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# Multitemporal unsupervised classification and NDVI to monitor Land cover change in Lebanon (1987-1998)

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**Abstract:** Three Landsat TM-images of different dates (June of 1987, 1994, and 1998) were analyzed to detect the land cover changes that have been occurred in two chosen sites (Hermel area and Dahr El Baidar area) in Lebanon. The images were registered for possible spatial comparison and were atmospherically corrected using ATCOR2 of the software ERDAS-IMAGINE for further analytical processes. A hybrid approach was carried out between the multitemporal unsupervised classification and the vegetation index differencing to simplify the search for change and no change pixels. The classification was performed on 12 bands images, i.e., the bands 1, 2, 3, 4, 5 and 7 were generated twice in the image, to obtain the possible land cover changes and discard what is not clear or what is due to cloud effect. A threshold value, the mean plus the double of the standard deviation, was applied on the NDVI-image differentiation to obtain the first change image for each year relative to the reference one (1987 image). The multitemporal unsupervised classified images were matched with the change images to resolve areas where change in land cover took place. Both positive and negative changes in the land cover were observed and analyzed for their type of change. Land rehabilitation for agriculture in Hermel area appeared to be more than 70 ha in 1998. However, the excavation in Dahr El Baidar for the same year reached around 165 ha.

**Keywords:** Remote sensing, multitemporal, land cover, NDVI, threshold.

**Resumé:** Trois images Landsat TM acquises à des dates différentes (juin de 1987, 1994 et 1998) ont été analysées afin de détecter les changements d'occupation du sol produits dans deux sites choisis (Hermel et Dahr El Baidar) au Liban. Les images ont été enregistrées pour une comparaison spatiale possible et ont été atmosphériquement corrigées en utilisant ATCOR2 du logiciel ERDAS-IMAGINE pour des processus analytiques supplémentaires. Une approche hybride a été conduite entre la classification multitemporelle non supervisée et l'indice de végétation afin de simplifier la détection des pixels qui ont changé et ceux qui n'ont pas changé. La classification a été effectuée sur les 12 bandes de l'image (les bandes : 1, 2, 3, 4, 5 et 7 sont créées deux fois dans l'image) afin d'obtenir les changements possibles d'occupation du sol et d'éliminer ce qui n'est pas clair ou dû à l'effet des nuages. Un seuil de tolérance, le moyen plus le double de l'écart type a été appliqué sur l'image NDVI afin d'obtenir le 1er changement de l'image pour chaque année relatif à la 1<sup>ère</sup> référence (image 1987). Les images classées et multitemporelles ont été croisées avec les images changées afin de détecter là où le changement de l'occupation du sol a eu lieu. Les changements positifs et négatifs de l'occupation du sol ont été observés et analysés en fonction du type du changement. La réhabilitation des terrains pour l'agriculture dans la région de Hermel occupe plus que 70 hectares en 1998. Cependant, l'excavation dans Dahr El Baidar pour la même année a atteint 165 hectares à environ.

**Mots-clés :** Télédétection, multitemporel, occupation du sol, indice de végétation, seuil.

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## Introduction

In Lebanon, like many other developing countries, reliable data on land cover are incomplete for long periods, especially during the war, which made data collection in the field extremely difficult. Drastic changes in land cover have taken place and are expressed certainly by chaotic

urban expansion (e.g. reaching in some cases 80% or more between 1987 and 2000 in the Bekaa valley) at the expense of agriculture, forestry (decrease in vegetation cover by 40% within the same area) and natural resources (Jomaa and Khawlie, 2002; Masri et al., 2002). These changes lead to various environmental stress processes, in particular the land degradation, as a result of mild and green cover deterioration (Bou Kheir et al., 2001a, b; Khawlie et al., 2002). Therefore, there is a definite and urgent need in Lebanon, like other places of the world, for continuous upgrading of the changes occurring in land cover.

In this concern, multitemporal satellite images can deliver information in a timely and cost effective fashion, which can not be obtained by conventional methods. As well, the increasing relevance of remote observations as a tool for studying, monitoring and managing the earth ecosystem leads to the development of new environmental monitoring systems from space. As illustrated, LANDSAT-5 Thematic Mapper (TM) bands are very useful in this concern, notably to induce the spectral signatures of vegetation (Casanova, 2000). Recorded results from previous studies have demonstrated that it is feasible to develop automated land cover monitoring methodologies (Coppin and Bauer, 1995; Eric and Daniels, 1997; Casanova, 2000).

