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Integrating Geomatics and Participatory Techniques for Community Forest Resource Assessment in Nepal

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'Here in the Himalayas it is man who is just tolerated, in meagre communities at infrequent intervals, where the mountains relent enough for him to survive by the exercise of heroic labours - and also by the exercise of much more intelligence than is recognised by those theorising agricultural advisors who come East in droves, laden with University degrees, and who would be dead within a month if left to fend for themselves on a potentially fertile Himalayan mountainside'.

(Murphy, 1967, p.178)

Declaration

No part of this work has been submitted for the award of a qualification at this or any other institution. All published work has been fully referenced.

Signed

Gavin H Jordan

Abstract

Community forestry resource information needs in Nepal have been increasing rapidly, due principally to a widening interest in responsible forestry, the increasing ability to process information and the possibility of obtaining commercial products from community forests. Coupled with limited resources for conducting inventories, this requires new methods to, and approaches for, community forest resource assessment. Participatory resource appraisals, involving local people in resource assessment, have been gaining popularity in recent years and have been employed in Nepal. Additionally, geomatics techniques for forest resource assessment have been rapidly developing, providing a number of tools that have not been fully evaluated for Nepal.

Community forest resource assessment needs to be integrated into the process of community forestry as far as possible, to increase participation. To achieve this, an understanding is required of the development of forest management, and why the emphasis has changed towards social or community forestry. Underlying social issues and social theory supporting participatory forestry are discussed. Current trends in information needs for community forestry are also identified.

Techniques for forest resource assessment are presented, and their potential for use in a participatory context discussed. The techniques come from a wide range of areas, involving geomatics, traditional and participatory inventory techniques, and rapid appraisal tools.

A research method is developed which addresses three key areas: examining the potential for a range of geomatics techniques for community forest resource assessment in Nepal; developing and testing an improved method of community forest resource assessment; and developing a framework for integrating geomatics and participatory assessment techniques, allowing the assessment process to be organised and evaluated.

Geomatics tools were found to have great potential to benefit the resource assessment process, assisting and simplifying the collection of spatial information. However, as geomatics and a quantitative approach to resource assessment have the potential to reduce participation, for the benefits to be realised a systematic framework needs to be used to provide an integrated, participatory method.

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List of Abbreviations

BA	Basal Area
CBA	Cost-Benefit Analysis
CFRA	Community Forest Resource Assessment
dbh	Diameter at breast height
DFO	District Forest Office/Officer
DoF	Department of Forests (Nepal)
DGPS	Differential Global Positioning System
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
FECOFUN	Federation of Community Forest User Groups in Nepal
FSC	Forest Stewardship Council
FUG	Forest User Group
GIS	Geographic Information System(s)
GPS	Global Positioning System
HMGN	His Majesty's Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
ISDM	Information Systems Development Methodology
LFMU	Local Forest Management Unit
MIS	Management Information Systems
MRI	Multi-Resource Inventory
NACFP	Nepal-Australia Community Forestry Project
NTFP	Non-Timber Forest Product
NUKCFP	Nepal UK Community Forestry Project
PARDYP	People and Resource Dynamics Project
PDOP	Positional Dilution of Precision
PGIS	Participatory Geographic Information System(s)
PM&E	Participatory Monitoring and evaluation
PPGIS	Public Participation Geographic Information System(s)
PPM	Participatory Photo Mapping
PRA	Participatory Rural Appraisal
PSP	Permanent Sample Plot
RA	Rapid Appraisal
RPP	Range-Post Planning
RRA	Rapid Rural Appraisal
SD	Standard Deviation

Chapter one: Community Forest Resource Assessment: the problem and the issues

1.1 The research problem

This thesis addresses the problem of obtaining resource information for community forestry management. The aim of this thesis is to establish a systems-based approach to Community Forest Resource Assessment (CFRA) where geomatics and other quantitative approaches are integrated in a participatory process, using the most appropriate techniques. In order to produce a current and workable method a number of potential tools for, and approaches to, resource assessment were evaluated. These were taken and/or modified from the range of participatory and quantitative methods employed for resource assessment.

The field work for this study was conducted in Nepal, a country at the forefront of community forestry development. The problems of CFRA in Nepal are indicative of those in other countries with a similar institutional and resource situation. The key problems are a lack of time and resources for conducting assessments, coupled with increasing information needs. This has meant that assessment approaches have tended to be either rapid and lacking in data for management planning, or too complex to be widely implemented. Additionally, the existing documented approaches to CFRA in Nepal are not felt to provide a systematic method allowing for evaluation or quality assessment of the approach (Jackson, Malla, Ingles, Singh and Bond, 1996: Ingles, Jackson, Singh, Dev, and Branney, 1996). Successfully addressing this problem requires a critical examination of existing techniques of CFRA in Nepal, and an evaluation of promising new techniques that may allow resource information to be collected more efficiently than before. A framework that can integrate the individual processes and activities of CFRA has to developed. It must ensure that participation is actively encouraged and the approach can be critically assessed.

The research conducted for this study was designed to improve the method of CFRA. A lack of defined methodological approach is a weakness which can in turn result in a lack of participation, organisation and evaluation.

There are two key outputs to this work. The first is an evaluation of geomatics and CFRA techniques in Nepal, to determine suitability and to improve existing method. The second is a systems based framework for CFRA, based on the rapidly evolving concepts of systems design, particularly Participatory Geographic Information Systems (PGIS); this also includes a method for evaluating CFRAs.

1.2 Why geomatics and participatory techniques?

A participatory approach is essential to community forestry. As well as participation being desired in the design, planning and implementation of community forestry it is also desirable in the planning and collection of forest resource data. A wide range of tools and techniques have been developed to obtain and portray forest resource information, spanning several disciplines. These techniques can be broadly divided into two groups: participatory techniques, and quantitative techniques, which incorporate an element of spatial data. Participatory techniques tend to be fairly simple and non-technical, encouraging a bottom-up approach to defining information needs and data collection. Quantitative approaches (particularly geomatics) are seen by many as the antithesis of this. The technology employed tends to be expensive, centralised, requires trained professionals and may be disempowering for the rural poor. Owing to this polarisation of approaches the fields of geomatics (and Information Technology in general) and rural development have remained largely mutually exclusive (Dunn, Atkins and Townsend, 1997). Despite the lack of interdisciplinarity currently displayed, geomatics technology can be a useful component of a CFRA. Much of the information required for CFRA is spatial or has a spatial component. Geomatics tools can be used to capture, analyse and display data that is difficult to obtain by using traditional participatory methods. Additionally, the information needs for community forestry have been increasing over the last few years (see section 2.5.2 and 4.1). With the potential that geomatics have to offer in this area, it is essential to examine how they can be incorporated into a participatory resource assessment.

This thesis argues that geomatics can successfully and beneficially be combined with participatory techniques for CFRA. For this to happen, the geomatics technology has to be integrated fully into a participatory process appropriate to the social and organisational context. It is argued that the focus has to be on the participatory process rather than the technology. This requires a fundamental shift in the GIS paradigm, which is firmly rooted in functionality and is technically orientated. This is illustrated by Huxold and Levinson (1995), who observe that 'for most people buying GIS technology is the most exciting phase of a project – for many people it is akin to buying a new car'. There is a new school of thought developing, often called participatory GIS, that has moved away from viewing geomatics as primarily technological tools, towards seeing them as part of a fully integrated participatory process or system. This is the most recent development in a decade old move towards producing a more socio-technical approach to GIS, rather than the traditional techno-centric view (Reeve and Petch, 1999). The theories of participatory GIS have been used and developed in this thesis to provide a conceptual basis for integrating geomatics techniques into a participatory process.

This thesis developed out of an initial desire to conduct a technological evaluation of a number of geomatics techniques, to assess their potential value for community forestry in Nepal. During the early stages of this work it became apparent that although thorough technological evaluations were necessary and important, it was also important to determine how these tools could be beneficially integrated into a participatory process. Initial fieldwork and scoping studies with community forestry professionals and Forest User Groups (FUGs) in Nepal identified a need to produce a process and framework for CFRA, within which the individual geomatics techniques could be placed. This thesis covers two main research areas: an evaluation of a number of geomatics and spatial tools for CFRA; and the development of a systems based framework for forest resource assessment.

1.3 Background to the thesis

Over the last two decades there has been a shift in developmental forestry towards community participation in forest management, particularly in the tropics and sub-tropical regions. Prior to this the traditional view of developmental forestry was one of 'expert' foresters imposing their technical knowledge on forests and communities, with little or no consultation with the local population (see section 2.2 and Westoby, 1962;

Van Gelder & O'Keefe, 1995; Messerschmidt, 1995). Apart from ethical and philosophical objections to this approach, it is unsatisfactory, as forestry projects operating without the support and involvement of the local population usually fail (Carter, 1996). It is important not to be too critical of the earlier approaches to developmental forestry, as the problems of management were very complex, forest ecology was less understood, and the paradigms for forest management different (Gilmour & Fisher, 1991).

In the early 1980s practitioners and academics became worried by the lack of local community participation in development, and by the fact that the 'trickle-down' effect of large scale projects was not apparent. This led to the widely documented 'paradigm shift' in development, away from the idea of imposing expert knowledge to an approach that encouraged local peoples participation (Chambers, 1983).

In forestry terms this led to an increased interest in participatory forestry: forestry projects where the local population are actively encouraged to take part in forest management, to a greater or lesser extent (see, for example, Carter, 1996; Hobley, 1996a). Initially this was termed 'social forestry', but increasingly the term 'community forestry' has been used. Hobley describes the evolution from social forestry to community forestry:

> 'Social forestry and farm forestry were the first new practices in recent history to bring foresters out of the forest and into the villages and farms of the people who are the forests' primary users. New community forestry programmes seek to go a step further, recognising the role of these users in the management of natural forests - bringing the people back into the forests.'
> (Hobley, 1996a, p.19)

Other terms used include 'environmental forestry', 'farm forestry', 'rural development forestry' and 'joint management forestry' (Hobley, 1996a, p.16). It should be noted that these definitions have been interpreted differently, for example Van Gelder & O'Keefe (1995) refer to 'people orientated forestry' as social forestry, including agroforestry and farm forestry within this term. In this work the term community forestry refers to participatory community orientated forestry. It has best been described as the control and management of forest resources by local people (Gilmour and Fisher, 1991).

Community forestry involves a high level of participation in forest projects by the local population. The actual level of participation varies greatly and is discussed in detail later (see section 3.6.1). The most important methods for facilitating participation have been termed 'rapid appraisal techniques'. These techniques come from the fields of Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA), Rapid Rural Systems Appraisal (RRSA), and Rural Systems Analysis (RSA) (Messerschmidt, 1995). Rapid appraisal methodology is good for obtaining qualitative information, which may be quite subjective, i.e. the relative importance of fuelwood compared to agricultural land. It provides a basic overview of a forest resource and the way people interact with it. It should not be claimed to provide quantitative data, or accurate spatial information, without including other research methodologies which are more suited to collecting quantitative data for analytical evaluation (Molnar, 1991; Bryant & Bailey, 1991).

There are a number of ways of collecting quantitative data to support community forestry management:

i. The traditional way is by a conventional forest inventory conducted by trained foresters. This approach is inappropriate for community forestry schemes, being expensive and alienating the local community (Branney, 1994a).
ii. Permanent Sample Plots (PSP's) may be used to provide information on forest dynamics.
iii. Remote sensing, satellite imagery and aerial photographs may provide some quantitative data.
iv. Community or participatory inventory techniques are gaining popularity, where the local community is integrally involved with conducting and, ideally, planning the forest inventory. This approach often produces both quantitative and qualitative data.

Additionally, other participatory methods such as participatory mapping may provide spatial information, although its geographical accuracy may be poor. Accuracy can be improved by combining this approach with (iii) above, and including other aspects of geomatics technology.

Geomatics, which refers to the integration of means used to acquire and manage spatial data (McDonnell and Kemp, 1995), is a field which has great potential for natural resource management. There are three main technologies involved in geomatics: remote sensing, Global Positioning Systems (GPS) and Geographic Information Systems (GIS). These technologies have been widely applied to conventional forestry (see for examples Haylor and Jordan, 1994; McKendry and Eastman, 1992). To date, there has been only limited direct applications of geomatics to community forestry (Carter, 1996).

As mentioned above, there is potential for integrating geomatics and rapid or participatory appraisal techniques (Kyem, 1999a; Abbot *et al.,* 1998; Dunn *et al.*, 1997; NCGIA, 1996; Poole, 1995; Hutchinson and Toledano, 1993). The most obvious application, and one which has been developed, is integrating participatory mapping, GPS and GIS (Stockdale and Ambrose, 1996). This has been used to 'rubbersheet' participatory maps (improve their spatial accuracy). Additionally, GPS can be used to georeference inventory data, locate Permanent Sample Plots, and to mark boundaries, communal areas, paths etc. More excitingly, if GPS can be used to georeference spatial information obtained from participatory methods, this information can be put into a GIS to organise and analyse the data. This provides scope for inputting diverse information, such as usage rights, fodder yields, timber values, slope angles etc., which can then be analysed, and used to provide the community with information to support informed decision making.

1.4 Problems and issues with integrating geomatics and participatory approaches

Although the above illustrates some examples of how geomatics have and can be utilised in CFRA, successful real-life examples are still limited (Weiner & Harris, 1999: Kyem, 1999a; Martin, 1999). This is due to two key sets of problems: technical and organisational. Geomatics technologies are complex to use, requiring fairly extensive training. To be able to use them successfully in developing countries and in a participatory context requires an innovative and imaginative approach – answers to problems will often lie outside of technical manuals or training programmes.

Organisational problems are considerable, ranging from how to charge batteries up with a limited electrical supply, through to how to increase the level of participation in resource assessment procedures. This last issue is of great importance. Very few geomatics applications in participatory resource assessment achieve a high level of participation from local communities. This is not surprising. It is difficult to obtain genuine and representative community participation even when using techniques specifically designed to encourage this. Once tools that require expert knowledge are introduced into the resource assessment, there is an increased likelihood of community alienation and misunderstanding. The only way of using these tools in a truly participatory context is to embed them within a structured participatory process.

Initial work for this study identified a number of specific issues that needed addressing within the area of integrating geomatics and participatory approaches for CFRA. These became the objectives for the study and formed the basis on which a framework for CFRA could be designed and evaluated:

(i) technical evaluation of geomatics technology for use in a participatory context for community forestry in Nepal

(ii) assessment of the information requirements for CFRA, and of the means of obtaining this information, with an evaluation of the accuracy of information obtained

(iii) development of an improved method for CFRA in the mountains of Nepal

(iv) development of an appropriate systems based framework for conducting a participatory geomatics forest resource assessment, including an evaluation strategy

Before examining the research problem in greater depth, it is important to provide some background theory and context for the development of participatory forestry, and the tools and techniques that are used to assess forest resources and the associated social issues. The next two chapters provide this. Figure 1.1 provides an overview of the structure and content of the thesis.

Chapter1: Introduction
Introduces the key problems and issues of integrating geomatics and participatory techniques. States the overall aim and objective of the thesis, and outlines the structure

Overall Research Aim:
To establish a systems based approach to CFRA where geomatics and other quantitative approaches to forest resource assessment are integrated in a participatory process

Literature review & background theory component
Provides the context within which the problem of integrating geomatics and participatory techniques can be examined. Identifies the areas as separate disciplines and determines that 'participatory GIS' contains the best body of theory and experience to successfully unite the fields

Chapter2: Forestry & community forestry
Describes and reviews the history of people orientated forestry, the development of community forestry, & identifies recent developments in community forestry in Nepal

Chapter 3: Forestry assessment tools
A wide ranging chapter covering geomatics tools, more traditional forest resource assessment techniques, and participatory appraisal theory & tools. The development of participatory GIS is also examined in detail

Chapter 4: The study area
Provides an overview of Nepal, the Dolakha area of Nepal and the Yarsha Khola watershed. Considers the natural and socio-economic environment.

Chapter 5: The research problem and methods
Explains the complex nature of the research problem, and identifies specific methods to be used. Details results of a scoping study to finalise methodology.

Chapter 6: The role of geomatics
Details the results of a series of evaluations of geomatics technologies to determine their use for community forestry in Nepal. GPS, GIS and participatory photo mapping are examined

Chapter 7: Participatory resource assessment
Examines techniques used to obtain forest resource information by conducting participatory inventories, and how the information can be organised in a GIS and fed back to the FUG

Chapter 8: A framework for participatory resource assessments
This ties together the previous two chapters and identifies the requirements for a workable, flexible framework for integrating geomatics and participatory techniques. Examines quality assurance and evaluation issues

Chapter 9: Discussion & conclusions
Discusses the wider issues identified by the research. Explores the potential role of geomatics for CFRA, and examines institutional issues affecting the potential for participatory geomatics. States the conclusions drawn from the research and identifies areas where further research could be conducted

Figure 1.1: Flow diagram illustrating thesis structure and content

Chapter 2: Forestry and Community Forestry

2.0 Chapter overview

This chapter provides a brief history of forest management, and discusses the changes away from industrial, production orientated forestry towards the 'environmental', 'social' and 'community' forestry that have occurred in many parts of the world, particularly in less developed countries. The drive behind this paradigm shift in the aims of forest management is also discussed. Current trends in community forestry are highlighted, with a particular emphasis on Nepal.

Much of this chapter provides contextual background and theory, regarded as essential for understanding both the increased information needs of community forestry, and the need for a focus on participation and social issues. This chapter attempts to show why, even for resource assessment, the emphasis should be on community.

2.1 A temporal overview of forest management

Forests have been managed by human populations for several millennia. Westoby (1989) implies that mankind may have been modifying forest cover (through the use of fire to create grasslands) for at least 1.4 million years. This early forest modification is also discussed by Mather (1990), who questions whether this can be termed 'management', preferring to term it use of an ecological resource. Certainly, anthropogenic forest modification has occurred for tens of thousand of years, outside of the areas glaciated during the last major ice age (*ca.* 11 000 years ago). In these once glaciated areas the history of forest modification is much shorter, with cultivation starting to significantly reduce the area of 'wildwood' (natural forest cover) in northern Europe about 4000 years ago. The concept of forests interrelating with environmental functions was understood by the classical era. Plato, discussing the exploitative felling of Attica in 1200 BC noted that:

'..there are some mountains which had trees not so very long ago, that now have nothing but bee pastures. The annual rainfall was not lost as it is now through being allowed to run over the denuded surface to the sea, it was absorbed by the ground and stored... the drainage from the high ground was collected in this way and discharged into the hollows as springs and rivers with abundant flow...'

(Plato, *Critius iii*, in Thirgood, 1981, p. 36)

In the United Kingdom there are detailed forest management records available from 1016, when King Canute drew up the *Charter of the Forest* (James, 1981), whilst globally, forest management has been documented for in excess of two thousand years. From these records, it is possible to illustrate the historical development of forest management, and perceptional attitudes to forest resources through simple linear models. Table 2.1 shows a sequential model based on work by Mather (1990) and Kimmins (1992).

