CHAPTER – VI

Changes in Structural and Functional Characteristics

6.1. Introduction

The questions of what, where and when are defined as the basic components for understanding of spatio-temporal aspects of structures and processes. The passage of time is normally understood through changes that occur to objects in space – their transformation over time and their movements in relation to one another (Peuquet and Wentz, 1994). Time as well as space are a concepts we instinctively use to understand and conceptualise the environment. From the understanding of the real world it is possible to derive the concept, that time is closely related to changes, because every change, in whatever way, an only take place if time passes by. The complex nature of time may be included to a GIS in several ways as a framework for observing changes in the spatial entities (Ott and Swiaczny, 2001).

Observing changes in the vegetation dominated landscape implies studying the changes that have happened to the vegetated surface over a period of time. The nature and properties of vegetation are fundamental attributes of a landscape. The nature of the vegetation in an area is determined by a complex combination of effects related to climate, soil, history and human influences. So, changes in vegetation cover could in-turn indicate change in one or more of the above said factors.

Vegetation health, condition and change through time are of great interest from a variety of perspectives. Satellite imagery, primarily due to its synoptic views of landscapes and multi-temporal sensing, is well suited for monitoring vegetation health and change through time. Temporal patterns or the change in reflectance properties over time have been used extensively for mapping vegetation at local to global scales. More recently, several investigators have found that use of temporal images could improve vegetation mapping at local to

regional scales using images such as Landsat TM or SPOT HRV or IKONOS. The use of temporal imagery appears most promising in environments with mixed evergreen and deciduous species, like Alagar hills forest environ.

In this chapter the observation of changes in the vegetation cover of Alagar hill forest environs have been attempted using the temporal images of Landsat TM and ETM of 23rd April 1990 and 15th May 2001 respectively. Apart from these images, IRS- 1 C image of 3rd May 2002 has also been used for visual inspection of changes in the forest cover. For the present study, changes in the vegetation cover has been brought out by comparing the spectral characteristics of Alagar hill vegetation, Normalized Difference Vegetation Index and Dominance and Diversity indices for two time periods. In order to understand the factors that are behind the temporal changes field checks, visual inspection of the satellite images have been conducted and Moisture Stress Index have been calculated.

6.2. Changes in Spectral Characteristics of Alagar hill Environs

The temporal changes in spectral characteristics of Alagar hill environs have been attempted for the present study using the temporal images of Landsat TM of 23 April 1990 and 15 May 2001. The study focuses on the temporal changes that have happened over a period of ten years in the green (band 2), red (band 3) and infrared (band 4) regions (Fig.6.1).

The changes in the reflectance in green band generally affect the greenness of the landscape which could easily be noted just by looking at the landscape. There are extreme changes observed in the histogram of green band (band 2) for these two time periods. Though the reflectance curve has more or less uniform structure, a heavy shift is observed among the minimum and maximum reflectance values. On 23rd April 1990, the reflectance of the vegetation in this band for Alagar hills ranges from 31 to 83 with a mean value of 45. However, at 15th May 2001, the range of reflectance values varies

between 53 and 153 with a mean value of 74. Further, a shift in the minimum and maximum values of the reflectance value is observed. The reasons for the shift may be attributed to two factors viz., 1) moisture stress and 2) change in the time of observation and atmospheric conditions. The time of observation, though both the images are taken during summer there is a gap of 22 days, which is a significant period especially for summer. Both the images were taken at a cloud free atmosphere but the azimuth and altitude of the sun is slightly different.

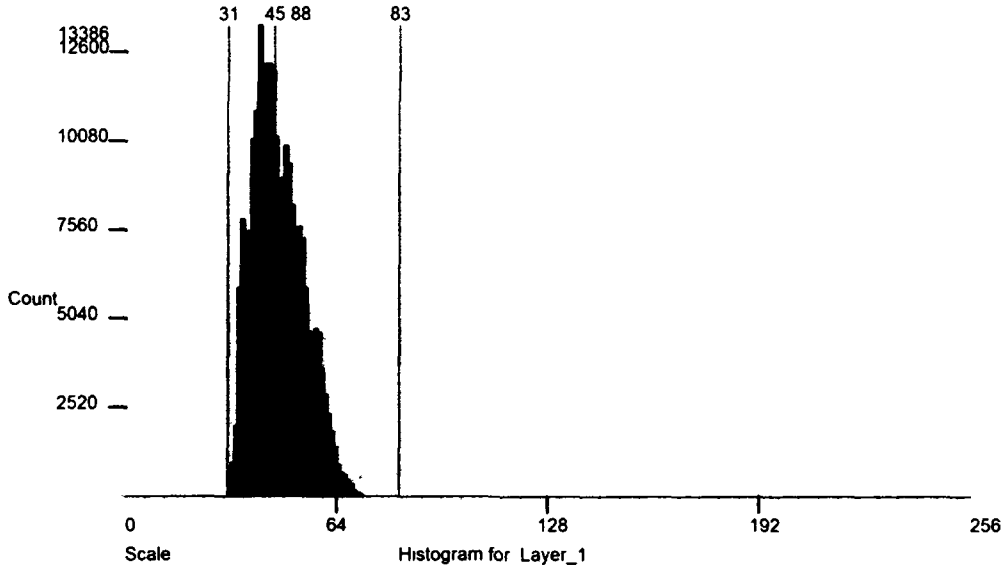
The histogram of red band reveals that there is no appreciable change in the lower limit of the reflectance value. However, there is a drastic change in the upper limit (the maximum) of the reflectance value. Chlorophyll absorbs red wavelength for photosynthesis and as a consequence higher absorption in the red band indicates higher productivity. There is also a significant change in the mean value. In 1990 the mean value for red band is 58.7 but in 2001 it is 77.3. This shows a significant shift in red reflectance spectra. Though there is reflectance beyond the value 123 in 2001, there is no significant deviation. However, increase in the reflectance spectra in 2001 indicates less absorption.

