CHAPTER – 4
METHODOLOGY

The present dissertation includes number of aspects like vegetation cover mapping, landscape analysis, biological richness modelling etc. Detailed methodology followed for carrying out the works has been outlined as follows:

4.1 Vegetation cover mapping

For vegetation cover mapping both spatial (satellite data, topographic map) and non-spatial data (ground truth data) were used to create a base map in the GIS domain. All these process has been outlined in detail in the following section.

4.1.1 Satellite data

Optimum season with minimum cloud satellite data were chosen for the study. IRS-1D LISS III digital data have been used in the present study to characterize plant biodiversity. The entire hills of Darjiling is covered under four scenes, the detailed description of these satellite data used for the visual interpretation have been listed in the following table (Table – 4.1). The false colour composite is shown in Fig 4.2

Table 4.1. Satellite data used for vegetation mapping in Darjiling hills

Sl. No.	Satellite	Sensor	Path/Row	Date of Pass
1.	IRS 1D	LISS III	107/52	13^{th} Jan 2002
2.	IRS 1D	LISS III	107/53	17^{th} Feb 2003
3.	IRS 1D	LISS III	108/52	10^{th} Jan 2002
4.	IRS 1D	LISS III	108/53	10^{th} Jan 2002

4.1.2 Ancillary data

Survey of India Topographic map (SoI) of 1:250,000 scale were used. SoI district boundary in digital form was available in the Forestry and Ecology Division of IIRS. The boundary with rectification with regard to actual natural boundary along river was adopted to calculate area of the district and the study area. SRTM (Shuttle Radar Topography Mission) digital elevation model (DEM) data has been used for terrain complexity analysis for biological richness modelling. Atlas of Forest Resources of India (Dasgupta, 1976) was also consulted to get an idea regarding the distribution of different forest types in Darjiling district. Population Census data for the district was used to extract information on population growth and socio-economic condition (Anonymous, 1991, 2001).

4.1.3 Image processing and GIS system

Following hardware and software facility available at Forestry and Ecology Division, IIRS, Dehra Dun were used in the present study.

1. Pentium 4 PC
2. Erdas Imagine 8.6 for image processing
3. ARC/INFO and ARC VIEW 3.2a for GIS analysis
4. SPLAM for deriving landscape matrices
5. Gramin GPS 12CX
6. MS Office 2000 [MS Exel and MS Word] for word processing and vegetation analysis

4.1.4 Analysis of satellite image

Digital analysis of the satellite is a recent trend, which started in the third quarter of 20th century thereafter, it has taken rapid stride and is utilised almost in all fields including geologists, environmentalists, foresters, planners and academicians alike. In the present study, visual method coupled with knowledge based human approach has been adopted for classifying and characterisation of vegetation.

Satellite data in a digital form were utilised to characterize the vegetation. They were radiometrically corrected, and geometrically co-registered using the SoI topographic maps (78A and 78B). The pre-processed satellite data were then subjected to visual mode of mapping using ERDAS imagine software and Arc View based on the image elements like tone, texture, association, shape, and location etc. of the data set. Mapping of different forest types was performed at 1:50,000 scale, so as to take care of smaller tonal variations and small patches of the forests.