Stage	*Trend in Resource Area/Action*	*Perception of Trend/Result*
1. 'Unlimited' resource	contraction	positive or neutral
I. Unregulated exploitation/clearing	little action or control over the use of the forest resource	over-cutting of local forests, unregulated exploitation of distant forests, colonisation and exploitation of forests in distant countries
2. Depleting resource	contraction	negative
II. Introduction of legal/political or religious taboos to regulate forest utilisation	centralised authoritarian, non-ecological, administrative approach - legislation and regulation based	beginning of forest management
	-------Forest transition-------	
3 Expanding resource	re-creation/expansion	neutral/negative
III. Development of an ecological approach to silvicultural and forest management	introduction of 'sustainability' as a forestry concept into legislation	sustainable supply of timber and many biological functions of the forest
4 Equilibrium?	(stability)	N/A
Development of 'environmental', 'social', or 'community' forestry	more people orientated and multiple objective approach to forestry	the management of a much wider range of resource functions - environmental, production, social, spiritual, recreational, aesthetics

Table 2.1 Sequential model of forest resource trends
Source: Adapted from Mather (1990) and Kimmins (1992)

Whilst this model is simplistic, Mather claims that it is valid for the majority of forest resources. It should be noted that it makes no allowance for private farm forestry or leasehold forestry (Ohler, 1999; Carter and Gilmour, 1989). Stage 1 of this model is characterised by a desire or need to reduce the forest area, to provide land for hunting, farming and building. At this stage the forest is often regarded as an 'enemy', harbouring dangerous animals, outlaws and evil spirits. This is expressed in folklore expressions such as 'beyond the pale'(pale being the boundary hedge between agricultural areas and the 'wildwood'). There is usually little control over the clearing of forest resources, and Government policy may actively encourage forest clearance, for example, through tenure rights for settlers of previously forested areas. This stage transforms into stage 2, when it is realised by some (usually hunters, environmentalists or economists) that there is a serious depletion of the resource. This results in a forest transition period, where the government, landed gentry or royalty enact legislation to control the reduction of the forest resource. The legislation tends to be authoritarian, and in Europe was often Draconian. If the resource depletion has been very severe prior to successful control, a third stage will occur, when the forest resource will be expanded. By this stage forest politics are usually quite complicated, and there will often be a variety of views as to whether forest expansion is beneficial or even desired, and whether it is being conducted in the best way to achieve the desired results. Quite complex forest management will be developed during this phase, based on the concept of sustainable yield, and developing ideas of ecological management (Kimmins, 1992). Mather (1990) believes that the sequential model may end in a period of equilibrium, when the resource is at its economically most advantageous size. Price (1989) suggests that there is little evidence to support this, and feels that if there is an equilibrium, it will be very dynamic, as the perceived value of economic, environmental and social functions of the forest resource alter. However, this later stage of forest management, whether resulting in equilibrium or not, requires a more people orientated type of forest management. This is the stage that a number of developed and developing countries are now at. As mentioned in the introductory chapter, this is variously termed social, environmental, responsible or community forestry.

It should be noted that in reality there is rarely a uniform transition process where the depletion of the forest resource is realised, shortly followed by the introduction of legislation aimed at controlling depletion, and a stabilisation/expansion of the resource. There may be many decades, or even centuries, between the introduction of legislation and the political will or infrastructural ability to enforce it. According to Mather (1990) much of the global forest resource is in the first two stages of his model, although legislation to protect and manage the forest will have been enacted. Examples of this include Zambia, where there is detailed legislation enforcing forest management, but an 11.6% loss in forest cover from 1980-1990; and Nepal, where there is genuine governmental concern about deforestation, but, again, a 10.5% reduction in forest cover from 1980-1990 (WRI, 1992; FAO, 1993a). Similarly, in the United Kingdom there were over fifty statutes concerned with forests and forestry passed prior to the eighteenth century (James, 1981), but the forest resource continued to degenerate until the early twentieth century.

Kimmins states that there has often been a failure to progress from stage 2 to stage 3, reasoning that this is often due to:

'political upheavals, social unrest, war, famine, and pestilence, as well as a lack of scientific knowledge and a frequent lack of political commitment to good stewardship of forest lands' (Kimmins, 1992, p. 50-51).

He also notes that in Europe progress had been made towards entering the third stage by the 12-13th century, but population increase and industrialisation reverted the situation back to stage 1. This illustrates that forest management may not progress from stage to stage in a uni-directional linear manner, but external influences may revert forest management back to a less developed level. Adlard (1993) comments that only in the recent post-industrial phase has progress towards high quality 'sustainable' forestry been made, and that this is highly dependent on political stability, participation and/or economic gain. Without these factors, quality forest management cannot thrive. Boydon (1987) also notes the current 'high energy' phase of human history has led to the rapid degradation of many forest ecosystems, and contains the potential to destroy entire natural systems through excessive resource extraction, pollution and mass destruction.

He states that there is a need to move into a more environmentally and socially considerate phase.

From the above it can be seen that contemporary forest management requires a combination of management techniques aimed at producing people or community orientated forestry, that is also 'sustainable' forestry. The development of this type of forestry is still affected (and hampered) by the policies of the last two centuries. Therefore examination of modern community forestry must start with the policies of the 1900s. It should be noted that the following discussion is limited anglophone policies, and particularly those of the Indian sub-continent. Different approaches to policy and public authority exist depending on the colonial history (Buttoud, 1997).

2.2 A history of the development of people orientated forestry

Colonial forestry was principally developed in India and Hobley (1996a) provides a review of Indian forest history, on which the following is based. The Indian Forest Service was formed in 1864, although there had been forest legislation prior to this, principally to preserve the forests and provide for continued exploitation rights. By the 1850s there were considerable worries about the state of India's forests, and a forest policy was enacted. It is interesting to note that during the 1870s there was considerable debate regarding whether Indian villagers should be allowed to manage their forest resources, or whether a policy of exclusion, with state control, should be adopted. The latter became law, restricting community forestry activities for a century. European foresters with a traditional background in classical forestry were sent to India, giving a highly technical slant to forest management. It should also be noted that policy also altered villagers *rights* to forest access and products to removable *privileges*. How this was interpreted and applied varied from region to region, a situation that today still has an impact on community forestry projects. The Indian model was applied elsewhere in the empire: DoFs were established in both Ghana (1908) and the Sudan (1910), to facilitate and control the extraction and subsequent supply of wood (Van Gelder and O'Keefe, 1995). Often the forestry practices deliberately excluded the local people, and many forestry associated activities, such as land appropriation, fines, cutting permits and the banning of traditional access rights, alienated foresters from villagers.

Although there were substantial changes in forest management in many less developed countries during the first half of the twentieth century (see Hobley, 1996b pp. 43-48), many DoFs inherited the ideas of this very traditional view of forest management on independence. This was enforced by donor and aid agency policies, which reflected the macro-economic development model in vogue at the time.

Until the 1970s most developmental forestry (and commercial forestry in developed countries) was based on the northern European macro-economic model (Van Gelder and O'Keefe, 1995). This involved growing large scale commercial plantations, with forest management geared towards high production. In a development context, it was presumed that industrial forestry would provide raw materials to trigger industrial development, earning foreign exchange, and initiating classical European style growth. In 1962 Westoby provided a key paper, linking industrial forestry with third world modernist development. This paper helped to shape developmental forestry theory for more than a decade. The type of forestry was designed to benefit the poorer members of society indirectly through stimulating economic growth, with the actual forestry practices based on those dating from colonial times. Wealth distribution would follow through 'trickle down' effects. Despite this change in orientation forestry was still characterised by traditional approaches, termed the 'fat controller' mentality by Van Gelder and O' Keefe (1995), namely:

- control orientated
- policing mentality
- often concerned with industrial outputs
- scientifically and statistically orientated
- based on European forest management practices, often even aged monocultures
- largely resource orientated

2.2.1 Reasons for a change towards people orientated forestry

During the 1970s a number of factors combined to encourage a change from the traditional macro-economic viewpoint towards a more people orientated view. The most important of these was the economic crisis that occurred in the early 1970s, due to American spending on the Vietnam war, and the 1973 increases in oil prices. This focused attention on energy sources, and a deficit in fuelwood availability was identified in many places (although this later proved alarmist - see Ives and Messerli, 1989). Secondly, the Sahelian droughts of 1968-1973 highlighted concerns over the environmental roles of tree cover in protecting rural resources. Thirdly, industry led theories of development changed towards people orientated development theories, such as rural development (Chambers, 1983). This was due to a realisation, enforced by the oil price increases, that industrialisation did not automatically lead to economic and social development. Indeed, many of the policies had led to increasing inequality between a small wealthy minority and a large, predominantly rural, poor (Chambers, 1985) - the perceived 'trickle down' effect not being apparent. Pandey (1983) illustrates how it failed to work in Nepal, with projects designed to promote industrialisation producing zero growth, due to a lack of infrastructure and suitable resources (Gilmour, King and Hobley, 1989).

Development in the early 1970s was over-shadowed by apparent eco-crisis, with significant livelihood degradation in many developing countries (Eckholm, 1975; Ives and Messerli, 1989). This influenced general development policy towards providing for basic needs (ILO, 1976) and although the specifics of basic needs strategies varied from country to country, the concept of providing adequate food, clothes, shelter, sanitation, transport and education was universal. What this represented was a major shift in development policy away from industrialisation towards the poorer members of society, and implied *participation* of rural people in decision making (Chambers, 1985). This general trend in development filtered through to developmental forestry.

The 1978 8th World Forestry Congress was titled 'forests and people'. At this conference Westoby publicly changed his view on industrial forestry promoting development, and instead endorsed 'social' forestry (Westoby, 1978). This conference represented a general shift in emphasis in developmental forestry (see FAO, 1978; World Bank, 1978). Forestry was now seen as a key vehicle for promoting social change, with participatory forestry emerging as a new world-wide practice for developmental forestry. In forestry terms this led to an increased interest in forestry projects where the local population were actively encouraged to take part in forest management, to a greater or lesser extent (see, for example, Carter, 1996; Hobley, 1996a). But by the early 1980s practitioners and academics had become worried by the lack of genuine local community participation in development, and that there still appeared to be little evidence of large scale projects benefiting the rural poor (Chambers, 1983). This led to the widely documented 'paradigm shift' in development, away from the idea of imposing expert knowledge, to an approach that encouraged local people's participation. There was a genuine revolution in the way that academics and proactive development agencies worked and thought (Pretty and Chambers, 1994).

However, Gilmour *et. al.* (1989) explains that although the policy changes following from this allowed for 'social' or 'community' forestry, e.g. putting people first and trees second, the forestry profession was still not ready to accept this, and community participation was largely tokenistic. It was realised that a fundamental move towards people orientated forestry required more than policy changes and introducing 'gender' and 'user group' terms into project documentation. A detailed participative process had to form the core of any effective people orientated forestry programme.

Before examining how people orientated forestry developed in Nepal, it is necessary to examine some of the key areas within people orientated, or community forestry, and look at some of the tools that have been developed to encourage a participatory approach.

2.3 Community forestry

It has been said that community forestry has more to do with people than trees (Gilmour and Fisher, 1991), representing a radical conceptual departure from forestry as discussed above. This is reflected in an approach dominated by the social sciences and participatory approaches. To fully understand community forestry a number of key social areas need to be examined, and these are considered below.

2.3.1 Pluralism

The ideas of pluralism are at the core of community forestry, and common property management in general (McKean & Ostrom, 1995; Ostrom, 1999). Pluralism is a philosophical concept recognising that there may be more than one set of values that are 'correct' for a given situation. Pluralism in a forestry context has been described as:

> '... the interplay of this multiplicity of ideologies, interests, actors and organisations, which have combined to create the current scenario and which can contribute to future development.' (Vira, Dubois, Daniels & Walker, 1998: 35).

Conceptually, pluralism lies between the theories of monism and relativism (Kekes, 1993). Monists believe that there is only one reasonable system of values. This is perhaps best illustrated by fundamentalist belief systems. Relativism believes that all values are entirely situation and context dependent, and that value systems cannot be justified on objective grounds. Pluralism acknowledges that whilst there are justifiable value systems, there may be many different value systems that are reasonable for a specific situation. It requires an acceptance of multiple, valid and reasonable values, realities, agendas and behaviours (Rescher, 1993).

The key features of pluralism are:

- accepting that for any situation there will be a number of equally valid value systems, based on different values
- accepting that if there are equally valid but different value systems, conflict is inevitable
- respecting other viewpoints, but not necessarily agreeing with them
- accepting compromise and attempting to reach solutions based on acquiescence

This last point is of particular relevance for community forestry, and is the least appreciated aspect of pluralism. Acquiescence seeks to minimise the number of people who disapprove of a course of action. Consensus seeks to maximise the number of people who approve of a course of action (Rescher, 1993). This has practical implications for the success of participatory projects; a marginalised stakeholder group who strongly disapprove of a forest plan are not likely to see it implemented.

A pluralistic approach is essential for both forestry departments and individual foresters working with FUGs. It is often difficult for forestry departments to take into account the complex political, social, economic and environmental factors that are necessary for community forestry, and this is true for developed countries as much as developing countries (Kennedy, Drombeck & Koch, 1998). Recognition of this problem has led to much developmental work directed towards institutional change and support (Eldridge & Nisar, 1995; Datta & Ray, 1996; Hobley, 1996c; FAO, 1997). Likewise, it is demanding for a forester to work in a pluralistic environment, where, in addition to traditional forestry skills, the forester should be able to:

- engage in dialogue with others
- listen effectively
- convey opinions and feelings effectively
- facilitate dialogue
- critically examine personal values, realities, agenda and behaviour
- accept the possibility of being wrong
- accept there is no 'right' way, just different perceptions
- forgo the role of 'expert'
- manage conflict constructively and beneficially

Historically, these skills were not considered core to a foresters training, and were rarely an integral part of forestry education and training (Temu, 1994). Dove (1991) noted that foresters in Pakistan made unwarranted assumptions about farmers, and it was tacitly assumed that foresters naturally had participatory and social skills. This situation has changed significantly recently, and training is starting to reflect these needs (Underwood, 1999; Jackson *et al.* 1996; Garforth, 1991; Field and Burch, 1988). However, it should be noted that it is only in the past few months that participatory training has moved beyond the donor supported environment into core forest department areas, and still only in limited geographical environments (Bacon, 1999, pers. comm.).

For community forestry to be implemented effectively it is essential that the ideas of pluralism are incorporated into the process. Due to the problems of a pluralistic approach to forestry outlined above, the effectiveness of this varies greatly. It has been widely observed that the success of community forestry at a FUG level is often dependent on the personal characteristics, enthusiasm and personality of the forest ranger (Hunt, 1998, pers. comm.). A successful forest ranger has to be sympathetic towards pluralism, and, perhaps without formal training, operate within this philosophical framework.

Geomatics techniques may have a part to play in providing a pluralistic approach to CFRA. GIS is a tool that can be used to portray multiple realities and viewpoints, and has capability for conflict resolution (Weiner, Harris and Burkhart, 1997).

2.3.2 The community

Community can be defined as:

"Commonness: people having common rights etc: the public in general: a body of persons in the same locality: a body of persons leading a common life…" (Chambers, 1990, p.289)

In forestry terms community has connotations associating it with 'people's forestry', objectives of providing direct benefits to rural people and with local people having a substantial role in decision making (Gilmour & Fisher, 1991). As a philosophical concept community is useful, but as a defined sociological term it is of less use.

The term community also has connotations of homogeneity, consensus and common interests, based on geographical locality, caste, religion, kinship etc. This does not equate with a pluralistic view and there is probably no village in the world where homogeneity is the case. Communities are often characterised by internal divisions, conflicts and differences in objectives and desires (Leach, Mearns and Schoones, 1999; Leach, 1997). Communities either need to be viewed as heterogeneous groupings based on locality (such as a village) or a community has to be divided into sub-groups. These sub-groups within a community have been termed 'interest groups', where there is some form of stronger group affiliation (Gilmour and Fisher, 1991). More recently, in a developed country context, communities have been divided into two similar types: communities of neighbourhood, and communities of interest (Forestry Authority, 1996). These communities of interest, or interest groups, are of great importance in community forestry

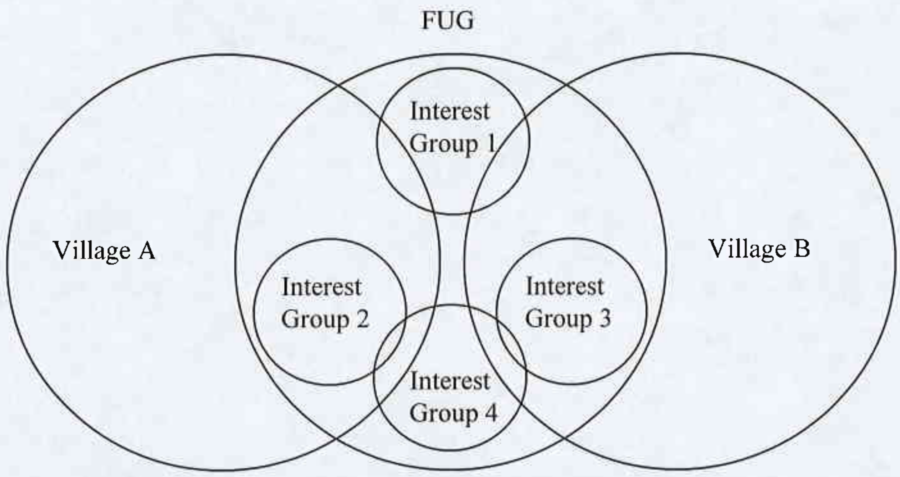
2.3.3 Interest groups and Forest User Groups

An interest group is composed of individuals who have a similar set of interests for a particular situation or development. In a community forestry context there are likely to be a number of separate interest groups, not mutually exclusive, each with different value systems and values, for example, individuals with significant private reserves of trees will have different interests to individuals with no personal forest resources. It is important that all interest groups are adequately represented in consultative processes. Gilmour and Fisher (1991) present the following minimal list of interest groups:

- women
- 'the poor'
- lower caste groups
- specialist distinct economic activities (e.g. blacksmiths or tea shop owners)

This list would in most cases be too brief: it is very rare that women or the poor form a homogenous interest group with common value systems (Rodda, 1991).

An FUG contains all the users of a community forest and has a committee comprised of representatives of all the interest groups. Figure 2.1 illustrates the composition of a FUG. A FUG is highly heterogeneous and it is important that all interest groups are fully represented within it. Membership of the FUG confers user rights to specific forest products. A key part of effective community forestry is ensuring that all interest groups are included in the FUG. This may be hard to achieve in realty. An example from the mid-hills and mountains of Nepal is transhumant interest groups. Herders often stay at villages en route for a few days, grazing on common property land, perhaps a community forest. This benefits some sectors of the local community: tea shop owners; brewers of beer; and the local village elite, who may charge a levy for grazing. It is difficult to involve such transient groups in consultation and they are often, deliberately or accidentally, excluded from such processes. This is now a significant problem in the Himalayan region: herdsmen find it difficult to use their traditional access routes to summer pastures, or graze in contravention of agreed community forest management plans.



Note: a FUG may have members from more than one village. Within the FUG are interest groups, which may also have members from one or more villages. Interest groups may have overlapping membership. The specific composition of a FUG will vary greatly in reality

Figure 2.1 The composition of a FUG

2.3.4 The politics of community forestry

Although politics are largely outside the scope of this study, it is hard to discuss community forestry without a brief consideration of the political issues. The following, frequently core activities within community forestry, are all highly political:

- institutional reform
- empowerment of disadvantaged interest groups
- restructuring village elite
- pluralism
- equitable control and distribution of common property resources

Community forestry, as with most development activity, is interventionist, except when it is community initiated collective action or an indigenous management system (Cornwall, 1995). Interventions have an effect on local power structures, and as these alter, some individuals will undoubtedly attempt to benefit from the changing situation. It is often the powerful members of rural society, the village elite, who benefit disproportionately. To minimise the likelihood of this occurring, all interest groups need to be involved in consultative processes aimed at producing an equitable distribution of common property resources. This will probably involve specifically focussing on disadvantaged interest groups within a community (Nelson & Wright, 1995). There are practical reasons for this:

- if people who utilise community forestry products fail to benefit from community forestry management arrangements, the silvicultural management rules will be ignored
- if interest groups are not involved in decision making and feel excluded from the decision making process during user group formation, they will ignore the management plan

(Gilmour & Fisher, 1991)

Equity, empowerment and restructuring are likely to be resisted by village elite's, as they reduce the likelihood of them netting the benefits of community forestry programs (Chambers, 1983; Ingles and Gilmour, 1989). As well as it being threatening at a local level, as community forestry becomes widely implemented (such as in Nepal) it represents a major national grassroots political force (FECOFUN, 1996).