The histogram of infra red region of EMR is the most significant one with reference to the studies related to vegetation. The higher reflectance in infra-red indicates good vegetation vigour. The histograms of the two time periods are more or less similar. There are no drastic changes either in the minimum or in the maximum values. This indicates that the existing vegetation condition is good. The mean value in IR region of EMR in 1990 is 80.4 and the mean value for 2001 is 76.7. Though it appears to be an insignificant change in the mean value, it is very much important. The decline in the mean value indicates a disturbance. This may be attributed to lose of ground cover vegetation during dry summer months.

Fig.6.1 Temporal Changes in Spectral Characteristics of Alagar hill Environs

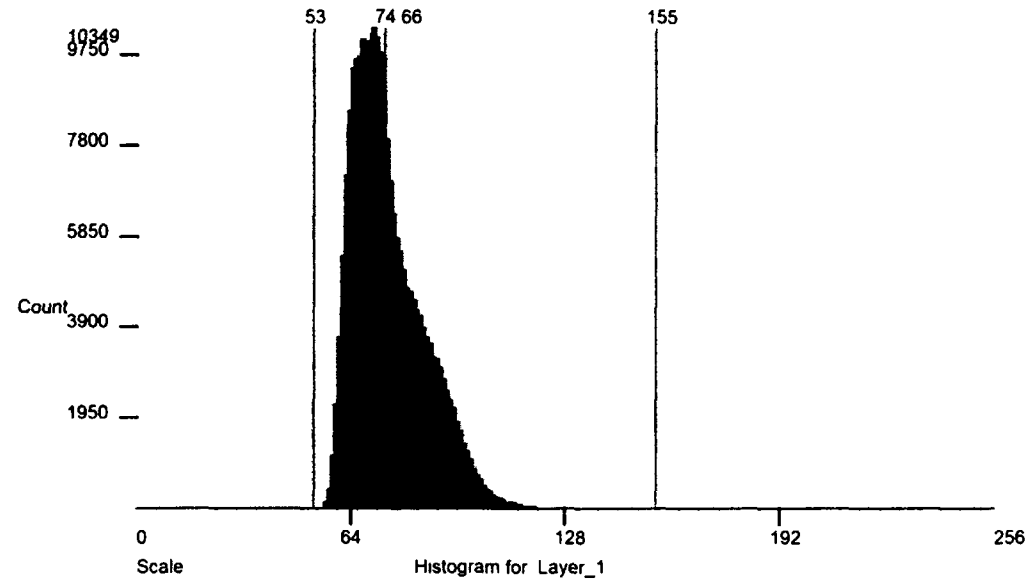
Histogram:
Bin Function Direct
Minimum. 31
Maximum 83
Mean· 45.8847

Landsat TM – 23 April 1990 Band 2 (Green)



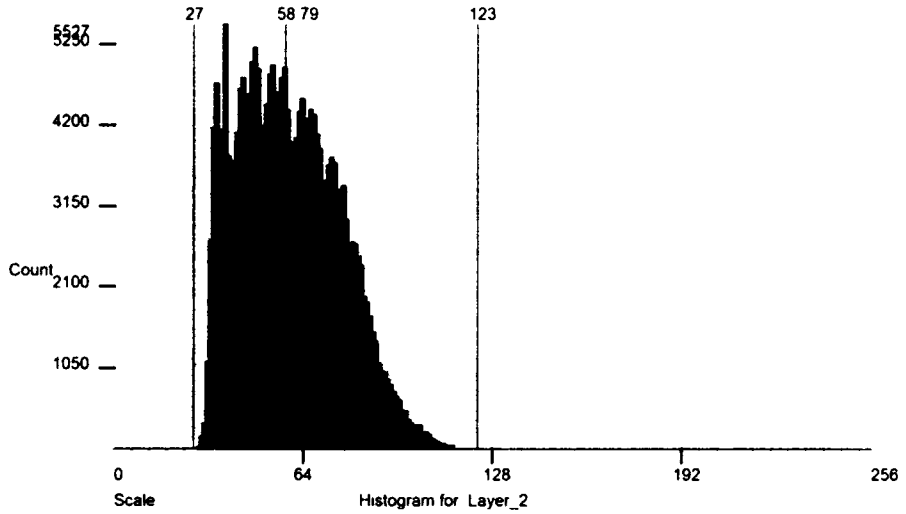
Histogram:
Bin Function: Direct
Minimum: 53
Maximum: 155
Mean: 74.6615