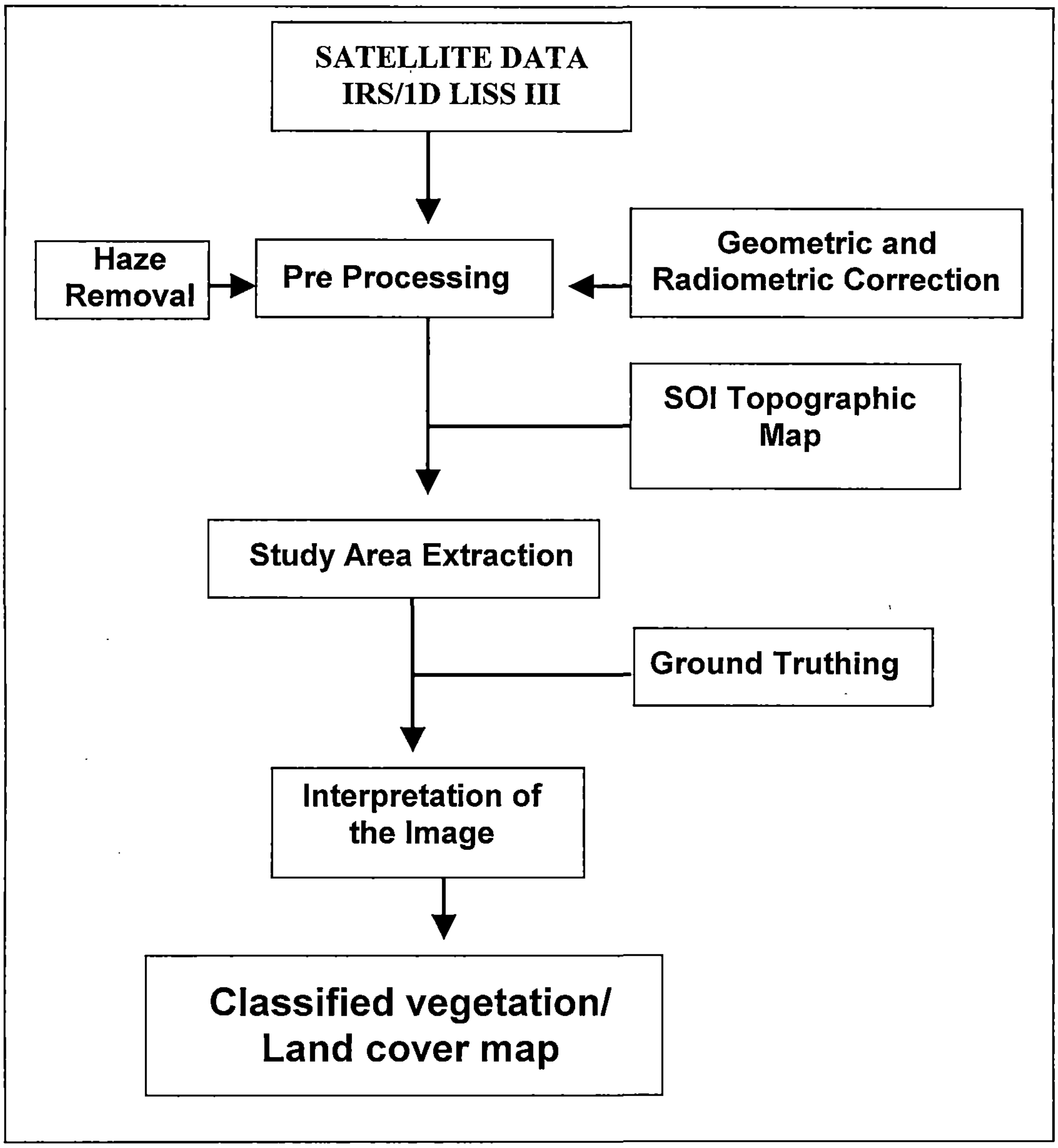
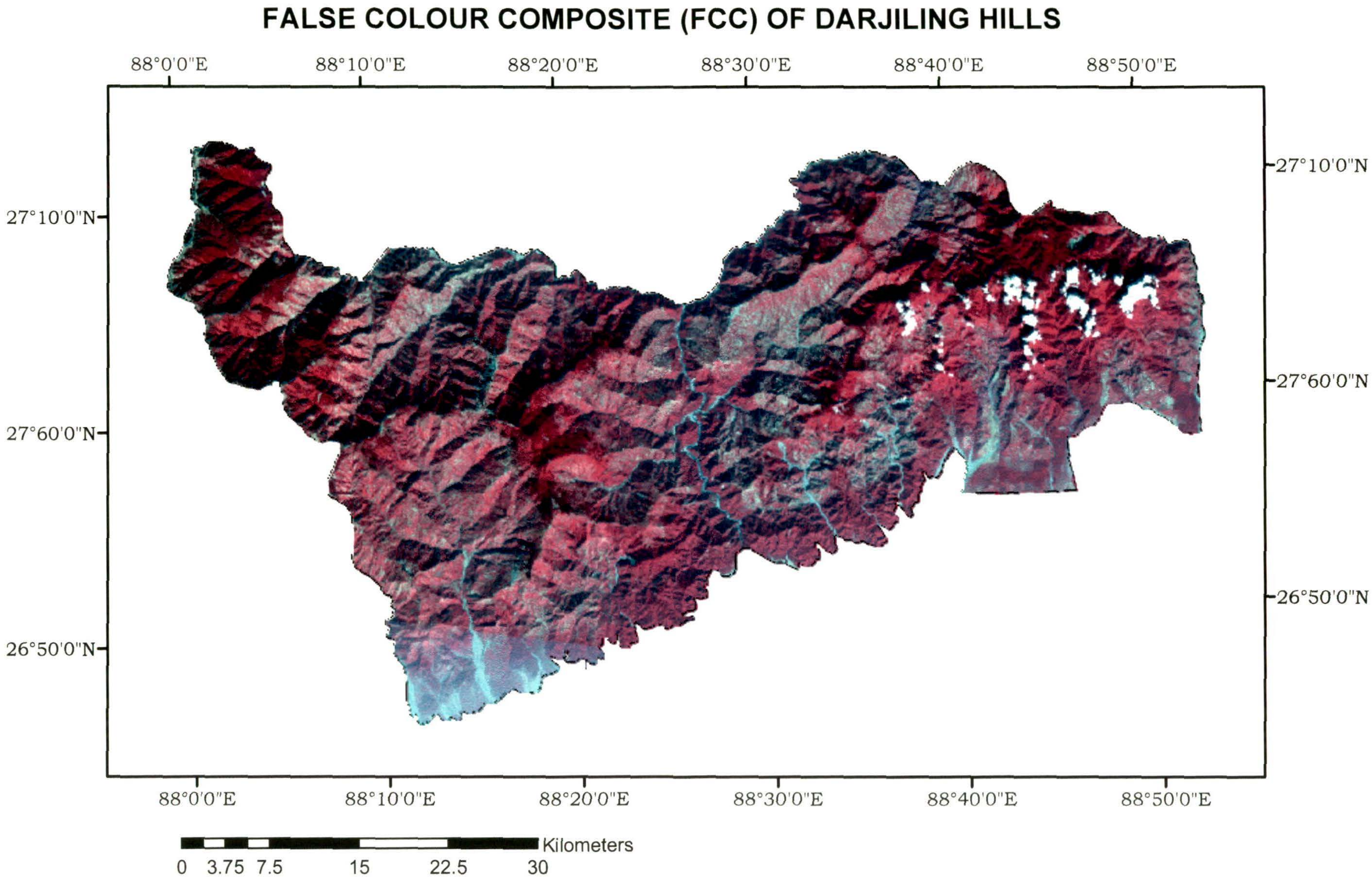


Fig: 4.1 Approach for vegetation cover/ land-use



FALSE COLOUR COMPOSITE (FCC) OF DARJILING HILLS
88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
88°50'0"E
27°10'0"N
27°60'0"N
26°50'0"N
27°10'0"N
27°60'0"N
26°50'0"N
88°0'0"E
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
88°50'0"E
Kilometers
0 3.75 7.5 15 22.5 30

Fig. 4.2

4.1.4.1 Selection of optimal season data

Ideally two season data are best to extract the forest vegetation depending on phenology, i.e. optimal growth, and leaf fall season. Owing to moist climatic condition and almost evergreen nature of the vegetation in this part, the spectral signature is clearly discernible at any season around the year. Also, as major part in upper hills of Darjiling district remains cloud-covered almost throughout the year; getting cloud-free data becomes difficult. In the present work, single season data with minimum cloud has been used for the study. The details of the date and season of the data used have been provided in table 4.1.

