Chapter 3
A Selection of Appropriate Tools for Mountain Environments

The fact that most of the development interventions in mountain areas have not had the desired level of impact, in the HKH in particular, can be attributed to the application of generalised development models and measures without a clear understanding of mountain conditions. While the recognition that socioeconomic and natural resource surveys in mountain areas should reflect the specific mountain conditions has gained firm ground over the last decade; incorporation of mountain specificities in interventions designed to solve the problem of mountain areas has not been successful (Jodha 1997). These mountain conditions, also referred to as mountain specificities, are reflected through inaccessibility, fragility, marginality, the diversity of mountain areas, and their specific niche (Jodha and Shrestha 1993). These mountain specificities provide both constraints and opportunities for sustainable mountain development.

The nature of the mountain specificities and the features of conventional development approaches that tend to disregard the imperatives of these specificities as described by Bhatia et al. are as follow.

- *Although mountain areas require situation-specific and discriminating development measures, the conventional development strategies tend to impose generalised models and measures evolved elsewhere. The mismatch between the features of generalised programmes and the imperatives of mountain conditions leads to several negative side effects.*
- *The interrelationships among different mountain characteristics call for an integrated approach to minimise the negative externalities of managing the specific problem, but the conventional development approaches deliberately segregate activities by sector or by administrative unit, thereby eroding the organic integrity of multiple-interlinked, diversified production systems in mountain areas.*
- *Since the low carrying capacity of mountain resources is well known, management of the pressure on them should be integral to development strategies. Conventional approaches, however, focus mainly on the supply side, giving disproportionately little attention to the demand aspects. The increased physical and market attention, and the state's greater focus on increased production rather than on resource protection, deliberately increases the overall pressure on mountain resources to an unsustainable level.*
- *Upgrading resources to handle the constraints of fragility and marginality and to create infrastructures reducing inaccessibility, as well as harnessing mountain niche, are important prerequisites for mountain area development. The conventional development strategies address these issues, but without sufficient territorial analysis and only selectively, primarily to meet the specific needs of the mainstream economy, e.g., for timber or*

hydropower, paying insufficient attention to the side effects on local people, local resources, and environmental stability in general. Selective overextraction of mountain resources and their exchange on terms not favourable to mountain areas are other negative side effects. Positive developments, such as improved accessibility, harnessing of mountain 'niche', and transformation of limited areas within the mountains have not benefitted the region in general, but often generate corridors of development with backlashes on neighbouring areas.

- *Factors such as inaccessibility, fragility, marginality, and diversity, realities of the mountain situation, remain unperceived or ignored by mainstream decision-makers. A consequence of this is disregard of the rationale of traditional resource management systems, including local resource-centred diversification, local resource regeneration and recycling, local demand rationing, and the formal or informal institutional arrangements that support the above. This is illustrated by the narrow focus on research and development concentration of support services and investment in more accessible areas and scant attention to the importance of biomass production, common property resources, and community-based approaches.*

In view of these mountain specificities, topical issues in applied ethnobotany are those that deal primarily with traditional practices related to natural resource use and sharing amongst the different knowledge and occupational groups in a given area. For example, the occupational groups could be those which collect, use, store, or trade medicinal plants, and so there are multiple stakeholders with a range of skills competing for a share of the resource. The competition for resources is not limited to one occupational group alone, as there are other users, such as those involved in grazing livestock in habitats rich in medicinal plants, and these may come into conflict with those who rely on the productivity of medicinal plants in one way or the other. State-sponsored conservation is gradually becoming another key competitor for resource partitioning (formalised sharing) through protection measures.

The collective methods referred to as Participatory Rural Appraisal (PRA) have evolved and refined methodology for socioeconomic and natural resource information collection providing ample opportunity for greater convergence of social, economic, and ecological parameters. For a quick recap, these methods are briefly described in Box 3.1 as outlined by Chambers 1996.

Experience is beginning to show that some of these methods have an edge over others in mountain areas. For example: participatory mapping, resource dependence profile, and complementary ecological methods such as profile diagrams and quantitative techniques of systematic data collection followed by statistical analysis etc. Some of these methods are, therefore, described in greater detail.

3.1 Participatory Mapping

One of the first steps to developing an understanding of the area spatially is by carrying out a participatory mapping exercise. Maps help identify elements that are of importance to different groups of people. They can examine a great breadth of subject matter and allow for a range of types of map to be produced for different uses (IDS 1996). Maps provide the following features.

Box 3.1: Participatory Rural Appraisal Methods

- Participatory mapping and modelling: people's mapping, drawing, and colouring on the ground with sticks, seeds, powders, etc or on paper to make social, health, or demographic maps (of the residential village); resource maps of village lands or of forests; maps of fields, farms, and home gardens; thematic maps (for water, soils, trees, etc) ; service and opportunity maps; and so on —; making 3-D models of watersheds and so on. These methods have been among the most popular 'discoveries' and can be combined with or lead to wealth or well-being ranking, watershed planning, and health action planning
- Local analysis of secondary sources: participatory analysis of aerial photographs (often best at 1:5000) to identify soil types, land conditions, land tenure, and so on — also satellite imagery
- Estimates, comparisons and counting: often using local measures, judgements, and materials such as seeds, pellets, fruit, stones, or sticks as counters or measures, and sometimes combined with participatory maps and models
- Transect walks: systematically walking with key informants through an area, observing, asking, listening, and discussing; identifying different zones, local technologies, and introduced technologies; seeking problems, solutions, and opportunities; and mapping and/or making diagrams of resources and findings (Transect walks now take many forms - vertical, loop, along a watercourse, combing. etc)
- Time line and trend and change analysis: chronologies of events, listing major local events remembered with approximate dates; people's accounts of the past, of how customs, practices, and things close to them have changed; ethno-biographies - local histories of a crop, an animal, tree, a pest, a weed; diagrams and maps showing ecological histories; changes in land use and cropping patterns; population and migration; fuels used; education, health, and credit and the causes of changes and trends in a participatory mode, often with estimation of relative magnitudes
- Seasonal calendars - distribution of days of rain, amount of rain or soil moisture, crops, agricultural labour, non-agricultural labour, diet, food consumption, sickness, prices, animal fodder, fuel, migration, income, expenditure, debt, etc
- Daily time use analysis: indicating relative amounts of time, degrees of drudgery, etc of activities, sometimes indicating seasonal variations
- Institutional or 'chapati'/Venn diagrams: identifying individuals and institutions important in and for a community or group, or within an organization, and their relationships
- Linkage diagrams: of flows, connections, and causality. This method has been used for marketing, nutrient flows on farms, migration, social contacts, impacts of interventions and trends, etc
- Well-being grouping (or wealth ranking) - grouping or ranking households according to well-being or wealth, including those considered to be the poorest—a good lead into discussions of the livelihoods of the poor and how they cope
- Matrix scoring and ranking, especially using matrices and seeds to compare through scoring, for example, different trees or soils or methods of soil and water conservation, varieties of a crop or animal, fields on a farm, fish, weeds, conditions at different times, and expression of preferences

Box 3.1 Cont.....

- Local indicators, e.g., what are poor people's criteria of well-being and how do they differ from those we assume for them?
- Team contracts and interactions - contracts drawn up by teams with agreed norms of behaviour; modes of interaction within teams to include changing pairs, evening discussions, mutual criticism, and help; how to behave in the field, etc (the team may be outsiders only, local people only, or local people and outsiders together)
- Shared presentations and analysis in which maps, models, diagrams, and findings are presented by villagers and/or outsiders, especially to village or community meetings and checked, corrected, and discussed. Brainstorming, especially joint sessions with villagers
- Contrast comparisons - asking group A to analyse group B and vice versa. This has been used for gender awareness, asking men to analyse how women spend their time.
- Drama and participatory video on key issues, to express problems and explore solutions
- Alternatives to questionnaires: A new repertory of participatory alternatives to the use of questionnaires which generate shared information that can be assembled into tables.

Source: Chambers, R. 1996.

- A framework for discussion about the relative location of resources
- An indication of important resources using maps as a spatial guide
- An indication of the issues that affect or are affected by these resources
- An analysis of the current status or condition of a location
- An awareness of existing facilities or natural resources
- Creation of a focus of interest in discussion about resources
- Stimulation of debate about the importance of specific resources
- Identification of elements that are important to different groups
- Development of a basis for comparison of different perspectives
- Creation of a baseline for assessing change over a period of time

In addition to understanding at the spatial level, maps also provide insights into the inter linkages of one land-use type with another in a landscape. Mountain communities are dependent on these diverse land uses for meeting subsistence and commercial needs at different times of the year. Often the principles underlying the management and use of this resource catchment by the local people are based on ecological knowledge gained from experiences that have taken place over hundreds of years. For example, in a mountain village, the landscape arrangement varies from undisturbed forest areas to those under heavy management ; hence different land-use types can be seen. As per Swift et al. (1996), a generalised gradient might move from unmanaged vegetation with restricted use to 'casual' management (including shifting cultivation, home gardens, and multiple-use commons) — to low-intensity management (including traditional compound farms and rotational fallow) — to middle-intensity management (including horticulture, pasture-mixed farming, and alley farming) — to high intensity management (including crop rotation, multi-cropping, alley cropping, and intercropping) — and finally to modernism (plantation, orchards, and intensive cereal and vegetable production).

This broad stratification can lead to a finer level of analysis of varying habitats in these land-use types, thus providing further assistance to decisions involving sampling and survey design. In '*Srishtigyan*: A Methodology Manual for People's Biodiversity Register' by Chhatre et al. (1998), the basis and methods for analysing landscape elements and geographic elements have been explained as per the details given in Box 3.2.

Box 3.2. A Methodology Manual for People's Biodiversity Registers (PBRs)

Logic of the Methodology

The documentation of the PBR involves an innovative method of looking at biodiversity and its use at the village level. The PBR would contain information on the entire resource catchment of the village concerned, irrespective of the distance from the village or the frequency or volume of use. The relationship between the village society and surrounding nature is usually complex, and there are many overlapping and interconnected uses that characterise this relationship. In order to understand this relationship, it is important to start with the flow of materials from nature through the village society as well as society outside.

