CHAPTER ONE - OVERVIEW

This chapter is an introduction to using a knowledge based systems (KBS) approach to support decision making when planning agroforestry research and extension.

An environment is provided that helps the user to store and access what is known about interdisciplinary topics such as agroforestry as an appropriate starting point for planning research and extension work. The knowledge is obtained by talking to people and consulting literature. We refer to these people and documents as the sources of the knowledge. A store, called a knowledge base, of explicitly recorded knowledge statements or facts is developed. When a knowledge base has been created on computer, there is an explicit and accessible record of the knowledge that can be used later to help in making decisions for and during development of research and development programmes. Unlike, many existing expert systems, the KBS approach is not intended to provide definitive or prescriptive answers to questions but to ensure that decisions are based upon consideration of relevant information.

The approach comprises a methodology for acquiring knowledge and storing this explicitly recorded knowledge and an associated computer software for creation and use of knowledge bases. The toolkit is called AKT, which stands for **A**groecological **K**nowledge **T**oolkit and can be used to provide various levels of support to suit different needs in knowledge analysis and decision making. Although the methodology was initially developed for agroforestry domain, it can be applied equally well in other disciplines.

This first part of the manual provides an overview of the approach, and of the thinking behind it. The manual as a whole provides guidelines on how to apply this approach when planning agroforestry research and extension.

1.1 BACKGROUND AND OBJECTIVES

Agroforestry either involves farmers growing trees or shrubs in various productive or environmentally protective niches on their farms or the integration of agricultural activities in forests. As such, agroforestry practices have multiple objectives and components and are characterised by their complexity. In recent years agroforestry has received considerable attention from people working to foster sustainable and equitable land use in the developing world.

Because agroforestry practices are generally complex, effective decision making in research and extension depends upon making effective use of all available knowledge. Increasingly, development professionals recognise the value of augmenting scientific and professional understanding with knowledge held by local people (Brokensha *et al*., 1980, Warren *et al*.,1995, Sinclair and Walker, 1999). This knowledge is of particular interest, but is often incomplete or contentious – and different knowledge sources, though complementary, may not be immediately compatible or comparable. Moreover, much of the information about the ecology of agroforestry practices is qualitative and may include observational information (such as qualitative correlations), or be descriptive. Precise environmental data and quantitative models are rarely available.

In order to combine local, scientific and professional knowledge, effective mechanisms are needed for accessing, recording, evaluating and synthesising knowledge on specified topics from these sources. Existing mechanisms for doing this, as they are currently applied in research and development institutes, are often inadequate (Walker *et al*., 1997).

The methodology outlined in this manual has been designed to allow the evaluation and use of complex, qualitative information about agroforestry practices. It has been developed with a particular emphasis on the local knowledge of farming communities in developing countries. It provides an approach to decision-support in planning agroforestry research and extension activities, which is appropriate to the nature of existing knowledge. The AKT software provides an environment for knowledge acquisition in order to create knowledge bases from a range of sources. Database functions and a graphical user interface allow flexible exploration, retrieval, and evaluation of the knowledge. More powerful means of retrieving information from knowledge bases by using automated reasoning techniques (widely used in the field of artificial intelligence) are also available. A task language allows more advanced users to make their own reasoning tools appropriate to their particular decision support tasks by customising the existing tools or by writing new tools.

1.2 WHAT DO WE MEAN BY 'KNOWLEDGE'?

To define knowledge is to enter a philosophical minefield but in order to work with AKT we must state explicitly what we mean by 'knowledge' in this context. For the purposes of AKT we define knowledge as *the outcome of the interpretation of data, independent of the interpreter*. Data is a recorded set of observations (which may be quantitative or qualitative) and information is a continuum that has data and knowledge as two extremes (Figure 1.1). Information, data and knowledge are distinct from understanding. Understanding is the outcome, specific to the interpreter, of the interpretation of information, data or knowledge.

