An Approach Towards Analysis of Home Gardens

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Home Gardens are an ancient and widespread agroforestry system. They can be defined as the land surrounding a house on which a mixture of annual and perennial plants are grown together with or without animals and largely managed by the household members for their own use or commercial purposes. The components of Home Garden systems are so intimately mixed in horizontal and vertical strata, as well as in time, that complete interaction exists between the soil, plants, other components and environmental factors on farmers' plots.

Home Gardens can be studied from the point of view of their organization, i.e., how they are composed (their floristic composition and diversity), the kinds of structure hidden in the apparently disorderly mixture of trees and crops, and the indigenous management techniques that make the systems sustainable over generations. The objective of this chapter is to review the range of methods available for Home Garden analysis.

Home Garden floristics

Species' inventory

The simplest and most rapid way of describing vegetation is to list the species present within a Home Garden and to attach to each species a subjective assessment of its abundance. Home Gardens are almost universally reported as being on average less than one hectare (e.g., FAO 1986; Altieri and Farrell 1984; Millat-e-Mustafa 1996), thus to get a broad view of the wide range of species and categories of plants in Home Gardens, it is always advisable for complete enumeration of individuals of species rather than sampling. In such a situation a north-south baseline could be established to divide a Home Garden into two roughly equal parts. Sample centre points are demarcated on this line at 10-m intervals until the boundary is reached. From the centre points, additional lines perpendicular to the baseline are demarcated towards the east and west as far as the Home Garden limit. By creating further points at 10-m intervals on these east-west lines, a 10 m x 10 m sample grid is generated. In each grid, the individuals of all species with their location coordinates, total height, crown diameter and crown height are recorded.

Species' frequency

The contribution made by each species in a Home Garden can be expressed as a percentage of the total number of species, which is called frequency. Since frequency often reflects the patterns of distribution of individuals as well as their density, it also expresses information about both pattern and abundance.

Species' composition

Plants can be classified taxonomically into families, genera, species, varieties, etc. This, however, is not the only way to classify plants. Species and individuals can be grouped into life form or growth form classes on the basis of their similarities in structure and function. A plant life form is usually understood to be a growth form, which displays an obvious relationship to important environmental factors. For example, a deciduous tree is a plant life form that responds to an unfavourable season by shedding its leaves. On the basis of functions, plants can also be grouped broadly into food- and fruit-producing species, timber and fuelwood species, spices, medicinal, ornamental and miscellaneous. Those species that could not be grouped under the first five categories are the ones classified as miscellaneous.

Distribution of number of trees by diameter classes

Distribution by diameter classes is a common method of grouping trees and many inventory data are available for trees already classified into diameter classes. Diameter at breast height (DBH) is the easiest tree measurement, in spite of the difficulty caused by the presence of buttresses. Measurement units, class intervals, and lower limits for diameter differ significantly from one species to another.

Density

Density is defined as the number of individuals of a particular species per unit area. Thus density can be found by using the formula

$$\text{Density} = \frac{\text{Average number of individuals}}{\text{Area sampled}}$$

Species' ordination

Species ordination refers to the arrangement of species in relation to environmental gradients, or axes that may correspond to environmental gradients. One of the main purposes of such an arrangement is the recognition of joint variation in community composition and environmental factors. Ordination produces a more realistic representation of community variation and provides a better way of identifying the environmental factors that control the distribution of a species. DECORANA - the most widely used ordination technique in ecology is a computer programme, written by Mark Hill in the late 1970s, which uses a refined version of correspondence analysis. The refinement is de-trending (DECORANA - DEtrended Correspondence Analysis) which is intended to reduce some of the distortion of the ecological data that can occur during normal correspondence analysis. DECORANA has several advantages over other ordination techniques (Hill and Gauch 1980) as follow.

- Its performance is the best of the ordination techniques tested, and both species and sample ordinations are produced simultaneously.
- The axes are scaled in standard deviation units with a definite meaning,

- The computing time rises only linearly with the amount of data to be analysed; very large data sets present no special difficulty.