Landsat ETM – 15 May 2001 Band 2 (Green)



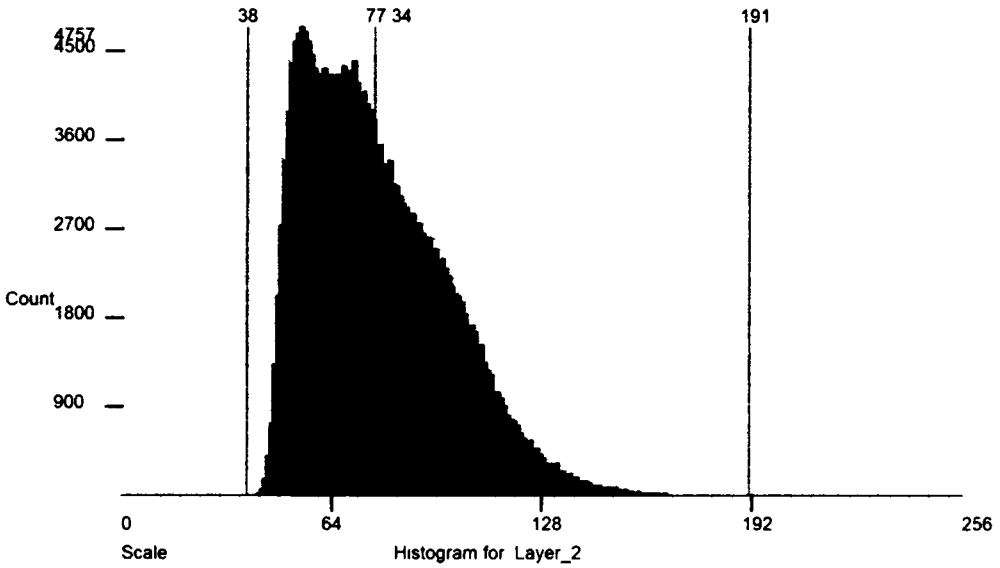
Histogram:
Bin Function Direct
Minimum 27
Maximum 123
Mean 58 7886

Landsat TM – 23 April 1990 Band 3 (Red)



Histogram:
Bin Function Direct
Minimum 38
Maximum 191
Mean 77 3448

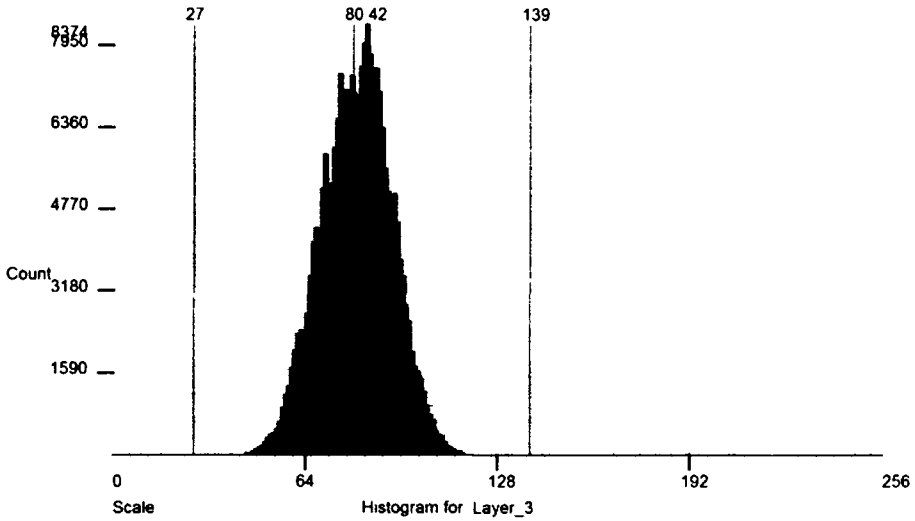
Landsat ETM – 15 May 2001 Band 3 (Red)



Histogram:

Bin Function Direct
Minimum 27
Maximum 139
Mean 80 4242

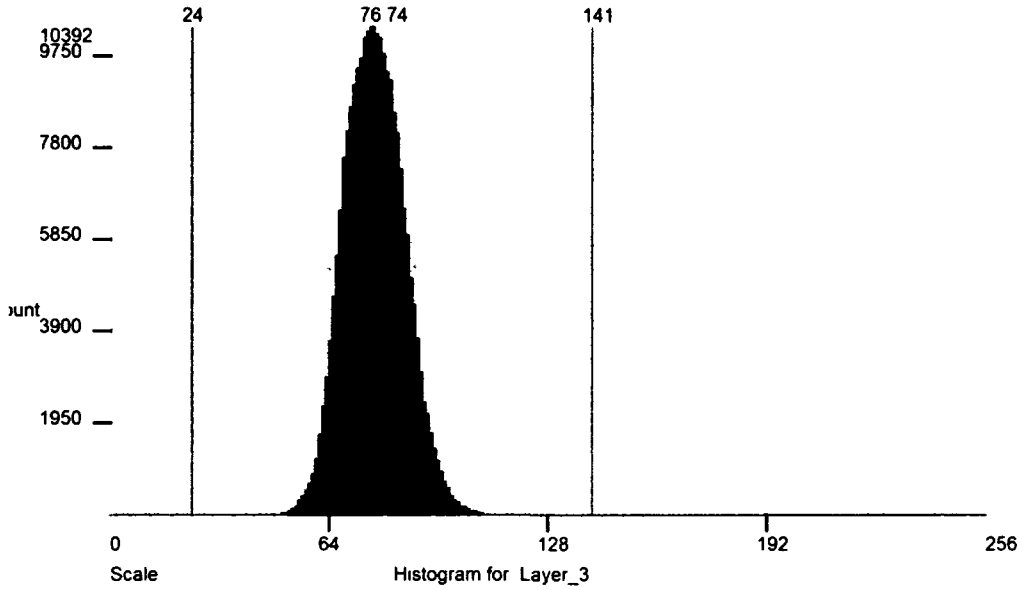
Landsat TM – 23 April 1990 Band 4 (Infra Red)



Histogram:

Bin Function: Direct
Minimum: 24
Maximum: 141
Mean: 76.7438

Landsat ETM – 15 May 2001 Band 4 (Infra Red)



Horizontal Axis 1 tic = 6 Data Value(s)

Vertical Axis 1 tic = 650 Counts

6.3. Changes in the NDVI of Alagar Hill Environs

The Normalised Difference Vegetation Index for the two periods (23rd April 1990 and 15th May 2001) of Alagar hill environs show significant changes in the vegetation surface of the landscape (Fig.5.6). Most of the changes occurred in the peripheral areas of the reserved forest. The NDVI value range between < 0.03 and >0.17 for these two periods. The actual values begin from less than zero and extend beyond 0.17 and reaches at 0.56. However, for the sake of convenience the values are grouped in to four classes with an interval of 0.07. The lower ranges of Alagar hills are found to be in the class of NDVI falling between < 0.03 and 0.10. However, during 2001 most of the lower ranges were well within the category <0.03. These lower ranges are characterized by the scrub vegetation. From the NDVI of 2001 it is found that the scrub vegetation at the lower ranges are affected appreciably when compared to the vegetation at higher ranges.

The higher ranges of Alagar hill environs fall in the NDVI class of > 0.17. In 1990 most of the higher ranges and mid altitude zones are in this class. This indicates a vigourous vegetation growth at that time. In 2001 only the high altitudinal zones (600m – 800m), characterised with dense forest cover, remains in that class. Even in the high altitudes the loss of thickness is vivid. The non-forested lands during 2001 are exposed and devoid of grass cover. The west, southwest and northwest facing slopes show patches of degradation.

The changes in the mid altitude zones (400m – 600m) characterised by open forest, are also significant. According Sriganesan (1984), this zone is covered by dry deciduous species and dry evergreen species of plants. The deciduous species due to the severity of climatic conditions would have shed their leaves during the early period of summer in 2001. The scrub vegetation at periphery also shows sign of changes, since it has annual vegetation categories. Many of them would have died due to the severity of dry weather and their seeds would be dormant waiting for the favourable season to retreat. The changes at

the periphery are drastic and affect the open forest category immediately above them. When the scrub cover is off, the boundary of open forest is open to the movement of species living in the scrub cover and human beings. Prolonged usages of this zone certainly affect the plant species of this zone. During summer the grazers use this zone and the villagers nearby use this zone for fire wood collection. Further, the perennial weeds would find a suitable habitat for its areal expansion. The invasion of weeds if once happened then the whole vegetation group would be at risk, since the weeds armed with the allelopathic effects would not allow other vegetation to grow in their vicinity.