Landscape Elements

For the purpose of documenting the PBR, the resource catchment is divided into Landscape Elements. A landscape element (LSE) is a patch within a landscape, homogeneous in appearance and distinct from surrounding patches. These LSEs may belong to a variety of LSE types, e.g., a pond, road, forest, habitation, etc. Several individual LSEs in a landscape may represent each LSE type. Thus, there may be five ponds or three forest patches or two roads. Alternatively, we can say that there are five elements belonging to the LSE pond, three to the LSE type forest, and two to the LSE type road. Each patch is a separate LSE. Its type could be any of these or others. For our purposes, we may consider only LSEs as patches larger than 0.25 ha (which are easily seen and distinguished from a distance), an agricultural field for example. Another distinction could be the linear elements, e.g., stream, road, canal, etc, that are long enough (say 100m or more). A landscape is thus composed of several patches (LSEs) belonging to a few types (land or water; linear or polygonal). Additionally, only the visually distinguishing features of a landscape element may be considered for its identification, irrespective of its past status or present access regimes. An illustrative list of possible landscape element types is given below.

Box 3.2 Cont.....

Forest: Any area with a natural or semi-natural growth of trees with various types of undergrowth would fall into this category. It could be further sub-divided into good natural forest, degraded forest, and scrub categories. A scrub forest would constitute bushes and shrubs mostly (including tree species). Mangroves and littoral forests along sea coasts would also fall into this category.

Plantation: Any tree crop on public or private land comprised of one or a few tree species being cultivated for commercial or non-commercial purposes would constitute a plantation. Examples include Poplar, Eucalyptus, Chir Pine, Teak, etc

Orchard: Any tree crop being cultivated intensively on private land for commercial purposes would constitute an orchard. Examples include coffee, tea, apples, areca nuts, oranges, etc.

Grassland: Any area on which grass is grown for fodder or grazing would be grassland. It could be public or private land. A distinction could be made between those areas closed to grazing for part of the year and those open for grazing throughout the year. The latter could be termed permanent pastures.

Cropland: All areas devoted to the production of agricultural crops would fall into this category. This could be further subdivided into rainfed and irrigated lands. Fallow, both long and short, would be included.

Barren Areas: There may be some areas in the village landscape that do not harbour any visible biomass or life. Examples of such areas could be rocky cliffs, sandy beaches, permanent snows, etc. These would be classified as barren. However, this should not be confused with 'wastelands' classified by the forest department or other state agencies.

Habitation: This is the area that is generally known as the village where homesteads are located. The pattern of habitation is extreme, ranging from a cluster of huts placed very close together to houses widely distributed over the landscape. Depending upon the situation, the Habitation LSE type may have to be clubbed with Cropland or Forest as the case may be. Whatever may be the case, it should be borne in mind that homesteads are sites that usually contain a wide variety of plants and animals— vegetable gardens, fruit and food trees, medicinal plants, etc.

Roads and Paths: A road in a village has a distinct biodiversity profile owing to its special status. It has been seen that new plants, such as weeds, enter the village through the roads and can be observed by its side before they spread to other LSEs.

Lakes: Lakes are larger water bodies of natural or man-made origin that are spread across a few villages. Lakes would include waterbodies created by dams. Naturally, they have a distinct appearance and biodiversity profile.

Ponds: Ponds are small water bodies, usually made by people and restricted to the boundaries of one village. They could be privately or communally owned.

Box 3.2 Cont.....

Backwaters: Bodies of water shrink during the dry period, exposing substantial amounts of land that are put to various uses by local communities. These areas, lying between the full reservoir level and the dead storage level of waterbodies, could be considered as separate LSEs.

Rivers and Streams: These would include all waterbodies with flowing water. They could be subdivided into perennial and seasonal, according to their characteristics.

Wells: Wells constitute an important resource in a village, especially from the point of view of drinking water for humans and livestock in arid and semi-arid areas. Information on the location of wells in the village is a useful planning tool.

Canal: A canal passing through a village affects the biodiversity of the area by causing changes in the moisture regime. It provides habitat for species that otherwise could not have established themselves.

Source: Chhatre et al. 1998

3.2 Resource Dependence Profile

The land-use pattern that emerges from participatory mapping is the starting point for gathering information for resource dependence profiles and livelihood analyses. When information is gathered about natural resources used in the community, the focus is on the types of resource used (or not used), how and for what purpose they are used, and who the users are. It begins to address equity issues such as who has greater access to resources and who has limited use or is excluded all together (Freudenberger 1994). Many methods are useful in such an analysis and some have been described in Participatory Rural Appraisal Tools and Techniques (Bhatia et al. 1998).

Transects - A systematic walk with a few key informants through an area observing, asking, listening, discussing, and identifying different zones and local technologies; seeking problems, solutions, opportunities; and making maps and diagrams of resources and other findings. This technique has the advantage of leading to field-based observations that can be discussed with local people.

Historical Transects - Historical transects illustrate changes, particularly in land use, over time, although these have been used also to indicate other aspects of historical information that have a spatial dimension. Most commonly, a period of several decades is covered—predominantly to identify changes that have occurred over time and space and examine the implications and causes of these changes.

Matrix Ranking - Matrix ranking helps to elicit information about local people's preferences with regard to tree species, types of livestock, crop varieties, and so on and the criteria on which those preferences are based. While the criteria are listed to the left, the preferences that are to be compared with one another are listed on top.

Wealth Ranking – This is a method that helps categorise households according to wealth or well-being in the community. Key informants first develop the parameters they think are important to consider while ranking households and then place households in appropriate categories based on those parameters.

Seasonal Calendar - This important PRA tool is applied to collect seasonal information such as intensity of rainfall or soil moisture, land use or cropping patterns, migration patterns, food availability, and monthly income and expenditure patterns. Local people use sticks or straw of different lengths along with counters (e.g., seeds) to chart out the relative quantities of some variables on the ground. Seasonal calendars also help record the views of the village about problems and opportunities.

Trend Line/Diagram - Trend lines are developed according to village perspectives to show patterns of change along with the causes, for example, rainfall, crop production, soil loss, deforestation, livestock holdings, and other topics of concern to the community. A group of local people knowledgeable about the topics to be examined is approached to help with this.

Venn or Circle Diagrams - Venn or circle diagrams are used as a tool to discuss the relative importance or position of different factors, commonly institutional or social structures, in a community. Key informants are asked to rank community institutions in order of importance and to construct diagrams that indicate the relationships between and among village units. Circles of different sizes and colours represent organizations, institutions, or prominent people. Their relationships to each other and relative importance in the community can be mapped out by placing these circles on the ground in relation to each other.

Semi-structured Interviews - This technique, also known as informal discussions, is considered the core of good PRA. It is a kind of open discussion, with open-ended questions, that can take place anywhere in the community, either with individuals and/or groups of key informants. Mental or written check-lists can be used. These conversations can take place on the path while observing community activities, over the garden fence, and in fields or homes.

In many circumstances, ethnobotanical research indicates that detailed analysis of non-timber forest products is required. This is also one of the most well-researched areas and many publications are available on the subject (FAO 1990; SPWD 1992). The two principal streams of analysis are the economic evaluation and sustainable harvest. Godoy et al. (1993) have carried out an excellent review of the four important aspects of quantity, price, marginal costs, and sustainability. They suggest that researchers should distinguish between two types of quantities: the inventory (stock quantity in the forest) and the flow (the quantity actually used by people). The difference in value between the flow and the inventory can be substantial and can depict the actual and potential profits. The authors have cited various studies to conclude that the most accurate method of placing a value on the products is to identify, count, weigh, and measure the NTFPs as they enter the village each day/ time. To address the problem of scattered users, a random sample of villages and households is observed. Although extractors may give accurate information, it is better to complement the information by direct observations. There are many measurable quantitative characteristics in vegetation ecology that have been described by Jha (1998) as per the paper presented in the national training workshop for Nepal held by the HKH ethnobotany project.

Quantitative Characteristics

Several vegetation characteristics are often measured or estimated with considerable precision. These are usually determined for individual species, although they can be used for whole strata of vegetation. The most common quantitative characteristics are: (a) frequency: percentage of sampled units in an area in which a species occurs; (b) density: number of individuals per unit area; (c) coverage: the percentage of soil surface covered by the vertical projection of the plant canopy; and (d) basal area: for tree species only, the cross-sectional area of tree trunks at 1.37m above the ground (expressed in square metres per hectare of land).

There are several methods for measuring important species; each method has advantages for certain types of vegetation and for certain purposes. The quadrat (or plot) method describes the vegetation inside an area of known size. Within this area density, frequency, basal area, and cover is determined by counting and measuring plants. For small plants (e.g., herbaceous plants, mosses, and lichens), a standard sampling quadrat can be constructed of wood or wire, or can be delimited by use of the stick and radius method. Large quadrats can be used to measure forest trees.

Plot-less methods of several types can be used for both large and small plants. In shrub vegetation or where there are small plants, the line intercept technique works well. For trees, the point-centered quarter method is effective.

Quadrat Method

Size of Quadrat for Forest: With a piece of string and three nails, an L-shaped structure is formed in the field. Thereafter, using another piece of string and a nail, an area of 5m x 5m is differentiated. All the plant species present in the area are recorded. The sample area is then enlarged to 10m x 10m, 15m x 15m, 20m x 20m, and so on. In each enlargement, the additionally occurring species are listed separately. The sample area is increased until the species added to the list become negligible.