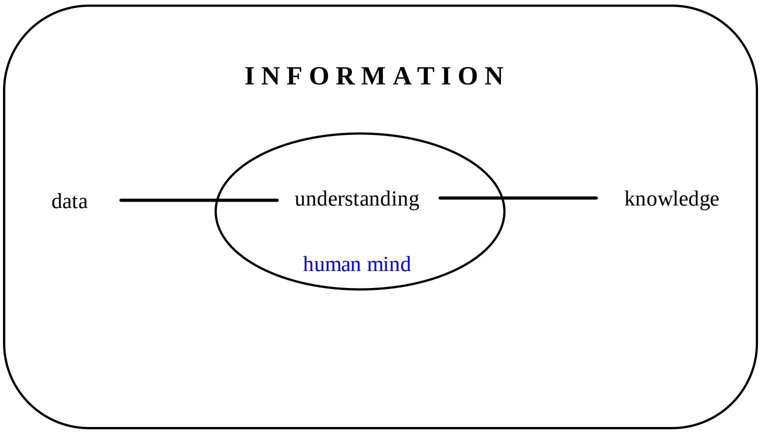

Figure 1.1. Diagrammatic representation of Information as a continuum, with Data and Knowledge as the two extremes.

Knowledge is seen as a central aspect of culture, derived from education and experience, that may be used in conjunction with a certain value system and competing priorities and possibilities, to make decisions.

Local knowledge and indigenous knowledge have often been used interchangeably. However, it is possible to distinguish between the two if 'local knowledge' is used to denote locally derived understanding which is based on experience and observation and 'indigenous knowledge' is used to denote that same understanding but modified by the incorporation of cultural beliefs and values as well.

1.3 KNOWLEDGE BASE CREATION

Creating a knowledge base involves four distinct stages; knowledge elicitation from the appropriate sources, converting the knowledge elicited into simple unambiguous statements, inputting those statements into AKT using formal representation and specifying/defining the formal terms used.

Knowledge elicitation is the process whereby selected informants are encouraged to articulate their knowledge. This is normally done through repeated interviews with farmers and domain experts. Knowledge can also be abstracted from written material.

Creation of unitary statements is the process of extracting knowledge from the text or interview material, and breaking it down into simple statements each containing one 'unit' of knowledge. These 'unitary statements' form the intermediate stage between knowledge articulation and representation.

Formal representation is the process of coding knowledge for input into a computer using a restricted syntax as defined by a formal grammar developed for the purpose. Formal representation results in statements with which you can reason automatically using computer software.

Formal Term (Keyword) specification is the process of identifying and organising key components of knowledge. Formal terms in AKT are either:

objects (e.g. ‘pests’, ‘crops’, ‘field’),
processes (e.g. ‘erosion’, ‘infiltration’, ‘growth’),
actions (e.g. ‘pruning, ‘harvesting’, ‘planting’),
attributes (e.g. ‘rate of erosion’, ‘pest population size’, ‘tree height’)
values (e.g. ‘3 m’, ‘10 t/ha’, ‘high’, ‘low’) or
links (user defined)(e.g. ‘eat’ as in ‘cows eat grass’, ‘pollinate’ as in ‘fruit bats pollinate *Parkia biglobosa*’)

They are terms which may need to be defined, may have synonyms and, in the case of objects, may be organised in an object hierarchy (e.g. an oak tree is a type of tree and a tree is a type of plant).

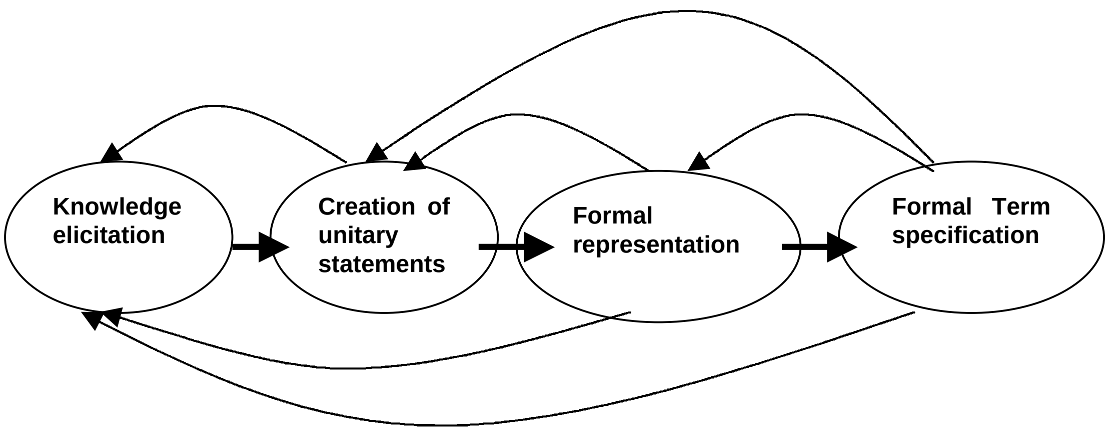

Figure 1.2 *The creation of a knowledge base. There are four principle activities in the creation of a knowledge base, as shown in the diagram. These occur in sequence (bold arrows), but evaluation during the creation of the knowledge base and consequent return to previous activities (fine arrows) means that the process is in fact a series of cycles*.