6.4. Changes in the Dominance and Diversity Indices

In dominance index, the brightest values represent the classes with the greatest number of pixels. In 1990, the brightest spots are found almost evenly in the peaks of the ranges of Alagar hill environ (Fig.6.2) and the concentration of the bright spots are more on the left side of the undulating ridges than on the right Catapult Ranges. This indicates that vegetation found in the left undulating ridges dominate the landscape of Alagar hill as a whole. The scenario has not entirely changed in 2001. Though the vegetation groups of left undulating ridges continue to dominate the landscape, its intensity is lowered over the period of time. There are a number of bright spots found on the peaks of the western slopes, which are characterised by the diverse landcover. This is not a good sign and indicates that the dominant landcover are slowly loosing their stronghold and pave way for other land covers such as open forest category or non-forested area to dominate.

In the diversity index (Fig.6.3) the brightest values represent areas with the most heterogeneous land cover. In 1990, the western slopes of the right Catapult Ranges were found to have the heterogeneous land cover in the landscape of Alagar hill environs. By 2001, the diversity has increased much in the west facing slopes. Most of the mid altitudinal zones of the western slopes of the left arm of right Catapult Ranges indicate a diverse land cover. Further a similar

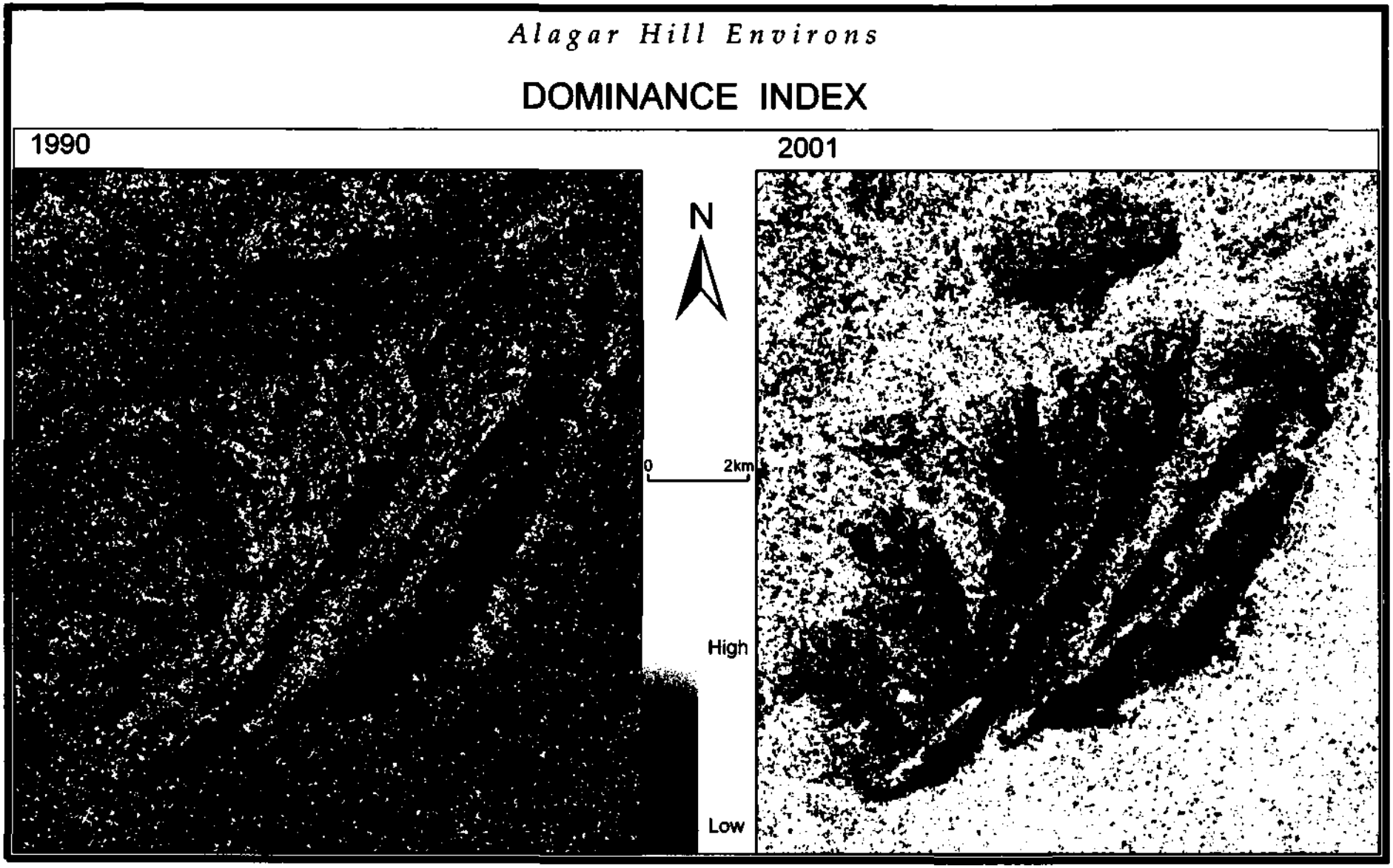

Alagar Hill Environs
DOMINANCE INDEX
1990
2001
N
0
2km
High
Low

Fig. 6.2

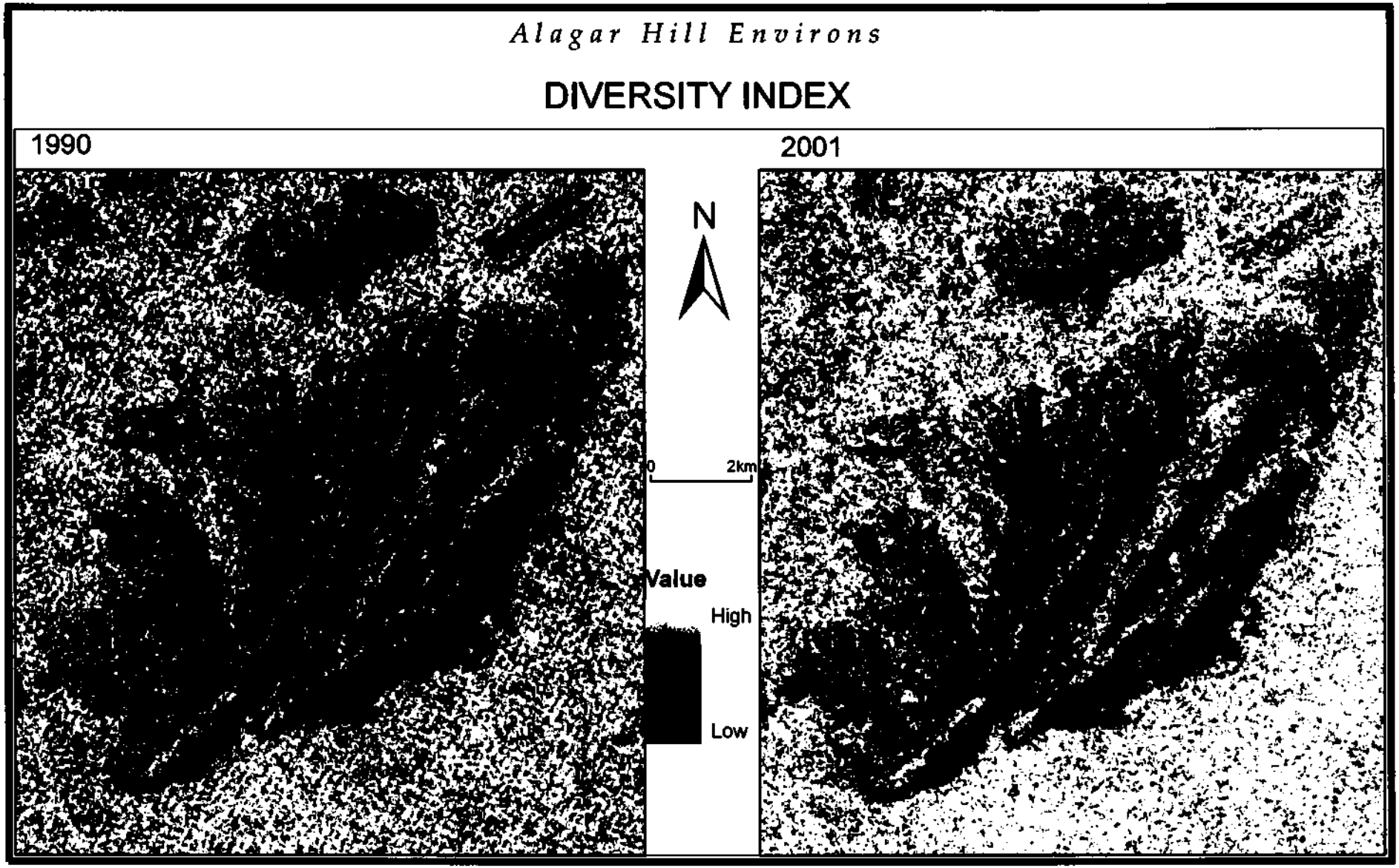

Alagar Hill Environs
DIVERSITY INDEX
1990
2001
N
0
2km
Value
High
Low

Fig. 6.3

trend started peeping into the vicinity of the higher altitudes of the left undulating ridges. This is not a healthy trend and this indicates that those lands which were diverse in 2001 and dominated by the dense forest category. From the above it could be envisaged that the higher altitudes which are characterised by the dense forest cover in left undulating ridges could be replaced by open forest category, if the similar trend continues.