Species' dominance

In given uniform climatic, topographic and edaphic conditions, it is considered that the dominant species is the most important factor in determining the character of the community and the relative abundance of the remaining species in the community. It cannot be said that the most frequent species is the dominant; for where there is a great difference in the life form of species, the largest species is often dominant, and it rarely happens that the largest species is also numerically the commonest. So the individuals of a species having greater Relative Importance Values (RIV) are dominant to individuals of any other species. To determine species' dominance, RIV are calculated according to the formula of Myres and Shelton (1980) as follows.

RIV = Relative frequency + Relative density + Relative cover

where,

$$\text{relative frequency} = \frac{\text{Percentage frequency of species A}}{\text{Sum of all species' percentage frequencies}} \times 100$$

$$\text{relative density} = \frac{\text{Density of species A}}{\text{Density of all species}} \times 100$$

$$\text{relative cover} = \frac{\text{Crown area of species A}}{\text{Crown area of all species}} \times 100$$

RIV is a unitless score that combines the three measures, giving each equal weight, and can be used as a ranking of the dominance of each species in the community. The maximum relative importance value of a species is 300.

Similarity of species

To find the species similarity between two communities, Sfrenson's coefficient of similarity, expressed as a percentage (Muller and Ellenberg 1974), can be calculated using the following formula.

$$\text{Similarity coefficient} = \frac{2c}{a + b} \times 100$$

where,

a = number of species present in community A
b = number of species present in community B
c = number of species common to both communities

Sfrenson's coefficient of similarity expresses the actually-measured coinciding species' occurrence against the theoretically possible one. When the communities under study contain the same species, the value of the index is 100 (the

maximum value) and when the communities contain entirely different sets of species, the value of the index is 0.

Species' diversity

Species' diversity is used to describe the relationship between the number of species and the number of individuals and diversity, as a consistent, measurable characteristic of communities. It can only exist if these communities have a definable structure which is a property of the communities as a whole and not of the separate species within it.

Species' diversity is determined using Shannon's index (Fowler and Cohen 1992) as follows.

$$H' = - \sum P_i \ln P_i$$

where,

H' = Shannon's index
P_i = proportion of a particular species in a sample

Shannon's index has probably been the most widely used index in community ecology. It has two properties that have made it a popular measure of species' diversity: (a) $H' = 0$ if, and only if, there is one species in the sample; and (b) H' is maximum only when all species are represented by the same number of individuals, i.e., a perfectly even distribution of abundance.

Shannon's evenness index

Evenness represents a measure of homogeneity or relative diversity, and it gives the real distribution compared to maximum dispersion taking into account the number of species present in a community. This is expressed as the ratio between the observed diversity, H', and the maximum theoretical diversity, H_{max} (calculated by assuming that the species present in a given sample are all represented by equal numbers).

From Shannon's index, evenness is estimated as follows (Zar 1984).

$$E = \frac{H'}{H_{max}}$$

where,

E = evenness index
H' = Shannon's index of diversity
H_{max} = ln S, where, S = number of species.

The value of E can vary from 0 (when there is only one species in the sample) to 1 (when the species present in a given sample are all represented by an equal number of individuals).

Species' richness index

The species' richness of a Home Garden corresponds to the total number of species present in it and is thus an indicator of the relative wealth of species in that Home Garden. Species' richness is estimated as Mergalef's index as follows.

$$R = \frac{S-1}{\ln n}$$

where,

R = Mergalef's richness index
S = total number of species
n = total number of individuals

Structure of Home Garden vegetation

The structure of Home Garden vegetation can be defined by two components: (a) the horizontal arrangement of species, i.e., the spatial distribution of individuals; and (b) the vertical arrangement of species, i.e., the stratification of the vegetation.

Horizontal structure

Typical Home Gardens usually present the appearance of a crowded haphazard assemblage of trees, shrubs, herbs, climbers and creeping plants. Most farmers try to optimise their Home Gardens by planting as many crops as they can in the limited space available and in the physical constraints of their home environment (Sommers 1978; Millat-e-Mustafa 1996).

The horizontal structure of vegetation is assessed in terms of species' locations within the Home Gardens. Species' locations within the Home Gardens are assessed in relation to distance from the living quarters. Four quadrants can be distinguished. The quadrant containing the living quarters is taken as the first quadrant. The next nearest quadrant to the middle of the living quarters is taken as the second quadrant and that beyond the third quadrant. The fourth quadrant is that most distant from the living quarters. The species present, grouped according to function, are assessed by quadrant. Each function group is also assessed as the percentage of the number of different species present in each quadrant. Species' location within the Home Gardens could also be considered with respect to major locations: only the border, only the interior part, and both border and interior parts.