4.1.4.2 Radiometric correction

As the study area falls in more than one scenes and path having different dates of acquisition, radiometric correction for each scene was performed separately to remove the atmospheric distortions. Dark pixel subtraction was performed on the scenes. Histogram equalisation was performed between two adjacent scenes for radiometric normalisation. To improve the contrast and interpretability enhancement techniques like linear stretching, Histogram equalisation etc. were performed.

4.1.4.3 Geometric correction

Prior to the analysis of the satellite data, it is imperative to rectify the images geometrically with the help SoI topographic map of desired scale. Each satellite data was geometrically corrected with the help SoI map using ground control points. Thereafter all the scenes were co-registered and mosaicked. The re registration of each image was performed using the nearest-neighbourhood resampling algorithm with a root-mean-square (RMS) error of 0.002 - 0.05 pixels.

4.2 Vegetation classification scheme

For vegetation classification method developed by the IIRS for Biodiversity characterisation project has been adopted to delineate broad vegetation cover type (Anonymous, 2003b). The classification is based upon the phenological and the floral composition of the tree species, following classification scheme was adopted for stratification using satellite remote sensing data.

A. Forests

1 Dominant Phenological Types

i. Tropical Semi-evergreen Forests
ii. Moist Mixed Deciduous Forests
iii. Sub-tropical Broad Leaved Hill Forests
iv. Temperate Broad Leaved Forests
v. Wet Temperate Forests
vi. Conifer Forests
vii. Sub-alpine Scrubs

2 Gregarious Types

viii. Himalayan Sal Forests
ix. *Rhododendron* Forests
x. *Alnus* Forests
xi. Bamboo Brakes

3 Local Specifics

xii. Riverine Forests

4. Plantation Forests

xiii. Teak
xiv. Cryptomeria
xv. Cinchona

5 Degradational Types

xvi. Degraded Forests
xvii. Open Scrubs

B. Non-forest Types

xviii. Tea gardens
xix. Agriculture
xx. Barren Land
xxi. River beds/ Water Bodies
xxii. Settlements
xxiii. Clouds and Shadow

4.3 Mapping

On-screen visual interpretation method was followed for stratifying different vegetation in Arc-View 3.2 GIS package. Visual interpretation keys (Table 4.2) were prepared considering tone and texture of vegetation in the satellite image. As many as possible, ground control points were recorded in the field using Garmin GPS 12CX and co-related with the vegetation.

Table 4.2 Interpretation key for visual classification of satellite data

Sl. No.	Land use/ Land cover Type	Abbv.	Tone	Texture
1	Tropical Semi-evergreen Forests	TSE	Medium red	Coarse to molted
2	Himalayan Sal Forests	HS	Dark brownish red, molted	molted
3	Moist Mixed Deciduous Forests	MMD	Dark red	medium
4	Riverine Forests	Riv	Brownish green	Medium
5	Sub-Tropical Broad Leaved Hill Forests	STBL	Light red	Medium
6	Wet Temperate Forests	WT	Dark red	Coarse
7	Temperate Broad Leaved Forests	TBL	Light red	Medium
8	*Alnus* Forests	Aln	Brown	Smooth
9	Conifer Forests	Con	Dark bluish to dull red	Coarse
10	Sub-Alpine Scrub	SAS	Light dull red	Smooth
11	Bamboo Brakes	BB	Light pink	Smooth
12	*Rhododendron* Forests	Rho	Light red	Medium
13	Open Scrub	OS	Light faded yellow	Smooth
14	Teak Plantations	Tpl	Chocolate Brown	Medium
15	*Cryptomeria* Plantations	Cpl	Dark Brownish red	Coarse
16	Degraded Forests	Deg	Light maroon with Cyan tinge	Coarse
17	Cinchona Plantation	Cin	Dark brownish red	Coarse
18	Tea Garden	TG	Red to pinkish red	Medium
19	Agriculture	Agri	Light pink tone to cyanish white	Medium
20	Barren Land	BaL	Blue-green to cyanish	Medium
21	Rivers/ Water bodies	R/WB	Dark to deep blue	Smooth
22	Settlement	Stl	Dull blue-green to cyanish	Coarse
23	Cloud and Shadow	CandS	White and Black	Smooth

4.4 Community analysis

Stratified random nested quadrat sampling method with proportionate sample to the size of the forest has been adopted for analysing vegetation composition. In the present study, minimum percentage for sampling was taken at 0.005 percent of the total area to get fair idea about the vegetation composition.

4.4.1 Sampling

Stratified random sampling with nested quadrate method was adopted to study various strata of vegetation. Conventional sample plot size of 20m × 20m for trees with more than 15cm circumference at breast height (CBH), within which two 5m × 5m plots were laid at the diagonal corners for shrub and sapling having ≥ 5cm CBH. For herbs and seedlings five 1m × 1m plot were laid at the four corners and one at the centre of the 20m × 20m plot, so as to maximise the participation of as many species for the interpretive quality in the phyto-sociological analysis. The schematic sampling design for phyto-sociological analysis has been provided in Fig 4.3. The epiphytes, lianas, climbers along with their host were also noted separately to keep an account of the floral composition for the particular sampling site in a forest.