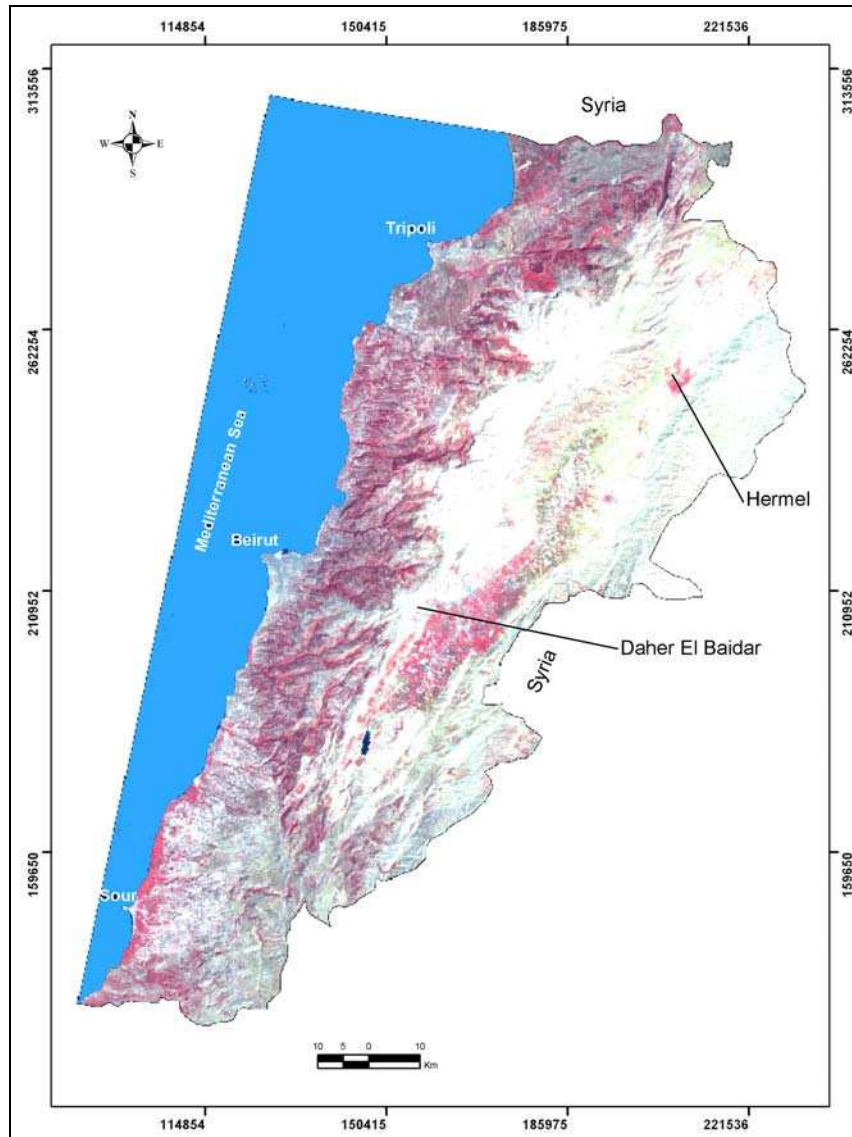
An efficient monitoring mechanism is required to cover the whole Lebanon, of about one million hectares, which is mostly rugged mountainous terrain with difficult accessibility. This paper is a case study that focuses on detecting land cover change in two chosen sites of Lebanon by using an hybrid approach combining multitemporal unsupervised classification and Normalized Difference Vegetation Index-differential (NDVI-differential) applied on three-landsat TM images. Previous works have proved the value of this hybrid approach (Lyon et al., 1998).