2.3.5 The process of community forestry

Community forestry processes, guidelines and implementation vary greatly from country to country, and within country. This flexibility is necessary to allow the effective application in a variety of situations (Hobley, 1996a). In Nepal, the process has been divided into four stages by the Nepal-Australia Community Forestry Project (NACFP) (Gilmour and Fisher, 1991; Bartlett, 1992):

- Investigation: the forest ranger spends time with villagers explaining community forestry to villagers and rapport building. Existing usage patterns, user rights and management systems need to be identified. Management structures and any conflicts over the resource also need to be noted. This is a critical part of the process, but as 'nothing is happening' in development terms, it may be rushed, jeopardising the success of the project (Fisher and Malla, 1987).
- Negotiation: once the major issues are identified, discussions are held with interest groups, and conflicts between interest groups are resolved. Negotiation will include resolving access and use rights. Efforts must be made to prevent the process being hijacked by village elite's. The FUG is then formed, ensuring that all interest groups are adequately represented. Once these participatory social processes are complete a forest management and operational plan must be developed and agreed by the FUG, in conjunction with the DoF. Once the operational plan is agreed by the District Forest Officer (DFO) the forest is officially transferred from state management to community management
- Implementation: the forest management specified in the operational plan is implemented by the FUG. The Department of Forests (DoF) staff play a supporting role, assisting with the training and supervision of new forestry tasks, and monitoring forestry and FUG activities.
- Review and revision: appraisal and re-negotiation of the management arrangements, within the FUG and between the FUG and the DoF. Typically as confidence is gained by the FUG they will take on more complex forest management tasks. This may require a revision of the documented operational plan.

This process is outlined in Figure 2.2. The key output of the process of management planning is the operational plan. This is a written statement of how the FUG are going to manage their community forest, and how the DoF will assist them. The operational plan includes information on:

- The particulars of the forest (what management will be performed on the forest, why it will be done, who will do it, where, when & how).
- Objectives of the operational plan.
- Limitations of the operational plan.
- Physical features of the forest: size, type, altitude & location, with map.
- Historical background and previous management.
- Present condition of the forest.
- Procedures adopted for protecting the forest (from fire, grazing, disease).
- Forest management (management sub-divisions, management objectives of each sub-division, rotation lengths, silvicultural operations, thinning criteria and schedules, income generation, coppicing, felling, annual work schedule.
- Forest development activities (nursery, planting, weeding and demarcation activities).
- Sale and supply of forest products.
- Prohibited activities.
- Penalties and fines for prohibited activities.

(DFO, Sindhupalchok, N.D.)

Although the above appears detailed, in reality the spatial and technical forestry information is usually very limited, and often the operational plan does little more than legitimise existing management practices being conducted (Gilmour & Fisher, 1991). The above list would be considered too prescriptive by many workers (Nurse & Chhetri, 1992), and is probably best viewed as areas needing considering whilst developing an operational plan.

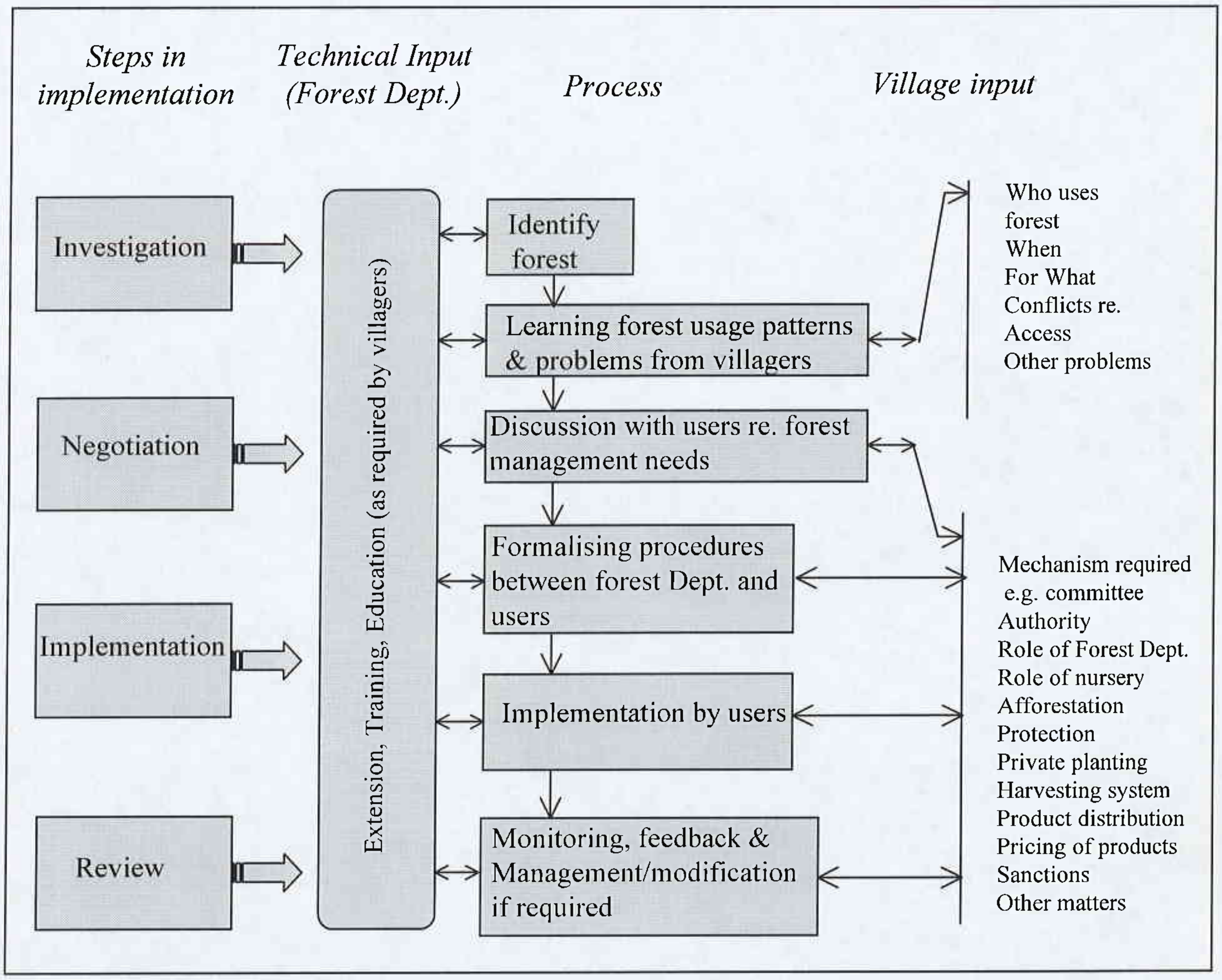


Figure 2.2 Flow diagram representing processes and linkages in management planning for community forestry based on the Nepalese model (modified from Gilmour and Fisher, 1991)

From the information above the following main points can be identified:

- Community forestry needs to be viewed as a process rather than a specific outcome.
- This process should be kept as simple as possible.
- Prior to finalising the operational plan much work needs to be spent on developing partnerships, identifying interest groups, participatory processes and user group formation. These social processes are fundamental to successful community forestry.
- The forest management plan needs some quantitative information on: spatial location; boundaries; sub-compartment size; base-line data; and changes to the forest resource. These are all necessary for forest management planning purposes.

2.4 A brief history of forestry in Nepal

This section briefly details the development of forestry in Nepal. Detailed histories are available (Hobley, Campbell and Bhatia, 1996; Hobley and Malla, 1996). The following illustrates the initial trend in Nepal towards state control of forests, with a policing and law enforcement role for forest management which did not alter until policy changes in the mid-1970s. This has had a profound effect on the development of community forestry in Nepal, as there was little trust between the DoF and villagers for a considerable period after the policy changes, and this still continues to be the case in parts of Nepal.

Prior to the overthrow of the Rana regime (hereditary prime ministers - ruling from a coup in 1846 until the restoration of the monarchy in 1950), there was little co-ordinated forest management in Nepal, with only *ad hoc* localised legislation (Gilmour and Fisher, 1991). During this period most forest legislation and management (principally timber extraction) related to the sale of timber to British India, which was an important industry in the first half of the twentieth century (Collier, 1976). Planning needs for timber exploitation led to the creation of the Nepalese Department of Forests in 1942, modelled on the Indian Forest Service.

In 1951 the Nepali congress overthrew the Rana regime and reinstated the monarch as constitutional ruler of Nepal. Soon after this attempts were made to introduce forest legislation. In 1952-1953 a draft forest policy was developed advocating, naming, and describing community forestry in similar terms to those used today (this was probably the first use of the term). This policy recognised the importance of forests for meeting villagers subsistence requirements. It is also interesting to note that the draft policy stated that the management of community forests should aim at 'meeting the present as well as the future needs of the population', almost exactly the same wording as that contained in the 1987 Bruntland Commission report (World Commission on Environment and Development, 1987). The policy classified Nepalese forests as protection, National or community forests, a similar classification as that used currently in Nepal (Bartlett and Malla, 1992). Unfortunately this far-sighted policy was not enacted. Instead, in 1957 the Private Forests Nationalisation Act was passed. The aim of this act was to move control of forest lands to the DoF, who would police and protect the resource. This was ineffective, due to the forest resource being part of village agricultural systems, and the almost total lack of trained forestry personnel (Gilmour and Fisher, 1991; HMGN, 1986). It has been widely stated that the 1957 Forestry Nationalisation Act prompted widespread deforestation due to villagers and land owners feeling that their forests had been taken by the Government (World Bank, 1979), and this has been the general view of development professionals. Gilmour and Fisher (1991) argue that a legislative change, which few people at a village level were aware of, would have had little effect. Hobley and Malla (1996) suggest that a more important factor causing forest degradation was cadastral survey activities, which led to opportunist seizure of forest land and its degradation. This period coincides with the establishment of a large number of unofficial indigenous management systems being established, which undermines the assumption that the 1957 act dis-empowered villagers.

The 1961 Forestry Act allowed land to be transferred from Government to village *panchayat* management (panchayat refers to a village based politico-administrative unit of 4 000 - 6 000 people), for village use. Although this provision was only implemented to a limited extent, and solely around Kathmandu, it provided a conceptual basis for community forestry (Mahat, Griffin and Shephard, 1986). In reality, the policing mentality of the Government towards forest management remained. The 1967 Forest Preservation Act further strengthened the role of the DoF as a law enforcement agency, with a reputation for corruption and with draconian powers: the act empowered forestry officials to shoot offenders below the kneecap (Talbott and Khadka, 1994; Mahat *et. al.* 1986). A number of other land reform acts around this period further reinforced the power of the DoF. During this period Nepal heavily exploited its forest resource, in line with the global development concepts of industrial forestry prevalent at that time (Westoby, 1962; Westoby,1978). Forestry activities were almost solely concentrated in the *Terai* (an extension of the Indo-Gangetic plain running along southern Nepal), with little systematic management of the hill forests.

The change towards community forestry in Nepal commenced in earnest in 1974 (Mahat, pers. comm. quoted in Hobley, 1990) or 1975 (Mahat, pers. comm. quoted in Gilmour and Fisher, 1991), with a meeting of community orientated foresters who advocated working with local people in forest management, a process they termed community forestry (Hobley and Malla, 1996). Proceedings of this conference, and a working group on the future development of Nepalese forestry, influenced the 1976 National Forestry Plan. This emphasised allocating land to village panchayats, allowing villagers to manage their own forests (with technical assistance from the Department of Forests). These initiatives were aimed at hill forests, which were particularly degraded. The 1978 Panchayat rules provided a framework for externally funded community forestry projects. Funding from environmental donor organisations quickly followed. This funding was exacerbated by the perceived 'super-crisis' facing Nepal at the time, which focussed international attention on Nepal.

In 1975 Eric Eckholm published a paper which is now regarded as initiating the view of the Himalaya being close to a major environmental crisis (Eckholm, 1975, also Eckholm, 1976). This was followed by a number of articles supporting this view, through to the mid 1980s (Myers, 1986). The views expressed developed into the so-called 'theory of environmental degradation' (Ives, 1987; Ives and Messerli, 1989). The theory links together environmental, social and political processes to form a logical explanation for Himalayan degradation in general, based on inter-linked 'vicious circles'. This theory appears self evident, and was not critically evaluated until the 1980s. Initial doubt regarding the validity of the assumptions was raised in 1982 when Houston found the Khumbu forests little changed from his previous visit in 1950 (the Khumbu was regarded as a prime example of Himalayan degradation) (Houston 1982; Houston, 1987). Other research seriously questioned the validity of the linkages in the theory (Byers, 1987; Ives, 1987), culminating in Ives and Messerli's classic debunking (Ives and Messerli, 1989).

The direct effect of the perceived super-crisis on Nepalese forestry was the publication of an alarmist report by the world bank, detailing the deforestation and erosion of Nepal, predicting no accessible forests remaining by 2000 *AD* (World bank 1979;

Griffin, 1988). This report influenced donor funding for the next decade, and still effects current practice (Hobley and Malla, 1996).

The reason a fundamental misconception of the state of natural resources in Nepal could occur is because very little resource assessment had been undertaken: there was virtually no base-line data or quantitative resource information available to allow changes to be monitored.[1] This is still largely the situation today.

The 1980s saw a high level of community forestry donor supported activity. Each donor project has tended to operate in one or more District, leading to different approaches to community forestry being implemented. As projects and personnel communicate freely, this has been beneficial in developing forms of community forestry ideally suited to the Nepalese hills. Community forestry in Nepal was given further policy support with the publication of the twenty year 'Master Plan for the Forestry Sector' (HMGN, 1990), which estimated that 47% of forest sector investment would be in community forestry programmes. The forest policy document formulated from the master plan also strongly supported community forestry.

In the early 1980s community forestry programmes were fundamentally concerned with educating villagers about the functions and importance of forests, and encouraging the planting and protection of trees. Community forestry was directed at reforestation. There was more emphasis put on trees than villagers needs or institutional support (Gilmour and Fisher, 1991). During the mid to late 1980s practitioners began to evaluate this approach, and many studies concluded that farmers planted and protected trees on their land without external encouragement or support. This led to a new focus on local level management of existing Government forest resources, with the FUG becoming the management unit.

At the beginning of the 1990s community forestry was starting to embrace the concept of participatory forestry (Hobley and Malla, 1996), and this has continued since. In

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[1] A detailed mapping project was undertaken in the mid-1980s in Nepal – the Land Resource Mapping Project. Although this provided large scale maps for planning and policy purposes, it did not provide enough detail for on the ground forest management. See Carson *et al.* (1986) and Carson (1985).

1990, after violent unrest, the Panchayat system was abolished, political parties legalised, and elections arranged. The new Government passed the Forest Act (1993), which acknowledges that community forests should be managed by FUGs (although the land is state-owned). The most recent important development within Nepalese community forestry is the legislative support for FUGs to establish forest products industries, allowing commercial objectives as well as traditional subsistence needs. This is still controversial at present, and has only been implemented in very limited circumstances (Hunt, pers. comm. 1998).

Currently community forestry has institutional support, legislative status and experienced community foresters in the Department of Forests and donor organisations. The area of community forests has increased significantly over the last six years, with in excess of 200 000ha of FUG managed forest in 1996 (Hobley and Malla, 1996). By 1997 it was estimated that 350 000ha of public forest was managed by 600 000 households, with over 5 000 official Forest User Groups. This represents approximately seven percent of Nepal's forest area (Poffenberger *et. al.* 1997). Community forestry is now entering a period of increased information needs, to allow forest management to be implemented. These information needs are discussed below

2.5 Recent developments in community forestry in Nepal

The framework and policy for community forestry in Nepal has recently changed significantly. The Master plan for the forestry sector (HMGN, 1990) was revised in 1993 with the Forest Act and in 1995 with the Forest regulations (HMGN, 1997). These recent revisions have focussed on the FUG as the institution which controls community forestry at a village level. It appears that in Nepal community forestry has 'come of age', and is firmly enshrined by policy as a core forestry activity. This is just one example of a more general global transition towards community orientated forest management (Poffenberger, 1996). Gilmour & Fisher (1997 p.29) note that:

'... an increasing number of nations in both south and north are developing policies and operational mechanisms to provide a much more active role for local communities and indigenous people in promoting sustainable forest management.'

As community forestry has become widely accepted and implemented, the research and operational agenda has changed. Gilmour and Fisher's quote above gives some indication of this: the aim is no longer just community empowerment through social changes, but issues such as sustainable management have become important. This links in with earlier discussions regarding the temporal development of forest management with time (see Table 2.1), indicating that as forestry gets more advanced the information requirements and institutional structures become more demanding and diverse. The developments in 'modern' community forestry to meet these demands can be conveniently divided into social/institutional developments and forest management developments. Of these, the forest management developments are key to this thesis, and will be examined in some detail. The main social/institutional developments will be briefly outlined, concentrating on Nepal.

2.5.1 Social/Institutional developments

Providing institutional support for FUGs has become a key task for the DoF. As community forestry progresses, the role of a forestry Government Department should be to provide support and facilitation for FUGs. This is difficult to do in reality, as it is outside most foresters training, although successful efforts have been made (Jackson *et al.*, 1996).

It has become increasingly recognised that effective gender representation in community forestry is vital. Women are the prime forest users for the two generally most important categories of forest product (fuelwood and fodder), and they make the day to day management decisions about where to collect produce. In many societies men are the traditional decision makers and it is difficult to obtain the views of women or get them genuinely involved in decision making. Attempts have long been made to fully integrate women into community forestry decision making, and this is still a priority. Current developments involve analysing decision making processes in detail and examining how decisions are implemented (Poudel, 1999a). Traditionally, gender equability has been monitored by examining male/female ratios on committees and in FUGs. Poudel (1999b) provides a case study where she suggests that women are being marginalised even though they represent 50% of the committee, illustrating that this is not a good indicator of equability. New developments involve moving beyond this and examining how women contribute to committees and what percentage of their ideas and innovations are actually implemented (Roche, 1997, Pers. comm.).

In Nepal FUGs have become powerful grassroots organisations , and there is now a national federation of user groups, FECOFUN (Federation of Community Forestry Users in Nepal). This is designed to spread awareness amongst disadvantaged social groups of the legislative changes in the Forestry Act and Forestry Regulations and their increased power (FECOFUN, 1996). This represents a shift away from community forestry as a DoF and donor-funded initiative into a peoples movement. It appears that in Nepal FUGs are now a powerful enough political force that they can set the agenda for how forests are managed by local communities. This grassroots benefit to poorer members of rural society is perhaps best illustrated by anecdotal evidence: Maoist guerrillas have advised Forestry Department staff that community forestry work will not be affected by their activities as it is beneficial for the people (Gilmour & Fisher, 1997).

Another recent development in Nepal is leasehold forestry. This aims to benefit the poorest members of rural societies. Blocks of degraded land are leased to groups of poor households, and these households have exclusive use of fodder, fuelwood and other forest products. As well as improving the quality of life and income generating capacity of the poor, environmental benefits ensue from a reduction in grazing pressures. Leasehold forestry was initially viewed as separate to community forestry, but increasingly it is being integrated with, or viewed as a special case of, community forestry (Ohler, 1999). It has been used as a tool for conflict resolution in user group formation, where there have been irreconcilable differences between the landless poor and the rest of village society.