The process of creating a knowledge base is summarised in Figure 1.2. In principle, the process is linear, but in practice it is iterative in nature. It is important to emphasise that the knowledge base should be evaluated at *each* stage of development. Evaluation of the knowledge base involves assessing the relevance, utility and ambiguity of individual unitary statements. It also includes checks for repetition and contradiction amongst statements. The completeness of the knowledge base, and the consistency and precision in the use of terms, should also be evaluated continuously during the process of building a knowledge base.

1.4 KNOWLEDGE BASE STRUCTURE

The following sections summarise the main features in AKT used in developing and using a knowledge base. These features are described in more detail in relevant chapters that follow. Exploring an example knowledge base will reveal most of these features and is recommended for novice users of AKT before starting to develop their own knowledge bases.

The core content of a knowledge base created within AKT is a set of unitary statements. Unitary statements represent knowledge that is perceived to be true by the source of the knowledge, even if not scientifically verified. Unitary statements are the smallest useful unit of knowledge, in that they contain knowledge that is useful without reference to other statements; they cannot be broken down any further into useful units of knowledge. Examples of unitary statements are:

Red soils are fertile.
Trampling by sheep increases soil erosion.
Cover crops reduce soil erosion.
Ficus auriculata has large leaves.
Water drip causes splash erosion.
Fodder from Artocarpus lakoocha is more nutritious than fodder from Ficus neriifolia.

1.4.1 STATEMENT INTERFACE

Formal representation of unitary statements in a AKT knowledge base involves using a formal grammar which is designed to allow representation of ecological knowledge. By ecological knowledge we mean information about organisms, the environment and the interactions amongst them including human actions that influence them (see Chapter 4.2 and Table 4.1). The formal grammar comprises four fundamental types of statement: attribute-value statements, causal statements, comparison statements and generic link statements. Each statement may be composed of elements from the formal terms described above: objects, processes, actions, attributes, values and links. For example a formal representation of the statement:

The germination percentage of oak seeds is high if the air temperature is between 15 and 25° C and the moisture content of the seed is between 80 and 90%.

would look like this:

att_value(process(part(oak, seeds), germination), percentage, high)
IF
att_value(atmosphere, temperature, range('15degreesC', '25degreesC')) and att_value(seed, moisture_content, range('80%',' 90%'))[1]

Each statement is tagged with its source(s), giving details of the literature or interview from which was derived. Most statements are only valid in certain conditions. The general format of a unitary statement is therefore:

assertion IF conditions (sources)

The formal representation of each statement is retained within the knowledge base. Formal terms in the formal statement are identified automatically by a parser[2], which checks the syntax of the formal statements. Each new formal term is added to the lists of terms, in the categories of object, process, action, attribute, value or (user defined) link. While developing the knowledge base, you can order related objects into object hierarchies. These capture both local and scientific classification of things and allow you to apply order-sorted logic techniques in reasoning (Robertson *et al*., 1991). By careful management of the content of the lists of formal terms and object hierarchies, you can ensure consistent use of terminology across the knowledge base. Consistent and parsimonious use of terminology greatly improves the subsequent performance of inference mechanisms as well as improving the ease with which your knowledge base can be understood by other people.

The lists of formal terms and object hierarchies also provide a framework for use of familiar database-type functions. Sets of statements can be abstracted from the knowledge base by searching the formal statements using combinations of any of the formal terms, sources, aliases and topics. There are three possible search strategies in relation to objects – searching for just one selected object, searching for a selected object and all objects below it

[1] Formal representation of unitary statements is explained step by step in Chapter 4.
[2] A parser is a computer program that checks the syntax of a statement to ensure that it conforms to a defined grammar.

in an object hierarchy, or searching for objects both above and below the selected object in an object hierarchy. In this way you can abstract sub-sets of the knowledge base which can then be treated as more focused knowledge bases in their own right. Search strings (aliases) may be converted into topics which are groups of related search strings amalgamated into one topic string, using Boolean connectives, for example; 'cattle OR sheep AND grass'. The 'Welcome' memo that appears on loading a knowledge base provides direct access to the topics, so that a new user may see immediately what sort of information is in the knowledge base, and have a means of accessing it.

