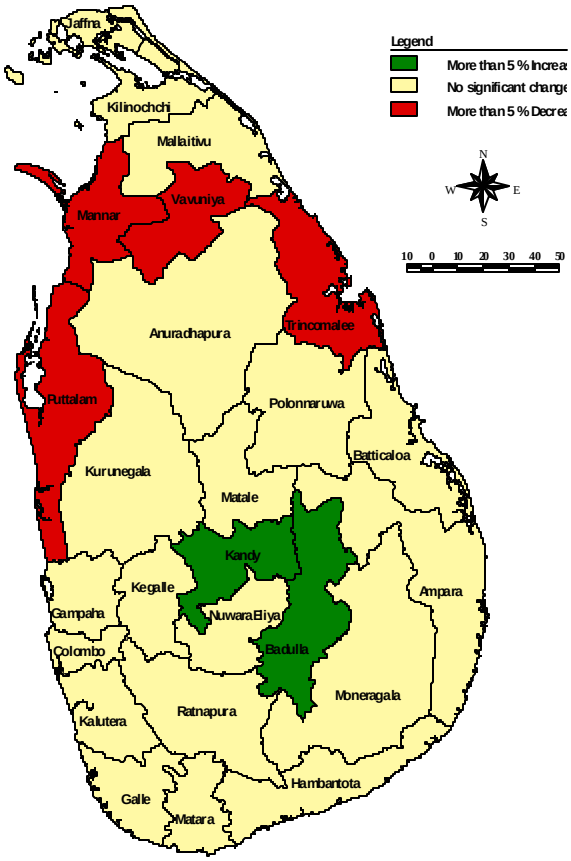


Figure 4. District variations in close canopy forest area 1992-2001.

When considering only 1992-2001 district-wise changes (Fig. 4.), major changes happening positively in Kandy and Badulla districts, with increase of total forest area respectively by 5.2 and 7.8 %. These relatively high forest cover areas are corresponding to the mountainous part of Sri Lanka, where the hydro-power generation of Sri Lanka is located. An amount of 1130 MW comes from this source, while the total country consumption peaks at 1300MW (Chandrasekara, 2001). It is believed that forest cover is crucial to conservation and a catalyst of water harvesting in Sri Lanka's upper catchments' areas (Finlayson, 1998). Degradation of the forest cover is prominent in Mannar, Puttalam, Trincomalee and Vavuniya (Fig. 4.), respectively by 7.3, 9.9, 6.2 and 7.7% decrease.

4. CONCLUSIONS

Closed canopy forest area reduction over Sri Lanka is becoming much slower since the 1980s. The actual dense forest cover of Sri Lanka is 25.7% (1,688,442 hectares) of the total island area. Variations of forest area per district in the 1992-2001 period show that four districts are having serious forest cover reduction, namely Mannar, Puttalam, Trincomalee and Vavuniya Districts for which the National Level Physical Planning Policy should be adjusted for accommodating forest conservation measures, or to the least some policies to slow down the degradation rate. Forest cover increase in the Central region districts of Kandy and Badulla is already within the context of the National Physical Planning Policy as to protect this sensitive area for water harvesting to supplement island-wide agriculture and power production especially.

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