2.5.2 Natural Resource developments

Social and institutional issues lie at the core of community forestry. Owing to their importance, there has been a tendency to overlook the 'technical' aspects of forestry, of which forest resource assessment is a main feature. There has been resistance to technical forestry input as it was seen as part of the 'old' forestry paradigm, and social scientists were worried that it would overshadow other activities (Gilmour & Fisher, 1991). Until the early 1990s there was little concern about forest resource management or the information requirements to enable this. A fundamental development in global forestry over the last decade has been a change towards a multiple objective approach (Lund, 1998). Modern 'developmental' forestry seeks to address three key sets of issues: social, environmental and economic. Until recently the last two have been under emphasised in community forestry in Nepal, probably rightly so. The social processes and functions were of overwhelming importance, and the political and legislative framework emphasised this aspect. This move towards multiple objective forestry, often incorporating ideas of sustainability and multiple forest products, has been coupled with a maturing of the forest resource for many FUGs, with greater potential for forest products. These changes have resulted in a number of new developments, some of which are pertinent to this study:

- there is a growing interest in the concept of sustainable forest management
- some FUGs are commercially producing timber
- there is a need for more accurate mapping of community forests
- timber certification

2.5.2.1 Sustainable forest management

Although much literature gives the impression that community forestry is automatically 'sustainable', this supposition cannot be justified. There is now a shift towards considering the quality of forest management in more depth (FAO, 1993b; Upton & Bass, 1995). The ultimate shift in this direction is actively planning for 'sustainable forestry', although in reality this is very difficult to assess, and there is no consensus amongst academics regarding defining sustainability, or how it may be achieved (Aplet *et. al.*, 1993; Clayton & Radcliffe, 1996). Assessing true sustainability is generally regarded as being outside the scope of resource assessment for management purposes (Upton & Bass, 1995). Many academics and organisations now refer to ‘responsible’ or ‘quality’ forestry as opposed to ‘sustainable’ forestry in recognition of these problems (Soil Association, 1994). This refers to a level of forest management which is acceptable to all stakeholders (Upton & Bass, 1995).

To manage a forest resource in a responsible manner requires data about the resource such as species composition, growth rates and regeneration success. This data is often required as base line data, to enable the determination of change in the forest resource and effects on the environment (ecological, economic and social) to be quantified. This is important as a pre-requisite for responsible forest management (FSC, 1994), or where Environmental Impact Assessments are to be conducted for forestry projects (IUCN, 1995) and is becoming a fundamental objective for many natural resource management projects (Graham-Smith, 1993). Donor organisations for forestry projects still often require quantitative information for project evaluation purposes. Base line data assessments may also be important for determining the value of a forest resource, or the value/potential for Non-Timber Forest Products (NTFPs) (Peters, 1993).

It is important to note that stakeholder groups are likely to have fundamentally different views on what ‘responsible’ forestry means: conservation organisations may feel it means zero interference with the resource; traditional foresters think of a maximum sustainable yield; rural development professionals may focus on institutional stability and local people may want the resource to provide a number of benefits ‘forever’.

Carter (1996) notes that forestry operations that are participatory and ‘sustainable’ should show that:

- local people are committed, active and skilled (or developing skills) in forest resource management
- tenure is secure
- forest product harvesting levels do not the damage the resource in the long term
- economic aspects are viable in the long term , and there is equitable distribution
- institutional structures support participatory forest management

Carter (1996) also notes that usually one or more of these criteria will only be partially met.

2.5.2.2 The commercial production of timber

The 1995 Forestry Regulations provided legislative support for FUGs to establish forest products industries. The FUG now has rights to acquire, sell and transfer forest products, and has control over funds accrued from forestry related activities (Neupane, 1999). This makes it politically powerful, and possibly in conflict with the DoF regarding income generating activities. Gilmour & Fisher (1997) comment that there have been strong objections from within the DoF regarding proposals to allow user groups to sell timber commercially. Ostensibly this is because this may encourage deforestation and removes planning control from the DoF. In reality, concerns about conflicts of interest between the DoF and FUGs regarding revenue from forest products is partly to blame. To ensure that community forests are being responsibly utilised (and probably to hamper commercial production), DFOs are generally asking for a management plan that details sustained yield production, and how it was calculated. It is anticipated that this information need is going to grow in Nepal, and may become a common reason for forest resource assessment.

There has been little attention on calculating sustainable yields of forest products for community forestry, or forestry in general, in Nepal. Joshi (1985), Thompson, Tamrakar and Mathema (1990), Thompson (1990b) and Neil (1990) provide some limited information. In most community forestry situations the calculation of yields is needs based, reflecting the number of forest users and how much timber/fuelwood is required by them. The forest resource is periodically inspected by the forest ranger to ensure that it is not seriously degrading. Some attempts have been made towards more accurate yield determination methods. Branney (1994a) developed a series of 'thumb rules' for different forest types and conditions in the hills of Nepal, and a series of guidelines (Branney, 1994b). The NACFP has issued a procedure for monitoring forest resources to calculate sustained yield (Jackson *et. al.*, 1996), but by the projects own admission there has been little uptake in practice due to the complexity of the methodology for busy, poorly trained forest rangers (Hunt, pers. comm, 1998; Jordan, 1998). This is discussed in more detail in section 6.1.2.

2.5.2.3 Mapping and boundary delineation of community forests

Traditionally, mapping of community forests has been done by sketch mapping or participatory sketch mapping (see chapter three, section 3.6.6.4). In some instances more detailed surveys have been conducted using chain and compass survey techniques by Department of Forestry staff, but these are time consuming and of a low reliability. Keeling (1996 p.12) notes that:

> 'The three main problems with maps in community forestry (in Nepal) has been poor quality chain and compass surveys, poor presentation of the maps and the large amount of time consumed in making them.'

Nepalese forestry legislation does not stipulate what information should be included in the map for the community forest working plan, simply stating that a map should be included. Some of the mapping techniques are, by western mapping standards, inherently spatially inaccurate. Forest areas due for handover were (and in some cases still are) defined by statements of the four containing boundaries (*Char Killaa*). The convention is that the boundaries of a forest are identified by statements defining the boundary land for each cardinal compass point. This method can only accurately denote the area of a forest if it is square with its axis aligned n/s and e/w (Keeling, 1996).

It is necessary to have an accurate estimate of the area of a community forest to be able to determine sustained yield productions and to conduct basic forest management planning. Additionally the accurate delineation of forest boundaries is key to resolving many of the conflicts that occur in community forestry. At the 1995 Community Forestry User Group Networking Workshop in Baitadi 15 of the 34 FUGs represented raised boundary definition issues as one of their main problems (Keeling, 1996; Keeling, 1998 pers. comm.).

Recent and current developments to improve mapping include the use of participatory sketch maps with trained facilitators, modified participatory sketch mapping techniques, such as PPM (see section 3.3.2), the use of cadastral survey data and the use of GPS (see section 3.2.2).

2.5.2.4 Timber certification

Progress towards responsible forest management may be assessed by independent accredited certifying organisations. This is termed forest certification and involves auditing the forestry operations to a pre-defined set of standards, usually including certain criteria and indicators for responsible forest management. Most of the standards for forest resource assessment are demanding, and require a breadth of resource management information not previously found in forest management plans. There are a variety of independent certification/inspection organisations, and a range of criteria and indicators for good forest management (the most comprehensive listing of these can be found in ISO, in press). Currently the standards adopted by the majority of independent certifying organisations are the Forest Stewardship Council standards (FSC, 1999; FSC, 1999). The principles and criteria of these standards are listed in Table 2.3.

There is a growing interest in forest certification for community forests amongst the donor community in Nepal, based on the potential to provide FUGs with markets for their timber, and the possibility of spin-offs such as eco-tourism. (Hunt, 1998, pers. comm.). It is perceived that there is an internal market for certified timer within Nepal, as much timber is used to manufacture tourist artefacts, and that tourists would pay a premium for certified timber. There are examples of well managed forests generating revenue from ecotourism ventures.

It should be noted that at present no forestry project in Nepal has been independently inspected by one of the accredited certifying organisations, although an EIA has been conducted in the Terai (IUCN, 1995), requiring some of the information in Table 2.2. This received a negative response from many environmental NGOs, owing to its lack of depth. It is doubtful if any current forestry project in Nepal has a sufficiently rigorous monitoring and data collection programme to meet FSC requirements.

FSC Mission Statement:

To promote management of forests that are:
environmentally appropriate: maintaining biodiversity, productivity and ecological processes
socially beneficial: local people and society at large enjoy long-term benefits from harvesting forests
economically viable: forests are properly valued, prices of forest products reflect the full costs and benefits of good management, and sufficient re-investment is made in the forest resource

Principles and criteria:

Principle 1: compliance with laws and FSC principles. Information requirements:
National laws
International treaties/agreements to which country is a signatory

Principle2: tenure and use rights and responsibilities. Information requirements:
Defined, documented and legally established tenure rights

Principle 3: indigenous people's rights. Information requirements:
Identification and recognition of indigenous people's land, territories and resources

Principle 4: community relations and workers rights. Information requirements:
Social end economic status of forest workers and local communities

Principle 5: benefits from the forest. Information requirements:
Full range of benefits and services (including NTFPs, environmental and social benefits)

Principle 6: environmental impact. Information requirements:
Biodiversity and associated values, water resources, soil types/quality, identification of fragile/special ecosystems/landscapes

Principle 7: management plan. Information requirements:
An up to date, written, implemented management plan

Principle 8: monitoring and assessment. Information requirements:
condition of forest, yields of forest products. chain of custody, management activities, social and environmental impacts

Principle 9: maintenance of high conservation value forests. Information requirements:
extent and condition of natural forests

Principle 10: plantations. Information requirements:
benefits from plantations

Table 2.2 FSC Principles and criteria for responsible forest management
Source: modified from FSC principles and criteria for natural forest management (FSC, 1994 and FSC, 1999)

2.6 Chapter summary

This chapter provided an overview of the development of community forestry, focussing on Nepal. Background was provided on the development of community forestry, to provide an understanding of how participation became a key part of developmental forestry, and to illustrate why the previous policing mentality still affects villager/forester relations. Some of the key social and social theory issues were highlighted, demonstrating that CFRA cannot be viewed in isolation from the social context. Current developments and issues were highlighted, and a commonality between these can be identified: they all require increased information about the forest resource or forest management. These information needs are currently not being adequately met.

Chapter 3: Forestry assessment tools and techniques

3.0 Chapter overview

This chapter provides background on a range of geomatics tools, traditional and participatory inventory techniques, and rapid appraisal tools. It examines how quantitative spatial techniques can be used in a participatory context. This is essential background information before considering the development of improved methods.

3.1 Geomatics

The introductory chapter defined geomatics and mentioned the main technologies it encompasses. Geomatics refers to the elaboration of traditional mapping techniques through using remote sensing, GPS and GIS. These technologies are rapidly becoming cheaper and will operate on a lap-top computer, making them accessible to small research projects and communities. Geomatics techniques have been widely applied to conventional forestry (see for examples Heit and Shortreid, 1991; McKendry and Eastman, 1992; Haylor and Jordan, 1994 and Heit, Parker and Shortreid 1996). To date, there has been only limited direct applications of geomatics to community forestry or participatory forest assessments (Carter, 1996; Jordan and Shrestha 1998; Mather 1998).

The field of geomatics can be divided into five areas (Poole, 1995):

- Basic mapping. In a participatory context this is a process where community spatial knowledge is gathered and recorded. It may involve participatory sketch mapping, or simple surveying.
- GPS. Used for obtaining accurate geographical locations, rapidly and cost effectively. It can be used in a 'participatory' manner, through group walks and participatory boundary surveys. It reduces the cost of land demarcation, and can be used to transform informal maps into cartographic forms.
- Satellite imagery. Useful for district, national or regional assessments, but its role for localised studies is limited due to low resolution. In mountainous areas this is

exacerbated by shadow and cloud. In many developing countries accessibility and cost are important issues.

- Aerial photographs. Traditionally a key element of forest resource assessment, for inventory planning and providing general resource information. They can be used in a participatory manner at large scales, linking in with basic mapping above.
- GIS. At a basic level these can be used for assimilating data from different sources and producing maps. They also have an important role for the analysis and dissemination of spatial information.

Poole (1995) has also identified a number of applications for geomatics technology within the areas of indigenous resource management. These are shown in Table 3.1.

Applications and Appropriate Geomatic Technology		
Application	**Data Needed**	**Geomatic Technology**
Land use and occupancy	Maps based on local knowledge and practice	Sketch mapping Participatory photo mapping GPS for increased spatial accuracy
Demarcation	Positional base maps or images if available	GPS
Gathering and protecting traditional knowledge	Traditional environmental knowledge	Sketch mapping Participatory photo mapping GPS for increased spatial accuracy GIS for map making
Boundary monitoring	Sequential visual data	GPS Sequential aerial photo's Satellite imagery
Resource mapping	Local data and base maps	Aerial photo & GPS GIS for map making
Ecological recuperation	High resolution imagery	Aerial photography
Impact monitoring	Aerial imagery	Aerial photo & GPS
Resource management	Comprehensive cultural & ecological	Aerial photo & GPS Satellite imagery GIS for analysis
Local communication	Local views	Sketch maps Aerial photos

Table 3.1 Applications of geomatics technology for indigenous resource management. Source: Poole (1995)

3.2 GPS

3.2.1 background

The Global Positioning System is a network of 24 satellites and control systems known as NAVSTAR (there is also a similar Russian network, GLONASS). This is an all-weather navigation and position fixing system operating 24 hours a day, which is accessed by using a receiver which captures radio signals transmitted by the satellites and uses this information to calculate the current position, or georeference (Hurn, 1989; Barnard, 1992). GPS allows very accurate geographical positioning to be determined by using a lightweight, relatively low cost hand held receiver.

Although originally designed for real-time navigation purposes, GPS receivers will store data in an internal memory, allowing downloading into a computer. The relative ease of spatial data collection using GPS makes them appealing for natural resource management field work.

The system has five components (Heywood, Smith, Carlisle and Jordan, 1998):

- the satellite constellation
- the satellite control and monitoring stations
- the national and regional base station networks
- the GPS receivers
- the users

The NAVSTAR satellite constellation was developed by the United States military, who maintain the system. The first satellite was launched in 1978, and by 1994 all 24 satellites were operational (Kennedy, 1996). The orbit configuration ensures that enough satellites are visible for global GPS receiver operation, although there is a problem in polar regions with poor geometrical alignment of satellites.

During their 12 hour orbit NAVSTAR satellites pass over control stations, which monitor their position. Exact locational information is transmitted from control stations to the satellites, along with information on the accuracy of the satellites atomic clock. Exact positional and temporal information is critical for accurate GPS data.

Base stations monitor satellite positions, and provide continuous information on the positional accuracy of GPS signals at specific locations. This is broadcast, allowing users to improve positional accuracy of their own GPS data (see below).

GPS receivers access radio signals from the satellites, and convert this into positional information. Van Sickle (1996) details the components of a receiver, which include a micro-computer for information processing and storage, and an antenna for receiving the radio signals. Better quality receivers allow attribute information to be added, have a large memory and have a wide range of datum's available. The reliability of the positional fix at any given time is indicated by the Positional Dilution Of Precision (PDOP) value. This ranges from zero upwards. A PDOP value of less than ten is generally considered to indicate a reliable positional location, a higher value indicates the spatial accuracy is unacceptably high (Magellan Systems Corporation, 1996).

GPS was developed for military use, but the majority of current users are civilian. There are two groups of civilian users: those using GPS as a real-time navigation aid (sailors, mountaineers etc.), and those using it for mapping, surveying and recording spatial information. Forest resource assessment falls under this second category, and uses of GPS for this purpose are focused on later in this chapter.

3.2.1.1 Operating a GPS receiver

When using GPS in the field for the first time at a new site, the operator inputs an approximate geographical position (accurate to within 100km), and the GPS receiver computes the precise location. This initialisation process may take several minutes prior to obtaining a positional 'fix'. Further positions at the site can be computed in less than one minute. For technical information on the use of GPS see Hurn (1989), Greer

(1993), Poole (1995), Magellan systems Corporation (1996) and Heywood *et.al.* (1998).

GPS can be used either in 'mobile' or 'stationary' mode. With mobile GPS the receiver is in motion during the recording of positional data, whilst with stationary GPS the receiver remains at a fixed point and a number of readings are averaged (Van Sickle, 1996). Additionally GPS receivers can be used in stand-alone ('absolute GPS') or differential ('differential GPS') mode. Stand alone refers to using one receiver which is taken into the field and used to collect information as described above. The advantages of using a stand alone receiver are rapidity, lower cost, and no post-processing work (see below). The disadvantage is a lower level of spatial accuracy. Using stand-alone GPS an accuracy of +/- 100m can be assumed. Accuracy can be increased by averaging several hundred fixes for each position. This takes five to ten minutes for each position. This method allows an accuracy of +/- *ca.* 50m. This high level of imprecision is due principally to 'selective availability', a deliberate degradation of the satellite signals by the American military, introduced in 1990. For many natural resource applications greater positional accuracy is required, necessitating Differential GPS (DGPS). DGPS involves having one GPS receiver, at a known location (for example a georeferenced forest range post) and another receiver, the 'rover', in the field recording positions. The receiver at the known location is static, and variations in the recorded position reflect errors in the satellite data. This error information can be used to correct the positional information for any GPS receivers in the vicinity, allowing accuracy's of +/-10m to be easily obtained, and sub-metre accuracy is possible (Magellan Systems Corporation 1996). Differential correction can be performed real-time, where the GPS collects broadcast correction information from a base station beacon or another GPS using a radio or telephone link, or after field data collection, by post-processing data. Post-processing applies the error correction information after data collection (usually performed in the evening after a days field work). This has the advantage of reducing the cost of data collection, as there is no need for a telephone or radio link, but the higher level of accuracy can only be obtained after data collection, not whilst the field work is being conducted.

3.2.2 Uses

GPS technology can be used to obtain accurate spatial locations rapidly and cost-effectively, allowing features to be identified by their geographical coordinates (known as georeferencing or geocoding). It allows information to be acquired that previously would not have been economically feasible (Dykstra, 1997). Usually GPS information is associated with the use of a GIS for organising and displaying GPS data. GPS has become a fundamental means of data acquisition for GIS (Kennedy, 1996). Key forestry applications for this technology include:

- mapping forest boundaries
- obtaining 'control points', which are georeferenced points for inputting aerial photographs into a GIS or geocorrecting aerial photographs (an operation known as 'rubbersheeting')
- locating sample and demonstration plots

Boundary mapping uses GPS as a survey instrument. The receiver is taken round the forest boundary (usually on foot, but possibly by vehicle), and the geographical position is recorded at pre-determined intervals, usually one second. This information is stored in the GPS receiver, and later downloaded onto a computer, and possibly post-processed. GPS is a standard tool for boundary mapping in most developed countries (Falkner, 1995; Leick, 1995; Liu and Brantigan, 1995; Poole, 1995).

The use of GPS for boundary mapping in participatory forest management is still very limited, although it has been cited as having great potential in a participatory or community forestry context. Carter (1996 p.18) states that:

> 'Perhaps the most exciting development in producing geographically accurate maps with local communities is the use of Global Positioning Systems'

References to using GPS in the Asian region, and particularly the middle hills of Nepal, are not so encouraging. Stockdale (in Carter, 1996, p. 195) states that using differential

GPS meant that only one or two locations could be obtained per day, when working in east Kalimantan. Branney (in Carter, 1996, p.145) states that:

> 'early Nepal Australia Community Forestry Project attempts to use GPS have been disappointing, probably due to interference caused by the mountainous terrain.'

