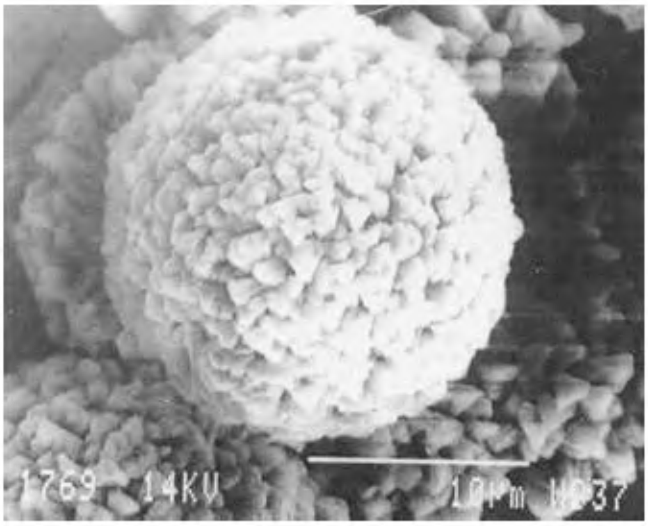

Figure 4 c. A globular self-assembled cluster of prismatic calcite particles as obtained after 96 h of soaking in sodium carbonate solution.

The SEM studies illustrated the role of self-assembled protein layers in film of the tobacco liquor solution (TLS) as a template which not only induces the nucleation and growth of the calcite particles but also provides an active motif for their self-assembly. Analysis of results revealed the presence of hierarchy at two different length scales in the growth of pyramidal calcite crystals.

1. Heywood, B. R., *Biomimetic Materials Chemistry* (ed. Mann, S.), VCH Publisher, New York, 1st edn, 1996, p. 143.
2. Busch, D. H., *J. Incl. Phenom. Mol. Recog. Chem.*, 1992, **12**, 389–395.
3. Bianconi, P. A., Lin, J. and Strzelecki, A. R., *Nature*, 1991, **349**, 315–317.
4. Wong, K., Heywood, B. R., Hodson, A., Mann, S. and Brisdon, B., *Adv. Mater.*, 1993, **5**, 49–53.
5. Meldrum, F. C., Wade, V. W., Nimmo, D. L., Heywood, B. R. and Mann, S., *Nature*, 1991, **349**, 684–687.
6. Heuer, A. H. *et al.*, *Science*, 1992, **255**, 1098–1104.
7. Marcus, M. A., Flood, W., Steigerwald, M., Brus, L. and Bawendi, M., *J. Phys. Chem.*, 1991, **95**, 1572–1576.
8. Tannev, P. T. and Pinnavia, T. J., *Science*, 1995, **267**, 1138–1143.
9. Knobler, C. M., *Adv. Chem. Phys.*, 1990, **77**, 397–425.
10. Chapman, R. G. and Sherman, J. C., *Tetrahedron*, 1997, **53**, 15911–15945.
11. Randall, J., Bagga, S., Adams, H. and Kemp, J. D., *Plant Sci.*, 2000, **150**, 21–28.
12. Torrigiani, P., Rabiti, A. L., Betti, L., Marani, F., Brizzi, M., Bagni, N. and Canova, A., *J. Virol. Methods*, 1995, **53**, 157–163.
13. Mathai, A. M. and Davis, T. A., *Math. Biosensors*, 1974, **20**, 117–133.

Received 6 November 2002; revised accepted 5 May 2003

SPOT VEGETATION multi temporal data for classifying vegetation in south central Asia

Shefali Agrawal*, P. K. Joshi, Yogita Shukla and P. S. Roy

Indian Institute of Remote Sensing, 4 Kalidas Road, Dehradun 248 001, Uttaranchal, India

Satellite remote sensing has enabled the acquisition of land use/land cover and vegetation information at different spatial and temporal scales. Vegetation instrument on-board Spot 4 satellite with four spectral bands – blue (0.43–0.47 μm), red (0.61–0.68 μm), infrared (0.78–0.89 μm) and short wave infrared (1.58–1.75 μm) at a spatial resolution of 1 km and temporal resolution of 1 day meets the requirement of vegetation mapping at a continental scale. This study focuses on the use of multitemporal SPOT VEGETATION data for vegetation mapping in south central Asia. The basis of classification is temporal dynamics, i.e. the pattern of change of Normalized Difference Vegetation Index (NDVI) values through a temporal domain which reflects the phenology of vegetation, crop cycle and the cropping system of agricultural practices. The temporal profile of NDVI facilitates the discrimination between different vegetation types and different types of cropping pattern.

OVER the past two decades, data from earth observation satellites has become important in mapping the earth's features and infrastructure, managing natural resources and studying environmental changes. Remote sensing and Geographic Information Systems (GIS) provide tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning, and change at local, regional, and global scales over time. Coarse spatial resolution (1 km resolution), combined with high temporal resolution component would allow for the early production of an actual global forest/non-forest status map. This effort could provide a first hand data, which can be used in conjunction with other data sets available to define the extent of deforestation. In the present study, SPOT VEGETATION data has been used to prepare a land use/land cover map of south central Asia. This initiative is part of the on-going global land cover-mapping project (GLC 2000) to which Indian Institute of Remote Sensing is a collaborator with Joint Research Center (European Commission) for mapping in the south Asia. The project aims to explore the possibilities of SPOT VEGETATION data sets for vegetation analysis.