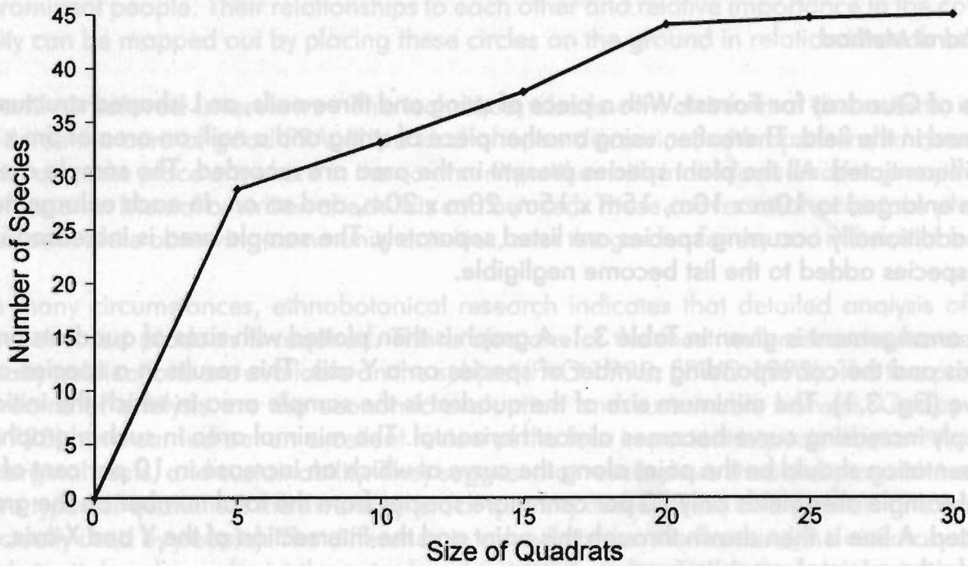
The arrangement is given in Table 3.1. A graph is then plotted with sizes of quadrats on an X-axis and the corresponding number of species on a Y-axis. This results in a species-area curve (Fig. 3.1). The minimum size of the quadrat is the sample area in which the initially, steeply increasing curve becomes almost horizontal. The minimal area in such a graphical presentation should be the point along the curve at which an increase in 10 per cent of the total sample area yields only 10 per cent more species from the total number on the graph plotted. A line is then drawn through this point and the intersection of the Y and X-axis, this marks the minimal requisite area.

This method appears theoretically sound, but field sampling and subsequent computation may take such a lot of time that its practicability seems limited. Hence, the International Forestry Resources' Institution (IFRI) in the USA has fixed circular areas of 10m, 5m, and 3m in radius for tree, shrub, and ground vegetation, respectively.

Table 3.1: Size of Quadrat and Number of Species Recorded to Determine Requisite Size of Quadrat

Size (m)	No. of species on different sites						per cent Increase in No. of species
	1	2	3	4	5	Av.	
5 x 5	27	26	31	30	28	28.4	0
10 x 10	37	30	33	35	30	33.0	4.6
15 x 15	40	39	30	37	35	37.8	4.8
20 x 20	44	42	46	41	45	43.6	5.8
25 x 25	46	43	47	42	43	44.2	0.6
30 x 30	47	45	42	44	44	44.4	0.2
							10% = 4.4

Figure 3.1: Species' Area Curve to Determine Requisite Size of the Quadrat for Analysis of the Vegetation



In spite of the lack of an absolute criterion for the minimal area, the species' area curve remains an important practical guide to quadrat size. In an area that measures tens of hundreds of hectares, plots or strips of forest are chosen that cover some three to five per cent of the total surface area.

On grassland, the sampling area can commence from 20cm X 20cm and should then be enlarged to 30cm x 30cm, 40cm x 40cm, 50cm x 50cm, and so on.

Number of Quadrats: After determining the requisite size of the quadrats, 20 to 40 quadrats of that size are laid down randomly in the study area. Species occurring in each quadrat are noted. Data are tabulated as shown in Table 3.1. Then again, a graph is plotted entering the number of quadrats on the X-axis and the number of species on the Y-axis. Here also, the point at which the curve starts to straighten out gives the minimum number of quadrats required for adequate sampling in the study area (Fig. 3.2).

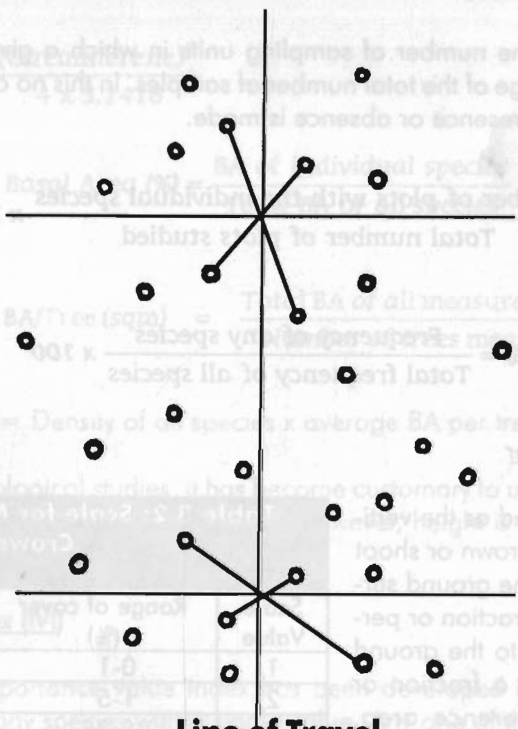


Figure 3.2. Species and Number of Quadrat Curves to Determine the Requisite Number of Quadrats for Analysis of Vegetation

Measurement of Density

Density denotes the average number of individuals of a given species out of the total of samples examined in a study area (the species may or may not occur in all the quadrats).

$$Density\ (ha) = \frac{Total\ number\ of\ plants\ of\ individual\ species}{Total\ number\ of\ quadrats\ studied\ x\ area\ of\ quadrats}\ x\ 10{,}000 sq.m$$

$$Relative\ Density\ (\%) = \frac{Density\ of\ individual\ species}{Total\ density}\ x\ 100$$

Density is usually used for large plants that have distinct individuals. For numerous plant species, counting becomes too time-consuming and, for vegetatively reproducing plants, it is impossible to determine what represents one individual. For rhizomatous grasses, for example, determining density is not feasible. Alternatively, one might choose to count an important, distinct, and less numerous plant part, for example, inflorescence.

Measurement of Frequency

Frequency indicates the number of sampling units in which a given species occurs. It is expressed in percentage of the total number of samples. In this no counting is involved, just a record of species' presence or absence is made.

$$Fequency\ (\%) = \frac{Number\ of\ plots\ with\ the\ individual\ species}{Total\ number\ of\ plots\ studied}\ x\ 100$$

$$Relative\ Fequency\ (\%) = \frac{Frequency\ of\ any\ species}{Total\ frequency\ of\ all\ species}\ x\ 100$$

Measurement of Cover

Usually cover is defined as the vertical projection of the crown or shoot area of a species to the ground surface, expressed as a fraction or percentage of a species to the ground surface expressed as a fraction or percentage of a reference area. Measuring the actual vertical projection downwards to the ground of plant crowns enclosed in sampling plots is time consuming, but a visual estimate of cover can often be made. A suitable scale for use on small plots is given in Table 3.2.

Table 3.2: Scale for Measurement of Crown

Scale Value	Range of cover (%)	Mid-point of cover (%)
1	0-1	0.5
2	1-5	3.0
3	5-25	15.0
4	25-50	37.5
5	50-75	62.5
6	75-95	85.0
7	>95	97.5

The average cover for a species in the plots can be estimated by assigning the mid-point of cover to each plot with a given scale value for a species and then averaging the mid-point values for all plots. Plots from which the species is absent are included in the average with a value of zero.

$$\text{Relative Cover (\%)} = \frac{\text{Cover of species A}}{\text{Total cover of all species}} \times 100$$

Basal Area

The basal area is one of the chief characteristics determining dominance and the nature of the community. It refers to the ground actually penetrated by the stems. Basal area can be measured through:

$$\text{BA (SQM)} = \pi r^2 \text{ or } \frac{3.1416 \times (\text{diameter})^2}{4}$$

$$\text{or BA} = \frac{(\text{Circumferene})^2}{4 \times 3.1416}$$

$$\text{Relative Basal Area (\%)} = \frac{\text{BA of individual species}}{\text{Total BA of all species}} \times 100$$

$$\text{Average BA/Tree (sqm)} = \frac{\text{Total BA of all measured trees}}{\text{Number of trees measured}}$$

Total BA per ha (sqm) = Density of all species x average BA per tree.

(In North American ecological studies, it has become customary to use tree basal area stem cover as an estimate of dominance. In forestry, however, height is used as an estimate of dominance).

Importance Value Index (IVI)

The concept of an importance value index has been developed in order to express the ecological success of any species with a single value. Any one of the tree quantitative parameters (density, cover, frequency) may be interpreted as an importance value. This depends on which of the values the investigator considers most important for a particular species, group of species, or community. For example, tree seedlings may occur with a high frequency in an undergrowth layer, whereas in terms of cover, they may be insignificant. Hence the sum of the relative value of these parameters is often used for the presentation and conclusion of results.

IVI = RD + RF + RC *

The importance value of a species reaches a maximum of 300 in stands consisting of only one tree species. The IVI may be converted into importance percentage by dividing IVI by three. The use of relative rather than actual parameters is of limited information value.

Plot-less Method

Plot-less sampling means sampling without a prescribed area unit. Plot-less methods are available for all three, commonly-used quantitative parameters (frequency, density, coverage). Usually the Point-centre Quarter and Line Intercept methods are employed as plot-less methods.

Point - centre Quarter Method

The relationship between density and distance between trees is the basis of the quarter method: as plants become denser, the distance between them decreases. A compass line is established and a point located systematically along the line is chosen as a sampling point. An imaginary line perpendicular to the compass line is used to divide the area around the point into four quarters (Fig. 3.3). The distance from the sampling point to the nearest tree in each quarter is measured, and the species and diameter or circumference at breast height of each of the four trees are recorded.