Apart from the limited number of fixes per day that could be obtained in east Kalimantan, the use of GPS appears to have been successful, and this work has been widely examined and quoted (Sirait *et. al.* 1994; Carter, Stockdale, Sanchez-Roman and Lawrence,. 1995; Stockdale and Ambrose, 1996). This study used GPS (and GIS) for mapping traditional forest territories, during a participatory resource assessment. It appears from the method described in the literature that the limited number of fixes obtained was due to a misunderstanding of the technology rather than a GPS problem.

Control points of a known spatial location allow information from aerial photographs or survey maps to be inputted into a GIS. GPS is widely used to obtain control points, particularly in developing countries where the quality of spatial information may be poor. Obtaining georeferenced control points can be done in two ways. A stand-alone GPS receiver can be used and fifteen to thirty minutes of readings (one per second) averaged. A more accurate method is to use DGPS. Five minutes of readings are required for an accuracy of *ca.* +/-5m. Control points need to be easily recognisable from aerial photographs or maps, and in positions where there is little obstruction of satellites. Control points can also be used to rubbersheet aerial photographs or inaccurate maps. A number of control points are generated using a GPS, and are used to orthorectify the image. This removes spatial distortions and errors (see section 3.3.1).

GPS has been widely used for locating demonstration and permanent sample plots within forests (Evans *et. al.* 1992; Feng and Huang,1994; Lawrence *et. al.*, 1995; Chen and Cihlar, 1996). This information is usually put into a GIS database of the forest resource. It is useful in large forests where it is difficult to physically relocate plots.

GPS is used for a number of other roles in natural resource surveying and management. Common uses include watershed mapping, creating or evaluating Digital Terrain

Models (DTMs), and planning or mapping roads (Arnold, 1995; Fix and Burt, 1995; Carlisle and Heywood, 1997). There are less usual applications: both helicopters and snowmobiles have been equipped with GPS for the cost effective, accurate and rapid mapping of windthrow damage and logging compartments in boreal forests (Johansson and Eriksson, 1995), and GPS has been used for tracking wild animals under forest canopies (Rempel *et. al.* 1995).

3.2.3 Advantages and disadvantages of GPS

GPS has a number of obvious advantages for resource assessment:

- it is rapid
- it is accurate
- it is a (relatively) cheap means of surveying
- the data is digital and can easily be entered into a GIS

GPS should be regarded as a major development for surveying and spatial resource assessment (Heywood *et al.*, 1998). However, there are a number of disadvantages with the technology. For the GPS to operate effectively, there should be an unobstructed view of four satellites (three satellites will allow a two dimensional fix to be calculated). This can be a limiting factor on the use of this technology in mountainous or densely forested terrain, particularly towards the polar regions where satellite configuration is poor. There are a number of ways of reducing these problems (Jordan and Carlisle, 1998). A dense canopy will seriously limit the effectiveness of GPS. Trunks and branches will completely block signals, and leaves reduce the quality of the signal. However, both this work and other studies indicate that GPS will work effectively under a fairly dense canopy if precautions are taken (Wilkie, 1989; Jasumback, 1993; Jordan and Shrestha, 1998). There have been assessments of the accuracy of GPS under canopies (Gerlach and Jasumback, 1989; Deckert and Bolstad, 1996), which indicate that the positional accuracy is not significantly reduced by a canopy.

There are a number of technical considerations when using GPS. The position of visible satellites (above the horizon) varies during the day, which means that GPS accuracy also varies. Mission planning software should be used to determine when the best satellite constellation is available. Depending on the satellite constellation the reliability of the positional fix varies. This is reflected by the PDOP value. Multipath errors may occur in mountainous terrain, although they are most serious in urban environments. They are caused by satellite signals being bounced or reflected off cliffs or buildings. Ionospheric delay is due to atmospheric disruption of the satellite signal. It results in increased error, as the receiver miscalculates the distance from the satellite. Water vapour is the main cause of delay. These error sources are discussed in more detail elsewhere (Gilbert, 1995; Heywood *et. al.* 1998).

When working in a developing country there are additional issues that need considering. Although GPS prices have reduced considerably a good quality system is going to cost at least £1000. This means that donor support or operating through a Government Department is probably necessary. They are outside the budgets of FUGs or Village Development Councils. To use GPS effectively requires a lot of training and some previous technological background. This makes using them in a truly participatory manner very difficult.

3.3 Aerial photographs

3.3.1 Background

Aerial photography has been an important tool for forest resource assessment for many decades. It is often used to provide a reliable estimate of forest area, a pre-requisite for reliable forest inventory work (Avery & Burkhart, 1994). Until the availability of satellite imagery in the 1970s it was the main method of remote sensing. Although satellite imagery has largely superseded aerial photography for large-scale studies at a district, National or regional level, it still remains the most important remote sensing tool in the mid-hills and mountains of Nepal. This is due to the extreme terrain rendering the image processing of satellite imagery very difficult. The Himalaya are the highest and youngest mountains in the world, with some of the steepest slope angles

(Price, 1981; Sill and Kirkby, 1991) and the shadow effects caused by ridges and valleys create great difficulty in classifying satellite images (Paracchini and Folving, 1994). The key problems with using satellite images in steep mountain terrain are shading caused by topography seriously affecting image classification, and limitations on the time of year images can be obtained due to cloud and snow cover (this may also affect aerial photographs). Additionally, most remote sensing imagery has a far lower resolution than aerial photography, and the analysis of satellite imagery is a specialised field, requiring expensive hardware and software, and highly trained personnel (Dykstra, 1997).

For work at a watershed level in a montane environment aerial photographs have a number of advantages over satellite images:

- aerial photographs do not need as much reclassifying as satellite images, so shadows are not such a limitation
- they are cheaper
- the software/hardware requirements for correcting aerial photographs are not as rigorous
- they are easier to interpret
- individual trees and houses can be picked out if the photographs are enlarged; this is essential for using them in a participatory capacity, as described below

The current trend in Nepal is to use satellite imagery for forest resource assessment in the Terai, and aerial photographs in the mid-hills and mountains (Pikkarainen and Paudyal, 1996, Annex 16), avoiding the problems of image interpretation.

Aerial photographs are now relatively inexpensive, and used in conjunction with field sampling can be used to produce maps showing land use, topography and infrastructure. However, aerial photographs suffer from image displacements due to aircraft tilt, topographic relief and varying distance of features from the camera. These drawbacks can be overcome by using orthophotographs, where the displacements have been corrected manually by photogrammetry, or by using digital orthoimages where image analysis software is used to manipulate the digital image, rectifying displacements (Falkner, 1995; Dykstra, 1997; Jordan and Shrestha, 1998). Displacement rectified aerial photographs have the advantage of being as positionally accurate as a map (under ideal conditions). The disadvantage is that they are five to ten times more expensive (Falkner, 1995), and more than this if only a small run of photographs are corrected.

Aerial photography has been a fundamental tool for capturing forestry data remotely. There are many examples of aerial photography being used for forest resource assessment (Tomar and Maslekar, 1974; Fox, 1986; Maclean, 1994; Falkner, 1995), and a history of its use in Nepal (Carson, 1985; Jackson *et. al.* 1994; Keeling 1996). Until recently the use of aerial photographs in Nepal was limited due to problems with access to photographs, and the high cost of them. The situation has recently changed to some extent, with the HMG Department of Survey having a series of high quality dia-positive images for most of the country that are available to Government Departments and approved projects.

Traditionally, aerial photographs have been used as a remote sensing survey tool, by professionals trained in photogrammetry and image interpretation. There is a wealth of literature available on these uses (e.g. Tomar & Maslekar, 1974; Paine, 1981; Howard, 1991; Falkner, 1995). A relatively new use of aerial photographs is using them as a participatory tool to facilitate the procurement of spatial and resource information, and to encourage participation.

The use of aerial photographs in a participatory capacity has been limited (Vogt, 1974; Conklin, 1980; Carson, 1985; Fox, 1986), and is being examined by other researchers in Nepal (Mather *et al.*, 1998; Mather, 1998). This has been termed 'Participatory Photo-Mapping' (Jordan & Shrestha, 1998). This is similar in philosophy to participatory sketch-mapping (Messerschmidt, 1995), but uses a large scale aerial photograph as a participatory tool.

Aerial photographs can fulfill two distinct roles as a participatory tool (Jordan & Shrestha, 1998). They can be used to facilitate participatory sessions, and they can be used as a source of quantitative information from participatory discussions.

3.3.2 Aerial photographs as a facilitation tool

To use aerial photographs as a participatory tool it is necessary to have large scale photographs of between 1:2 500 and 1:5 000 of a reasonable quality, so houses and key features are identifiable. A scale of 1:5 000 appears to be the optimum (Poole, 1995; Carter, 1996; Jordan & Shrestha, 1998). These are becoming available in Nepal and some other countries (Mather, 1998). Aerial photographs are introduced into a participatory discussion, often by the participants themselves (Mather 1998). One of the key aspects of this approach is its animation and excitement. It is important to have good facilitation so that the villagers have key features pointed out to them, and as they start to identify features, they are told what has been identified correctly. Generally, villagers can identify features rapidly (Mather, 1998). Once the villagers are able to interpret the image, questions can be asked regarding usage patterns, access, areas where there are conflicts, and other questions about the FUG.

Mather (1998) identified 5 key ways in which aerial photographs contribute to participatory and other community forestry processes:

- Authenticity: people are confident in aerial photographs as accurate records of the distribution and condition of their resources.
- Consistency of information: unlike traditional participatory maps the information from aerial photographs was consistently interpreted by different groups. Information was therefore transferable from one group to another.
- Non-literate media: the information portrayed on aerial photographs was self-evident to many people (interpretation being relatively independent of education or social status).
- Facilitation: any instrument that supports participatory processes is an aid to the facilitator. More specifically information contained within aerial photographs allows the facilitator to direct discussions to address specific issues.

- Potential as a base for the survey map: early indications are that the use of geometrically restored aerial photographs may reduce time spent by DFO staff in field-survey substantially, and at the same time improve the accuracy and precision of survey.

The last of the points above refers to the other potential role of aerial photographs for participatory forestry, and is discussed below.

3.3.3 Aerial photographs as a source of quantitative information

To plan and conduct an inventory, and to interpret data, it is important to know the approximate area and dimensions of each compartment. In many community forestry situations there may be no reliable spatial information for the forest resource available. Mapped information may be unreliable. Cadastral survey information has been examined for its value as a base map for community forestry, but varies in its accuracy depending on the survey methods that were employed, is often of questionable reliability and in many cases it is difficult to locate any mapped features on the ground (Keeling, 1996). Participatory sketch maps are not spatially accurate, and should not be used to determine the area of a community forest. Aerial photographs provide a potential means of obtaining this information. The external boundary is defined during the participatory process, and then internal boundaries are added. Information may be obtained regarding the use of each compartment and the condition of each compartment. Other information such as where medicinal plants are obtained, water sources and areas of conflict can also be mapped onto the aerial photograph. A map is produced of the forest, with external and internal boundaries marked, and other features obtained from the participatory process. Although only limited work has been conducted in this area, it appears that participatory photo maps are far more accurate than traditional participatory sketch maps, particularly if the images are geometrically corrected (Mather, 1998).

3.3.4 Problems with aerial photographs

A number of problems with using aerial photographs in Nepal have been identified

(Jackson *et al.*, 1994):

- they are expensive
- they are difficult to obtain
- they require good skills for effective interpretation
- they present problems with shadows and distortions in areas with high relief

As noted above, the first two have become less restrictive in Nepal due to a new series of photographs becoming available in 1996/1997 and a relaxation of bureaucratic and military restrictions on spatial information. Opinion of the significance of the other two points varies between researchers, but generally they have been found to be a beneficial tool when working in the mountains of Nepal.

3.4 GIS

This section provides information on the background, history and traditional uses of GIS for natural resource management. This provides an understanding of what the technology of GIS can provide and be used for. The changing emphasis in GIS away from technological capability towards organisational and institutional issues is documented, followed by a description of participatory GIS. This is discussed in some detail as this provides key parts of the background and focal theory for this study. This section ends with a critical discussion of the advantages and disadvantages of GIS in a participatory context.

3.4.1 Background

Geographic, or Geographical, Information Systems are used to produce, organise and analyse spatial information. For more than a decade the term has referred to computer based systems, but manual GISs have been used for much longer (CGISE/IGISE, 1990). Burrough (1986) provides one of the classic definitions of GIS:

> 'a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world.'

A more recent definition, described by the author as a working definition, is:

'A (GIS) is a group of procedures that provide data input, storage and retrieval, mapping and spatial analysis for both spatial and attribute data to support the decision making activities of the organisation.' (Grimshaw, 1994).

There are a number of components and requirements for the traditional view of a GIS. Star and Estes (1990) described these (see Figure 3.1).

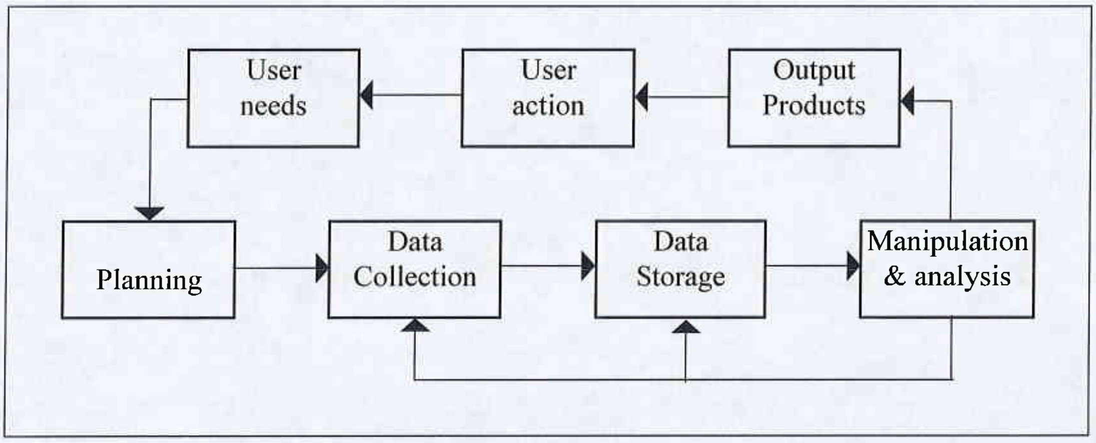


Figure 3.1 A simplified GIS overview (from Star and Estes, 1990)

Figure 3.1 illustrates that a GIS has been traditionally seen as a database with capabilities for spatially-referenced data, and a set of operations for working with the data (Star and Estes, 1990). The key components can be divided into a number of discrete processes, which can be used to illustrate the advantages of GIS:

- data input
- data management
- data processing
- analysis and modeling
- data output

Data input involves assimilating information in a way that can be interpreted by the GIS. This may involve digitizing mapped information, entering GPS data, or scanning information from aerial photographs. There are a wide variety of ways of obtaining data for input: base map information may be available digitally on compact disc; satellite imagery is available on the same medium. Data management is essential for any data base to allow information to be accessed easily. Data processing is the restructuring of input information to allow it to be interpreted easily. This may include reclassifying data into new classes (such as altitude zones, converting contours lines to slope maps and assigning vegetation indices). Analysis and modeling allows for the combining of processed data to provide information previously unavailable. This is a major part of GIS technology, and what distinguishes it from earlier computer assisted cartography techniques (Wheate, 1988). It is worth noting that this capability of GIS is often under used, particularly in developing nations (Poole, 1995). Modeling allows spatial relationships to be examined and decision analysis to be performed through techniques such as multi-criteria evaluation (Carver, 1991; Heywood, 1992, Jordan, 1994). For more complex modeling, algorithms and mathematical models can be utilised. Many GISs have a range of modeling tools incorporated within them. The data generated by GIS processing and analysis can be outputted in the form of maps or three dimensional images (such as Digital Terrain Models, DTMs). Supporting information, such as statistical analysis data or meta-data can be outputted as tables.

Functionality describes what a GIS can do. The technical terms of the different types of functionality have been well documented elsewhere (Burrough, 1986; Maguire and Raper, 1990), but some of the functionality of a GIS in relation to natural resource management is illustrated in Table 3.2.

General requirements	Examples
Data input	accept GPS information
data editing	Remove GPS 'outliers'
data management	Change GPS file structures
data display	Drape GPS over a DTM, and print it
Functionality	**Examples**
Identify areas	Be able to distinguish between rangeland and forest
Identify lines	Be able to distinguish between the 1300m and 1400m contour
Identify areas within a certain distance from a line	Locating villages that are further than 10km from a road
Spatial statistical analysis	Calculate the area of forest
Reclassify areas	Merge separate coniferous and deciduous categories into a general forest category
Classify areas of interest and those of no interest	Be able to identify all mature forest
Identify areas based on multiple criteria	Be able to identify all mature forest above 1300m and less than 1km from a village
Conduct time-series scenario modeling	If 10% forest cover is removed from areas within 2km of villages every decade, where will the forest cover remain in thirty years?

Table 3.2 General requirements, functionality and examples of functionality for a GIS. Based on Cornelius, Heywood and Jordan, 1996.

3.4.2 A brief history of GIS technology

The processes incorporated into a computerised GIS, as described above, were previously conducted manually, overlaying maps on acetate sheets, and incorporating spatial statistics. Organising complex spatial information manually is time consuming, particularly when one variable alters, and requires a fundamental re-analysis. Major advantages of GIS are that information can be easily updated, altering the entire database in a time efficient manner, and spatial modeling that was too complex or time consuming to conduct by hand can now be performed. These were regarded as major changes when computerised GISs first became widely accessible (Berry, 1987). In addition, the visual output from a GIS system is generally of high quality. But Calkins and Tomlinson (1977) pointed out that manual techniques could provide the same information as computerised approaches, and Star and Estes (1990) state that there are still applications where manual approaches are entirely appropriate. It is common when working in developing countries to use a manual GIS for field work (determining sample plot locations or mapping/monitoring boundaries), and collate and analyse the information in more detail using a computerised GIS (SNV,1996).

The history of computer based GISs is usually traced back to the Canadian Geographic Information System (CGIS), conceived in the 1960s and fully functional by 1971 (Heywood, 1990). This was the first of a number of GISs developed in the 1960s by Government agencies as a response to a new awareness of complex natural resource issues (Peuquet and Marble, 1990). A GIS required a very large financial outlay which could only be afforded by Government Departments (Haylor and Jordan, 1994). Additionally the technology of this time was slow, bulky and cumbersome (Tomlinson, 1984). Two major developments contributed to the wider use and access of GIS. The first of these was the availability of remotely sensed satellite imagery, which from the early 1970s provided accurate base data for cartography at a reasonable cost (Cracknell and Hayes, 1993). Secondly, in the late 1970s and early 1980s there were rapid advances in computer technology with increased memory size, faster processing speeds and lower system costs. Research institutions could now afford to invest in GIS which led to rapid system and software development. By the mid 198's GISs could be run on PCs. A problem associated with the *ad. hoc.* development of GIS was a proliferation in the number of systems. Towards the end of the 1970s there were hundreds of different GIS types available (U.S. Fish and Wildlife Service, 1977; Marble *et. al.*, 1981). This caused problems of interaction and data conversion. These still remain as problems with the use of GIS, along with data accuracy and the cost of data acquisition (Rowley, 1993; Woodsford, 1993). However, the 1990s have seen GIS become available as standard commercial software, easily integrated with Desk-Top Publishing, database and spreadsheet software, and the cost has dropped to several hundred dollars for fully functional GISs (some are available as shareware via the Internet). There are a number of technological developments that are currently occurring with GIS. These are listed in Table 3.3.