Land cover information is time sensitive. The identification of crops, for instance, may require imaging

*For correspondence. (e-mail: shefali_a@iirs.gov.in)

on specific days of flowering and this information (phenology) may be used in the classification process to accurately discriminate vegetation types.

Phenology is the science dealing with the influence of climatic and seasonal changes on the recurrence of annual phenomena of animal and plant life, such as bird migration and unfolding of leaves, etc. The forest types vary in general as a function of environmental and climatic factors including temperature, rainfall, humidity, seasonality – often governed by latitude and topography.

With the use of multitemporal satellite images we can detect and monitor phenological variations and timings over large areas, at a lower cost, and frequently several times each week. This information helps in the classification process to accurately discriminate vegetation types based on their growing characteristics.

The use of multitemporal images not only results in higher classification accuracy but also gives consistent accuracy in all classes being mapped. Multitemporal data is especially advantageous in areas where vegetation or land use changes rapidly. This offers many opportunities for more complete vegetation description than could be achieved with a single image. For example, the differences between evergreen and deciduous trees can be highlighted by the fact that the former may appear quite uniform throughout the year, whereas the latter varies widely between leaf-on and leaf-off periods. The discriminant power of multitemporal observations is based on their characterization of seasonal dynamics of vegetation growth[1].

Vegetation indices (VIs) have been extensively used for monitoring and detecting vegetation and land cover changes[2]. The development of vegetation indices is based on differential absorption, transmittance, and reflectance of energy by the vegetation in the red and near-infrared regions of the electromagnetic spectrum[3]. Various studies have indicated that only Normalized Difference Vegetation Index (NDVI) is least affected by topographic factors. The NDVI is usually assumed to be broadly indicative of, and associated with, plant photosynthetic activity and aboveground primary production. Some investigators have attempted to sort out the complex relationships between the NDVI and various eco-climatological variables.

Overall, the NDVI has been shown to be sensitive to the phenology of vegetation, including ecosystem scale