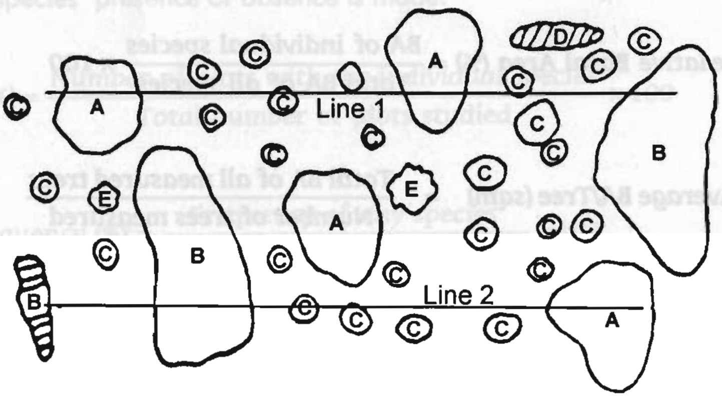


Figure 3.3: An Illustration of the Estimation of Cover Using Line Intercept

The sampling points should be far enough apart, so that trees in the front quarters of one point are not re-sampled in the back quarters of the next points, twenty metres is a common distance in many forests. At least 40 points should be measured in order to provide reasonable data; and more if rare species are of interest. The quadrat method may be combined with the quarter method by measuring understorey vegetation, sampling, and seedlings in a plot.

* Earlier emphasis was on relative dominance

$$\text{Mean distance } (d) = \frac{\text{Sum of all points to tree distances}}{\text{Number of distance measured}}$$

Mean area occupied by an individual tree - d^2

$$\text{Density (tree per ha) } D = \frac{10{,}000m^2}{M \text{ in } m^2}$$

$$\text{Relative Density } (\%) = \frac{\text{No. of individuals of species A x 100}}{\text{Total No. of all species measured}}$$

$$\text{Densit of species A (per ha)} = \frac{\text{Total trees / ha x RD of sp. A}}{100}$$

$$\text{Frequency } (\%) = \frac{\text{No. of sampling points at which species A occurred at least once x 100}}{\text{Total No. of sampling points}}$$

Cover by Line Intercept

The line intercept method is especially valuable for determining cover where vegetation makes travel difficult, or where plots are troublesome to establish. After the boundaries of the stand have been determined, sampling lines are established through it at appropriate intervals, usually by means of a metric tape. The distance of occurrence of each species along the edge of the tape is measured and recorded by species (Fig. 3.4). The following measurement on the intercept, calculations can be carried out by

$$\text{Cover } (\%) = \frac{\text{Total distance measured for sp. A x 100}}{\text{Total distance of lines}}$$

$$\text{RC } (\%) = \frac{\text{Distance measured for species A x 100}}{\text{Total distance measured for all species}}$$

Indices of Similarity of Species

The simplest similarity indices compare samples of vegetation only in terms of which species are present. A few commonly used indices are:

$$IS_J = \frac{C}{A + B - C} \times 100 \text{ (Jaccard's)}$$

$$IS_S = \frac{2C}{A + B} \times 100 \text{ (Sorenson's)}$$

Where,

IS = Index of similarity

A = Total number of species in one sample
B = Total number of species in the other sample
C = The number of species occurring in both samples

<u>Measurement of Tree Size</u>

The size of a tree is described by the size of its trunk (circumference, diameter) and by its total height (Field data sheet).

<u>Trunk Size</u>

Trunk size is usually determined at a height of 1.37m above the average level at the base of the tree, called breast height. Trunk size can be expressed as its circumference (cbh) or diameter (dbh) at breast height. Measurement of the circumference is easy to take with an ordinary measuring tape. If the diameter is desired, the tree is assumed to be circular, and dbh is calculated.

$$dbh = \frac{cbh}{\pi} \text{ (where } \pi = 3.1416)$$

Sometimes a special 'diameter tape' is used. This tape is calibrated to read the diameter of a circle of the same circumference as the tree. Often tree trunk size is expressed as the area of its cross section at breast height, called basal area (BA).

<u>Tree Height</u>

Tree height is usually calculated from two measurements: distance from the tree to the observer and the angles from the eye of the observer to the base and to the top of the tree. The horizontal distance (d) can be measured directly. However, on steep slopes, horizontal distance must be calculated using the distance from the eye to the base of the tree (D) and the angle of the measurement D from the horizontal (b), so that

$$d = D \cos \beta$$

From d and the angle a and b, one can calculate the height (H) of the tree,

$H = d \tan \beta$

The angle can be measured using a simple instrument constructed from a circular protraction. Tree height is also measured by using the Abney Level (Field data sheet).

Volume of a Tree Trunk

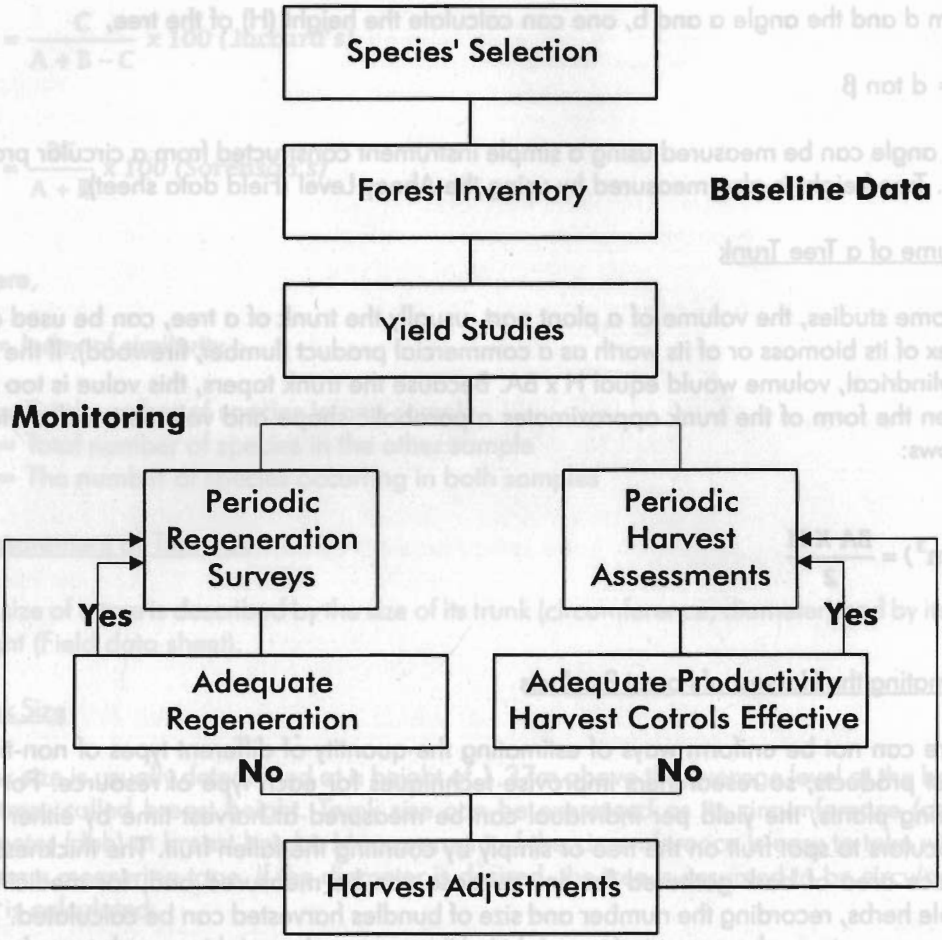
In some studies, the volume of a plant part, usually the trunk of a tree, can be used as an index of its biomass or of its worth as a commercial product (lumber, firewood). If the trunk is cylindrical, volume would equal H x BA. Because the trunk tapers, this value is too high. Often the form of the trunk approximates a parabolic shape and volume is calculated as follows:

$$V(m^3) = \frac{BA \times H}{2}$$

Estimating the Harvest of Forest Products

There can not be uniform ways of estimating the quantity of different types of non-timber forest products; so researchers improvise techniques for each type of resource. For fruit-bearing plants, the yield per individual can be measured at harvest time by either using binoculars to spot fruit on the tree or simply by counting the fallen fruit. The thickness and surface area of bark gathered for any purpose can be measured and, for medicinal or edible herbs, recording the number and size of bundles harvested can be calculated. These measurements can be converted to weight in kilogrammes by weighing a sub-sample of the collected material and then multiplying by the total potential amount that can be gathered per individual or per unit area (Martin 1995).

Many programmes have looked closely at the question of sustainability of non-timber forest products on project sites throughout the world in different biological and cultural settings; e.g.., the Biodiversity Support Programme (BSP). The BSP is a USAID-funded consortium of the World Wildlife Fund, The Nature Conservancy, and the World Resources' Institute. A primer on this subject authored by Peter (1994) and brought out by the BSP has recommended six basic steps for achieving sustainability in exploitation of non-timber forest products: (i) species' selection, (ii) forest inventory, (iii) yield studies, (iv) regeneration surveys, (v) harvest assessments, and (6) harvest adjustments. Peter emphasised collection of baseline data about the current density and productivity of the species concerned and monitoring the impact of harvesting in order to make appropriate adjustments in harvest levels and techniques as depicted in Figure 3.4. Decisions concerning choice of appropriate tools from the many methods that have been described would depend on the nature of the non-timber forest product and the local conditions.



Source: Peters 1994

Figure 3.4: Baseline Data Monitoring and Adjustment in Harvesting Techniques

3.3 Profile Diagrams

Profile diagrams, for many decades, have been an extremely popular approach to understanding the structure of vegetation through recognition of more or less continuous layers of vegetation on the basis of height. Ecologists have used this approach extensively to simplify and describe the organization of complex vegetation types. This technique was pioneered in the tropics by Davis and Richards (1933). It involves a complete visual representation of the stratification of the community in a profile diagram. A properly drawn profile diagram can be very informative, giving a diagrammatic representation of features that cannot be concisely and effectively conveyed by a written description alone. In particular, a series of profile diagrams is an excellent way to show variations within a heterogeneous area or along a gradient of environmental changes. Over the years, profile diagrams have been used by ethnobotanists to understand the native logic in making decisions about multicropping plantations and agroforestry practices. These local, indigenous practices, particularly with regard to agroforestry, have been documented by Aumeeruddy (1994), using profile diagrams effectively.