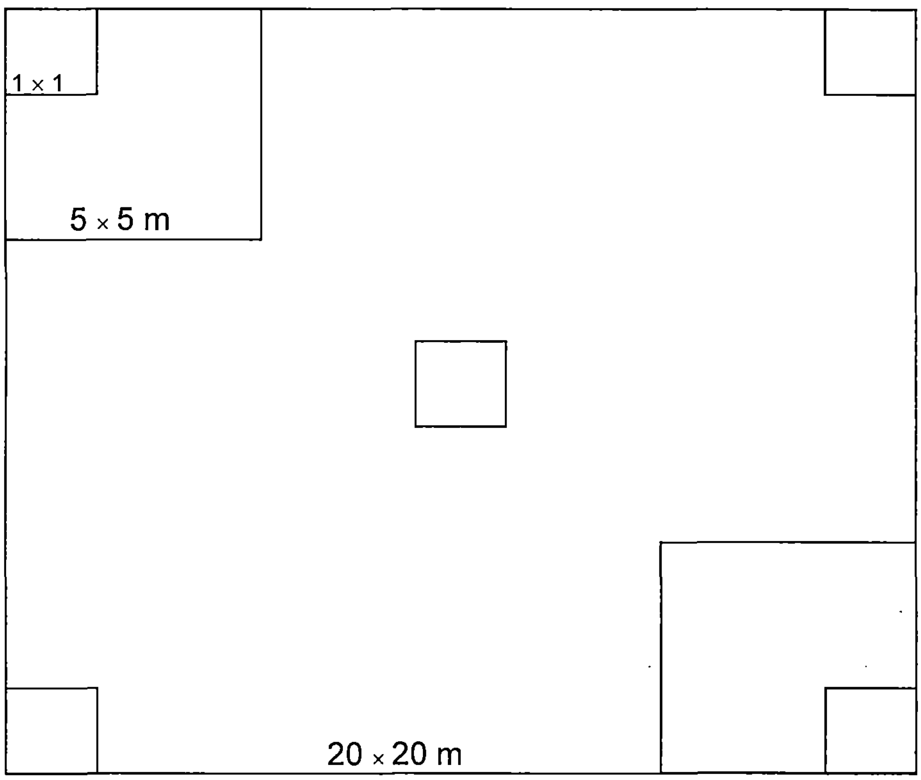


Fig: 4.3 Sampling design for the Phytosociology

4.4.2 Identification of specimens

Identification of the specimens was done in the field as far as possible with their local names. Ethno-botanical uses if any were recorded consulting the local people. Unidentified voucher specimens were collected properly dried under blotting paper, poisoned with 8% Mercuric chloride in rectified spirit. The dried and poisoned specimen were mounted on a standard herbarium sheet and labelled with relevant information. Identification of voucher specimens was done at Taxonomy and Environment Biology Laboratory of North Bengal University by matching the specimens at NBU herbarium and consulting literatures. Unidentified specimens were also matched at Botanical Survey of India (Himalayan Circle), Gangtok, and at Central National Herbarium at Shibpur, Howrah.

4.4.3 Phyto-sociological analysis

For each forest types, number of individual for each life form were recorded to determine their Frequency, Density, Abundance, Basal area etc. Finally, the data were analysed for computation of Importance Value Index (IVI), which is the sum of the relatives of Frequency, Density and Dominance suggested by Misra (1969) and Phillips (1959). However, for shrubs and herbs, Abundance has been considered for computing the importance value, which is simple and gives equally good result (Samanta and Das, 1998)

4.4.3.1 Frequency

Frequency is the degree of dispersion of an individual species in a community. It expresses the percentage and represents the chance of occurrence of species in a given habitat. Relative frequency is the percentage frequency of a particular species in comparison to total frequency of all other species.

$$\text{Frequency (F\%)} = \frac{\text{Number of Quadrate in which species occurred}}{\text{Total number of quadrate studied}} \times 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Sum of the Frequencies of all species}} \times 100$$

4.4.3.2 Density

This indicates the abundance of a species in a unit area. Density of a species expresses the numerical strength in a community. This parameter gives an idea about the dominance and rarity of a species and is also an indicator of the standing biomass and productivity of the region (Ambashat *et al.,* 1995). Relative density shows the percentage of representation of the species in terms of number of individuals in comparison to all other species in a community. They are calculated as follows.

$$\text{Density (D)} = \frac{\text{Total number of individual of a species}}{\text{Total number of quadrate studied}}$$

$$\text{Relative Density (D)} = \frac{\text{Density of a species}}{\text{Sum of the Densities of all species}} \times 100$$

4.4.3.3 Abundance

It is the number of individuals of a species occurring in all the sampled area of a particular vegetation type. This parameter fairly gives an idea about the commonality of a species in a habitat under consideration. Like Relative Frequency and Relative Density, Relative Abundance is the ratio of the species to number of quadrat studied for a given vegetation type. They are calculated as follows.

$$\text{Abundance (A)} = \frac{\text{Number of individuals of a species occurring}}{\text{Total number of quadrates studied}}$$

$$\text{Relative Abundance (A)} = \frac{\text{Abundance of a species}}{\text{Sum of the abundances of all species}} \times 100$$

4..4.3.4 Basal area

It is the total ground area occupied by a tree and is calculated by taking measurement of a tree trunk at breast height (1.37 m) above ground. Basal area provides information on the proportion of its dominance in a forest community. It indicates the relative size, volume and weight of a tree. This is also on of the parameter assigned for determining the importance value of a species. Basal area is calculated by the following formula.

$$\text{Basal Area (BA)} = \frac{(\text{CBH})^2}{4\pi}$$

CBH: Circumference at breast height.

4.4.3.5 Importance Value Index (IVI)

IVI is a statistical quantity, which gives an overall picture of a species and indicates their importance in the plant community. It is calculated by summing up the relative values of frequency, density and dominance/ abundance of species (Misra, 1969). As, this is the sum of the three phyto-sociological parameter, it helps in understanding the sociological structure of a species in a community, thus it is called the Importance Value Index.

$$\text{IVI} = \text{RF} + \text{RD} + \text{RDm (RA)}$$

4.4.4 Diversity indices

Various diversity indices were studied to understand the diversity of communities in space and time. Diversity indices serve as important surrogates for measuring biodiversity (Sarkar and Margules, 2003). Comparison of species diversity between different ecosystems in various climatic zones, gives information about the diversity and dominance. Out of the numerous indices formulated by different workers for diversity study, the commonly used diversity indices have been adopted.