6.5. The Possible Factors Responsible for Change

In order to understand the possible factors responsible for the changes the field check and visual inspection of temporal images has been done (Plate. 3; Fig.6.5). The inspection involves identifying pockets of areas which shows drastic changes in the reflectance characteristics of the vegetation over the period of observation. The observations indicate that the forested area of about 10 hectares has been cleared atop Alagar hills in the year 2001. The shape of the clearance is more or less rectangle in shape; this clearly indicates interferences by human beings. Though the exact reason for the clearance and what has been cleared is unknown, yet it is confirmed that it is illegal.

The visual inspection of satellite images clearly indicates that Alagar hill environs are not entirely devoid of human disturbances (Plate.4). Further the disturbances are vivid in the densely forested area. Changes in climatic conditions may be a prominent factor apart from the human interferences for the drastic changes that have happened in Alagar hills. Rainfall is one of the prime factors in the growth of vegetation. Below normal rainfall in the years viz., 91, 94, 95, 99 and 2001 would have caused the moisture stress and made changes in the vegetation vigour.

Moisture stress could be calculated using the following expression, (Rock et al., 1986; Haris et al., 2006)

$$\textbf{Moisture Stress Index} = (\text{Mid IR}_{TM5}) / (\text{NIR}_{TM4})$$

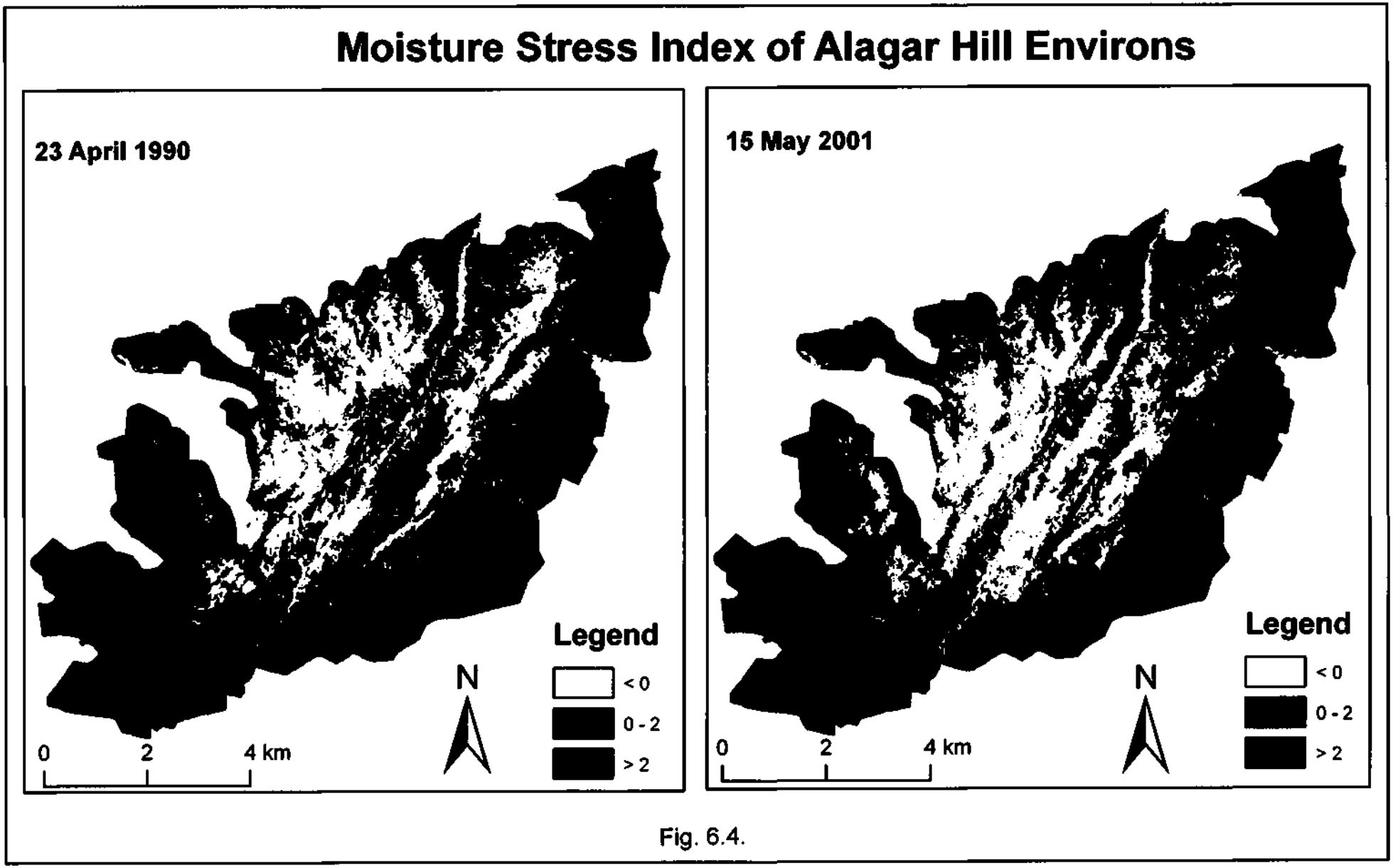

Moisture Stress Index of Alagar Hill Environs
23 April 1990
15 May 2001
Legend
< 0
0 - 2
> 2
N
0
2
4 km

Fig. 6.4.