Current developments in GIS
Increased Integration
Greater emphasis on decision support and modeling
Multimedia applications
Application oriented systems
Improved data handling and exchange
New spatial analysis techniques
Improved peripherals
Integration with general office software and communication systems
Artificial intelligence
Scene generation and virtual reality

Table 3.3 Current developments in GIS. Source: modified from Cornelius, Heywood and Jordan, 1996

3.4.3 Uses of GIS: applications in natural resource management and participatory assessment

Manual GISs have been utilised in natural resource management for many decades, and are still used extensively, for example, by the UK Forest Enterprise for landscaping and other uses. Typically, manual GISs involve maps with a series of overlays, usually on acetate sheets, with buffer zones, felling coupes and other relevant spatial information displayed on them (Haylor and Jordan, 1994). Increasingly, computerised GISs have been used for natural resource management, particularly since 1987 and the increased interest in 'sustainable' management, with the associated requirements for more resource information (Levinsohn and Brown, 1991). The historical development of GIS is integrally linked with natural resource management, illustrated by the CGIS mentioned above (Heywood, 1990). Natural resource applications (specifically forestry) encompass the full scope of GIS applications and provide a good overview of the potential of GIS (McKendry and Eastman, 1992). The availability of relatively low cost GIS has enabled it to be used by researchers, small forestry Companies, development projects and forest managers (Schreier *et. al.*, 1990). This had led to a great diversity of applications. The key areas relevant to this work can be divided into:

- GIS as an environmental tool
- GIS for forest management and strategic planning
- GIS for assessing deforestation and deforestation risk

GIS is used as an environmental tool to collate and organise data obtained from a variety of sources, which can then be used for modeling and decision making. There are numerous examples of GIS being used for this role (Height and Shortreid, 1991; Sample, 1994; Height, Parker and Shortreid, 1996; Hinton, 1996), and it has become a standard tool. One reason for this is that environmental systems are dynamic, and GIS is good at incorporating change into data display and models (Risser and Treworgy, 1985; Bridgewater, 1993). It should be noted that most applications do not use the full modeling potential of GIS, and it has been used largely as a policy making tool, using simple overlays which can only provide basic combinations of conditions (Burrough, 1986; Aspinall, 1993). There are exceptions, and the use of GIS for environmental modeling has been reviewed (Fedra, 1993).

GIS has been widely used for forest management and strategic planning purposes (Davidson 1991; Shah *et. al.*, 1991; Trapp, 1994; Sano *et. al*, 1996). It has been found useful for production forecasting, planning landscapes and updating growing stock databases (Stewart, 1993). Another key use of GIS in this area has been for forest inventory work. Most work in this area has been concerned with traditional inventories, concentrating on the collection of physical resource data (McKendry and Eastman, 1992). There are few examples of uses where socio-economic or community oriented information has been included, although some exist (SNV, 1996; Stockdale and Ambrose, 1996). This is discussed in more detail below.

GIS has been used for assessing deforestation and deforestation risk. In Nepal the classic study has been in the Jhikhu Khola watershed (Schreier *et. al.*, 1990; Schmidt and Schreier, 1991). This used historical records to identify changes in forest cover. The procedure was quite simple but effective; the forest area mapped in 1950 was overlaid with the forest area measured in 1980, and the change calculated. It was found that about fifty percent of the forest area had been lost to shrubland and agriculture. This assumes that the 1950 maps were accurate, which is questionable. Another study in Nepal modelled deforestation risk within the Sagarmatha National Park. This identified spatial variables affecting the utilisation pressure on the forest resource, and used Multi-Criteria Decision Analysis (MCDA) modeling techniques to produce a model of deforestation risk (Jordan, 1993, 1994). Other early deforestation studies using GIS were conducted in Thailand (UNEP/GRID, 1990)and Brazil (Stone *et. al*, 1991). GIS is commonly integrated with remote sensing techniques for assessing deforestation (Gastellu-Etchegorry *et. al.*, 1993; Palihawadana and Jewell, 1995; Adinarayana and Krishna, 1996).

Whilst these applications illustrate worthwhile uses of GIS for developmental work they are all characterised by a low level of participation by stakeholder groups, and particularly local communities. The definitions of GIS and the benefits ascribed to GIS have made no mention of the human or social aspects of GIS. The above approaches are characterised by a techno-scientific approach. Since the mid 1980s this type of approach to developmental natural resource management came under increasing criticism, as practitioners and researchers in less developed countries started to focus on participation and processes. The use of GIS generally did not reflect this new paradigm. GIS was developed and applied in technology rich countries and diffused to technology poor countries mainly through donor funded research and development projects. It tended to be applied in a similar way as in technology rich countries and it was assumed that problems and approaches were similar. Amongst workers concerned with participatory development, GIS was seen to have few advantages, and introduced real risks of disempowerment and encouraging top down planning. A key problems was that GIS applications were not intended to *directly* benefit local communities, although this may have been the 'super goal' of the work. The use of GIS was intended to add value to the work to benefit planners, researchers, government departments, donor agencies and corporations.

3.4.4 A change in emphasis

The above descriptions, history and applications of GIS all have a strong techno-centric basis. This is due to most GIS specialists having an IT background, and until recently an almost single-minded focus on technological aspects. However, this is rapidly changing. Reeve and Petch (1999) describe how the IT industry as a whole has started to appreciate the difficulties of integrating computer based systems into organisations, and the benefits of GIS for organisations are starting to be critically analysed rather than tacitly assumed. Until recently the overriding issue when purchasing a GIS was the functionality provided. This tends to lead to vastly over-specified GIS requirements, with power and functionality that is never used (Winfield, 1991). Indeed, most GISs are overloaded with functions, and new additions are mainly for marketing purposes.

There have been a number of expensive, high profile GIS projects which have failed to realise their expected benefits, or in some cases been cancelled altogether (Legg, 1997). The instinctive reaction has been to look for technical explanations of failure: inadequate hardware or software; or incorrect data transfer standards. More recently, GIS professionals have started to acknowledge that the major problems with systems are due to neglecting the human and organisational aspects. Systems have been driven by a technology-push rather than a demand pull (Reeve and Petch, 1999). Examples of this within a development context include the World Bank and other donor agencies exerting great pressure on African countries to adopt hi-tech GIS (Kyem, 1999b).

Recognition of the limitations of a techno-centric approach to GIS has resulted in a gradual shift towards a *socio-technical* view of GIS. Figure 3.2 illustrates the differences between the two approaches.

Techno-centric computing	*Socio-technical computing*
• Focus on technology	• Focus on people & technology
• Technology push	• Demand pull
• Because it's possible	• Because its needed
• Others are doing it	• WE need it
• Hierarchic	• Democratic
• Specified by technologists	• Specified by users

Figure 3.2 Techno-centric and socio-technical computing. Source: Reeve and Petch (1999), p.6.

This change in emphasis can be illustrated by diagrams illustrating the components of GIS. Figure 3.1 is techno-centric, but by the mid 1990s a more socio-technical view was being taken, illustrated by Figure 3.3.

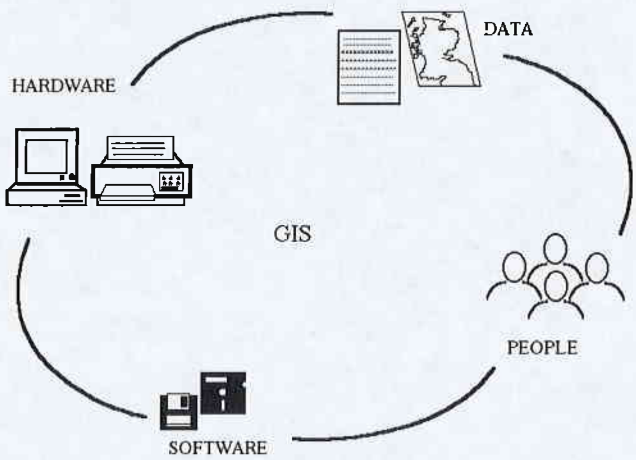


Figure 3.3 Key GIS components (from Cornelius, Heywood and Jordan, 1996)

It is only in the last three to four years that GIS literature has started to emerge focussing on organisational issues rather than technological details. This has included examining GIS from a social interactionist perspective, where organisations are viewed as complex social structures that may not behave rationally. In such an environment the successful adoption of new technology is by no means assured. Whether an information system is successful will depend on a complex interaction of formal and informal political and social processes within an organisation (Campbell & Masser, 1995; Reeve & Petch, 1999).

Whilst the above represents a fundamental move away from regarding GIS as a pure technology towards viewing it as an information system, it is still conceptually based on using GIS centrally in large organisations. Social aspects are considered because they assist in the implementation and adoption of the system, not because they are viewed as desirable or essential. As the information system emphasis moves further from technological aspects towards social issues, a recently emerging field of GIS is found. This has been termed Participatory GIS or Public Participation GIS (PGIS and PPGIS). Problem with traditional uses of GIS lies not with the technology, but with the way that GIS has been implemented and applied. However, there are few successful examples of a PGIS being successfully implemented, and frameworks for constructing PGIS are still embryonic. Before examining these areas, a brief history of the development of PGIS is presented.

3.4.5 Some background to Participatory GIS

In the late 1980s the United States National Science Foundation established the National Center for Geographic Information and Analysis (NCGIA). One of the NCGIAs research initiatives (initiative 19) in the mid 1990s was titled 'GIS and Society'. A summary of the initiative states that 'there is a need to incorporate social implications of how people, space and environment are represented in GIS and focus attention on the social contexts of GIS production' (NCGIA, 1996). At the same time that this initiative was launched a key publication set a new tone for examining GIS: *Ground truth: the social implications of Geographic Information Systems* (Pickles, 1995). These events led to the development of the concept of PGIS/PPGIS. It was first discussed in detail at a workshop at the University of Maine in 1996. Ideas were further developed at a conference at Durham University (Abott *et al.,* 1998). Since then a 'specialists' workshop to identify a research agenda has been held in Santa Barbara (Jordan, 1999), and a conference has been has been held at the University of Minnesota (University of Minnesota, 1999). Despite all this activity there is still little consensus regarding the features of a PGIS, or even whether they are desirable developments. The intellectual debates in this area have introduced the criticism and self-examination of the social sciences to GIS. Active practitioners have shared their experiences to try and improve on existing PGIS methodologies. This has led to a number of key characteristics of PGIS being identified, and identifying areas which are research priorities (see section 3.4.7).

3.4.6 The characteristics of a PGIS

There is no rigid definition of a PGIS/PPGIS available. However, there are a number of characteristics that would be expected from a PGIS. PGIS has connotations of empowerment for poorer members of society, representing their views and trying to reduce social inequities. Participatory GIS attempts to use the power of GIS to benefit local communities and grassroots organisations. It is more socially orientated than traditional uses of GIS:

- the range and nature of information collected should be influenced or decided by the participants
- data is obtained from a variety of stakeholder groups, usually with the emphasis on local communities
- data is ideally analysed by the participants, or the objectives of the analysis should be decided by them
- information is fed back to the local community
- there are mechanisms for receiving and acting on feedback from participants

A traditional GIS and a PGIS have a number of characteristics which identify them, as shown in Table 3.4. The distinction is not as clear cut as Table 3.4 indicates, the boundaries between GIS and PGIS are fuzzy.

GIS characteristics	PGIS characteristics
Techno-scientific focus	socio-technical focus
Outcome orientated	process & outcome orientated
Driven by technology push	driven by user demand
Hierarchical, top-down	grassroots, bottom-up
Authoritarian/despotic	democratic, open & participatory
End result is control	end result is empowerment
Geared towards 'the correct solution'	respects pluralism and multiple realities
Users are professionals	users are participants & community

Table 3.4 A comparison of GIS and PGIS characteristics
Source: Jordan & Kyem n.d.

A participatory GIS will usually contain a mixture of 'traditional' GIS data, such as spatial boundaries and land use classes, along with a variety of social data, such as land use patterns, community perceptions of resource importance and wealth ranking information. Some participatory GISs have attempted to integrate participatory methods into data capture (Jordan & Shrestha 1998; Stockdale and Ambrose, 1996) and participatory resource assessment has become an issue in its own right (Carter, 1996).

Participatory GIS for developmental work in natural resource management is still in its infancy, with a limited number of applications, and the lack of use of GIS for local level needs when compared to National or regional use has been commented on (Haase, 1992; Simonett, 1992; Cornelius, Heywood and Jordan, 1996). Some of the applications that purport to involve participation only examine human impact on resources (Yonzon *et. al.*, 1991). However, there are a number of examples of GIS being used as a participatory tool. The Kayan Mentarang Nature Reserve Project in East Kalimantan combined oral histories, sketch maps, Global Positioning Systems and GIS for customary land-use mapping (Stockdale and Ambrose, 1996; Sirait *et.al.*, 1994). The maps were used to identify customary forest-tenure boundaries, seeing how traditional and Government instituted systems of management could be co-ordinated, and for formalising and protecting customary tenure arrangements. It was noted that a constraint was the ability of social scientists and map-makers to accurately capture the complex relationships of traditional resource management systems. In south Africa a comparative study integrating individual interviews, participatory workshops, transect walks and GPS boundary identification has been conducted. This information has been entered into a GIS database to examine local perspectives and multiple realities on natural resource access, in south Africa and the USA (Weiner *et. al.*, 1997; Harris *et al.*, 1995). The work is still ongoing, but a major aim is to explore how community participation can be developed, particularly representing disempowered persons and sections of communities. Others have adopted the technology to increase local community participation in the management of Forest Reserves in Ghana (Kyem, 1997, 1999a), assist native American communities redefine themselves and their territories (Beltgens, 1995; Smith, 1995), codify local people's knowledge about land rights and local resources (Arvello-Jimenez and Conn, 1995; Forbes, 1995) and to present visually compelling images of local knowledge and thereby raise the possibility of incorporating such experiences into conventional decision-making processes (Bird, 1995; Fisher, 1994).The socio-political power of GIS information has also been examined (Dudley, 1996). This explores the worrying potential of participatory information being controlled by the state or other authority, and being used for purposes entirely different to that which the participants thought it was for. But PGIS has also been used to advocate for the inclusion, participation and recognition of marginalised groups (Jarvis and Stearman, 1995: Nietschmann, 1995). Broader ethical and societal issues of participatory GIS are explored by Pickles (1995).

3.4.7 A critique of PGIS

The application of GIS in a developmental capacity has been criticised by social theorists and some practitioners due to its tendency to be centralising, expensive, difficult to understand and disempowering (Taylor, 1991; Yapa, 1991; Cleveland, 1985). Emphasizing the pervasive influences of GIS on human society, critics argue that GIS is an elite technology whose adoption provides a tool for the rich and powerful members of society to entrench their power and extend their dominance over the poor majority (Curry, 1994; Pickles, 1991; Johnson, 1993). They contend that the technology's primary function of preparing data to facilitate decision making identifies it more with executives, administrators and other elite members in society, rather than promoting underprivileged groups. Additionally, they point to the control GIS exerts over information, which represents a major source of power in human societies (Curry, 1994; Pickles, 1991). They also claim that GIS has a tendency to confer power on people based upon their technical expertise, affluence and status, and less on their knowledge and experience with events in their communities (Curry, 1994; Pickles, 1995). Other workers are also against the expansion of GIS applications into non-Western societies on the basis of incompatibilities between Western culture and techniques for gathering and analyzing data, and similar techniques and practices traditionally used by indigenous people (Mark, 1993; Rundstrum, 1995).

Much of this criticism is justified: GIS has generally not been applied in a thoughtful or participatory manner for most developmental work. The application of GIS has not always been demand led (Kyem, 1999b; Hanna and Boyson, 1993; AFTEN, 1991). Whilst the application of GIS technology has generally been slower in natural resource management than in business and Governments (Dangermond, 1991), it has been even slower and less enthusiastically embraced in participatory resource management. This may be attributed to social scientists mistrust of GIS technologists, who often have little understanding of real-life resource management problems. This has been discussed in more detail by Hutchinson and Toledano (1993), based on work they conducted in India (Hutchinson and Toledano, 1990). The situation has improved since the early 1990s, with more professionals having dual skills in participatory resource management and GIS.

The academic 'home' of PGIS is within theoretical geography, with a blend of acrimonious and constructive engagement over PGIS having occurred between social theorists and 'technical' geographers (Openshaw, 1991; Taylor and Overton, 1991). Much of this was due to attempts to academically legitimise GIS and keep it within the field of geography. It has been stated that as soon as a worthwhile use is found for a geographical technique, it ceases to be geography. As the 1990s have progressed there has been an increase in interdisciplinary approaches, and the entrenched positions of the social and technical geographers have changed to a constructive synthesis. This has resulted in areas of agreement, places of agreement to differ, and recognisable *terrae incognitae* of knowledge with new areas for intellectual growth (Sheppard *et al.*, forthcoming). The academic debate has led to a theoretical base for PGIS that can be divided into five areas (each of which is an identified research theme – see UCGIS, 1998):

- the institutional approach
- the legal and ethical perspective
- the intellectual history
- the critical social theory
- Public Participation GIS perspective

Whilst the above developments have provided a body of theory to support PGIS, and have introduced a number of social perspectives to the debate, much of this has been highly theoretical. It is felt that practical social theory, and techniques, have been largely ignored by the PGIS community. There is very little reference to, or understanding of, the vast body of existing literature and knowledge within participatory development. The bullet points in section 3.4.6 above, illustrating the social aspects of PGIS, could equally describe a participatory appraisal. The need to integrate participatory research methods and participatory appraisal techniques with PGIS has been commented on, but infrequently (Dunn, 1997; Weiner and Harris, 1999). It is considered that this is a major failing with PGIS, and attention should be focussed on integrating these two bodies of knowledge.

It is felt that a PGIS is best thought of as a participatory process incorporating geomatics techniques. In community forestry terms:

'a PPGIS should be a process; it starts with the public participation procedure and intrinsically involves feedback to, and from, the Forest User Group. Decision-making should not be made centrally, the PPGIS should be a decision support tool for the FUG, providing information they can use for their management decisions. Although the software and decision analysis processes are outside of the sphere of access of the FUGs, with associated problems (Harris et al., 1995), it can be argued that the decision making process can be brought back to the FUG. This is a central issue in making a PPGIS genuinely people orientated'. (Jordan, 1998 p.7).

Again, the above could refer to a standard participatory process. As well as the lack of integrating participatory skills and knowledge into the PGIS debate, it is felt that theoretical aspects have dominated at the expense of practical research. There are still fundamental practical questions that need to be addressed:

- can a generic framework or system for a PGIS be developed? Models of how a PGIS can be developed and operated have not been produced. This work needs to be based around a participatory approach
- how can genuine and equitable participation be encouraged, and does the use of geomatics technology encourage or hinder this?
- how can the success of a PGIS, and the value added by using geomatics, be evaluated?

3.4.8 Advantages and disadvantages of using GIS

This final section on GIS examines some of the problems with using GIS. Many of these problems are technical, and it is important to realise that PGIS still requires high quality technical GIS, as well as high quality participatory approaches. Care must be taken with the interdisciplinary PGIS approach that 'sloppy' social science is not combined with 'sloppy' GIS.

Many of the advantages of GIS have been presented throughout the previous sections, and are summarised in Table 3.5.

Direct benefits of GIS	• savings in staff time • savings in storage space (digital data rather than paper copies) • can produce maps cheaply and quickly • can produce customised maps (of specific use for community groups etc.) • ability to combine and analyse data in new ways, with a greater modeling capability • ease of updating data models and models, allowing quick recalculations if there are changes in criteria • best way of managing, integrating and displaying spatial information
Indirect benefits of GIS	• provides a tool for decision making • allows better information flows within organisation/project • centralised holding of spatial information in organisation/project, providing easier management and less duplication • high quality images in a format decision makers are used to

Table 3.5 The advantages of GIS. Sources: McKendry and Eastman, 1992; Daplyn *et. al.*, 1994; Haylor and Jordan, 1994; Cornelius *et. al.*, 1996

As with any technology, there are problems with using GIS. These disadvantages are presented in Table 3.6, and the problems that are particularly significant in developing countries are discussed below.