More recently, Aumeeruddy and Michon (in press) used forest architectural profiles as an ecological approach to understanding agroforestry dynamics. The forest architectural profile has been used to understand the structure, ecology, and dynamics of agroforests in Sumatra as well as in other parts of the world. First described by Oldeman (1974) as a method of understanding the dynamics of tropical forests, this technique of analysis was adapted to agroforestry systems by Michon (1985).

In the architectural analysis of forests, trees are considered to be dynamic building elements in the natural landscape. They are thus classified according to their developmental stage as:

'trees of the future',
'trees of the present'; and
'trees of the past'.

The current mixture is subdivided into several 'vegetation layers' corresponding to the different strata in which tree crowns occur. Their description gives a momentary 'snap-shot' of the forest architecture and provides a framework that facilitates a vision of the forest in the future.

In an agroforest, each plant is both a structural element of an architectural landscape and a component of an agricultural production system. Therefore plants are classified as:

'plants with potential production',
'plants in actual production', or
'plants in declining production'.

The group of fully productive plants can be subdivided into 'producing elements' in the same way as the 'trees of the present' can be subdivided into their structural elements.

In the field, the application of this technique involves drawing every tree within a 50m x 20m plot. The trees are drawn to scale in plan and in profile with regard to crown size, height, height to first main branch, crown diameter, and diameter at breast height. The scale drawing (1cm = 1m) includes each tree relative to its coordinates in the plot. This facilitates the analysis of different layers of production and of the efficiency in use of available space. The dynamic changes, which may occur in the overall structure of the garden over a long period, are also evident.

Architectural forest profiles of this sort constitute visual transcriptions that are better than pictures or endless tables of figures. They contain a complete set of data, and these data can also be used to calculate densities, frequencies, coverage, and so on. They enable the comparison of different agroforestry systems from different areas and provide an archive document that may be used later to monitor changes in the structure and composition of such systems.

Though many studies have described vegetation structure through profile diagrams, detailed procedures of field work and drawing have rarely been explained in the methodology. The following procedure for producing a profile diagram has been adapted from Hall (1992) by Dr. M. Millat-e-Mustafa who presented it in his report on the Marma Home Gardens of Bangladesh.

Size of the Plots

To obtain a representative sample of a vegetation type, it is necessary that it is of at least a certain size to cater for variations imposed by small-scale relationships with the environment (e. g., the concentration of regeneration near a particular parent tree). It is also advisable to ensure that bias is avoided in terms of what the diagram eventually shows. The diagram should not be produced with the purpose of showing a particular feature, for example. Both these potential problems can be overcome by using a large rectangular plot. A line of four contiguous 25m x 25m plots is considered adequate and it gives a profile length of 100m. If the assessment is full for the entire strip, one can use any portion of the 25m width for depicting the diagram. If an assessment of the entire strip is required, a portion of the 25m width can be used to draw a diagram.There are two approaches to this. The first is needed when different profiles are to be compared; here the width must be the same in each one. The second is used when the profile is only to show a particular example: here the choice of width depends on the informativeness of the resulting diagram. The widths commonly used in forests are 5m, 7.5m, and 10m. If, as recommended here, the full 100 x 25m area is assessed first, the choice of width for the diagram can be decided as it is being drawn. If it is less than 12.5m, it is possible to have two separate strips and diagrams from the area, giving a certain measure of replication. If the structure is of interest with special reference to a particular species, the entire 25m width will be useful.

Setting Out the Plot

On slopes, plots along contours are recommended. If the influence of a local feature on the vertical structure is being examined, then the alignment should cross it. On flatter terrain with less features; the alignment should be on a cardinal point of the compass - this makes any subsequent alignments faster and less subject to error. It is also necessary to decide whether a 100m is a horizontal distance or a distance measured over the ground. To set out the plot, it is always advisable to mark all corners, including the corners of the individual 25m x 25m units, with stakes or ranging poles and connect them with string.

Field Measurement

For the purpose of the diagram, what is to be enumerated must be defined. Either a height or a diameter criterion will do. Diameter is preferred because it allows more readily for extension of assessment to woody climbers : with a height criterion, climber data become anomalous. A diameter of three centimetres at breast height is commonly used as the minimum for inclusion. If combination with a standard plot assessment is anticipated, data collection may extend to three further categories of plant on a presence/absence basis with a separate assessment for each 25m x 25m. The categories are (a) regeneration (too small to enumerate) of species represented in high numbers, (b) regeneration of species potentially able to reach sizes large enough for enumeration but apparently not doing so, and (c) other vascular plants. Very high numbers can present serious difficulties, delaying progress and making it worth considering a review of either or both plot size and size criterion depending upon the amount of time available.

Provision for the following information should be kept in the data collection pro forma.

i) Origins of data must be specified in general terms (date of field work, personnel, locality, sample number/profile number) and specifically with respect to the plot (which unit of the four making up the 100m x 25m strip) and to the position within each unit.
ii) Location coordinates need two columns, e.g., one could be headed 'down' and the other 'across' in the case of slopes.
iii) Every plant should be given a reference number as the enumeration proceeds, regardless of whether or not its name is known. In case of unknown species, provision for a temporary code name and a remark on a feature by which it can be recognised again should be kept.
iv) Plant characteristics fall into two categories: the characteristics of the crown (the height from which it starts, the height it reaches, how far it spreads horizontally) and the stem (diameter or girth measurement at breast height).
v) Environmental information should cover the general conditions of the site - elevation, slope, and surface features such as gaps in the canopy, thickets, rocks, roads, paths, streams, recent tree falls, recent exploitation, saw pits, buildings, and old habitations.

Characterising the Plant

When the plant is enumerated it must be characterised both by its location and by its own features. Three main points to look at are: the stem characteristics, the vertical disposition of the crown, and the spread of the crown. The stem is measured at breast height. If there is more than one stem large enough for inclusion originating from a single base, each must be measured and recorded. The crown features are only considered in detail for self-supporting plants, because of the difficulty of deciding where climber crowns are. The tree crown into which the climber disappears is observed and this climber is referred to on the proforma instead of giving crown details.

With self-supporting plants, first where the crown begins and the full height have to be determined. Note first that all heights recorded should relate to the point at which the stem emerges from the soil: in steep terrain, with trees that lean to one side, it is important to remember so that the approach is consistent. The crown base is taken as the first permanent living branch – if the bole forks, for example, the fork is the base of the crown. Epicormic shoots obviously below the general crown level can be ignored. Crown height is the highest point reached. Smaller plants can be more accurately estimated by using a two-metre ranging pole as a scale and knocking or shaking the plant will often make the position of the top clearer. Larger trees give difficulties. Conditions in the forest do not permit satisfactory use of instrumentation, because the presence of foliage at all levels obscures the higher levels. The practice is to move around to a position from where one can gauge the topmost parts; and see a two-metre ranging pole positioned at the base. It is better to have several people estimate the height and agree on a value. This is not ideal, but with experience a team becomes sufficiently consistent and accurate, and there is no alternative when it is not permissible to cut the tree.

The crown spread could be taken as a horizontal projection of the crown vertically down to the soil, but this would be far too time-consuming and would entail collecting data that would not instantly be adding much value to the profile diagram. So, for quick work, attention is limited to spread on only one line – the long axis of the 100m x 25m strip— because this represents what would appear to an observer if he/she looked at the forest as he/she will look at the finished diagram. Again, it relates the spread to where the plant leaves the soil. This can be achieved by standing beneath the extremity of the crown and, if necessary, moving across the strip perpendicularly until the line from the observer to the plant base is parallel with the long axis of the 100m x 25m strip. Now the horizontal distance to the point at which the plant leaves the soil will give the crown spread.

So far, all data recorded relate to trees/climbers rooted within the demarcated strip. However, not all of the canopy is derived from these trees: some of it extends into the strip from trees rooted outside. These extensions should also be recorded.

For each case, note the positions along the boundary which are vertically beneath the crown periphery. Note where the plant is rooted in relation to the plot. Note the maximum projections of the crown into the plot. Note the depth of the projecting crown where it crosses the boundary. Give the plant a code name or its proper name.

<u>Drawing the Diagram</u>

First, produce the map showing the horizontal distribution of all the plants enumerated and of those outside with crowns extending into the strip. These are plotted using the coordinate information and indicated by their reference numbers. Graph paper or squared paper for this map and a scale of five mm to represent one metre are usually used. Decide which tree the observer will reach first on his/her way across the 100m x 25m strip. This will be the first to be shown as a complete tree. Next mark the spread of the crown to each side and lightly outline a rectangle enclosing the crown. Within this, draw in the crown outline aiming at the highest point (this being directly over the rooting point) and the widest visible part (this being half way between the highest point and the crown base), giving symmetry about a horizontal axis. Label the crown and trunk. Repeat the process with the tree next–closest to the plot boundary and so on. Parts obscured by trees already drawn are not shown.

Now estimate the horizontal spread by assuming symmetry about a line parallel with the long axis of the strip passing through the crown. Sketch another rectangle with one side fixed by the extent of the crown spread, as before, and the other fixed by an assumption that, if the spread recorded is equal on each side, the crown has a circular horizontal projection. If it is eccentric, assume a width of twice the average of the two extensions. Draw in the horizontal shape of the crown within the rectangle. Now estimate the vertical depth of the crown, assuming the middle height is the widest part and that there is symmetry about a horizontal plane through this. Represent the spread further into the strip as a lightly drawn rectangle with the lowest side at the height of the crown base to the tree top, only including half the crown in this rectangle. Draw in an outline of this half of the crown. Knowing how far the tree is rooted from the boundary of the section of the plot selected for the diagram will allow a line to be drawn indicating where, if at all, the boundary could be projected to intersect the crown. If it intersects, the heights of the top and bottom of the parts of the canopy intruding are known. A line similarly drawn to represent the boundary on the drawing of the horizontal projection will indicate the length of the boundary below the crown. Use the length and the height to make another rectangle. Draw, within this, the intrusion of the crown as it will appear to an observer standing at the edge of the profile strip.