Vertical structure

A prominent structural characteristic of the Home Garden is the great diversity of species with many life forms varying from those creeping on the ground, such as sweet potatoes, to tall trees of 10 m or more, e.g., the coconut palm. These create the forest-like multi-storey canopy structure of many Home Gardens. On a more local scale, a structural approach can be used to simplify the

organization of complex vegetation types. The vertical structure of the Home Gardens can be summarised by referring individuals to different vertical strata on the basis of specific height classes.

Architecture

The architecture of Home Gardens is reflected in an assemblage of relationships between the dimensions of various parts of the plants. The architecture of Home Gardens can be described by means of a profile diagram. The profile diagram enables the construction of a scale diagram of the vegetation using accurate measurements of the position, height, height to the first branch, and depth and crown diameter of all the trees on narrow sample strips. Since spacing is a three-dimensional property, it is important to choose a transect-width for the profile diagram that conveys the correct plant spacing of the garden. The width should usually not exceed a few metres.

Crown cover

Cover is defined as the proportion of ground occupied by perpendicular projection on to it of the aerial parts of individuals of the species under consideration, and it is usually expressed as a percentage. Because of the overlayering of different species, the total cover of an area may exceed 100 per cent and, in the case of Home Gardens, it may reach several hundred per cent. Crown cover is calculated according to the formula of an ellipse as follows.

$$C = 0.25 \times D_1 \times D_2 \times p$$

where,

D_1 = largest crown diameter
D_2 = diameter perpendicular to D_1.

Crown volume or crown bulk is calculated according to the formula of an ellipsoid as follows.

$$V = 0.167 \times D_1 \times D_2 \times (H - LCL) \times p$$

where,

D_1 = largest crown diameter
D_2 = diameter perpendicular to D_1
H = total height
LCL = height up to lower crown limit
thus, $H - HCL$ = crown depth

To find the dominant position of certain species in different strata, the crown-depth could be divided into one-metre stratum units. The number of trees of the same species appearing in each stratum is counted. Taking each stratum separately, the stratum with the highest number of trees is accorded 100 per cent value, and its tree number is used as a basis for the percentage calculation of tree numbers in other strata. The figure will show the distribution of individual trees at different heights.

Indigenous management techniques

Exploration of indigenous management techniques of Home Gardens is always a complex exercise and the use of a multi-method approach using a combination of techniques is often advantageous (Kilahama 1994; Southern 1994). Participatory rural appraisal (PRA) is one of the most effective multi-method approaches as it encourages local people to express knowledge in their own terms by minimising the influences of the researchers (Chambers 1990). The various participatory methods that could be used to investigate indigenous management techniques are outlined below.

Tree-use matrix

Tree-use matrix is a powerful technique that can be used to understand farmers' decision-making processes in recognising the uses of different species of plants through interactions among farmers and family members (Freudenberger, 1994). The scoring technique, which is an output of the tree-use matrix exercise, is a useful tool to rank species according to their multiple uses. The ranking highlights the differences in priorities and differences in decision-making criteria used as expressed by good and bad properties of each species.

Procedure of tree-use matrix exercise

In a tree-use matrix exercise, a vegetation survey is made to list species present in the Home Garden. The farmer of that Home Garden is then asked to collect the leaves/twigs of each species present in his/her Home Garden to allow cross-checking of species with the list made from the vegetation survey. If any species is missing, the farmer is asked to provide it. To begin the exercise, leaves/twigs of all species present in the Home Garden are placed in lines away from the observer to represent rows of a table marked on the ground. Columns representing uses are then marked out. In the cells, the farmer places a number of beans proportional to the importance of each species for each use (e.g., four for very good, three for good, two for fair, one for not good). After the matrix is completed, the beans against each species are counted. A preference list of species is then made putting the species with highest score first. Cross-checking preferences of species is then made by asking the farmer to order the species according to his/her preference. How the farmer arranged the species is checked with the score of the species. Inconsistencies are resolved by consulting further with the farmer.