1.4.2 DIAGRAM INTERFACE

A diagram-based interface for knowledge representation and retrieval is also available within AKT to support the viewing of statements and the links between them. For most new users, the diagram interface also serves as the first mode of entry in recording knowledge.

A diagramming approach to representing information about agro-ecosystems is familiar to many resource managers and provides an intuitive means of synthesising and representing complex information. It has also been used successfully in cross-cultural situations to form a clear consensus about the important causes of land use problems (Lightfoot, *et al*, 1989), and in enabling articulation of local knowledge (Conway, 1989). Thus, it has been shown that diagrams in knowledge elicitation can result in a set of knowledge that is significantly more comprehensive and coherent than that which results from other approaches to elicitation.

Producing a diagram is also a powerful means of enabling the developer to synthesise available knowledge on a particular topic and, as a result, to increase his or her understanding of that topic. Diagrams can be used to make an explicit statement of what is known about the topic. Furthermore, it enables developers to assess the completeness of their current understanding or of the available knowledge, through the identification of missing linkages in the diagram. The facility for diagram generation provided within AKT, (see Chapter 8) is a powerful tool in this respect.

The diagramming interface uses a restricted syntax such that two nodes with a link between them is equivalent to a unitary statement. The two nodes and link are parsed to create both a formal representation of the unitary statement and a natural language equivalent. Figure 1.3 illustrates the correspondence between two nodes with a link and a formal unitary statement. In this way, you can add to a knowledge base without learning the formal grammar. A range of tools provides a flexible diagramming environment. The ability to develop hierarchically linked sets of diagrams overcomes the space limitations, which can be associated with a diagramming approach.

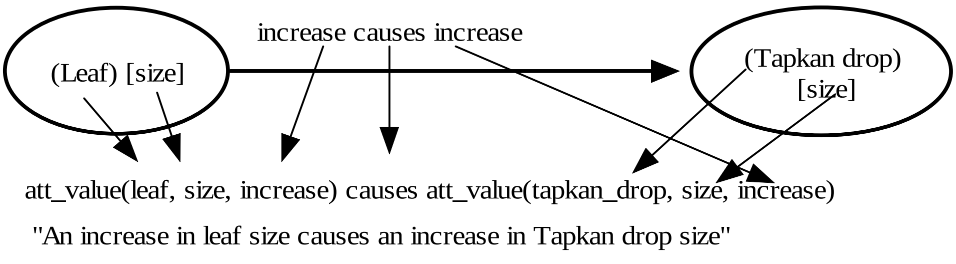

Figure 1.3 *Correspondence between the content of a diagram and natural language and formal statements.*

The diagram syntax does not make use of the full range of combinations possible with the formal grammar, so some types of statement (attribute value statements and comparison statements) can be entered only through the text interface. Nevertheless, while diagramming is less expressive than text, it allows creation of coherent knowledge bases by less experienced users. The diagramming and text based interfaces can be used interchangeably which allows the user greater flexibility. There is also a facility for the automatic diagramming of selected sets of text-entered statements, to gain an overview of selected parts of the knowledge base.

1.5 REASONING WITH KNOWLEDGE BASES

A knowledge base is developed in AKT in order to create a synthesised report of the current state of knowledge on a defined topic. The knowledge may then be used for a range of reasoning tasks. Some examples of different user level reasoning tasks are listed in Table 1.1.

Table 1.1 *Some examples of user level reasoning tasks*

- Generating synthesised reports of the current state of knowledge (local, scientific or combined) on defined topics as a resource for extension and planning.
- Exploring the knowledge base in order to identify discrepancies between knowledge held by a local community and scientifically verified information.
- Correlating scientific information with local description to broaden the range of applicability of research results.
- Facilitating research planning and prioritisation, by identifying key gaps in understanding that constrain the productivity, stability and sustainability of an agroecosystem.

The formal grammar balances three competing needs:

- the need for an ***expressive*** grammar which allows a significant proportion of ecological knowledge about agroforestry to be represented;
- the need for a ***simple*** grammar which can be successfully applied by users with only limited training; and
- the need for a ***flexible*** grammar which can be combined with a range of appropriate inference mechanisms to automate reasoning tasks.

To maximize flexibility, a task language is provided within AKT, which is designed to allow you to customize reasoning tasks. This may be done by adapting existing tools to suit your particular needs, or by creating completely new tools, the need for which was not envisaged by the software development team.