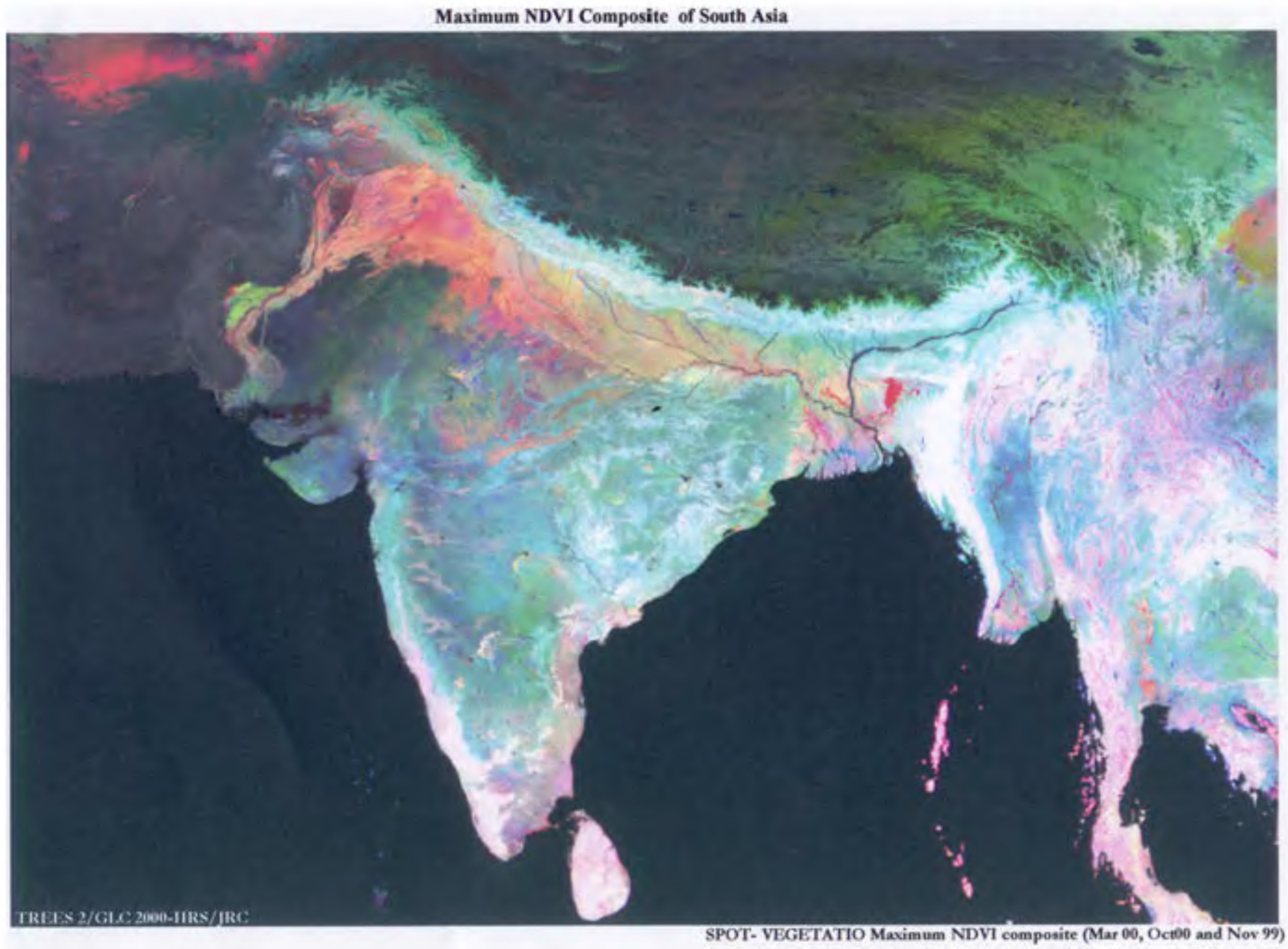

Figure 1. Maximum Value Composite (MVC) of Normalized Difference Vegetation Index (NDVI) (Study Area – South Asia).

cycles of plant greenup and senescence[4,5]. It is also sensitive to the crop cycle and the cropping system pattern of agricultural land use. Observed changes in the NDVI through time are generally thought to reflect vegetation type, phenology and local environmental conditions. Therefore compared to land cover classification using single date data, multitemporal data sets are often found to improve the accuracy of classification.

The VEGETATION instrument on-board SPOT 4 can offer a valuable tool for vegetation mapping at regional scale. The high temporal resolution of one day allows the capability for image selection according to best quality, least cloud cover and the optimal phenological stage of vegetation cover, which plays a significant role in discriminating the vegetation types[6].

For many years mapping at a regional scale has been carried out using National Oceanic and Atmospheric Administration (NOAA) – Advanced Very High Resolution Radiometer (AVHRR). NOAA, being a meteorological satellite suffers certain limitations on calibration, geometry, orbital drift and limited spectral coverage; while variations in spectral coverage has restricted its utility by introducing substantial errors into various stages of processing and analysis. The Vegetation instrument overcomes these restrictions[7]. It is one of the first sensors designed specifically for global vegetation monitoring.

South Asian region extending from 1.1°–37.5°N latitude to 60°–105°E longitude is characterized by high biological diversity and climatic variations. Generally there are two broad climatic seasons, summer (April–June) and winter (October–February). The area with diversified relief has annual rainfall varying from 100 mm in desert area to 11,000 mm in Northeastern hills. The mean annual temperature varies from 2° to 50°C defining the landmasses into different zones, viz. tropical, subtropical, temperate and alpine.

Most of the Indian subcontinent falls in the biotic region of tropical deciduous forest and tropical scrub forest. Tropical evergreen and patches of rainforest occupy a narrow belt along the western coast, northeast Himalayas and islands. Champion and Seth[8] have classified the vegetation into 16 major groups in parts of this subcontinent.

Figure 2. Classified landuse landcover map of south Asia.