4.4.4.1 Species diversity

Species diversity is the expression of community structure and indicates the complexity of a habitat. Shannon-Wiener index (1963), which incorporates both species richness and evenness components, is one of the most widely used index for measuring species diversity in an ecosystem (Ricklef and Miller, 2000; Ilorkar and Khatri, 2003). This index has also been used to describe the landscape diversity by many landscape ecologists. Higher diversity is encountered when the number of species and the evenness component are large i.e. low dominance.

Shannon-Wiener Index (1963)

$$H' = -\sum[(ni/N) \ln(ni/N)]$$

Where; 'H' is the index value

'ni' is the number of individuals of a species.

'N' is the total number of species in the habitat type.

4.4.4.2 Species richness

Species richness is another mode of expressing the diversity and is described by the number of species present in a sample or habitat per unit area. The simplest species richness index is based on the total number of species and the total number of individuals in a sample or habitat. Menhinick's index (1964) and Margalef's index (1968) have been adopted to understand the species richness. Menhinick's index unlike Shannon-Wieners index and Simpson's index gives more weightage to the rare species.

Menhinick's Index (1964)

$$D = S/\sqrt{N}$$

Where; 'D' is the index value

'S' is the total number of species

'N' is the total number of individuals of all species.

Margalef's Index (1968)

$R1 = s\text{-}1/\ln(n)$

Where s = number of species and n = number of individuals of a species.

4.4.4.3 Concentration of dominance:

Simpson's index is often used to measure the concentration of dominance of species. Like Shannon-Wiener index of diversity, it also emphasis on the dominant species. This relates to the number of chances of a particular species that could be encountered during sampling. Its maximum value ranges between 0 – 1.

Simpson's Index (1949)

$\lambda = \sum pi^2$

Where; 'pi' is the proportional abundance of the i^{th} species.

pi = ni/N

'ni' and 'N' are same as Shannon-Wiener index.

3.4.5 Similarity Index

Similarity index help to compare different habitat types and their suitability for migration and evolution of species. Of the many mathematical formulations, Sorensen's index of similarity (1968) has been adopted in the present study.

$$S = \frac{2C}{A + b}$$

Where; S: index value

C: number of species common to both sites

a: number os species in site 'a'

b: number of species in site 'b'

4.5 Landscape analysis

Specialised package 'Spatial Landscape Analysis Modelling' (SPLAM), which is developed IIRS in windows environment for operational execution of the Biodiversity characterisation at landscape level, was used for landscape analysis. Vegetation type map created in the GIS domain was converted into grid format. The SPLAM compatible grid format of vegetation type map was imported in the SPLAM platform. Various landscape matrices such as patchiness, fragmentation, porosity, interspersion and juxtaposition were then studied one at a time. All these landscape parameters along with the biotic interference buffer were then subjected to complex linear model to obtain Disturbance index (DI) and Biological richness index (BR).

4.5.1 Determination of mask size

To understand the spatial extant of vegetation in a landscape, a suitable mask size was determined for analysing all the landscape parameters, which was taken for DI analysis. The mask size starting from 250 m up to 1500 m have been studied with an increment of 250 m at each successive interval. The best interpretable mask size was chosen to generate an output map. The pixel size was automatically resampled to 62.5 m at 1:250000 scale.

4.5.2 Landscape parameters

For deriving landscape matrices, the vegetation type map was subjected to run at various mask size. Finally an optimum mask size for each parameter was fixed and moved over the vegetation type map in a non-overlapping manner.

4.5.2.1 Fragmentation

Fragmentation is a measure of number of forest patches in a landscape. The vegetation type map was reclassified into two classes' viz. forest and non-forest class. A mask of definite size was convolved throughout the spatial data layer to derive number of forest patches within the grid cell. Ten levels of fragmentation produced by SPLAM analysis was then recoded to three levels: very high, moderate and low/ least fragmented. Non-forests and cloud and shadow were excluded for area calculation.

4.5.2.2 Patchiness

Patchiness is a measure of the density of patches of all types or number of clusters in a given mask. This parameter is handled internally in the SPLAM programme. Mask size was defined for this matrix and the output patchiness image was recoded to three levels and area estimation was made.

$$P = -\frac{\sum_{i=1}^{n} D_i}{N} \times 100$$ (Romme, 1982)

Where, P= Patchiness

Di = Dissimilarity value for the i^{th} boundary between adjacent cells

N = Number of boundaries between cells.

4.5.2.3 Porosity

Porosity is the measure of number of patches or density of patches within a particular type, regardless of patch size. Its analysis was done only for the dominant phenological classes. Since porosity determines the level of gap in the natural vegetation, it is vital to judge porosity occurring in these vegetation types. Porosity image obtained was similarly recoded into three levels and the area estimation was done.

$$PO = \sum_{i=1}^{n} Cp_i \qquad \text{(Forman and Godron,}$$

Where Cp_i is the number of closed patches of the i^{th} cover class.

4.5.2.4 Interspersion

It is a count of dissimilar neighbour with respect to central pixel and measures the spatial intermixing of vegetation types. It represents the landscape diversity and dispersal ability of a species (Lyon, 1983). For determination of interspersion a convolution window of definite mask size was used with the vegetation type map to compute number of dissimilar pixels in the nearest neighbourhood. The output generation of interspersion image was recoded to four levels and area statistic was calculated.

$$\text{Interspersion} = \sum_{k=1}^{h} Ck \qquad \text{(Lyon, 1983)}$$

if, $Ck \neq$ central pixel
'h' is number of pixels within the mask size.