1.6 APPLICATION OF THE KNOWLEDGE-BASED SYSTEMS APPROACH TO AGROFORESTRY RESEARCH AND EXTENSION

To date, knowledge bases have been created in conjunction with agroforestry research programmes in Nepal, Sri Lanka, Thailand, Tanzania and India, Indonesia and Kenya. Users may be researchers or extension workers, though the system is most powerful where there is an institutional investment in making better use of qualitative information. The system currently being used in a range of applications by governmental and non-governmental organisations around the world, some of which are listed below:

i. Assessing farmers' knowledge in participatory crop improvement programmes for maize/millet (Agricultural Research Station, Pakhribas, eastern midhills of Nepal) and cassava/maize (Corpoica, Caribbean Region, Colombia) in the government sector.

ii. Assessing farmers' knowledge of soil fertility and green manure in an NGO crop improvement programme in the Nepalese Terai (LI-BIRD).

iii. Assessing farmers' knowledge of gap rejuvenation techniques for jungle rubber agroforests in Indonesia (ICRAF).

iv. Assessing local knowledge of rubber intercropping practices in Sri Lanka (Rubber Research Institute).

1.7 THE UTILITY OF THE APPROACH

It is difficult to quantify the utility of output resulting from the application of the knowledge based systems approach. Many of the primary outputs are less tangible than the definitive answers produced by a more traditional decision support system which may include quantitative models or expert systems. The KBS approach is not intended to produce definitive and, therefore, testable recommendations. Nevertheless, trial applications of the approach to date have demonstrated that it can have a real and significant impact on agroforestry based research and development programmes (see Box 1).

Box 1. Researchers in Nepal design different types of research when they learn about what farmers already know

In the eastern mid-hills of Nepal it was assumed during the 1980s by the forest service that the planting of trees on farmland was constrained by lack of appropriate planting material and so nurseries were set up and seedlings offered to farmers. Take up of seedlings by farmers was low, and it was later discovered through acquiring local knowledge that farmers were, in fact, already managing abundant natural regeneration on their crop terrace risers (Thapa *et al.*, 1995). Basically there were plenty of naturally regenerating seedlings – farmers cut back those they did not want to develop into fodder trees. Furthermore they chose which species they did allow to grow on the basis of a sophisticated understanding of the seasonal feeding value of the fodder they produced (Thapa *et al.*, 1997) and the extent to which they affected crop yield and soil erosion (Thapa *et al.*, 1995) – aspects that research and extension staff had not adequately considered in choosing nursery stock. Farmers also used terminology not always understood by research and extension staff to describe tree-crop interactions. Perhaps most notably, farmers were concerned about canopy modification of rainfall drop size, because they thought that larger drops caused higher rates of soil erosion. The process of water droplets falling from leaves was locally known as *tapkan*.

Not only had research and extension staff been unaware of this farmer knowledge, but also it was actually contradicted in the scientific literature which held until recently that drop size was independent of canopy morphology (Brandt, 1989, Thornes, 1989). Scientific understanding of how leaves of different types affected drop size was revised, and brought in line with that of the Nepalese farmers in 1993 when new instrumentation allowed more reliable measurement of drop size (Hall and Calder, 1993). The key point here is that once researchers were made aware that tree-crop interactions were important to farmers and that farmers had a cogent interest in minimizing negative impacts of trees on soils and crops they could see the relevance to farmers of research in this area and had the terminology to communicate with farmers about it. In the last few years researchers at frontline agricultural research institutions serving the eastern mid-hills have done work directly on tree-crop interactions (Joshi and Devkota, 1996), and there are now plans for tree-crop interactions to form a central basis of agroforestry research in the Western Development Region (Paudel, *et al.*, 1997).

1.7.1 THE EXPRESSIVENESS OF THE AKT APPROACH AND IMPLEMENTATION

The formal grammar has proved effective in capturing a significant proportion of the description of an agro-ecosystem as given by farmers (see Box 2). It was designed as a means of capturing qualitative descriptions of components of the agro-ecosystem and the ecological relationship between these components, rather than capturing technical knowledge about the management of a practice. Technical knowledge is captured by the grammar only in relation to the impact of management actions on the ecological relationships and their impact on management objectives. The justification for this emphasis on 'deeper' explanatory knowledge lies in the postulates that:

- actual management techniques are subject to diverse influences – available knowledge about the ecology of the system, economic considerations, personal preferences, and so on: and

- of these, explanatory ecological knowledge may often be portable between sites and across cultures while many other influences are site and culture specific (Walker *et al*., 1991).