For trees rooted outside the whole 100m x 25m plot, the procedure is slightly different. Here direct observations are made on the position and shape and height of the intruding crown. The crown intrusion should be indicated on a map and also sketched on graph paper in a vertical sense, making the same assumptions as before about horizontal symmetry. If a line other than the 100m x 25m plot boundary is used to demarcate the strip depicted in the diagram, the dimensions for constructing rectangles (within which an appropriate outline can be drawn) can be obtained from the map and the graph-paper sketch.

Climbers are indicated by connecting their rooting point, with a sinuous line representing the stem, to the crown of the tree into which they disappear. Number the stem and indicate the presence of the climber in the crown with its reference number.

For visual impact it helps to shade the crowns to draw attention to the individuals in the diagram that belong to different species or ecological groups (e.g., potential emergent, potential upper canopy species). Four profile diagrams of home gardens in different parts of Bangladesh drawn by Dr. Millat-e-Mustafa are given in Figure 3.5.

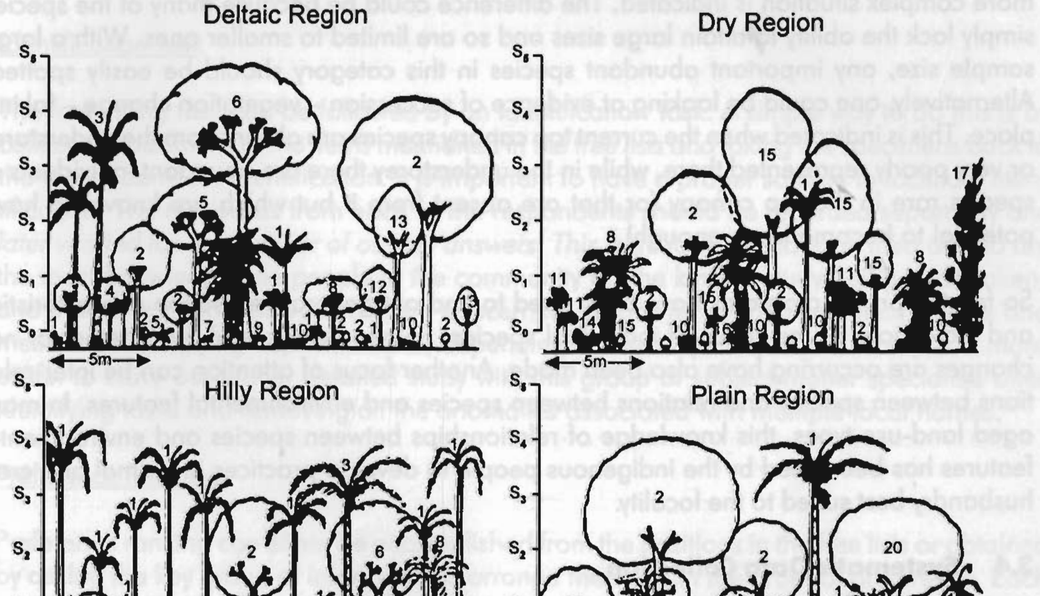


Figure 3.5: Profile Diagram of the Traditional Home Gardens in Bangladesh

Indications from the Completed Diagram

There is little sense in going to the trouble of making a profile diagram unless we know what we want it to show. It actually shows the vertical arrangement of crown foliage above the forest floor. Everything is not shown because some of the foliage is contributed by plants that are too small to enumerate, but, for any vegetation for which this technique is useful, the method recommended will cover over 95per cent of the foliage.

The general features shown are the general canopy height and how any protruding emergent crowns relate to this. It can also be seen whether the foliage is spread throughout the vertical range or concentrated in certain layers and, because of our large sample size, in addition we can see localised changes in gross structure and the exact nature of such changes.

We can acquire still more information if we have named our plants. Whether or not there are distinct layers of foliage, we can see if there are differences between the species that contribute to the upper canopy and those that contribute to the under-storey. If the same species are represented well at all levels and there is a wide distribution of foliage overall, it can be safely concluded that regeneration is taking place. However, if it is well represented wherever there is foliage, but there is a layer with little foliage in the profile, this could indicate that regeneration has ceased (no small plants) or is erratic (poor representation in intermediate sizes).

Where differences are evident between the species well represented at different levels, a more complex situation is indicated. The difference could be because many of the species simply lack the ability to attain large sizes and so are limited to smaller ones. With a large sample size, any important abundant species in this category should be easily spotted. Alternatively, one could be looking at evidence of succession – vegetation change – taking place. This is indicated when the current top canopy species are absent from the understorey or very poorly represented there, while in the understorey there are abundant individuals of species rare in the top canopy (or that are absent from it but which are known to have potential to become large enough).

So far, the profile diagrams have been used to find out general vegetation characteristics and indications of the status of individual species. Some inferences about whether or not changes are occurring have also been made. Another focus of attention can be inter-relations between species and relations between species and environmental features. In managed land-use types, this knowledge of relationships between species and environmental features has been used by the indigenous people to develop practices in animal and crop husbandry best suited to the locality.

3.4 Systematic Data Collection

This group of methods can either complement or supplement quantitatively the information collected through participatory methods. The virtue of using popular tools in systematic data collection is primarily to obtain information that can be used for statistical analysis. However, one important starting point in using these tools is the definition of a domain for the subject of interest that not only limits the scope of data collection, but also helps to build up the data more systematically.

Since most ethnobotanical research depends on interviewing, the domain can be defined as an organized set of words, concepts, or sentences, all on the same level of contrast, that jointly refer to a single conceptual sphere. For greater precision, the domain should be defined by the informants. There are many ways to compile the list of items to define the domain of study items. The most useful general technique is the Free Listing Task. Steps described by Weller and Romney (1988) and Martin (1995) are mentioned as follow.

Free Listing

This technique helps us to understand whether the domain is considered culturally important and easily recognisable by the people being interviewed. By framing the right question, free listing can provide a fairly complete set of native categories. When people are asked to recall things, they tend to list the most significant ones. In addition, prominent categories are cited by almost everybody, thus giving some idea of the things that are culturally the most important. This information given helps the researcher to come up with a ranking index. This index can be used to decide the size of the data set to be included in the domain.

It also helps the researcher to decide the number of respondents for the free listing task. However, for a medium-sized domain (less than 100 or so total categories), the inquiry should be carried out with approximately 20-30 people. Once it is observed that most of the responses given by new informants are being repeated from the old lists, the sample can be considered to be complete. A composite list can be obtained by accumulating information from all the lists.

Identification Task

The free listing task can be followed by an Identification Task. A simple way to do this is by collecting specimens of the items mentioned in the free lists and taking the specimens back to the respondents for identification. It is important to have a proper sample to facilitate identification. The responses from each of the respondents should be recorded separately and later verified for the number of correct answers. This technique provides an idea of who are the most knowledgeable people in the community for the kind of study being undertaken; and it also helps to resolve confusion concerning synonyms for the same item. This is one method of identifying key informants, depending on the objective of the survey. It is more useful to carry out further detailed study with this group of subject matter specialists after identifying tasks and removing all the anomalies associated with multiple local names.

Preference Ranking

Preference ranking can either be accomplished from the positions in the free lists or obtained by asking the key group of informants to arrange the items in the order of preference. Each person arranges the items according to personal preference, perceived importance in the community, or any other criterion. Each rank is given an integer value (1,2,3, and so on) with the most important or preferred item assigned the highest number. These numbers are totalled for all respondents, giving an overall ranking for the item by the sample group of respondents. Efforts should be made to cross-check this order of preference with data obtained from interviews or other sources to see if there is consistency in the responses. A more complex version of preference ranking, useful for ranking based on multiple dimensions, is known as Direct Matrix Ranking. Direct Matrix Ranking takes into consideration several attributes at a time to provide more composite scores of the overall multiple use value of the items.

Pair-wise Ranking

In a paired comparison task, items are presented two at a time and respondents are asked which is 'more' or which is 'less'. For n items, a pair comparison design creates n (n-1)/2 pairs. For example, if we wanted someone to order ten items using this method, we would then create 45 pairs and place them in random order both within and between pairs. For each pair, respondents are asked which is 'more'. A total order is obtained by totalling the number of times each item is chosen. To tabulate the responses, simply add up all the codes or ranks assigned to each item and present them as shown in Table 3.3.

Table 3.3:. Scores and Ranks Assigned to Each Item Using Pairwise Ranking Method

A	B	C	D	E	F	G	H	I	SCORE	RANK
								A		
								B		
								C		
								D		
								E		
								F		
								G		
								H		
								I		

In order to gain insight into people's reasoning, respondents can be asked to describe why one option is better or worse than the other. In addition, you can ask if the preferred item has any negative qualities or if the one not chosen has any positive aspects. Some researchers ask for these comments after each choice, whereas others prefer respondents to complete the entire task before giving their general observations on the overall pattern that emerges.

Pile Sorting

Pile sorting is initiated after the study items have been selected for more detailed data collection. In pile sorting, informants are asked to sort either the items or cards, each bearing the name/figure of an item, into piles so that items in a pile are more similar to each other than they are to items in separate piles. In the unrestricted version of the pile sorting task, respondents can make as many or as few piles as they wish. In the restricted version of the pile sorting task, respondents are asked to create a specific number of piles. Respondents are generally asked to group items according to their similarity, without reference to specific criteria. The respondents rather than the researcher decide what criteria are more appropriate and determine similarity. Pile sorting is easy to administer and allows for the collection of data among a large number of items.

Pile Sort Tabulation

An item-by-item similarity matrix is created from each individual's sort by tabulating the co-occurrence of items in piles, so that items that are together are counted as similar. For example, if we collected data on the similarity of seven items and a respondent put items A, B, and C together in a pile, D and E in a pile, and left F and G by themselves (see Table 3.4), we would create a seven by seven table to tabulate similarity among the items. Since A,B, and C are categorised together, A and B are similar, B and C are similar, and A and C are similar. Since D and E are also put together in a pile, D and E are considered to be similar. Thus, each pair would get 'a point of similarity'. This is indicated in the table by the number one. For this individual, all other pairs are 'dissimilar and are recorded as zeros. Similarity matrices are tabulated for each individual and then combined across people. The similarity matrix can then be analysed by a descriptive method such as hierarchical clustering or multi-dimensional scaling.