This gives the zoomed view of resistance, the central pixel or class with respect to its surrounding. A higher value of interspersion means dispersal ability of the central pixel class will be low.

4.5.2.5 Juxtaposition

This matrix helps to understand suitable proximity among different adjacent vegetation types for the movement of species. The added weightage through juxtaposition gives the correct perspective in ultimately deriving DI (Jeganathan, 2003). For deriving juxtaposition matrix relative weightage for a pair of vegetation types was assigned based on the similarity of species, which were computed from the ground truth data.

$$J = \frac{\sum_{i=1}^{n} D_i (J_i)}{J_{max}} \times 100 \qquad \text{(Lyon, 1983)}$$

Where, J_{max} = average total weighted edge per habitat unit of good habitat
D_i = The edge desirability weight for each cover type
J_i = the length of edge between combinations of cover types on either side of an edge.

Weights were assigned for 16 vegetation types based on the similarity of species for a pair of vegetation in question, in the form of a matrix. Values ranging from 0 – 10 were assigned. Maximum weight was assigned for similar forest types of natural classes (9 out of 10) and less for man made/ degraded form and 0 representing total dissimilarity of vegetation. The methodology adopted for deriving juxtaposition by assigning weight from ground truth data is provided in Table 4.3 and Table 4.4. The juxtaposition image from the relative adjacency of vegetation cover class was recoded to 4 categories. Area and percentage area was calculated.

Table 4.3: Percentage of common species encountered between adjacent vegetation cover

TSE	100															
HS	30	100														
MMD	48	65	100													
Riv	29	42	43	100												
STBL	41	27	30	27	100											
WT	5	7	4	5	13	100										
TBL	5	5	7	5	12	76	100									
Aln	14	9	12	10	22	17	15	100								
Con	0	0	0	0	1	24	28	5	100							
SAS	1	0	0	1	4	28	36	9	33	100						
BB	43	43	42	43	39	9	9	25	0	2	100					
Rho	1	0	0	1	3	37	48	7	37	68	3	100				
OS	2	3	4	0	3	25	22	24	15	50	5	22	100			
Tpl	27	41	40	47	21	3	4	11	1	1	37	1	1	100		
Crypl	4	6	5	6	12	31	35	22	12	26	8	28	27	4	100	
Deg	32	42	37	43	30	5	5	13	0	0	61	0	3	40	5	100
Forest Types	**TSE**	**HS**	**MMD**	**Riv**	**STBL**	**WT**	**TBL**	**Aln**	**Con**	**SAS**	**BB**	**Rho**	**OS**	**Tpl**	**Cpl**	**Deg**

TSE: Tropical Semi-evergreen Forests; **HS**: Himalayan Sal Forests; **MMD**: Moist Mixed Deciduous Forests; **Riv**: Riverine Forests **STBL**: Sub-tropical Broad Leaved Hill Forests; **WT**: Wet Temperate Forests; **TBL**: Temperate Broad Leaved Forests; **Aln**: *Alnus* Forests; **Con**: Conifer Forests; **SAS**: Sub-alpine Scurbs; **BB**: Bamboo Brakes; **Rho**: *Rhododendron* Forests; **OS**: Open Scrubs; **Tpl**: Teak Plantation; **Cpl**: *Cryptomeria* Plantation; **Deg**: Degraded Forests

Table 4.4: Juxtaposition matrix derived from field data for adjacent vegetation classes

Forest Types	MMD	HS	TSE	STBL	WT	TBL	Con	BB	SAS	OS	Aln	Tpl	Deg	Riv	Cpl	Rho	Cin	Agri	TG	BaL	R/WB	Stl	C&S
MMD	10																						
HS	7	9																					
TSE	5	4	9																				
STBL	4	3	5	9																			
WT	1	1	1	2	8																		
TBL	1	1	1	2	8	8																	
Con	0	0	0	1	3	3	7																
BB	5	5	5	4	1	1	0	5															
SAS	0	0	1	1	3	4	3	1	5														
OS	1	1	1	1	3	3	2	1	6	4													
Aln	2	1	2	3	2	2	1	3	1	3	4												
Tpl	5	5	3	3	1	1	1	4	1	1	2	3											
Deg	4	5	4	3	1	1	0	7	0	1	2	4	3										
Riv	5	5	3	3	1	1	0	5	1	0	2	5	5	3									
Cpl	1	1	1	2	4	4	2	1	3	3	3	1	1	1	3								
Rho	0	0	1	1	4	5	3	1	7	3	1	1	0	1	3	3							
Cin	1	1	1	2	2	3	1	0	0	2	2	1	1	1	2	0	0						
Agri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
TG	2	1	1	3	1	2	1	1	0	1	1	1	1	1	0	0	1	0	0				
BaL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
R/WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Stl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
CandS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MMD: Moist Mixed Deciduous Forests; **HS**: Himalayan Sal Forests; **TSE**: Tropical Semi-evergreen Forests; **STBL**: Sub-tropical Broad Leaved Hill Forests; **WT**: Wet Temperate Forests; **TBL**: Temperate Broad Leaved Forests; **Con**: Conifer Forests; **BB**: Bamboo Brakes; **SAS**: Sub-alpine Scurbs; **OS**: Open Scrubs; **Aln**: *Alnus* Forests; **Tpl**: Teak Plantation; **Deg**: Degraded Forests; **Riv**: Riverine Forests; **Cpl**: *Cryptomeria* Plantation; **Rho**: *Rhododendron* Forests; **Cin**: Cinchona Plantation; **Agri**: Agriculture; **TG**: Tea Garden; **BaL**: Barren Land; **R/WB**: River/ Water bodies; **Stl**: Settlement; **CandS**: Cloud and Shadow

4.5.2.6 Biotic interferences

Information of road and settlements, have been extracted from SoI topographic map to understand biotic influence on forests. Three levels of buffer zone with successive 500 m interval (500, 1000 and 1500 m) was adopted from road and settlement based on field observations. Weights were assigned inversely proportional to the distance from the source of disturbance in a definite mask size.