Systems, management and data problems:	System costs Data costs and data accuracy Time needed to learn the system Lack of availability of digital data Organisational issues Data exchange issues
Problems specific to natural resource management:	The need to ground truth The need to integrate GIS with Remote Sensing GIS tends to be office based Limitations with modeling abilities of GIS
Problems relating to participatory applications:	Access to data Uncertainty regarding quality of existing datasets Data often not geo-referenced

Table 3.6 The disadvantages of GIS. Sources: McKendry and Eastman, 1992; Daplyn *et. al.*, 1994; Haylor and Jordan, 1994; Cornelius *et. al.*, 1996

A major system-based problem is the cost of a GIS. A large organisation may spend several hundred thousand pounds on a GIS. But a GIS and supporting hardware can cost as little as £2000, and for viewing software (or a low cost GIS) and a computer, the cost can be less than £1000. This still presents problems in developing countries, restricting its availability to larger District offices. This has implications for the participatory use of GIS, as the cost encourages centralisation and office based applications (see below).

In many countries (almost all developing countries) thematic digital data is usually difficult to obtain. This means either digitizing it or obtaining it through a consultancy contract. Both of these methods may introduce data errors. Additionally the quality of the original analog data may not be known.

Introducing a GIS into an organisation or project requires a lot of planning and consultation between Departments. All potential users of spatial information need to discuss issues such as base scales for the GIS, functionality's and attributes to be recorded. Data sharing will be required and a high level of inter-Departmental cooperation is necessary. In many developing countries hierarchical and compartmentalised management structures exist, which do not encourage interdisciplinary approaches. Fundamental institutional reform may be needed before the advantages of a centralised GIS can be maximised. This may take a considerable period of time.

A key problem with natural resource management is the need to ground truth. A lot of GIS modeling and classification work is not verified by fieldwork (Jordan, 1994). Ground truthing tends to be expensive and time-consuming, but without it there is no way of assessing the validity of GIS models or images. GPS is playing an increasingly important role in ground truthing, as spatially located attribute information can be (relatively) easily obtained. Forests can be classified by broad-level inventory using remote sensing, but even with this the need for ground truthing remains essential (McKendry and Eastman, 1992).

GIS tends to be office based, which makes it remote from forest resources and forest users. The increasing availability of low cost, PC based GISs means that it is possible to take them into the field or be based at a field office (Carver *et. al.*, 1995). This increases the potential for participatory GIS.

It has been stated above that the modeling capacity of GIS is often under used. Although Forestry uses have tended to a display a higher degree of simulation modeling and multi-objective planning procedures than other applications, due to the dynamic features of a forest resource (both ecological and management related, McKendry and Eastman, 1992), GIS modeling is still limited and unimaginative.

Some of the problems discussed above relate to participatory applications of GIS (particularly the traditional office based nature of GIS). A problematical area of using GIS in a participatory context relates to data (Daplyn *et. al.*, 1994). Common problems are:

- sampling flaws, raising questions on data quality and utility
- unplanned variation in seasonal timing (for example, division of household labour for agricultural tasks)
- having to rely on aggregated data rather than primary data
- no georeferencing of data
- limited geographical coverage
- no information on data quality, variability or confidence
- data derived from unexplained models (such as farming systems at different altitudes derived from a study of three villages)

Much socio-economic and participatory information available is not collected with the objective of entering it into a GIS. Spatial considerations are not fundamental, and georeferencing of data may be poor (for example, village names) or non-existent. Additionally, data may not be reliable for a number of reasons, a particular concern in the Himalayan region (Thompson and Warburton, 1985). This may be due to poor experimental design, unjustified extrapolation, or converting participatory information into quantified data without explaining the method or sample size. Caution should be applied when using existing data sets, and they should be evaluated as thoroughly as possible.

To summarise this section on GIS, consideration needs to be given to the participatory process within a PGIS, social issues, technical details and institutional considerations. It is considered that most of these issues have been addressed previously in participatory development, and PGIS is best regarded as a new development in participatory methodology. Additionally, thought needs to be given as to why geomatics should be incorporated into the participatory process: what is the added value?

3.5 Forest resource assessment

This section provides some background information on forest resource assessment and traditional forest inventories, and then explores two more recent developments: multi-resource inventories and CFRAs. The last of these is a particularly appropriate approach for community forestry in Nepal.

Forest resource assessment, or the measurement of forest resources, can take many forms. Traditionally, forest resource assessments were associated with the measurement of timber resources, to determine how the forest was developing and to quantify the value of the timber. This key area of forestry became known as forest mensuration (Martin & Ek, 1990). The approaches of traditional forest mensuration are geared towards production forestry and view forest products as timber based commodity products. As forestry became concerned with multiple uses and objectives, the scope of forest resource assessment increased to include environmental functions, biodiversity, NTFPs, habitat monitoring and social values. This broader type of assessment became known as Multi-Resource Inventories (Lund, 1998). More recently, forest resource assessment has become concerned with participatory issues, processes and information needs, and the concept of participatory resource assessments has gained popularity, reflecting the general increase in participatory approaches to natural resource management. These areas are detailed below. Surveys and inventories are dealt with separately, although the distinction in the literature is not always clear. In this text inventory refers to a systematic forest resource assessment, but statistical validity is not necessarily inferred (Avery & Burkhart, 1994). Survey refers to a more variable process, where the scope and precision the information collected is far more changeable. Statistical significance may not be as important. It should be emphasised that there is no prescriptive approach to forest resource assessment, and the techniques used are highly dependent on specific objectives and resource features.

3.5.1 Inventories

Inventories are a core part of traditional forest management planning, providing essential information on the forest resource for management purposes (Philip, 1994). The development of inventory techniques dates back to the foundation of forestry science, in 18th century Germany (Westoby, 1987). These early inventories had no statistical base until the 19th century, when forestry was one of the first users of statistical sampling techniques (Carter, 1996). This has continued throughout the 20th century, with modern forest inventory utilising detailed statistical theory. More details can be found in Freese (1984), Philip (1994) and Avery & Burkhart (1994).

Inventory activities can be conveniently divided into two broad categories:

- for national/regional planning
- for local level forest management planning (district and range post planning)

These two areas are fairly distinct, with separate objectives and methodologies. National and regional planning is often based on the use of satellite imagery and image interpretation, to determine the broad type, extent and condition of forest resources. It is also concerned with trends in the resource, such as deforestation. Local level forest management planning is usually based on aerial photography and fieldwork: physically measuring attributes of the forest resource. For the purposes of this work only the second category is relevant. There are a number of reasons for conducting a local level inventory, for:

- a wood based feasibility study

- long and short term management planning
- land acquisition purposes
- logging or timber sales

Prior to conducting an inventory it is important to determine what the specific objectives and desired outcomes are. These will determine the intensity and precision of the work, and specific methodologies to be utilised. Increasingly a systems based approach to forest inventories is being employed, with a focus on the planning stage (Avery & Burkhart, 1994; Lund, 1998).

Because inventories are context dependent, it is difficult to generalise about the methodology to be employed. However, the following information is usually required for a timber production orientated inventory:

- the area (ha or km^2)
- species
- age or age distribution (may just use size of trees in a natural forest)
- the growing stock
- size class distribution
- mean volume per tree
- yield class
- natural regeneration (not always required)

The above will be required for each 'sub-unit' of the forest area. A sub-unit is a relatively homogenous unit with similar ages and species of tree within it, commonly referred to as a Local Forest Management Unit (LFMU) or compartment. The information listed above is of two types: information concerning the resource at the time of measurement, and information predicting how the forest will alter with time: the yield class. This uses the top height and age of the trees to determine the mean annual increment (growth rate) of the stand. It is a generalised model based on data from many different Permanent Sample Plots (PSPs). If yield class tables are not available, information on growth rates must be obtained in other ways: PSPs can be established but they require many years of data before they provide worthwhile growth rate data, and must be carefully looked after; or information from secondary sources (academic papers or other similar forests) can be used.

Forest inventories rarely sample 100% of trees in a forest, unless the area is very small, the trees are vary valuable, or highly heterogeneous. Sampling occurs at a pre-determined intensity, which is dependent on variability of the tree population, desired statistical reliability, and practical constraints (usually time, money and trained personnel). Sampling intensities usually range from 10% to <1%. Full details of sampling techniques and sample plots can be found in Philip (1994) and Hamilton (1975).

3.5.2 Surveys

Survey in forestry terms generally refers to one of two activities:

- a rapid, low accuracy inventory
- a resource assessment activity focussing on non-timber related attributes

The first activity above is often termed a timber 'cruise'. These are often used for obtaining initial information on large areas of forests, often using techniques such as line transects (a 1-10km straight line through a forest continuously measuring a *ca.* 10m wide strip). This obtains a fairly crude measurement of size classes, growing stock, species distributions and good and poor parts of the resource for specific activities - usually logging (Philip, 1994). This activity is usually performed prior to more detailed inventory work. The second type of survey is usually subject specific. Examples include economic, ecological, topographical, habitat or socio-economic surveys. These may have a lot (some ecological surveys) or very little (socio-economic surveys) in common with inventories. Within a project or organisation many surveys may be conducted in the same resource area, with little interaction or information sharing between the departments or personnel who conduct them. This leads to inefficiencies and duplications of information gathering. It also encourages compartmentalisation, and a lack of interdisciplinarity. A realisation of this problem led to the development of Multi-Resource Inventories (MRIs).

3.5.3 Multi-Resource Inventories

MRIs can be described as data collection strategies designed to meet all or part of the information requirements for two or more products, functions (such as watershed protection) or sectors, such as agriculture or forestry (Lund, 1998). An example of a MRI would be a traditional forest resource inventory, combined with wildlife and regeneration surveys. They are characterised by being multidisciplinary and cross sectoral.

MRIs were developed because decisions are rarely made in a single resource use context. It was felt that they would provide a greater level of resource information to allow improved decision making. MRIs can be considered to be decision support tools, incorporating a number of specific inventory and survey techniques within a systems based approach (Lund, 1998). This is illustrated by Figure 3.4, from the most recent major publication on MRIs. This coordination between departments, organisations and personnel also provides for a cost effective means of utilising resources.

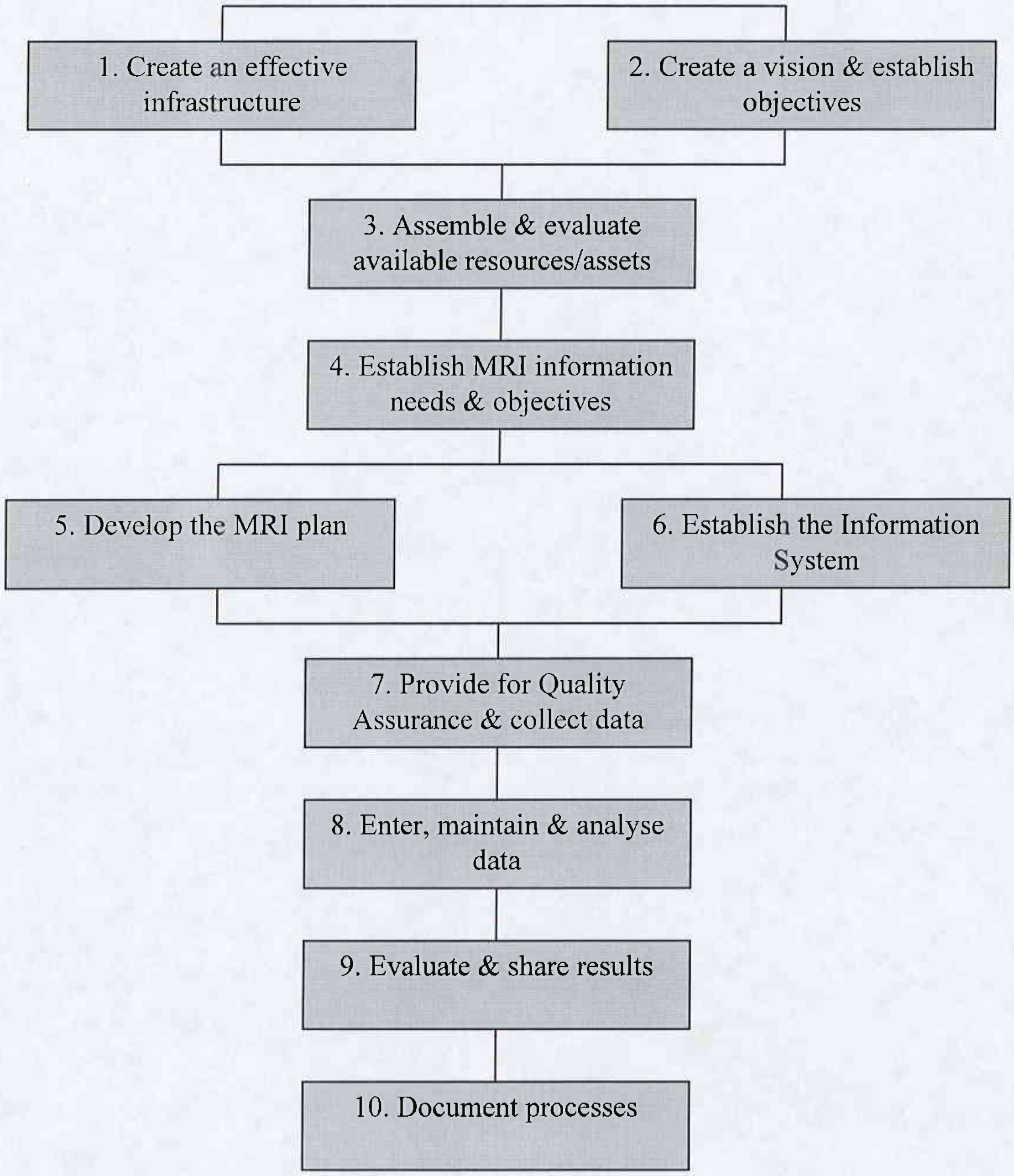
The Key reasons for conducting MRIs are to:

- reduce costs
- improve information databases
- avoid many field visits to same site for different purposes

From a production and resource perspective there are a number of discrete objectives for MRIs (Lund, 1998):

- determine the condition, production, potential & amounts of key ecosystem components or processes
- identify a benchmark of the current physical & biological situation for forecasting projected changes
- provide ecological information as a basis for protection & management decisions

- tie specific units of land to information about resources



(Source: from Lund, 1998, P. 29)

Figure 3.4 Steps in implementing an MRI

An MRI is usually different from a traditional forest inventory as there are wider objectives. Information is collected for a number of purposes, often to address the information needs of multi-objective or ecological forest management. Additionally, a proper MRI is a system, in much the same way as GIS is a system. MRIs tend to be analysed more from the perspective of management science, with many elements in common with a Quality Assurance system, as functionality & reliability are key elements.

3.5.4 Participatory Forest Resource Assessment

As modern 'ecological' forestry has demanded a wider set of data to assist with multi-objective forest management, developmental forestry has required a participatory approach to resource assessment, to include local peoples knowledge and information needs. This approach has been defined by Carter (1996 p.14) as:

> ' … working with local people to quantify or measure the extent, composition and worth (to them and possibly to outside parties) of a forest owned or used by them.'

Participatory forest resource assessment covers a great variety of activities and needs, and it is difficult to provide a generalised approach. A UK Forest Research Programme study attempted to document and examine a number of participatory forest resource experiences in developmental community forestry (Carter, 1996). This provides the best available source of case-study material and discussion on participatory forest resource assessments (or CFRAs), and provides most supporting references below. As with other participatory approaches, the techniques used vary greatly from situation to situation, and a common method cannot be identified. One generalisation that can be made is that the forest resource assessment has to be part of a thorough participatory process. Ingles *et al.* (1996) notes that prior to conducting forest centred activities, more traditional participatory research may need to be conducted. It is felt that this is essential, either as an integrated part of the CFRA, or as a separate activity.

A CFRA can be considered as an inventory involving local people, with some or all of the resource assessment objectives defined by local people. It will usually utilise some of the concepts of MRI, and it would be unusual for timber production to be focussed on solely (although this may be the case, see Dunn and Otu, 1996; Jordan, 1996). It is more likely to be primarily geared to assessing the potential of a number of different forest products, including NTFPs, fuelwood and/or non-monetary benefits (Kyem, 1999a).

Quantifying data reliability (using statistical tools such as confidence limits and standard errors) may be less important than the social elements within the inventory process, and is usually perceived as less important than with a traditional inventory. Sampling intensities may be lower, or sampling may be more directed (towards 'good' or 'bad' parts of the resource). However, participatory resource assessments do not preclude the use of statistical techniques, and they will add value to the results of the assessment (for an example, see Stockdale and Ambrose, 1996). Data reliability may be further assessed by comparing the results against previous studies, or re-sampling a part of the participatory resource assessment using traditional inventory techniques (Lawrence and Roman, 1996).

CFRAs are usually associated with participatory forestry in a developmental context, and are often a part of the process of local people taking control of forest resources (Carter *et al*. 1995). They are particularly useful where little local level forest management information is available, the situation with most forests in developing countries. They are often used to provide base-line data which can be used, with caution, to provide information for determining sustainable yields, biodiversity information, monitoring NTFPs, or certification purposes (for examples see Gronow and Safo, 1996; Jordan, 1996; Lawrence and Godoy, 1996: Stockdale and Ambrose, 1996). The level of information provided is generally lower than for forestry activities in developed countries, but still allows informed management decisions to be taken.

It is important to realise that the focus of CFRA should be on participation, and techniques such as focussed RRA are very important to determine community priorities and information needs (Messerschmidt, 1995). Techniques should be designed so that local people can understand the process, collect information and make decisions on how it will be used for forest management purposes. As far as possible ownership of information should be with the assessment participants. Experiences have tended to show that participation is greater in data collection than data analysis, which is often outsider-controlled (Carter *et al.*, 1995).

CFRA also utilises traditional forest assessment tools and approaches (see section 3.5.1) and spatial technologies. Some of these techniques require technical competence, and others (such as GPS) are difficult to use in a genuinely participatory manner. It is important that these are still part of a participatory process, and at the least it should be explained to local people what is being done and why, and the information that the community will receive from the activity.

A number of advantages and disadvantages of using CFRA to obtain resource information have been identified. These are presented in Table 3.7.

CFRAs represent an important tool for community orientated forestry (Jackson *et al.*, 1996). They provide a 'middle way' between the time consuming, costly and non-participate traditional forest inventories and the social science approach which generally ignores quantitative resource assessment. They represent the only practicable way to collect resource information useful at a community level (Hunt, 1998), allowing forest resources to be utilised and managed in a responsible manner.

Advantages	Disadvantages
high level of community participation	not easy to replicate (specific methodologies will vary according to the situation)
high level of community ownership (ideally)	may be difficult to get information back to the community
information gathered geared towards local needs	may be high level of uncertainty regarding data accuracy (a low level of statistical reliability)
utilise appropriate technology	
cheap (compared with a conventional inventory)	
may be sustainable (if the FUG have been adequately trained and receive tangible benefits from the process)	

Table 3.7 Advantages and disadvantages of a participatory approach to forest resource assessment

There is a danger with an approach which is on the interface between traditional forest assessment and a social sciences approach to development. It is easy to produce poor quality forest resource assessment, coupled with poor quality participatory work. It is felt that two elements are required to prevent this happening: a multi-disciplinary team and a systematic approach to CFRA. The need for multi-disciplinary teams has been discussed before, specifically in the context of community forestry (Gilmour and Fisher, 1991), and this is now common practice. A systematic approach to CFRA has not been considered in detail. It is felt that the framework approach associated with MRIs should be adopted for CFRA. This would allow for a more systematic approach and allow for participation, evaluation and co-ordination to be built into the assessment process. Although an entirely *ad hoc* approach to participatory resource assessment results in a high level of creativity and transferable experiences, it is felt that these advantages could be maintained by providing a framework rather than a prescriptive approach (Clayton and Radcliffe, 1996). The framework would provide a methodological approach for CFRAs. This is discussed in chapter four.