Semi-structured interviews

This is a guided interview that is started by checking the different management issues for which the farmer's opinion is wanted. On each key topic the farmer is free to express his/her own views. The interview is guided to cover the key topics on the checklist while leaving room to pursue any relevant subjects brought up by the farmer. A semi-structured questionnaire indicating key topics for exploring indigenous management techniques of Home Gardens used by Millat-e-Mustafa (1996) is mentioned below.

Question 1: 'What planting materials do you use for your Home Garden plants?' This is to elicit farmers' knowledge about regeneration procedures with differ-

ent Home Garden plants. The relative advantages and disadvantages of various types of planting material for different species are ascertained through further questions.

Question 2: 'What are the sources of different planting materials?' This is to establish the relative contribution of different sources of planting materials in the Home Gardens.

Question 3: 'Do you follow any criteria to select mother trees to collect planting materials?' This retrieves farmers' knowledge about the introduction of improved varieties of species in the Home Gardens. If the farmers say 'Yes', then details of the criteria for mother-tree selection and the types of species for which mother trees are selected could be sought with more questions.

Question 4: 'What sizes of seedling are available to plant and which one do you prefer and why?' This is to explore farmers' silvicultural knowledge about different sizes of seedling.

Question 5: 'Do you adopt any spacing at the time of planting?' This question is to gather information about any horizontal arrangements of species in the Home Gardens. If the response is 'Yes', further questions could be asked to ascertain the planting spacing and the reasons for its use.

Question 6: 'Do you carry out weeding, lopping, pruning, thinning, coppicing, pollarding in your Home Garden?' Weeding and thinning determine the horizontal structure of the Home Gardens, while pruning determines how the farmers regulate sunlight in the Home Garden. In the case of 'Yes' answers, further questions could be posed to find out why, and to what the operations are applied.

Question 7: 'Do you water and manure your Home Garden plants?' This question is used to produce an idea of the effort given to managing the Home Garden. If the reply is 'Yes', the frequency and quantity of watering and manuring, and the name of the species to which these were applied, could be determined with further questions.

Calendars

Calendars are tools that help to explore changes taking place over the period of a year. They can be useful in counteracting time biases because they are used to find out what happens in different seasons. Knowledge of local calendars and classification systems often provides important information about gender roles in different farming activities (Molnar 1989).

Daily activity and seasonal calendars are in common use to explore gender roles in Home Gardens. A daily activity calendar is used to find out day-to-day gender roles in Home Garden activities. The calendar is drawn on the ground, putting different sections of the day (morning, late morning, afternoon, late afternoon, evening and night) against different genders (male adult, female adult, male child and female child). Seasonal calendars are used to find out the seasonality of household labour for the Home Garden. Hiring-in labour for Home

Garden management activities in different seasons can also be recorded. In all cases, beans are used to indicate the number of days engaged in different activities.

Sketch mapping

A sketch map is a simple diagram which informants can use to present the physical aspect of their Home Garden. It is a simple, schematic device which presents information in a readily understandable visual form (Conway 1989). Sketch maps can be used to show, roughly to scale, the spatial relationships of living houses, cattle and poultry sheds, ponds, yards, vegetable gardens, planting area, specific locations of species on the ground, etc. Another use of sketch maps is for gaining insight into people's perceptions of their environment. Sketch maps create new avenues for discussion about different management aspects of the Home Gardens.

Garden planning by semi-structured map

This is a technique to help make predictions about decision-making which involves creating hypothetical scenarios in which local experts can be asked 'What if?' questions (Benfer and Furbee 1990). Changing one or more of the characteristics of the scenario and repeating the knowledge-elicitation exercise can help researchers identify the dynamics of decision-making rules. This technique can be started by drawing out the boundaries, area and soil type of a fictitious garden so that a farmer could demonstrate how she/he would approach the design and planning of a new Home Garden by diagramming and answering 'What if?' questions. The exercise aims to discover what factors are taken into account when considering garden establishment and development.

Conclusion

This chapter has outlined the methods most frequently used for describing and analysing vegetation of Home Gardens. In some circumstances the choice of method is immediately obvious, but more frequently the researcher is faced with selecting from as many as half-a-dozen, all of which appear to have equivalent advantages and disadvantages. In this situation the final decision will have to be made on the basis of the objectives of the study.

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