4.6 Disturbance Index (DI)

The DI is computed by adopting a linear combination of defined parameters on the basis of probabilistic weightages. Five landscape parameters and a composite road and settlement buffer were considered to derive the final DI output. Paradigm for DI is given in Fig. 4.4

$$DI = \int \left\{ \begin{array}{l} \text{Fragmentation, Porosity, Interspersion, Patchiness,} \\ \text{Juxtaposition and Biotic Disturbances} \end{array} \right\}$$

(Anonymous, 2003b)

Proportionate weights were assigned to these parameters and fed in SPLAM. Relative interactive weights assigned to various landscape parameters for disturbance index modelling is given in Table 4.5. Disturbance image obtained was then recoded to three categories based on the degree of disturbances.

Table 4.5: Relative interactive weights assigned to various landscape parameters as correlates of disturbance index (DI)

Sl. No	Levels	Buffer	Fragme-ntation	Patchine-ss	Porosity	Interspe-rsion	Juxtapos-ition
1	Low	0.2	0.2	0.2	0.2	0.2	0.9
2	Moderate	0.4	0.4	0.4	0.4	0.4	0.7
3	High	0.8	0.7	0.7	0.7	0.7	0.4
4	Very high	-	-	-	-	-	0.1
	Probablistic weightage	0.20	0.30	0.20	0.15	0.05	0.10

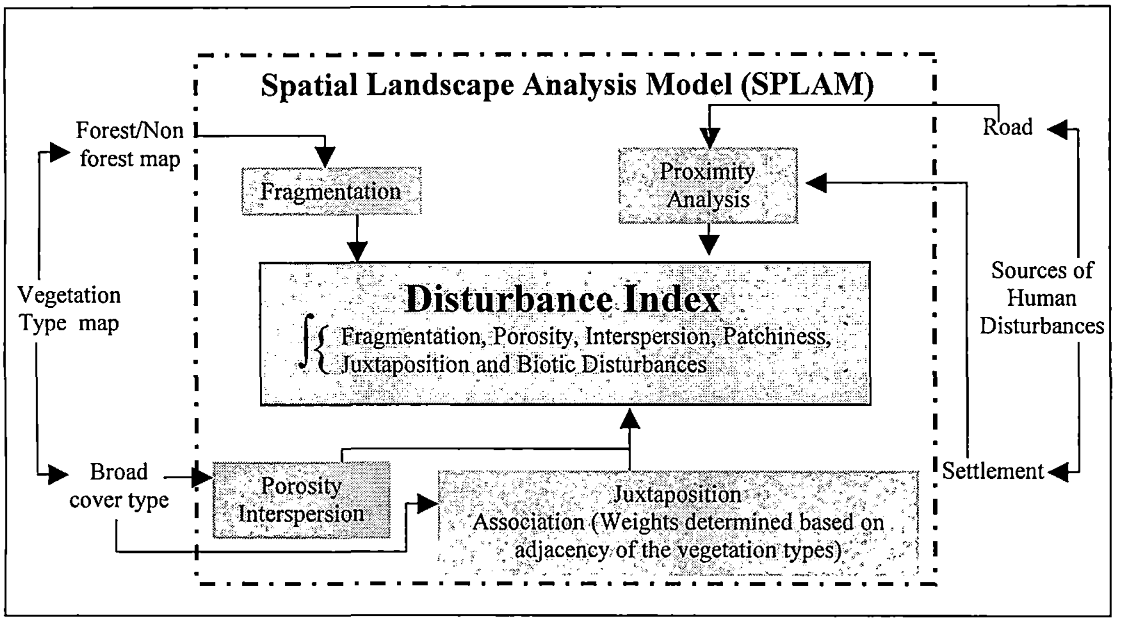


Fig 4.3 Paradigms for disturbance regime (Source: IIRS, 2003)

4.7 Biological Richness Modelling

Biological richness at landscape level is determined as the function of Ecosystem Uniqueness, Species Diversity, Biodiversity Value, Terrain Complexity and DI. The first three parameters were derived from the ground truth data. Terrain complexity was extracted from SoI topographic map and SRTM data.

4.7.1 Ecosystem uniqueness

The ecosystem uniqueness was determined by parameters like, representativeness of native flora, endemic species on local and regional scale (Bhujel, 1996; Bhujel and Das, 2002; Das, 2004) and on the perceived threatened status based on IUCN and Red Data Book (Nayar and Sastry, 1987; 1988; 1990). Weights are assigned based on the abundance of these parameters, which are then added to derive a relational weight of an overall habitat. Normalised weights obtained for various forest types were fed as an input to simulate the biological richness index.

4.7.2 Biodiversity value

Biodiversity value for a forest type was evaluated based on the various roles played by a species in providing goods and services to society and also to the physical environment. Importance value was based on the primary uses such as forage for livestock, medicinal uses, food value, fuel wood and charcoal. Secondary direct benefits, such as production of oil, fibre, mat making, ropes, baskets, tanning leather and indirect benefits like shade, hedges, soil stabilization, nitrogen fixation, scientific importance (Belal and Spruiguel, 1996) have also been included.

Economic evaluation of a plant species was done based on first hand knowledge form the local people and by consulting various related literatures (Bhattacharjee, 2001; Das and Mandal, 2002; Gurung, 2002; Rai, 2002; Chettri *et al.,* 2005) and websites.