Table 3.4: An Individual's Items Sorted into Piles

A			
B	D		
C	E	F	G
Pile 1	Pile 2	Pile 3	Pile 4

Since A,B,C were together in a pile:

cell (A,B) = 1
cell (A,C) = 1
cell (B,C) = 1

	A	B	C	D	E	F
B	1					
C	1	1				
D	0	0	0			
E	0	0	0	1		
F	0	0	0	0	0	

3.5 Statistical Data Analysis

There have been attempts in recent years to incorporate suitable quantitative methods of research into ethnobotanical studies and undertake data collection, processing, and interpretation using statistical tools. Different approaches are available for collecting and analysing the quantitative ethnobotanical data, depending mostly upon the objectives of the researcher and the study. Barik (1998) has observed the following types of ethnobotanical studies in which the quantitative methods have been quite effective in deriving results and drawing conclusions.

i) Importance of vegetation to different groups
ii) Comparing the uses of plants by ethnic communities through sample plots or flora of the region
iii) Studying the importance of different vegetation types to a particular community
iv) Determining the relative importance (or uses) among different medicinal plants, families, and species

The data processing techniques in ethnobotany may range from calculating a simple index to complex computational techniques of multivariate analysis such as classification, ordination, and constrained ordination. The problems in ethnobotany may be classified into two broad categories statistically. A class of problems in which measurements are taken only of one attribute or response variable and for which data so obtained are analysed through a set of techniques called univariate analysis. The other class of problems deals with the measurements of a set of different variables and the statistical techniques applied to such data are called multivariate analysis. Because of the complexities involved in most ethnobotanical phenomena, it is more the norm rather than the exception that ethnobotanical researchers need to collect observations on many different variables. The three most widely used multivariate analysis techniques are regression analysis, principal component analysis, and cluster analysis. In order to demonstrate the use of one such technique, steps involved in cluster analysis of the following example are provided as described by Barik (1998).

The basic data for this example is taken from the final report of an ICIMOD research fellowship study (1996-97) by Dr. Archana Godbole. The title of her manuscript is 'The Use of Indigenous Knowledge in Mountain Natural Resource Management: A Case Study of Wancho Community, Tirap District, Arunachal Pradesh, India'. Dr. Godbole made a shortlist of 15 species (A - O) as important sources of fuelwood in Zadua village. In order to determine the overall preference for fuelwood, she carried out pairwise ranking with 23 women respondents (1 - 23) from the village. The names of species and respondents are given as Annex 3. The results of this pairwise ranking exercise are summarised in Table 3.5, referred to as the basic data matrix.

Statistical analysis of this data was carried out by Dr. Moe Myint, GIS Specialist at ICIMOD, using cluster analysis. The utility of cluster analysis of such data is that the respondents can be grouped according to their resemblances based on their response to questions about species' preferences in the 'Paired Comparison of Fuelwood Species' data. The respondents in each cluster should have a number of common characteristics that set them apart from the respondents of other such clusters. More convincingly, the objective is to classify the informants into groups so that informants within a particular group are more similar to each other than the informants between the clusters. These clusters of informants may represent different ethnic groups or people from different socioeconomic backgrounds.

Step 1. Obtaining the Basic Data Matrix

The basic data matrix for 'Paired Comparison of Fuelwood species' by women respondents according to the preference for each species, is given as Table 3.5.

Step 2. Standardising the Basic Data Matrix

The basic data matrix is standardised so that groupings of respondents and preferences match more distinctly. The result is as follows (Table 3.6).

Table 3.5. Ranking Given by Women (1-23) According to Preference of Each Species (A-O)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	15	15	15	13	15	14	14	15	15	14	14	13	15	15	15	15	15	15	15	14	13	15	16
B	13	14	13	9	14	15	15	14	14	8	15	14	14	14	13	13	13	14	14	15	13	14	14
C	13	13	14	9	12	13	13	13	3	3	13	4	2	12	13	14	3	8	13	13	12	12	13
D	11	12	12	7	13	11	10	12	12	6	9	11	11	13	12	9	13	13	12	11	11	13	12
E	3	3	2	2	2	2	2	3	4	2	2	4	5	2	2	2	3	4	3	1	3	2	3
F	11	10	9	5	7	6	6	10	10	5	7	3	9	7	10	12	8	2	10	5	5	7	10
G	4	3	7	5	4	3	3	3	1	3	4	2	1	4	4	7	7	8	4	3	2	4	3
H	5	5	6	3	8	6	6	5	6	7	5	4	5	8	4	5	6	4	5	5	6	8	5
I	7	8	4	7	5	9	9	8	10	8	9	11	11	5	4	4	8	2	8	9	10	5	8
J	7	8	7	11	8	8	6	8	9	8	5	4	9	8	7	7	10	1	8	5	8	8	8
K	2	2	3	4	2	5	5	2	4	13	3	4	8	2	3	3	2	12	2	5	6	2	2
L	7	7	4	13	5	9	10	7	6	12	12	10	5	5	7	5	12	10	6	9	8	5	7
M	10	11	10	11	10	4	4	11	6	11	9	4	4	10	10	9	8	6	11	4	3	10	11
N	6	5	11	15	10	12	12	5	12	15	7	15	13	10	9	9	5	6	6	12	13	10	5
O	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1

Table 3.6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	0.552	0.552	0.552	-1.987	0.552	-0.718	-0.718	0.552	0.552	-0.718	-0.718	-1.987	0.552	0.552	0.552	0.552	0.552	0.552	0.552	-0.718	-1.987	0.552	1.821
B	-0.256	0.332	-0.256	-2.607	0.332	0.920	0.920	0.332	0.332	-3.195	0.920	0.332	0.332	0.332	-0.256	-0.256	-0.256	0.332	0.332	0.920	-0.256	0.332	0.332
C	0.632	0.632	0.871	-0.321	0.394	0.632	0.632	0.632	-1.751	-1.751	0.632	-1.513	-1.990	0.394	0.632	0.871	-1.751	-0.560	0.632	0.632	0.394	0.394	0.632
D	-0.070	0.466	0.466	-2.213	1.002	-0.070	-0.606	0.466	0.466	-2.749	-1.142	-0.070	-0.070	1.002	0.466	-1.142	1.002	1.002	0.466	-0.070	-0.070	1.002	0.466
E	0.372	0.372	-0.698	-0.698	-0.698	-0.698	-0.698	0.372	1.442	-0.698	-0.698	1.442	2.512	-0.698	-0.698	-0.698	0.372	1.442	0.372	-1.768	0.372	-0.698	0.372
F	1.291	0.915	0.539	-0.964	-0.212	-0.588	-0.588	0.915	0.915	-0.964	-0.212	-1.716	0.539	-0.212	0.915	1.667	0.163	-2.092	0.915	-0.964	-0.964	-0.212	0.915
G	0.070	-0.466	1.678	0.606	0.070	-0.466	-0.466	-0.466	-1.538	-0.466	0.070	-1.002	-1.538	0.070	0.070	1.678	1.678	2.213	0.070	-0.466	-1.002	0.070	-0.466
H	-0.398	-0.398	0.365	-1.925	1.892	0.365	0.365	-0.398	0.365	1.129	-0.398	-1.162	-0.398	1.892	-1.162	-0.398	0.365	-1.162	-0.398	-0.398	0.365	1.892	-0.398
I	-0.141	0.265	-1.360	-0.141	-0.954	0.671	0.671	0.265	1.078	0.265	0.671	1.484	1.484	-0.954	-1.360	-1.360	0.265	-2.173	0.265	0.671	1.078	-0.954	0.265
J	-0.432	0.152	-0.432	1.905	0.152	0.152	-1.016	0.152	0.737	0.152	-1.601	-2.185	0.737	0.152	-0.432	-0.432	1.321	1.905	0.152	-1.601	0.152	0.152	0.152
K	-0.708	-0.708	-0.382	-0.057	-0.708	0.269	0.269	-0.708	-0.057	2.875	-0.382	-0.057	1.246	-0.708	-0.382	-0.382	-0.708	2.549	-0.708	0.269	0.595	-0.708	-0.708
L	-0.322	-0.322	-1.432	1.899	-1.062	0.418	0.788	-0.322	-0.692	1.529	1.529	0.788	-1.062	-1.062	-0.322	-1.062	1.529	0.788	-0.692	0.418	0.048	-1.062	-0.322
M	0.632	0.970	0.632	0.970	0.632	-1.396	-1.396	0.970	-0.720	0.970	0.294	-1.396	-1.396	0.632	0.632	0.294	-0.044	-0.720	0.970	-1.396	-1.734	0.632	0.970
N	-1.061	-1.348	0.375	1.523	0.087	0.662	0.662	-1.348	0.662	1.523	-0.774	1.523	0.949	0.087	-0.200	-0.200	-1.348	-1.061	-1.061	0.662	0.949	0.087	-1.348
O	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	4.587	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209	-0.209