Box 2. Farmers' recognition of deficiencies in their knowledge about below-ground tree-crop interactions

While farmers recognised six tree attributes (leaf size, leaf texture, inclination angle, crown diameter, crown density and tree height) that affected *tapkan* (see Box 1) and shade, and described causal mechanisms for how each attribute affected them, their knowledge of below-ground competition was restricted to a rough classification of 40 out of the 90 tree species found on farms as being either *malilo* – enhancing soil fertility and less competitive with crops, or *rukho* – competitive with crops (Thapa, 1994). Causative knowledge about why trees were classified in these ways included only two elements: a gross classification of root systems as predominantly shallow or deep and some knowledge of the speed of decomposition of leaf litter (which occurred above-ground and so could be observed). As trees were regularly lopped for fodder, a number of issues pertinent to practical management arose with respect to species differences in root systems characteristics and the effects of different lopping strategies on root development and competitiveness, which farmers were hitherto unable to address.

The rigorous approaches to representation and analysis, which are used in AKT, have made it possible to explore the comparability and compatibility of knowledge from different sources. Application of the grammar across a range of agroforestry research programmes has shown that ecological knowledge can be made comparable across sites and cultures – including the divide between scientific or professional knowledge and the ecological knowledge held by farming communities (see Box 3 and Box 4).

1.7.2 THE KNOWLEDGE BASE AS A RESOURCE

Creating a knowledge base involves a significant investment of time – particularly when many people have to be interviewed. The product therefore, should be a resource that is suitable for many purposes. AKT has been designed in a way that should allow development professionals within research institutions to make routine use of a set of centrally maintained topic-specific or problem specific knowledge bases for a range of purposes, and to improve the content of the knowledge bases as appropriate (Sinclair *et al*., 1993).

While this is possible with the current software, a clear vision of the range of tasks for which the knowledge base is intended is required from the outset. Thus an effective set of criteria can be developed to enable decision making during knowledge representation. This clarity of purpose is particularly important where more than one individual is involved in creating the knowledge base, or where the knowledge is derived from more than one group of informants. For example, comparison of the knowledge bases created to date suggests that a list of key processes might be identified which are likely to be important in any description of the ecology on an agroforestry practice. While the terminology used in the lists of processes of these different knowledge bases is not immediately comparable, it is apparent that the same fundamental processes (shading, rainfall interception and nutrient cycling for example) are being described in each knowledge base. Starting from a common knowledge base template may facilitate the creation of knowledge bases that are generic in their content and can be combined successfully. Earlier approaches to develop templates at a statement level (Haggith *et al*., 1992) proved difficult to implement, but this more flexible, higher level approach may prove effective in facilitating the development of coherent and comparable knowledge bases.

Box 3. Comparative analysis of scientists' and farmers' knowledge about the tannin content of tree fodder and its implications for feeding farm animals

The existence of formally documented records of farmers' and researchers' knowledge about the nutritive value of tree fodder (Thapa, 1994; Thapa *et al*., 1997) made it possible to compare the equivalence of terms used by farmers and scientists. This was done using automated reasoning (Kendon *et al*., 1995) and it was found that there was some equivalence between the way in which farmers used the term 'leaf bitterness' and scientists used the term 'tannin content' – put simply, fodder that scientists described as having a high tannin content tended to be described by farmers as bitter. However, while scientists had some detailed knowledge about the role of tannins in protein digestion by ruminants and decomposition of leaf litter, they knew very little about the actual tannin contents of the 90 native species used by farmers and how this varied seasonally. In contrast, farmers did not possess detailed knowledge about the mechanism of action of tannins in ruminant digestion, although they did associate leaf bitterness with low palatability and nutritive value (Thapa *et al*., 1997), and their local classification of fodder appears to encompass implicitly effects of tannins on protein supply to the duodenum in cattle (Thorne *et al.*, 1997). Farmers could, however, articulate detailed knowledge about how leaf bitterness varied in a large number of tree species throughout the season. This demonstrates complementarity between farmers' and scientists' knowledge that could be exploited in designing appropriate research (farmers' understanding of intraspecies variability has already led researchers to revise strategies for sampling tree material for analysis of nutritive value). Clearly, because of complementarity, the combination of what farmers and scientists know represents a more powerful resource than either knowledge system alone.