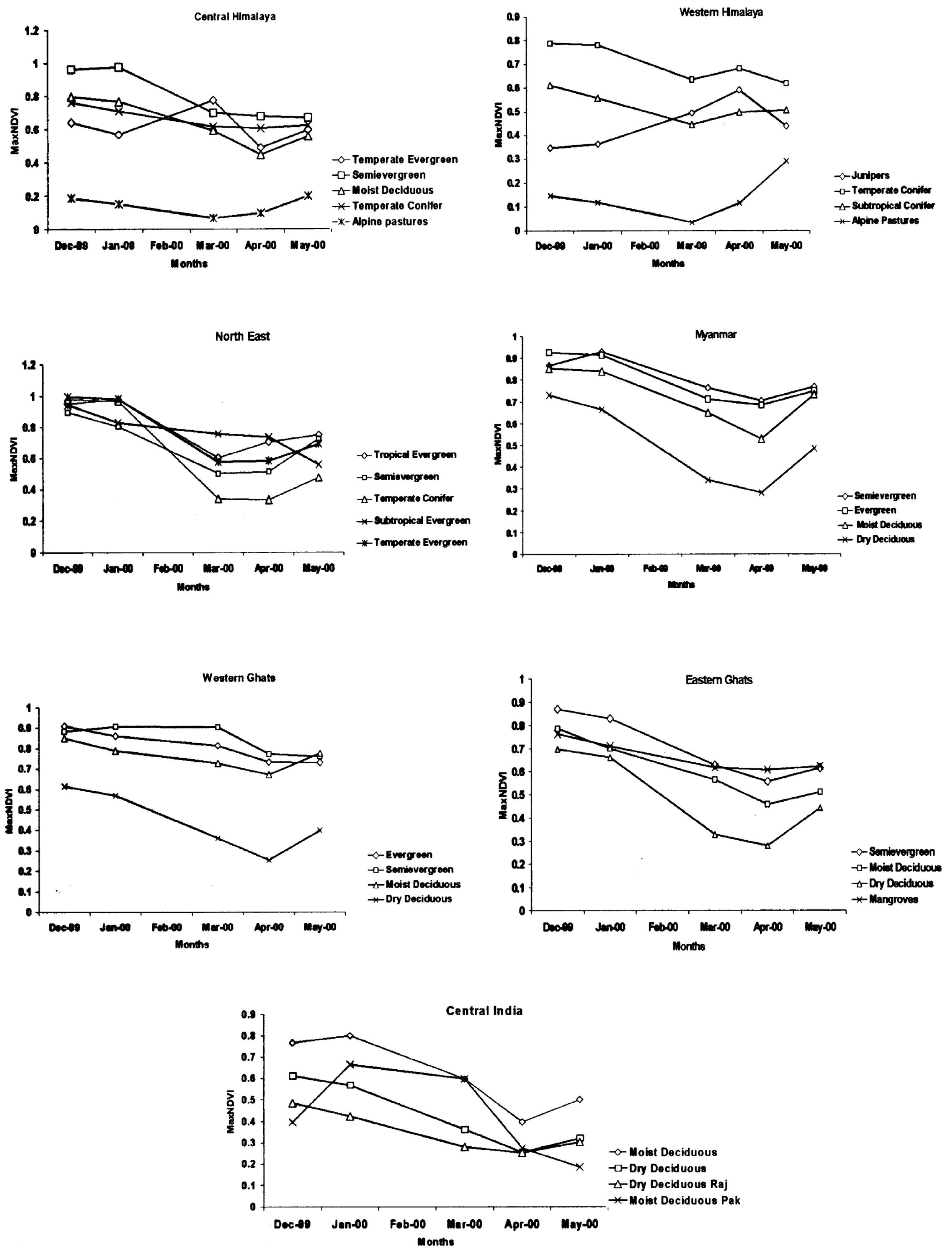

Figure 3. Normalized Difference Vegetation Index (NDVI) curves of different forest classes for seven different eco-regions of south Asia.

The subcontinent is a confluence point of major terrestrial biogeographical realms (Indo–Malayan, Eurasian and Afro-tropical) and Antarctic realms for marine biogeography. For the convenience of vegetation/ecological studies the region can be subdivided into seven ecological zones, viz. Northeast, Western Himalayas, Central Himalayas, Eastern Ghats, Western Ghats, Central Highlands and Myanmar[9].

In this study, an attempt has been made to classify vegetation in the south Asian region using distinct phenological growth stages and spectral characteristics at the mesoscale.

Multidate SPOT VEGETATION data has been used for this purpose. SPOT VEGETATION data with four spectral bands – blue (0.43–0.47 μm), red (0.61–0.68 μm), infrared (0.78–0.89 μm) and short-wave infrared (1.58–1.75 μm)

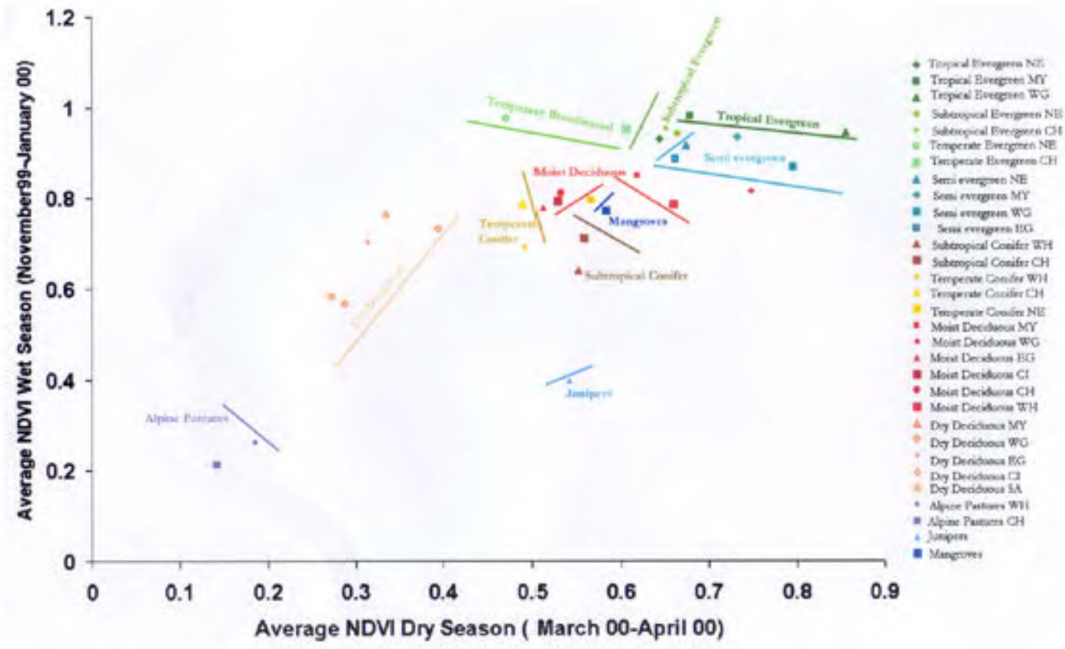

Figure 4 *a*. Scatter plot of average Normalized Difference Vegetation Index (NDVI): wet (December 1999–January 2000) versus dry (March–April 2000) season for different forest types of South Asia.