Step 3. Computing the Resemblance Matrix

This next step in cluster analysis is to compute a Q-mode resemblance between the respondents (1-23). Although any of the numerous resemblance functions available could be used, distance measures have been used for multi-state characteristics' data in 'Paired Comparison of Fuelwood Species' because of their heuristic value. The results of the Resemblance matrix based on the Bray - Curtis Index (measure of similarity) are as follow.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.000																						
2	3.151	0.000																					
3	13.710	5.687	0.000																				
4	0.000	0.000	0.000	0.000																			
5	8.215	3.849	3.771	0.000	0.000																		
6	0.000	10.612	21.276	0.000	10.101	0.000																	
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000																
8	3.151	0.000	5.687	0.000	3.849	10.612	0.000	0.000															
9	8.994	4.090	6.658	0.000	5.134	8.237	75.368	4.090	0.000														
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000													
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000												
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000											
13	3.422	2.692	3.417	14.334	3.092	3.046	4.250	2.692	1.341	6.890	5.975	25.133	0.000										
14	8.215	3.849	3.771	0.000	0.000	10.101	0.000	3.849	5.134	0.000	0.000	0.000	3.092	0.000									
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.084	0.000	0.000								
16	0.000	89.303	0.000	0.000	56.570	0.000	0.000	89.303	35.354	0.000	0.000	0.000	4.687	56.570	0.000	0.000							
17	4.136	2.707	3.756	0.000	3.428	5.870	11.812	2.707	2.906	34.795	16.802	0.000	2.462	3.428	12.950	8.569	0.000						
18	7.353	4.928	5.824	0.000	5.087	7.847	16.160	4.928	4.610	54.887	29.623	0.000	2.817	5.087	18.013	12.228	2.640	0.000					
19	1.985	0.416	4.095	0.000	2.846	8.004	55.076	0.416	3.481	0.000	0.000	0.000	2.527	2.846	0.000	17.719	2.466	4.327	0.000				
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.920	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.349	0.000	0.000	0.000	27.624	42.211	0.000	0.000	0.000		
22	8.215	3.849	3.771	0.000	0.000	10.101	0.000	3.849	5.134	0.000	0.000	0.000	3.092	0.000	0.000	56.570	3.428	5.087	2.846	0.000	0.000	0.000	
23	2.027	0.345	3.818	0.000	2.883	5.574	14.321	0.345	3.124	145.233	28.469	0.000	2.452	2.883	11.415	9.132	2.306	3.985	0.596	0.000	76.271	2.883	0.000

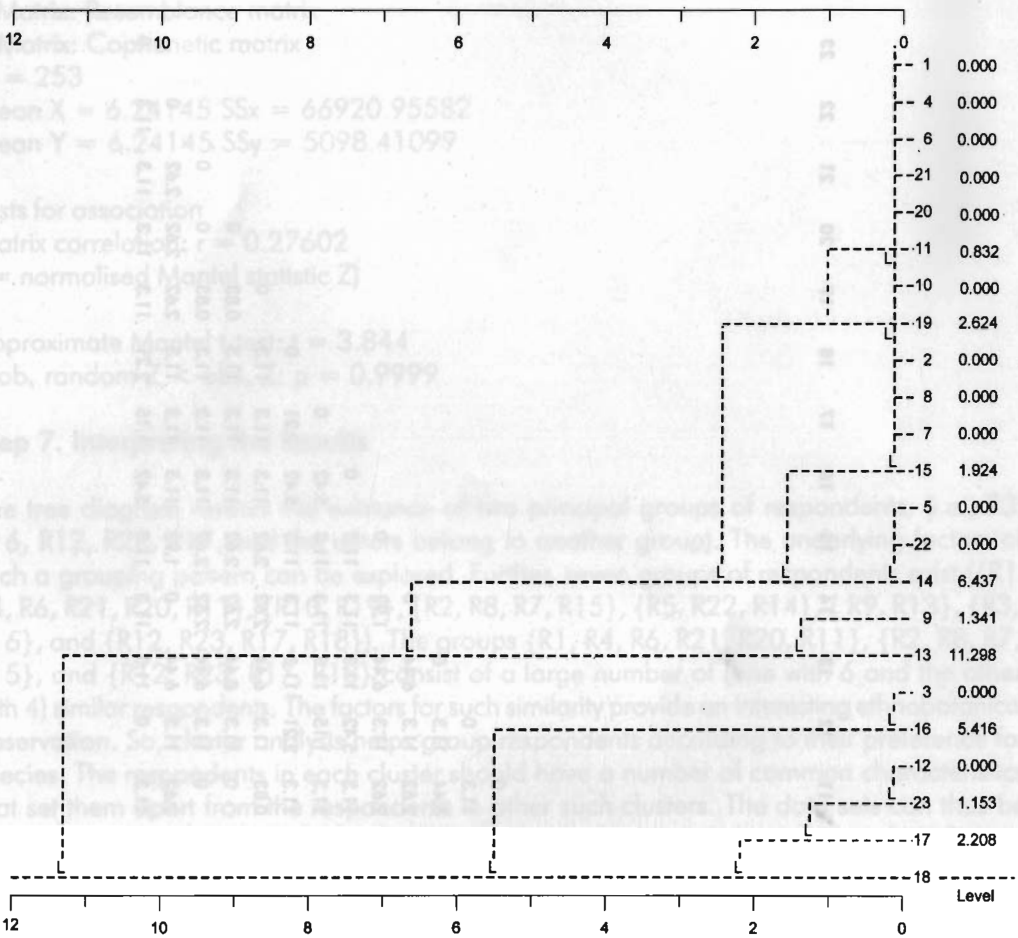
Step 4. Executing the Clustering and Obtaining the Tree Matrix

The clustering technique used here is a sequential, agglomerative, hierarchical, and non-overlapping procedure based on the Unweighted Pair Group Method with Arithmetic Averages (UPGMA) method of clustering. The result of the tree matrix based on the UPGMA is as follows.

1	0.0000000
4	0.0000000
6	0.0000000
21	0.0000000
20	0.0000000
11	0.8323634
10	0.0000000
19	2.6236309
2	0.0000000
8	0.0000000
7	0.0000000
15	1.9242874
5	0.0000000
22	0.0000000
14	6.4372405
9	1.3413647
13	11.2976978
3	0.0000000
16	5.4159862
12	0.0000000
23	1.1531470
17	2.2081708
18	------------

Step 5. Drawing the Tree or Dendrogram.

The tree matrix derived above produces a tree on a scale showing the clustering scheme as follows.



Step 6 Computing the Cophenetic Matrix and Cophenetic Coefficient, and Plotting

A tree is not exactly like the data matrix it represents. It is necessary to know how well the tree and the resemblance matrix matches. The values that appear in the table below came from the tree and are compared with those of the basic data matrix.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0																						
2.62	0																					
11.3	11.3	0																				
0	2.62	11.3	0																			
2.62	1.92	11.3	2.62	0																		
0	2.62	11.3	0	2.62	0																	
2.62	0	11.3	2.62	1.92	2.62	0																
2.62	0	11.3	2.62	1.92	2.62	0	0															
6.44	6.44	11.3	6.44	6.44	6.44	6.44	6.44	0														
0.83	2.62	11.3	0.83	2.62	0.83	2.62	2.62	6.44	0													
0	2.62	11.3	0	2.62	0	2.62	2.62	6.44	0.83	0												
11.3	11.3	5.42	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	0											
6.44	6.44	11.3	6.44	6.44	6.44	6.44	6.44	1.34	6.44	6.44	11.3	0										
2.62	1.92	11.3	2.62	0	2.62	1.92	1.92	6.44	2.62	2.62	11.3	6.44	0									
2.62	0	11.3	2.62	1.92	2.62	0	0	6.44	2.62	2.62	11.3	6.44	1.92	0								
11.3	11.3	0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	5.42	11.3	11.3	11.3	0							
11.3	11.3	5.42	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	1.15	11.3	11.3	11.3	5.42	0						
11.3	11.3	5.42	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	2.21	11.3	11.3	11.3	5.42	2.21	0					
0.83	2.62	11.3	0.83	2.62	0.83	2.62	2.62	6.44	0	0.83	11.3	6.44	2.62	2.62	11.3	11.3	11.3	0				
0	2.62	11.3	0	2.62	0	2.62	2.62	6.44	0.83	0	11.3	6.44	2.62	2.62	11.3	11.3	11.3	0.83	0			
0	2.62	11.3	0	2.62	0	2.62	2.62	6.44	0.83	0	11.3	6.44	2.62	2.62	11.3	11.3	11.3	0.83	0	0		
2.62	1.92	11.3	2.62	0	2.62	1.92	1.92	6.44	2.62	2.62	11.3	6.44	0	1.92	11.3	11.3	11.3	2.62	2.62	2.62	0	
11.3	11.3	5.42	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	0	11.3	11.3	11.3	5.42	1.15	2.21	11.3	11.3	11.3	11.3	0

The Cophenetic Matrix is computed as follows.

The result of matrix comparison between the cophenetic matrix and the resemblance matrix is as follows.

X Matrix: Resemblance matrix
Y Matrix: Cophenetic matrix
N = 253
Mean X = 6.24145 SSx = 66920.95582
Mean Y = 6.24145 SSy = 5098.41099

Tests for association
Matrix correlation: r = 0.27602
(= normalised Mantel statistic Z)

Approximate Mantel t-test: t = 3.844
Prob. random Z < obs. Z: p = 0.9999

Step 7. Interpreting the Results

The tree diagram reveals the existence of two principal groups of respondents, (i.e., R3, R16, R12, R23, R17, and the others belong to another group). The underlying factors of such a grouping pattern can be explored. Further, seven groups of respondents exist ({R1, R4, R6, R21, R20, R11}, {R10, R19}, {R2, R8, R7, R15}, {R5, R22, R14}, { R9, R13}, {R3, R16}, and {R12, R23, R17, R18}). The groups {R1, R4, R6, R21, R20, R11}, {R2, R8, R7, R15}, and {R12, R23, R17, R18} consist of a large number of (one with 6 and the other with 4) similar respondents. The factors for such similarity provide an interesting ethnobotanical observation. So, cluster analysis helps group respondents according to their preference for species. The respondents in each cluster should have a number of common characteristics that set them apart from the respondents in other such clusters. The data sets can thus be reduced to homogenous groups or clusters with an objective to demonstrate the relationships of the respondents to each other and to simplify their relationships so that some general statements about the class of respondents can be made. In ethnobotanical research, often most interest lies in knowing the preferences for species and the reasons behind it. It may relate to peoples different ethnicity, socio-economic situations. Ethnobotanists have used cluster analysis to find out the preferred traits in a wide variety of agricultural crops encompassing studies on evaluation of seed selection criteria and analysis of highly diverse agronomic practices.