Quantitative weights were assigned to the known uses for the species within a range of 1 – 10. Total scores for the species were obtained by multiplying the number of individuals of a species so as to take care of evenness factor. Total importance value was calculated by the formula given below.

$$TIV\% = \frac{U_1+U_2+U_3+\ldots\ldots\ldots U_{10}}{\text{Maximum value x number of uses}} \times 100$$

4.7.3 Terrain complexity

SRTM digital elevation model (DEM) data was utilised as a source to analyse the terrain complexity. Since the study area has a sharp mountainous terrain, contour interval of 100 m was taken. Spot heights were extracted from the SoI topographic map. The image obtained was then recoded to 4 categories based on the level of complexity of the terrain. This layer was then taken as one of the inputs for simulating the biological richness.

4.7.4 Species diversity

Shannon-Weiner index of diversity (1963) was calculated for all forest types from the ground truth data. The index values were then normalised by a single variable. Normalised value within the range of 1 – 10 was used for simulation.

4.7.5 Biological Richness Index (BR)

BR index was generated by assigning relative weights to Ecosystem uniqueness, Species diversity, Biodiversity value, Terrain complexity and DI. An interactive weightage for the spatial and the field based data on different gradient levels have been shown in Table 4.6. All parameters, except disturbance index were assigned positive weights as they are directly proportional to biological richness. For disturbance index, reverse weight was assigned as it is inversely proportional to richness. Biological richness was computed by adopting a linear combination of the defined parameters on the basis of probabilistic weightage. Biological richness image obtained was then recoded to four levels based on the richness of biodiversity.

$$BR = \int \left\{ \begin{array}{l} \text{Ecosystem uniqueness, Species diversity, Biodiversity} \\ \text{value, Terrain complexity and DI} \end{array} \right\}$$

(Roy and Tomar, 2000)

Table 4.6: Weights assigned for Biological Richness modelling

Level	Disturbance Index	Terrain complexity	Species richness	Biodiversity value	Ecosystem Uniqueness
Low	0.9	0.3	0.3	0.3	0.3
Moderate	0.7	0.5	0.5	0.4	0.4
High	0.5	0.7	0.7	0.5	0.6
Very High	0.2	0.9	0.9	0.7	0.8

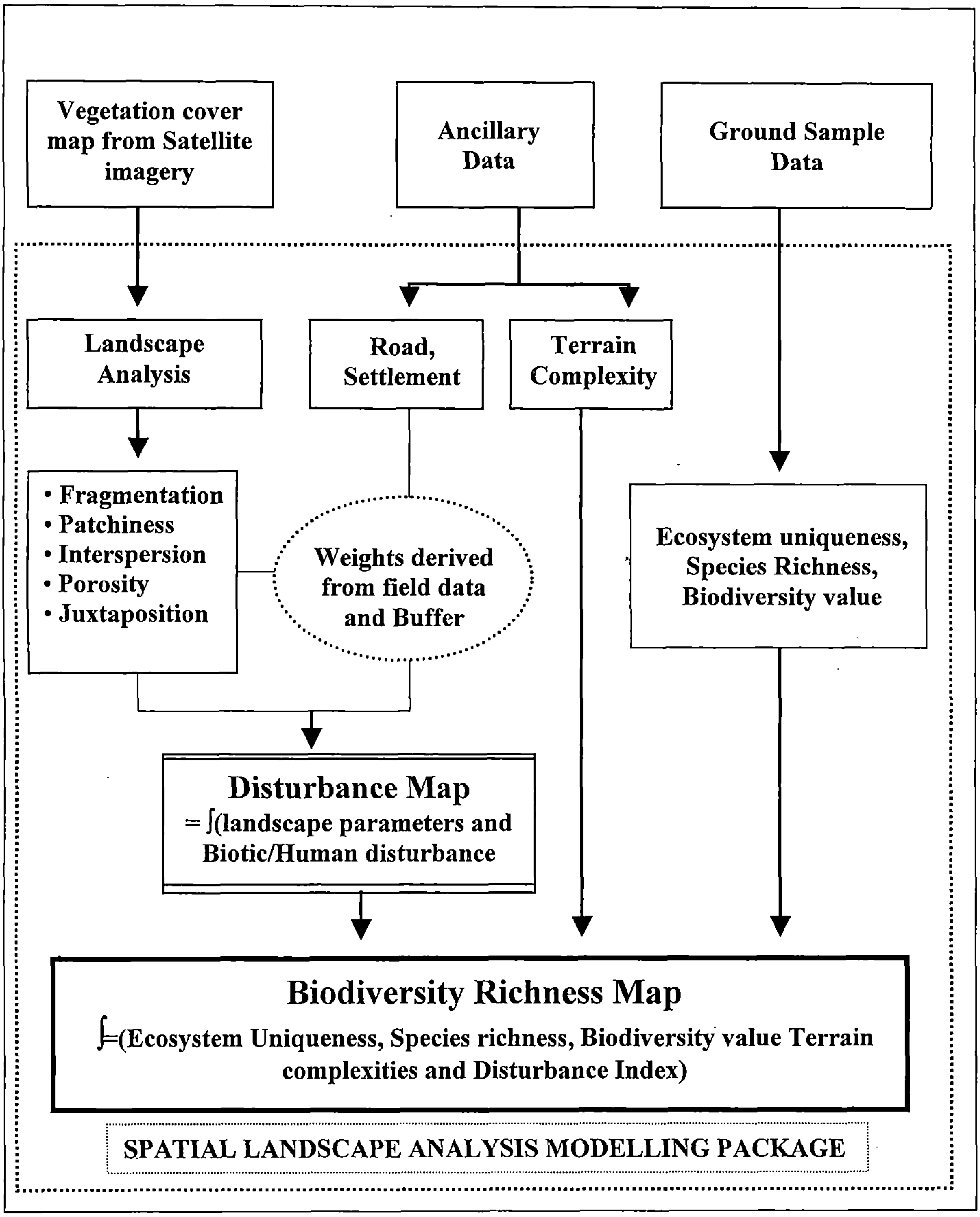


Fig: 4. 5 Paradigm for Biological richness map generation (Source: IIRS, 2003)