## **Methodology**

This study was done on two chosen sites in Lebanon: Hermel area and Dahr El Baidar area (Figure 1). Hermel area is located at the north part of the Bekaa valley, the most agricultural zone in Lebanon and is considered at the same time among the most prone areas to desertification (National Action Program to Combat Desertification-Lebanese Ministry of Agriculture, 2003). In this area, farmers are investing in rehabilitating different marginal lands for cultivation purposes. These emerged newly agricultural areas need monitoring on frequent bases as they could be listed under unsustainable agricultural practices. On the other hand, Dahr El Baidar is a mountainous area located at the mid road between Beirut and the Bekaa valley constituted of limestones and dolomites rocks that are highly excavated for construction purposes. Directly to the south of this area, there is the largest famous cedars forest in Lebanon. This led the different institutions and the non-environmental organizations NGO to think about a monitoring plan in order to reduce the expansion of excavations for environmental and touristic purposes.

Several researchers in the world have attempted to use digital satellite data to address the change detection problem. They also stated that accurate geometric and atmospheric corrections are needed before monitoring multitemporal vegetation changes and trends from satellite data (Nieuwenhuis et al., 1999). Several procedures of land cover change detection using digital data have been proposed which could aid in updating resources inventories. These methods include comparison of land cover classifications, multirate classification, image differencing, image rationing, vegetation index differencing, principal components analysis and change vector analysis (Ashbindu, 1989).

This study is based on three Landsat TM images of different dates for Lebanon: 30/06/1987, 30/06/1994 and 25/06/1998. Late June images were chosen as they are free of clouds, the grasslands still green and the deciduous trees rejuvenated young leaves as well as to work in the same seasonal changes between the different scenes. In fact, the change in land cover must result in changes in radiance values and changes in radiance due to land cover change must be large with respect to radiance changes caused by other factors (Ashbindu, 1989). These other factors include: (i) differences in atmospheric conditions, (ii) differences in sun angle and differences in soil moisture (Jenson, 1983). The impact of these factors may be partially reduced by selecting the appropriate data. For example, landsat data belonging to the same time of the year may reduce problems from sun angle differences and vegetation phenology changes.



**Figure 1.** Locations of the chosen study sites (Hermel and Daher El Baidar).

A series of preprocessing operations was performed on the three images. The first is image registration and radiometric calibration (Conghe, 2001). The image of 1987 was registered and considered as the reference year for the other images to be registered upon. The atmospheric correction was achieved by using ATCOR2 "AT (Atmosphere)-COR (Correction)" (laboratory of CIHEAM-Greece), as add-on module to the image processing software ERDAS IMAGINE.

ATCOR2 determines, theoretically, the radiance by calculating the physical components of the atmosphere present at the time of image acquisition. This type of correction requires the input of many parameters, most of which have to be estimated according to comparison with reference data. The 1987 image was atmospherically corrected using constant atmospheric conditions and no haze correction. The atmospheric model used was mid-latitude summer atmosphere, maritime aerosols (arid climate atmosphere) with visibility of 45 km. For the 1994 and 1998 images, similar processing techniques were applied. The atmosphere and aerosol parameters were found to be identical in all three images. However, the visibilities for the 1994 and 1998 images were 50 km. Once the images are being generated, additional analysis was needed to separate those pixels showing change from others, which do not.