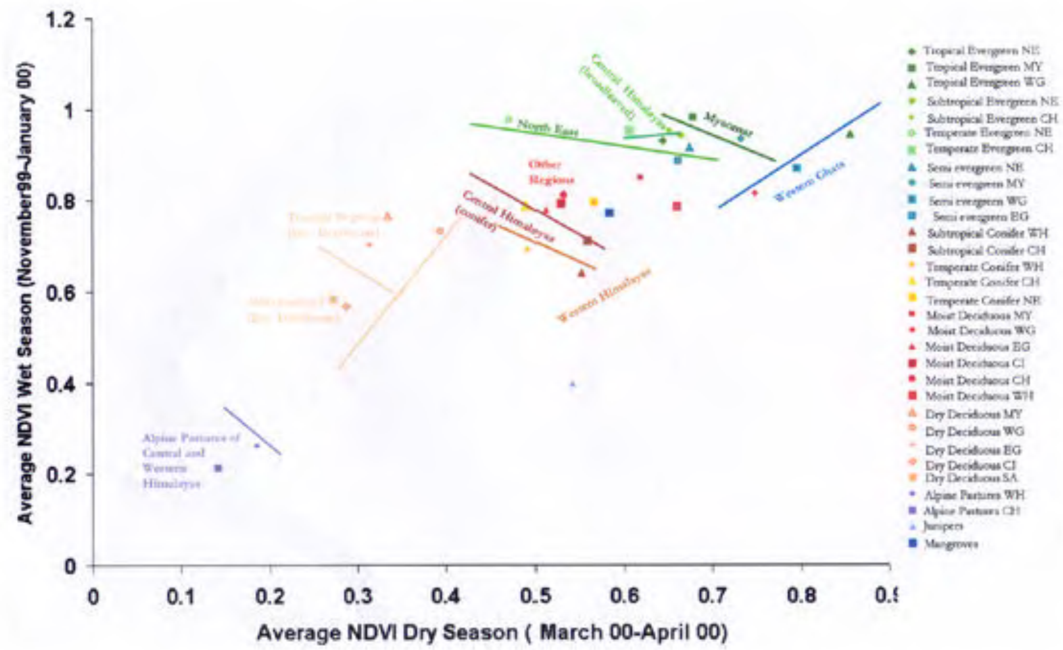

Figure 4 *b*. Scatter plot of average Normalized Difference Vegetation Index (NDVI): wet (December 1999–January 2000) versus dry (March–April 2000) season for different forest types of South Asia (based on eco-regions).

at a spatial resolution of 1 km and temporal resolution of 1 day meets the requirement of vegetation mapping at a continental scale using phenological variability in vegetation.

The raw data was received from the Joint Research Centre (JRC), ISPRA, Italy as a part of the collaborative project between Indian Institute of Remote Sensing and JRC. The data received was geometrically rectified and georeferenced.

The data has stripes of missing data at regular intervals due to inherent sensor characteristics. These stripes shift daily by a constant factor. Basic preprocessing of the data has been carried out to overcome this error by generating five-day composite image. Threshold values are used for a preliminary level correction for thick clouds.

For classification, the general approach used consisted first of an analysis of the temporal NDVI values, followed by a development of methods to discriminate forest from non-forest and to discriminate among various forest types and land cover classes.

To reduce noise, daily data have been transformed into maximum-value composites (MVCs) (the term 'noise' is used in a broad sense indicating disturbances in the time-series signal, and no statistical distributions are assumed). For each five-day period, the highest NDVI is selected to represent the period. The method reduces negatively biased noise due to interference of clouds and atmospheric constituents. However, residual atmospherically related noise, as well as some noise due to other factors, e.g. surface anisotropy, will remain in the data. Further, a monthly maximum NDVI composite was generated from nine months data sets ranging from November 1999, December 1999, January 2000, February 2000, March 2000, April 2000, May 2000, October 2000 and December 2000. The composites produced not only provided maximum information of vegetation but also gave the phenological variation among the different vegetation types and thus precise discrimination among different vegetation types. Figure 1 shows the colour composite of MVC images for the month March 2000, October 2000 and November 1999. The areas in white are regions with high NDVI values in all the three months.

Temporal curves were constructed to examine seasonal profile of the land cover types. The plot revealed a strong temporal pattern for vegetation throughout the growing season. A separation between land cover classes like agriculture, forest types and grasslands were apparent. The phenological cycle of vegetation becomes important in interpreting the graphs. In examining the temporal pattern of NDVI values among crops, a general pattern emerged as well.

At a preliminary level, the data was divided into the seven ecological zones in order to overcome the large amount of variability in the vegetation classes in the region and to avoid misclassification. Then analysing the maximum NDVI composite spanning from November 1999 to December 2000, the image was stratified into vegetated and non-vegetated lands. NDVI time-series profile is an ideal reflector to vegetation growing regularity and therefore vegetation classification based on NDVI time-series is more feasible than spectral classification. An unsupervised clustering algorithm (ISOCLASS) on the nine-month MVC images was used to define classes within the vegetated and non-vegetated stratum. The data from Defence Mapping Meterological Satellite Program (DMSP)[10] was used as a reference for mapping the urban areas in the SPOT VEGETATION data set. As per the requirement of the GLC 2000 project, the FAO land cover classification