Box 4. Identification of leverage points by comparison of what farmers do with what they know

Continuing the unfolding example related to Nepalese hill farming used in Boxes 1-3, in addition to documenting farmers' and researchers' knowledge, a detailed tree inventory was conducted, permitting comparison of what farmers said about trees and how they actually incorporated them into their farming systems (Thapa, 1994). Statistical analysis of the location of trees that farmers classified as *malilo* and *rukho*, showed that farmers had a higher proportion of *malilo* trees growing in association with crops than *rukho* trees, consistent with *malilo* trees being considered less competitive with crops and enhancing soil fertility. In contrast, nearly half of the trees that farmers had, which they classified as causing heavy *tapkan*, were grown on crop terrace risers where, according to local knowledge, they would reduce crop yield and promote soil erosion. Thus, despite having a clear understanding that larged-leaved tree species were competitive with crops and promoted soil erosion, farmers still planted them in association with crops. The explanation for this was that farmers were trading off the negative impacts of these trees on crops and soil against their high fodder value at key times in the dry winter season. Subsequent analysis of formally documented local knowledge (Joshi, 1998), indicates a positive relationship between leaf size and palatability of tree fodder among the species used by farmers (>70% of trees classified by farmers as large-leaved were also classified as having high palatability, whereas < 20% of trees classified as small-leaved were highly palatable). This represents a key constraint in the system where farmers are having to sacrifice crop yield and tolerate soil erosion in order to obtain fodder at key times in the season. Hence, this identifies a leverage point where research, to introduce or breed a smaller-leaved tree with the same fodder characteristics as the large-leaved species that farmers are currently using, for example, may represent an adoptable advance that addresses current constraints.

1.7.3 THE UTILITY OF REASONING MECHANISMS

The application of reasoning tools in knowledge base management makes the development of concise and coherent knowledge bases much less difficult and time consuming than it would otherwise be.

The application of reasoning tools has also allowed novel approaches to knowledge analysis to be applied to complex sets of information. These approaches would be untenably time consuming and complex to apply without automated reasoning.

Finally, trials have shown that reasoning tools are effective in allowing users access to the content of the knowledge base, either to learn from it via tutorials, or to use the knowledge in decision-making.

The two main automated reasoning features supplied by AKT are:

1) property inheritance
2) causal diagramming

1.7.3.a Property Inheritance

In an object hierarchy that is organised in the form of an inverted tree with the root at the top and the branches below, the lower objects inherit the properties or characteristics of the objects from which they are descended. Take for example, an object hierarchy describing plant taxonomy, in which the name of the hierarchy, or the SuperObject is 'plant' whilst somewhere further down the tree one of the members (sub-objects/descendants) of the object hierarchy is 'lettuce'. Thus the statement 'watering plant causes plant growth to increase' would mean that, by property inheritance, we could infer the statement 'watering lettuce causes lettuce growth to increase'.

1.7.3.b Causal Diagramming

In some knowledge bases there may be hundreds of statements and it is difficult to determine the overall structure. To enable the user to see what structure does exist between statements, AKT uses automated reasoning techniques to:

(a) represent each statement by two nodes with a link between them describing their relationship;
(b) sort the statements into related sets of nodes and links;
(c) draw the resulting nodes and links in such a way that the user can immediately see what relationships exist between the statements.

Various facilities are also provided in AKT to allow the user to manipulate these diagrams to improve the representation and intelligibility of the knowledge within the knowledge base.

Key points of chapter one

- Agroforestry is interdisciplinary and involves complex decision making for planning and extension programmes.
- The knowledge-based systems approach (KBS) offers a practical method of capturing, storing and retrieving knowledge from diverse sources.
- Creation of a knowledge base involves knowledge elicitation and knowledge representation using AKT, a tailor made software for the purpose.
- AKT offers both a text mode and diagram interface for knowledge representation and retrieval from a knowledge base.
- The task language provides a user-friendly environment for developing and implementing 'tools' for processing and outputting knowledge from a knowledge base.
- Several successful applications of KBS approach have demonstrated the use and utility of this novel method in incorporating local and scientific knowledge effectively in planning research and development programmes.
- The process of creating a knowledge base can have a significant impact on the knowledge base developer's understanding and perception of domain under investigation.
- Formalisation of knowledge enables the comparison of knowledge from different sources (e.g. farmers and scientists).