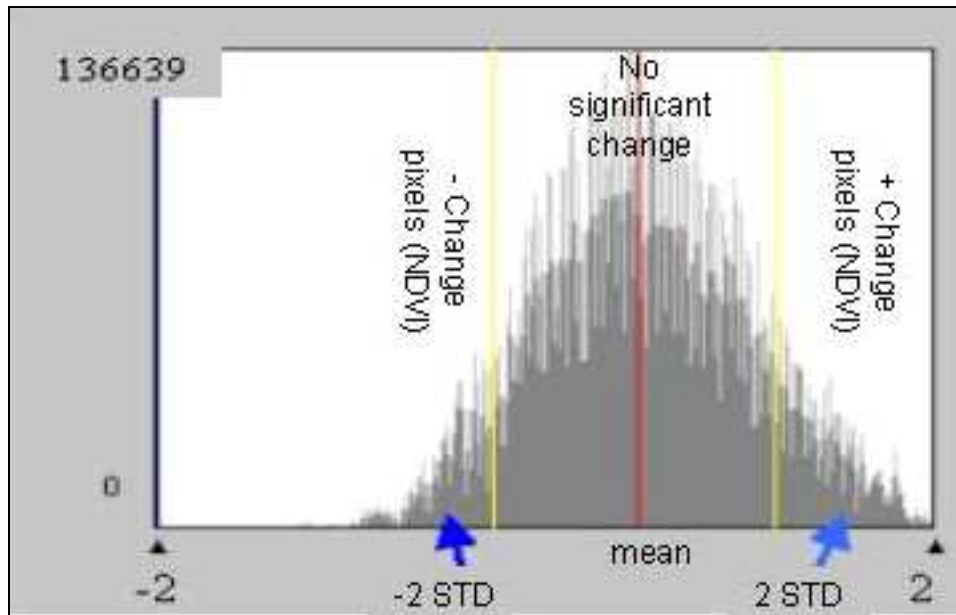
The Normalized Difference Vegetation Index (NDVI) was computed for each of the three images. The NDVI of the reference scene, 1987 was subtracted from the NDVI obtained from each of other two images (Lyon et al., 1998) to accomplish an NDVI-difference image. As a first step, the change images (areas of change in the NDVI) were established using the histograms of the NDVI-difference images and extracting the pixels that fall in the area of the mean plus the double of the standard deviation (Figure 2). This threshold value was selected based on test and trials. In other words, the change image demonstrates both an increase and a decrease in the NDVI value. Previous studies articulate that pixels showing significant change are found in the tails of the histogram distribution, while pixels showing no significant change tend to be grouped around the mean (Singh, 1986). As a result from the first step, two change images were acquired which they are between the reference year 1987 and the other two years respectively (1987-1994 and 1987-1998).

The second step was the preparation of multitemporal unsupervised images. The direct multivariate classification method was used to establish the unsupervised classification images where each two images (1987+1994 and 1987+1998) were superimposed and 12-band images were obtained. They were generated out of the two six-band images of different dates (bands 1, 2, 3, 4, 5 and 7). The thermal band was excluded. The unsupervised classification produced a set of land cover classes (locations where land cover did not change between dates and a set of change classes).

As a third step, the multitemporal unsupervised images and the change images were overlaid using the spatial modeler of the image processing software (ERDAS). As a result, the final changes images (1987+1994 and 1987+1998) were obtained showing the areas where a valuable change in NDVI had occurred either positive or negative.