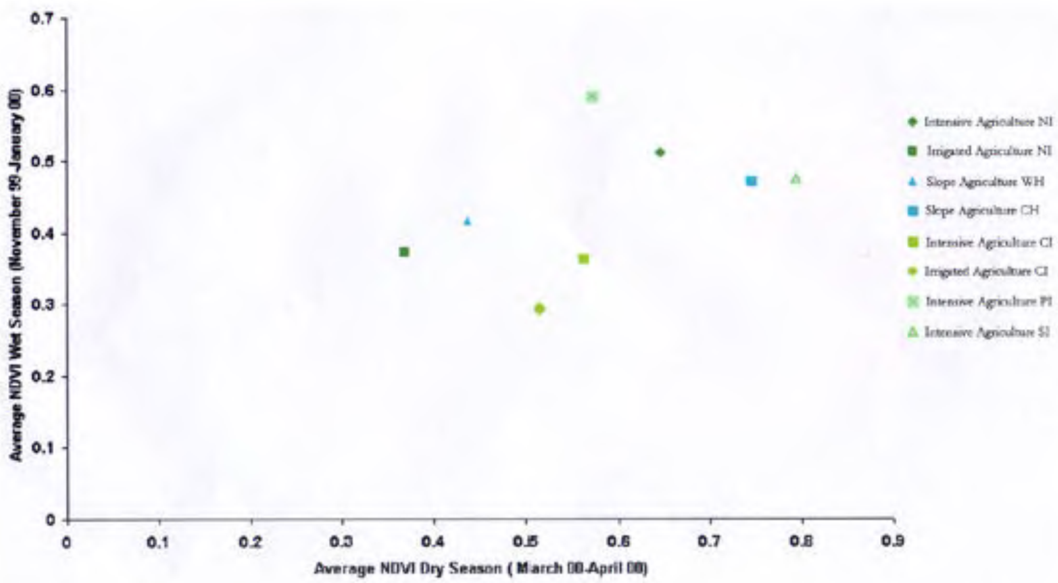

Figure 5. Scatter plot of average Normalized Difference Vegetation Index (NDVI): wet (December 1999–January 2000) versus dry (March–April 2000) season for different agricultural areas of South Asia.

scheme was adopted for defining the classes, the primary objective being to provide a uniform and consistent data set, which is comparable across the regions and countries. Finally, a mosaic of all the land use/land cover classes obtained in the different eco-regions was generated (Figure 2).

Ground truth, available vegetation maps and fieldwork has been undertaken through a network established under the project. The network had its first meeting through a workshop on 'Tropical Forest Cover Assessment and Conservation Issues in Southeast Asia' organized at the Indian Institute of Remote Sensing, Dehradun from 12th to 14th February wherein all these maps and information were shared and deliberated[11]. In addition to this, information has also been supported by the TREES Phase I Report on Mapping in Myanmar and Northeast India[12]. The post classification refinement criteria were done using interactive techniques.

In this study, an attempt has been made to stratify the different vegetation classes using the temporal data set and also to observe the phenological variations among the different types of forest in the different regions. The temporal NDVI images provide the rhythmic growth of vegetation and hence are able to distinguish the same species type occurring in different ecological and climatic conditions.

Temporal plots were selected for each vegetation class and were analysed for the study area. The representative sites selected for each cover type indicate the internal variations of the NDVI response. For each location, the average NDVI value was plotted. Figure 3 shows the temporal plots for the vegetation classes in the seven ecological zones

In general, the vegetation types in the Central Himalayas follow the phenological pattern, which is characteristic of each vegetation class. However, a sharp decline is observed in the temporal profile of temperate conifer in the month of March, which is attributed to the presence of snow in the region.

The variation in the NDVI values for the Northeast India is governed by the phenological variations and seasonal variability. The tropical evergreen forest shows higher values in January and February with a sudden drop in the values during March. The suppressed values in March are attributed to the snow cover and cloud in the region. The tropical semi-evergreen forest also depicts similar pattern with lower NDVI values. Temperate forest has shown the lower NDVI values due to morphology and anatomy of the vegetation. The forest shows lower values in March and April. Subtropical forest follows similar trend as semi-evergreen forest. The NDVI values during January and February have been found to be uniform with lower values during April. The temperate conifer follows the pattern of tropical evergreen forest with lower values in March.

The temporal profiles of the NDVI are representative of the phenological variations and seasonal variability of the land cover classes in the Western Ghats region. The evergreen, semi-evergreen and moist deciduous forest have relatively similar phenological variation with almost

Table 1. Area statistics of the land cover classes

Major forest classes	% Area	Major non-forest classes	% Area
Tropical Evergreen	1.84	Bush	2.62
Subtropical Evergreen	0.17	Shrubs	0.08
Temperate Evergreen	0.68	Plain Grasslands	1.17
Tropical Montane Forest	0.001	Slope Grasslands	3.05
Semi-evergreen	5.47	Desert Grasslands (cold desert)	1.76
Temperate Conifer	3.68	Alpine Grasslands	6.24
Subtropical Conifer	0.35	Alpine Meadows	8.83
Moist Deciduous	4.95	Rangelands/Sparse vegetation (cold areas)	1.23
Dry Deciduous	4.17	Rangelands/Sparse vegetation (hot areas)	0.88
Northern Tropical Thorn Forest	1.01	Gobi	1.14
Southern Tropical Thorn Forest	1.69	Cold Desert	2.20
Dry Woodland	0.05	Thorn Scrub/Hot desert	1.84
Mangroves	0.10	Coastal Vegetation	0.18
Junipers	0.08	Abandoned Jhum	1.37
Savannah Grassland	0.07	Current Jhum	0.08
Degraded Forest	0.50	Irrigated agriculture (single crop)	16.80
Sparse Woods	0.21	Irrigated Intensive agriculture	10.02
		Slope Agriculture	1.53
		Rain-fed agriculture	2.07
		Snow	4.48
		Water Body	1.20
		Swamp	0.08
		Salt Pans	0.14
		Mud Flats	0.12
		Barren	3.22
		Bare rock	2.23
		Coral reefs	0.006
		Settlement	0.33