Temporal Changes in Alagar Hill Environs
Visual Inspection of Satellite Images

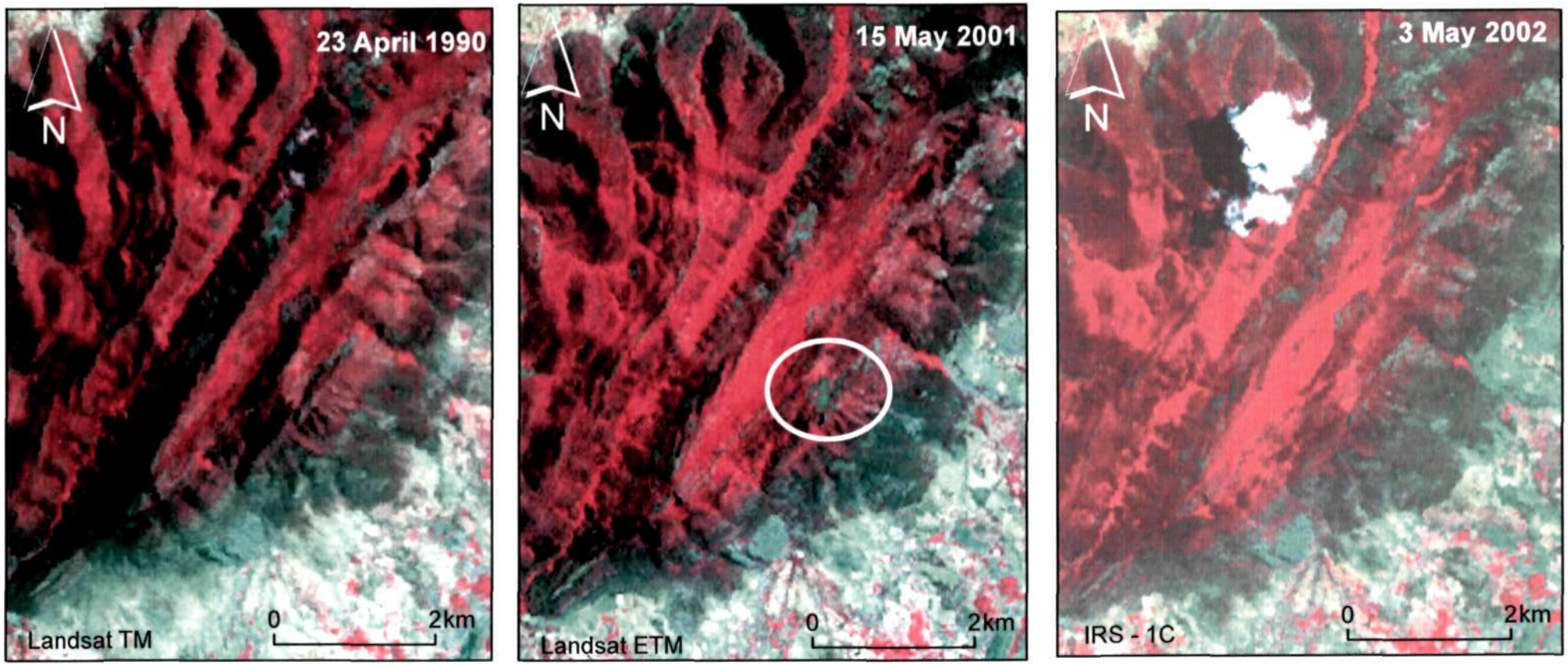


Fig. 6.5.

Moisture stress index are calculated for 1990 and 2001 and the results are shown in figure.6.4. In the Moisture Stress Index the index value 0 indicates low moisture stress and >2 indicates high moisture stress and the value 0 to 2 indicates a medium level moisture stress. Notable changes are observed in different zones. Alagar hills reserved forest. The periphery experienced a high moisture stress in the year 2001 while the mid altitudinal zone during both the time periods experienced a medium moisture stress. However, at high altitudes the moisture stress is limited. The moisture stress has direct relationship with the vegetation vigour. The high altitudinal zone shows similarity between moisture stress with the NDVI. From the evaluation it is inferred that climatic changes and human interferences hold the key for the changes observed in the forest cover of Alagar hill environs.