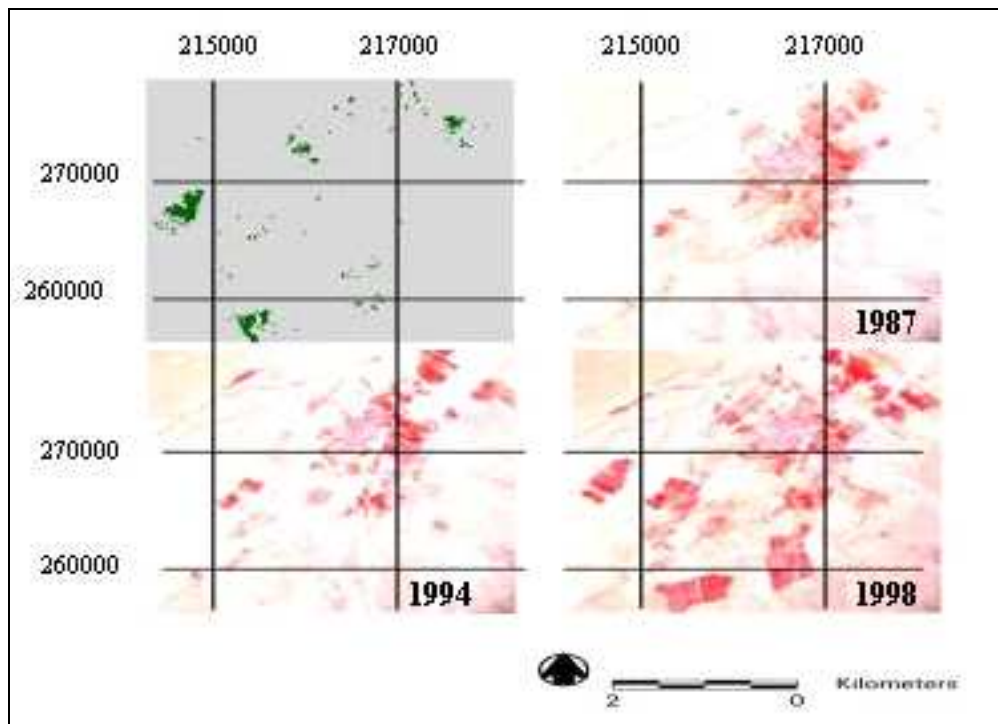
## **Results and Discussion**

Multitemporal unsupervised classification and NDVI differencing have been used in this study to investigate the land cover changes. The unsupervised classification produced a class-to-class change map and it was very complex method involving many classes: (i) no change; (ii) possible change in forest; (iii) possible change in agriculture; (iv) possible change in soil; (v) change from forest to agriculture or soil or water, (vi) change from agriculture to forest or soil or water, (vii) change from soil to forest or agriculture or water, (viii) change from water to forest or agriculture or soil. In this classification, spectral changes within one multispectral image cannot be easily separated from temporal changes between images because temporal and the spectral features have equal status in the combined data set. This lead us to use the vegetation indices differencing (NDVI-differencing) with the threshold technique in order to delineate the vegetation change areas. The efficiency of NDVI in detecting changes was proved by many researchers (Lyon et al., 1998; Ross and Christopher, 1999).



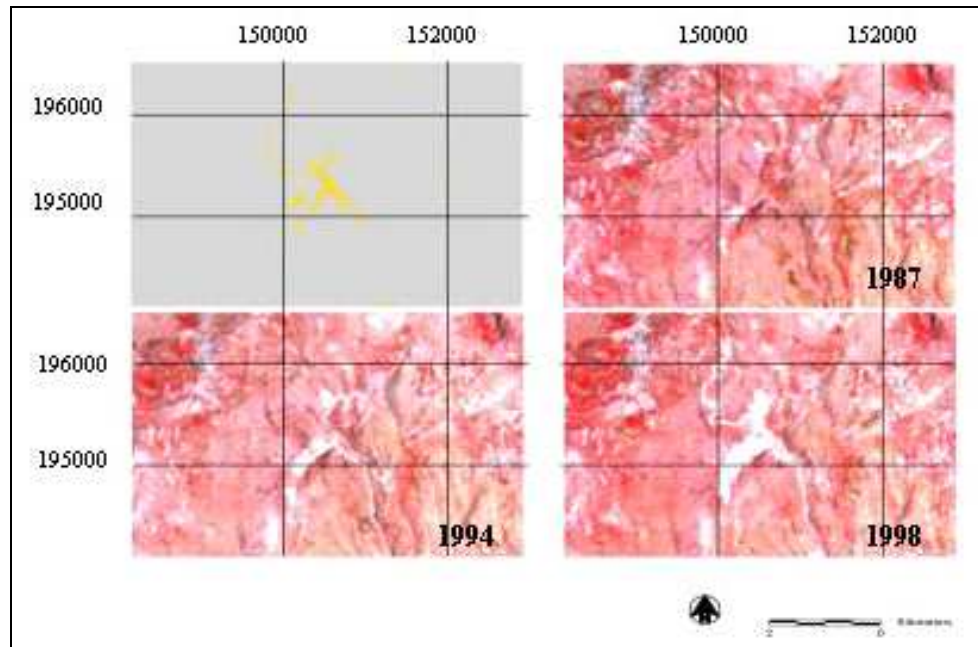
**Figure 2.** Histogram of the image resulted from the difference between the NDVI of the year 1987 and that of the year 1984.

The images resulting from these two procedures (unsupervised classification and threshold of the NDVI differencing) were compared in order to identify the type of land cover changes either positive or negative. Positive changes in NDVI are the areas that witnessed the normal cultivation, land rehabilitation for agriculture purposes, reforestation or protection. At least 70 ha of land in north Bekaa, Hermel area, were rehabilitated and used for agriculture in 1998 (Figure 3). The image of 1998 showed a significant increase in NDVI with respect to the two other images (1987 and 1994).



**Figure 3.** Positive change in NDVI, land rehabilitation in Hermel area.

On the other hands, negative changes in NDVI are mainly the result of quarries and excavations as well as deforestation. 165 ha of Dahr El Baidar were changed due to the presence of lots of quarries in 1998 (Figure 4) while in 1994, 40 ha excavations were appeared with respect to the image of 1987.