equal reflection. The March and April data sets provide the delineation among the classes. The dry deciduous region has lower NDVI value with a sharp offset in April, discriminating it from other classes.

The deciduous forests of the central highlands have been found with a unique and distinct phenological variation. The moist and dry deciduous forests follow the same phenological variation with high NDVI values for the moist deciduous forest. Both the vegetations have low foliage cover in the month of April in the studied time period. The dry deciduous forests of Rajasthan have been found with low foliage cover in comparison to central India. It gives a clearly distinguished phenology of the vegetation types in the different bioclimatic regions.

The NDVI curves of the vegetation in the Myanmar are the true representatives of the phenological variations in the region. The tropical evergreen and semi-evergreen forests show a similar trend with the offset from January onwards. The moist and dry deciduous species have a characteristics curve with higher foliage cover in the moist forest.

The vegetation classes in the Eastern Ghats region follow phenological variations. Due to the presence of high moisture content, the mangroves show a constant pattern. Eastern Ghats also shows the similar set of phenological variation as the Western Ghats. The availability of mangrove and relatively less NDVI values differentiate it from Western Ghats. The mangroves have almost similar reflectance in March, April and May. The other vegetation types show similar trends with semi-evergreen, moist deciduous and dry deciduous in decreasing order of NDVI values.

All the forest types in the Western Himalayas have shown almost similar phenological trends. The alpine pastures

Table 2. Comparison of LCCS classification with Champion and Seth[8] classification scheme

LCCS classification scheme		Champion and Seth classification scheme	
Land cover class	Classifiers	Land cover class	Classifiers
Tropical Evergreen Forest (Broadleaved)	A3A10B2C1D1E1-010	Tropical Wet Evergreen (Southern and Northern Tropical Wet Evergreen) Tropical Dry Evergreen	1A and 1B $7C_1$,
Tropical Semi-Evergreen Forest	A3A10B2C1D1E1-E4-01	Southern Tropical Semi-Evergreen and Northern Tropical Semi-Evergreen	2A and 2B
Moist Deciduous Forest (Broadleaved Climate: Tropics-Humid)	A3A10B2C1D1E2-01014	Andaman Moist Deciduous, South Indian Moist Deciduous and North Indian Moist Deciduous	3A, 3B and 3C
Dry Deciduous Forest, (Broadleaved) Climate: Tropics-Dry semi-arid	A3A10B2C1D1E2-01011	Southern Tropical Dry Deciduous and Northern Tropical Dry Deciduous	5A and 5B
Sub tropical Evergreen Forest (Broadleaved)	A3A10B2C1D1E1-02	Northern Sub-Tropical Broadleaved wet hill Forests	8B
Subtropical Conifer (Needleleaved Forest, Climate: Subtropics)	A3A10B2C1D2E1-02	Himalayan Sub-tropical Pine Forests, Assam Sub-tropical Pine Forests	$9C_1$ and $9C_2$
Temperate Evergreen Forest (Broadleaved Evergreen Forest, Climate: Temperate Continental)	A3A10B2C1D1E1-B7-05014	East Himalayan Wet Temperate Forest	$11BC_1$
Temperate Conifer (Needleleaved Evergreen Forest, Climate: Temperate Continental)	A3A10B2C1D2E1-050	Himalayan Moist Temperate and Himalayan Dry Temperate	12C and 13C
Mangroves (Broadleaved Evergreen Medium High Forest On Water Logged Soil, Water Quality: Saline)	A3A12B2C3D1E1-B6-R3	Tidal Swamp Forests	4B
Northern Tropical Thorn Forest (Aphyllous Woodland, Climate: Tropics-Dry semi-arid)	A3A11B2C1D3-01011	Northern Tropical Thorn Forest	6B
Southern Tropical Thorn Forest (Aphyllous Woodland, Climate: Tropics-Moist semi-arid)	A3A11B2C1D3-01012	Southern Tropical Thorn Forest	6A
Tropical Thorn Scrub (Aphyllous Sparse Medium High Trees, Climate: Tropics)	A3A14B2C3D3-B6-01	Euphorbia scrub, Acacia senegal forest, Rann saline thorn Forest, Salvadora scrub, Desert dune scrub	$6E_1$, $6E_2$, $6E_3$, $6E_4$, $6S_1$
Savannah Grassland (Grassland with Trees, Climate Tropics)	A6A10B4C1E525F2F5F10G2-E7-01	Low Alluvial Savannah	3_1S_1

have shown relatively lower NDVI values. Subtropical forest has shown a similar pattern with higher values. The juniper has shown invariably higher values in April.