**Figure 4.** Negative change in NDVI, land degradation through quarrying in Dahr El Baidar area.

## Conclusion

Remote sensing analysis of land cover change at country scale has many advantages. It leads to upgrade on frequent basis the different maps of land cover change of the Lebanese territory. Successive monitoring also reveals the spatial and temporal patterns of changes, and helps to understand the processes behind that. Thus, the causes of change could be studied and analyzed accordingly. Moreover, the rate of change could be brought and transported on yearly bases for the decision makers.

This study suffers the absence of spatially high-resolution images, which limits the accuracy of change-detection measurements. Although, the images had 30-meter resolution, it was simple to recognize the type of land cover change. On the other hand, field verification for the type of changes is required.

## References

- [1] Ashbindu, S. (1989). Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, 10(6): 989-1003.
- [2] Bou Kheir, R., Shaban, A., Girard, M-C. and Khawlie, M. (2001a). Impact of human activities on soil-water erosion in the mountainous coastal region of Lebanon (in French). *Sécheresse*, 12(3): 157-165.
- [3] Bou Kheir, R., Girard, M-C., Khawlie, M. and Abdallah, C. (2001b). Soil-water erosion in the Mediterranean zones: a review (in French). *Etude et Gestion des Sols*, 8(4): 231-245.
- [4] Casanova, J.L. (eds) (2000). *Remote sensing in the 21<sup>st</sup> Century, economic and environmental applications*. A.A. Balkema, 3000 BR Rotterdam, Netherlands.



- [5] Conghe, S. (2001). Classification and change detection using Landsat TM data: when and how to correct atmospheric effects? *Remote Sensing of Environment*, 75: 230-244.
- [6] Coppin, P.R. and Bauer, M.E. (1995). The potential contribution of pixel-based canopy change information to stand-based forest management. *The Northern U.S.J. Environment Management*, 44: 69-82.
- [7] Ecic, F.L. and Daniels E. (1997). Land-cover changes in sub-Saharan Africa (1982-1991): Application of remotely sensed surface temperature and vegetation indices at a continental scale. *Remote Sensing Environment*, Elsevier Science Inc., 61: 181-200.
- [8] Jenson, J.R. (eds) (1983). *Urban suburban land use analysis. Manual of Remote Sensing*. vol. 2, second edition. Falls Church, Virginia: American Society of Photogrammetry. 1571-1666.
- [9] Jomaa, I. and Khawlie, M. (2002). Land use/Land cover change detection 1987 – 2000. A case study of Baalbeck – Hermel area, Bekaa Valley district – Lebanon. 2<sup>nd</sup> EU/DGI Committee Meeting on “Aid to Decision Making: GIS/RS to Combat desertification” and “Advanced Training Workshop: Advanced techniques for monitoring the environment” held at the National Council for scientific research, Beirut, Lebanon January 2002.
- [10] Khawlie, M., Hansmann, B., Darwish, T., Haddad, T., Jomaa, I. and Bou Kheir, R. (2002). Enhancing the role of remote sensing for encountering desertification in Lebanon. Remote Sensing for Developing Countries, 2<sup>nd</sup> workshop EARSeL, Bonn, September 18-20, 2002.
- [11] Lebanese Ministry of Agriculture (2003). National Action Program to combat desertification: United Nations convention to combat desertification with technical support of GTZ (Germany).
- [12] Lyon, J.G., Yuan, D., Lunetta, R.S. and Elvidge, C.D. (1998). A change detection experiment using vegetation indices. *Photogrammetric Engineering and Remote Sensing*, 64(2): 143-150.
- [13] Masri, T., Khawlie, M. and Faour, G. (2002). Land cover change over the last 40 years in Lebanon. *Lebanese Science Journal*, 3(2): 17-28.
- [14] Nieuwenhuis, G.J.A., Vaughan, R.A. and Molenaar, M. (eds) (1999). *Operational remote sensing for sustainable development*. A.A. Balkema, 3000 BR Rotterdam, Netherlands.
- [15] Ross, S.L. and Christopher, D.E. (1999). *Remote Sensing Change Detection: Environmental monitoring methods and applications*. Taylor and Francis Ltd., 1 Gunpowder Square, London.
- [16] Singh, A. (1986). *Change detection in the tropical forest environment of northern India using Landsat*. Remote Sensing and Tropical Land Management, M.J. Eden and I.T. Parry, Eds, John Wiley & Sons, London, 237-254.