The seasonal spectral profile of different vegetation and land cover classes has been used as a discriminant in the classification approach[13]. It is for the first time on this continent that such a spectral profile has been generated with authentic ground data. The spectral profile clearly indicates a possibility of discriminating features.

An attempt has been made to assess the NDVI values between wet (November 1999–January 2000) and dry (March–April 2000) seasons for forest types (Figure 4 *a*). The scatter plot clearly indicates the separability among the different classes. The high altitude forest types evergreen and semi-evergreen are discriminated from the deciduous types. The high altitude vegetation of cold desert, viz. alpine pastures and junipers have low NDVI values. However, the tropical evergreen forests have similar values to that of subtropical forest, which may be attributed to the presence of secondary forests in the region.

It also evident from the scatter plot (Figure 4 *b*) that there is differentiation among the vegetation types based on the eco-regions, i.e. vegetation types occurring in similar geographical conditions are clustered together. The evergreen and semi-evergreen forests are separate from that of the Northeast. The deciduous forest type for arid and semi-arid regions shows a different phenological pattern than those of the tropical regions.

A similar plot for the agricultural classes in the region was generated (Figure 5) and it was observed that the different agriculture classes are also separable. The study highlighted the potential of multi-temporal resolution satellite images for understanding the phenological variations of the land cover features.

The region is endowed with vast natural resources in the form of tropical evergreen, semi-evergreen, subtropical evergreen, temperate broad leaved, moist deciduous, temperate conifer, alpine scrub, varied cropping pattern, etc. To classify this, a hierarchical classification approach was adopted. At the first level, the major forest and non-forest classes were obtained followed by the detailed classification using unsupervised approach. A total number of 45 classes based on the FAO land cover classification scheme (LCCS) was obtained[14]. Table 1 shows the area statistics for the land cover classes. The mapped classes are compared to the corresponding classes described by Champion and Seth[8] and are shown in Table 2.

SPOT VEGETATION data with its high temporal resolution has potential for use with regional land cover mapping and the high frequency of coverage enhances the likelihood for cloudfree observations and makes it possible to monitor change in land cover conditions over short periods, such as a growing season. These data sets are useful for monitoring land cover transformations at a wider scale.

The study demonstrates the utilization of multi-temporal satellite data for assessment of phenological status of different types vegetation. The study of these phenological patterns and foliage activity monitoring through NDVI will help in understanding vegetation dynamics in terms of climate change impact, carbon sequestering process and earth–atmosphere energy interactions.

The data sets generated are of invaluable significance for geosphere–biosphere studies, climate change and monitoring large-scale landuse/landcover change. The results indicate that SPOT VEGETATION data has immense potential for generation of landuse/landcover at regional level and the interaction among the institutions/experts at regional level helped in creating a firm baseline data in the Asian region. Existing data can be used as preliminary baseline data for further landuse/landcover studies.

1. Agrawal Shefali, Sarnam Singh, Joshi, P. K. and Roy, P. S., Workshop on classification methods, 28–29 March 2001, ISPARA, Italy, 2001.
2. deFries, R., Hansen, M., Townshend, J., *Remote Sensing Environ.*, 1995, **54**, 209–222.
3. Jensen, J. R., in *Introductory Digital Image Processing: A Remote Sensing Perspective*, Prentice Hall, New Jersey, 1996, p. 316.
4. Justice, C. O., Townsend, J. R., Holben, B. N. and Tucker, C. J., *Int. J. Remote Sensing*, 1985, **6**, 1319–1334.
5. Davenport, M. L. and Nicholson, S. E., *Int. J. Remote Sensing*, 1993, **14**, pp. 2369–2389.
6. Stibig, H. J., Beuchle, R. and Gond, V., Workshop on Vegetation, Belgrade, April 3–6, 2000.
7. Http://www.spotimage.fr/data/images/vege/vegetat/book_1/4/42/e42c.htm.
8. Champion, H. G. and Seth, S. K., in *A Revised Survey of Forest Types of India*, New Delhi Govt. Publication, 1968.
9. Anonymous, National Biodiversity Strategy and Action Plan Project report, 2002, pp. 424.
10. Elvidge, C. D., Baugh, K. B., Kihn, E. A., Kroehl, H. W. and Davis, E. R., *Photogramm. Engg. Remote Sensing*, **63**, 727–734.
11. Anonymous, Proceedings of the International Workshop on Asian Forest Cover Assessment and Conservation Issues, 2002.
12. Roy P. S., Sein Aung, Sarnam Singh, Shefali Agrawal, Joshi, P. K. and Stutee Gupta, Assessment of Forest Cover in Northeast India and Northern Myanmar, 2000.
13. Barkart, M., Sibylle Itzerott, Marc Zebisch, Classification of Vegetation by chronosequences of NDVI from remote sensing and field data: The example of Uvs Naur Basin (www.uni.postdam.de/u/Geoekologie).
14. Gregoris, di Antonio and Louisa, J. M. Janson, in *Land Cover Classification System: Classification Concepts and User Manual*, FAO, Rome, 2001.

Received 5 December 2002; revised accepted 25 March 2003