CFRA has been practiced in a variety of forms in Nepal since the early 1990s, and a number of approaches have been documented (Ostravee, 1998; Branney, 1994a, b; Jackson *et al.,* 1994; Metz, 1991). As these have been specifically modified for the circumstances of community forestry in the mountains of Nepal they have been reviewed as part of the development of a forest resource assessment method for this study, in section 6.1.

3.6 Participatory and rapid appraisal techniques

Traditionally, managed and planned forestry has focused on the biological and economic aspects of forest management. As discussed above, community forestry, whilst considering these issues, has a more people-oriented focus. This important distinction between the management goals of 'traditional' and community forestry has lead to a fundamental difference in the tools and techniques applied in forest management. Traditional forest management has its roots in biological science, economics and quantitative measurement, with areas such as silviculture, mensuration, yield prediction, forest economics and nursery practice being key areas in traditional forestry. Community forestry uses a people centred approach, tending to be less concerned with quantitative approaches, instead using techniques developed from the social sciences, and more specifically, from participatory agricultural research.

This section outlines the philosophy and approaches of participatory and rapid appraisal techniques as applied to community forestry. These are important for CFRA because they are utilised throughout the process (particularly in the early stages) for determining community objectives, priorities and assessment needs. Some of the key tools used as part of, or in conjunction with, CFRAs are examined.

3.6.1 The background and philosophy to participatory and rapid appraisal techniques

Successful community forestry involves a high level of participation in forest projects by the local population. The actual level of participation varies greatly, as illustrated in Table 3.8. The most important methods for facilitating participation are a series of methods described as 'rapid appraisal techniques' (see section 1.3). These refer to some form of group assessment research technique focused on indigenous knowledge, people's participation, local needs and contextual understanding, using a series of rapid diagnostic methods (Messerschmidt, 1995; Carter, 1996).

Level/Type of local peoples participation	Characteristics of participation	Level of outsider control	Potential for sustaining local action/ ownership	Role of local community
1. Co-option	Tokenism - representatives chosen but have no real input or power	Very high	Very low	Subjects
Manipulative participation	Participation is a pretence with people's representatives on official boards, but having no real power			
2. Co-operation	Tasks are assigned with incentives, but by outsiders who decide the agenda and direct the process	High	Very low	Employees/ subordinates
Passive participation	People participate by being told what has been decided and what to do. Unilateral announcements by project management, without listening to people's responses			
Participation for material incentives	Participation through contributing resources i.e. labour, in return for food, money or other material incentives			
3. Consultation	Opinions asked: outsiders analyse information and decide on a course of action	High	Very low	Clients
Participation by Consultation	External agents define problems and information gathering processes, and control analysis. No share in decision making, no obligation to consider community views			
Functional participation	Participation seen as a means to achieve project goals & reduce costs. Involvement may be interactive with shared decision making, but often only after major decisions have been made			
4. Collaboration	Local people work together with outsiders to determine priorities. Outsiders direct the process	Quite high	Low	Collaborators
5. Co-learning	Local people and outsiders share knowledge & work together to formulate action plans. Outsiders facilitate	Low	Quite high	Partners
Interactive participation	Participation is seen as a right, not just a means of achieving project goals. Groups take control over local decisions and resource allocation, giving a stake in maintaining structures or practices			
6. Collective action	Local people set and implement their own agenda; outsiders absent	Very low	Very high	Directors
Self-mobilisation	Local people develop contacts with external institutions for resources and technical help, but retain control over how the resources are used			

Table 3.8 Levels of participation in participatory development
Source: Modified from Cornwall (1995), in Carter (1996), and Bass *et.al.* (1995) in Hobley (1996)

Rapid appraisal methods are good for obtaining qualitative information, which may be quite subjective, for example, the relative importance of fuelwood compared to agricultural land. It provides a basic overview of a forest resource and the way people interact with it. It should not be used to provide quantitative data, or accurate spatial information, without including other research methodologies which are more suited to analytical evaluation (Molnar, 1991; Bryant & Bailey, 1991).

Arguably the two most important areas of participatory and rapid appraisal techniques (and the terms usually used) are Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA). Whilst these two areas are differentiated, some practitioners of community forestry have preferred to put them under the umbrella of rapid appraisal tools or techniques (Messerschmidt, 1995 (footnote p.1); Nurse, Bartlett & Singh, 1992).

PRA and RRA are closely related families of approaches and methods. RRA developed and spread in the 1980s, and PRA has developed and spread in the 1990s (Chambers, 1994a). Prior to the widespread implementation of RRA and associated techniques, rural assessment tended to be more conventional. McCracken, Pretty and Conway (1988) drew up a table contrasting the techniques used in both conventional and RRA approaches, which is reproduced in Table 3.9.

Techniques Employed	Conventional	RRA
Statistical analysis	Often a major part	Little or none, use of triangulation
Formal Questionnaires	Often included	Avoided
Interviews with local farmers and key informants	Through formal questionnaire if at all	A major component using semi-structured interviewing
Qualitative descriptions and diagrams	Not as important as the 'hard data'	Considered at least equally important
Sampling	Statistically acceptable sample sizes regarded as necessary. Often random sampling	Often small sample size, selecting 'key' areas, or farms, households etc. 'Statistical' requirements not always adhered to
Consulting secondary data sources	Yes	Yes
Measurements	Detailed, accurate	Qualitative or indicators used
Group discussion	Informal unstructured sessions	Via semi-structured workshops and brainstorming

Table 3.9 Comparison of conventional and RRA approaches
Source: McCracken, Pretty & Conway 1988, p.11

3.6.2 The Rise of RRA

An obvious question is that if RRA techniques are so powerful for rural assessment purposes, why did it take so long for the development community to adopt what appear to be common sense procedures? Chambers (1994a) suggests it was the attitudes of outsider professionals, who believed that their knowledge was superior to that of the rural poor. The way that these professionals traditionally approached interactions with villagers ensured that these views were enforced. What was required was a paradigm shift in development theory and practice, something widely reported throughout the associated literature (for examples see Gilmour and Fisher, 1991; van Gelder and O'Keefe, 1995, Pretty and Chambers, 1994; Jamieson, 1987; Chambers 1994b). A paradigm acknowledges that scientific discovery does not follow the idealistic model of impartially testing a hypothesis, but relies on a theoretical and methodological belief system which provide assumptions for work within a field of study (Kuhn, 1970). This can be described as a 'professional culture', a set of rarely questioned assumptions (Gilmour and Fisher, 1991). The old paradigm for forestry development was one with professional experts holding all forestry knowledge, backed up by Western economic and scientific theory. Therefore the idea of providing expert knowledge and ‘assistance’ to the rural poor was so deeply ingrained into the culture of development that it was virtually unquestionable.

During the 1970s many individuals started to recognise the value of different approaches that were contrary to the traditional culture of developmental research. Practitioners began to realise that rural development ‘tourism’ (a brief tour to easily accessible project sites to meet selected villagers) created great bias; quantitative questionnaires were both unreliable and wasteful of time and resources, and that local people had a wealth of knowledge valuable to the development process, sometimes called indigenous technical knowledge (Chambers 1994a). Initially, and in many cases still, practitioners had to struggle against the requirements of development organisations, who wanted traditional quantitative information and were wary of the less ‘scientific’ information provided by these new ways of thinking. This challenging of assumptions, the realisation of the value of participatory approaches, and institutional resistance to change by the ‘establishment’ closely parallels the changes in developmental forestry that occurred in the 1970s, as outlined in section 2.2.1 above. Indeed, the combined changes in these professions was a reflection of the wider changes occurring in general rural developmental theory and, in some cases, practice.

Another contributing factor to the rise of RRA was a move away from concentrating on resource rich, homogenous environments, to looking at poorer and heterogeneous environments. Owing to the higher diversity and greater complexity of these systems, there became an increasing need to understand the agricultural and forestry frameworks in greater detail (McCracken *et. al.*, 1988). The need for a greater level of understanding of human-environment interactions led to the development of Farming Systems Research (FSR). McCracken *et. al.* (1988, p. 9) describes the key features of this approach as:

> “...an applied, holistic and iterative approach, conducted by multidisciplinary teams, with a degree of farmer participation...”

The new techniques developed in FSR became known as Rapid Rural Appraisal, a label apparently originating from conferences in 1978/1979 at the Institute of Development

Studies, Brighton (Moris and Copestake, 1993). However, Gilling and Cropley (1993) note that it is debatable whether the development of the term RRA really represented a major change in approach, because good researchers were using similar approaches prior to this. Nevertheless, they suggest that coining the term RRA provided pseudo-academic support for previously unacceptable informal approaches.

3.6.3 Characteristics of RRA

Whilst it is difficult to rigidly define the 'RRA approach', since a key feature is the need to be adaptive and responsive to changing circumstances, Conway (1986, p.11) describes it as:

"...a systematic, but semi-structured activity carried out in the field by a multi-disciplinary team designed to acquire quickly new information on, and new hypotheses about, rural life."

McCracken *et.al.* (1988, p. 9) provide a similar definition, stating that RRA is:

"...methodologies which make use of a multidisciplinary team, working with farmers and community leaders to develop in a quick, yet systematic fashion, a series of hypotheses.."

RRA consists of a variety of different tools and techniques to enable the acquisition of information. The particular tools chosen and how they are applied varies depending on the situation. RRA should be viewed not as a method, but more as a strategy for working where there are unknowns (Moris and Copestake, 1993). A general philosophy is outlined by McCracken *et. al.* (1988), and has been tabulated in Table 3.10 below.

Themes	Explanation	Practicalities
Optimal Ignorance	Amount & detail of information required to formulate useful hypotheses are regarded as an expense to be minimised	Multidisciplinary team agrees a sufficiency of knowledge of key processes/properties, and do not exceed this
Triangulation	Use of several sources & means of gathering information. Rapid build-up of diverse information approaches 'truth'	Secondary data, direct observation, semi-structured interviews, diagrams etc. all employed, compared & contrasted
Key features		
Iterative	Processes & goals not immutably fixed prior to appraisal	'Learning as you go', information gathered constantly sets/alters agenda for later stages
Innovative	No simple, standardised methodology	Techniques developed for individual situations depending on skills/knowledge available
Interactive	Team members & disciplines combine to foster interdisciplinary insight	Systems perspectives used to aid communication
Informal	Emphasis on semi-structured and informal interviews, and discussion	In contrast to more traditional approaches
In the community	Learning takes place in the field, or immediately after, in short, intensive workshops	Allows villagers perspectives to be utilised

Table 3.10 The philosophy and scope of RRA
Source: Compiled from McCracken *et. al.* (1988) pp. 12-13

Using the themes and features outlined in the above table, provides a more cost effective means of gaining information than traditional methods, and also provides greater insight to local peoples activities and conditions.

A criticism sometimes voiced regarding RRA is its extractive exploitative or elicitive nature (Chambers 1994a). Usually outsiders collect information, which is taken away and analysed elsewhere. This may be a valuable procedure, but it is essentially non-participatory. This is the key difference between the somewhat academic classifications of RRA and PRA.

3.6.4 The characteristics of PRA

Whilst the concept of PRA had a history stretching back to the 1970s, it wasn't until the mid 1980s that participation was becoming a key concept in rural development circles (see for example Fernandes and Tandon 1981; Cernea 1985; Shanks 1987; Arnold 1989; Westoby 1989). A key event was the 1985 conference on RRA held at Khon

Kaen University, where one type of RRA identified was termed 'participatory RRA' (Chambers, 1994a). Similarly, the preface of McCracken *et. al.* (1988) also lists participatory RRA as one of four classes of RRA.

Chambers (1994a) notes that although PRA is seen as an extension of RRA, it also incorporates or parallels other research technique groupings:

- Activist Participatory research: using dialogue and participatory research to empower people.
- Agroecosystem analysis: a combination of ecological systems analysis, spatio-temporal considerations, causal flows and relationships, and decision making. (The classic example is in Conway (1987), and more information on agroecosystem analysis, an important source of techniques for PRA, can be found in Conway (1986)
- Applied anthropology: providing an appreciation of the wealth and usefulness of indigenous knowledge.
- Field research on farming systems: demonstrating the rationality of what often appears to be untidy and unstructured rural practices.
- Rapid Rural Appraisal: discussed above, and also the most important component of PRA.

Chambers (1994a) points out that it is fallacy to completely isolate these areas or attempt to temporally distinguish them from each other, as they tend to intermingle and cross fertilise.

3.6.5 Differences between RRA and PRA

There are some key differences between RRA and PRA that are worth noting:

- RRA is extractive by nature, PRA is facilitating and participatory.
- RRA attempts to utilise local peoples knowledge, PRA tries to utilise local peoples knowledge and analytical capabilities.
- The ideal objectives of RRA and PRA are learning by outsiders and empowerment of local people, respectively.

- With RRA the role of outsiders is investigative, with PRA it is facilitative.
- Whilst RRA is a rapid approach, PRA requires a longer time period to build up trust with the community.

Some authors consider that these differences between RRA and PRA (and the other groupings above) make it important to differentiate between these types of research. Chambers (1994a) discusses this issue, and concludes that there is a continuum between RRA and PRA, and that the two are somewhat indistinct, although their goals may be different (PRA is often associated with personal and institutional change). Gilling and Cropley (1993) believe that there is a distinct difference, based on the length of time needed to establish meaningful rapport with villagers. Some authors barely distinguish between the two (Moris and Copestake 1993; Messerschmidt 1995) and it is interesting to note that much of the case study and fieldwork based literature makes little or no distinction between PRA, RRA or the other terminology used above. Usually a descriptor is added to participatory i.e. participatory mapping, inventory, resource assessment, survey, planning. Appropriate tools and techniques are utilised from PRA, RRA or elsewhere from the social, anthropological or more quantitative sciences. This can be clearly seen in the more 'practical' literature such as *PLA* notes, the *Rural Development Forestry Network* papers, or *Forests, Trees and People* newsletter. It should also be noted that RRA and PRA are not the sole major groupings, and terms such as Participatory Action Research are also commonly used.

As far is this work is concerned, the term 'rapid appraisal tools' is felt to be most appropriate, where tools of both RRA and PRA are used for participatory forest resource assessment as appropriate.

3.6.6 Rapid appraisal tools

This section provides a brief overview of the main rapid appraisal tools used in community forestry, and provides detail of those with particular relevance for forest resource assessment. In-depth information on other tools can be found in Molnar, 1989;

Davis-Case, 1990; Poffenberger *et al.*, 1992; Thuvesson, 1995; Messerschmidt, 1995; Jackson *et al.*, 1996 and Subedi and Sharma, 1997.

It is important to distinguish between rapid and participatory appraisal tools, sometimes known as diagnostic tools or rapid diagnostic techniques (Fox, 1989; Messerschmidt 1995) and the rapid/participatory appraisal process. The tools form a 'toolkit' of specific techniques which are selected as required during the process, or used individually (Davis-Case, 1990). Table 3.11 contains brief information regarding some of the more common tools used for general RRA/PRA work.

The tools listed in Table 3.11 do not constitute a definitive list, and new tools are being constantly developed (for example, see Guy & Inglis, 1999). As noted above, a number of these tools have great potential for use in participatory forest resource assessment, and are discussed in more detail below.

Tools commonly used for rapid appraisal purposes

Tool	Brief description
Secondary data review	A conventional approach, but important for developing a more holistic picture.
Semi-structured interviews	A loosely structured interview with some questions to provide focus, but with much emphasis on providing a depth of knowledge rather than yes/no responses.
Focus/interest group interviews	As above, but with sub-groups of the community with a common interest.
Key informant interviews	As above, but with individuals who are key players or stakeholder group representatives.
Direct observation	Observing events, processes, relationships, activities & recording them, perhaps using indicators (e.g. of prosperity).
Calendars (time lines, work schedules, seasonal calendars)	Recording changes in crops, labour activities, household income etc. to obtain a picture of seasonality.
Ranking	To determine priorities and the relative importance of services, crops activities etc. Wealth ranking and pair-wise comparison ranking are common adaptations.
Historical mapping	To determine how resources, population and activities have altered, as a diagram or with some spatial component.
Participatory sketch mapping	Mapping resources with focus groups to determine resource usage patterns, ownership etc. May be modified to increase spatial accuracy, perhaps by using aerial photographs.
Group walks and transects	A tour or transect through farming and forest resources to obtain an idea of type, extent and condition of resources and farming systems.
Decision trees	An attempt at recording decision making processes within the community, e.g. for expanding agricultural area where forest resources are limited.
Flow diagrams	To provide an understanding of agricultural or forest production processes.
Workshops	A means of two-way communication between local communities and Non-Governmental/Governmental staff.
Picture and flannel boards	Used to help illustrate and visualise processes.
Community environmental assessment	For monitoring and evaluating environmental change from a communities perspective.
Stories, portraits and case studies	These provide rich information on a community and real life information.
Diagrams and diagrammatic models	Schematic tools to present information in a visual and understandable manner to aid understanding and communication.
Ocular estimates	Visual, rough quantitative estimates of e.g. the area or condition of a forest resource.

Table3.11 Tools commonly used for rapid appraisal purposes
(Souses: McCracken *et al.,* 1988; Davis-case, 1990; Messerschmidt, 1995; Subedi & Sharma, 1997)

3.6.6.1 Focus group semi-structured interviews

The major difference between a semi-structured interview and a formal survey is the use of a list of topics rather than a questionnaire (Fox, 1989). The topics may take the form of open ended questions, and directed enquiry. Semi-structured interviewing can be described as a guided conversation where only the topics and key questions are pre-determined. New questions or insights arise as a result of the discussion (Subedi & Sharma, 1997). This provides a great degree of flexibility, allowing salient areas to be probed in detail. It is important to avoid the use of leading questions, and best to avoid questions requiring a yes/no answer, as a greater depth of understanding is required. For example, the question 'Do you use fuelwood' would be better replaced with 'What do you use for fuel' or 'Where do you get your fuel', with further probing to follow. Why? Where? What? When? Who? and How? can all be used to re-phrase questions to obtain more detailed responses (McCracken *et al.*, 1988, Oppenhiem, 1992). Focus group interviews, which involve the same techniques as above but with an 'interest group', can be used as a means of rapidly obtaining a basic understanding of relevant community information. Focus group interviews have also been identified as being particularly useful for learning about natural resource utilisation patterns, and the spatial distribution of land use practices (Fox, 1989).

3.6.6.2 Group walks and direct observation

Direct observation is important for validating information gained from interviews, and in generating additional questions that may not be apparent until the resource and usage patterns are examined (Chambers, 1985). The following activities may be undertaken during a group walk for community forestry resource assessment purposes:

- identification of key features (forest blocks, species, rangeland, grazing land, topographical features)
- identification of internal forest boundaries
- noting features for future geo-referencing (ridge tops, large boulders, isolated trees etc.)
- examining what products are obtained from various locations
- discussion with group walk participants about the resource and how it is used

It should be noted that the information obtained only provides basic familiarisation with the resource, obtained by ocular estimate (Bartlett and Nurse, 1991).

3.6.6.3 Participatory sketch mapping

This technique involves facilitating FUG representatives or interest groups with drawing a map of their natural resources. Seven key stages have been identified in the preparation of participatory sketch maps (adapted from Jackson *et al.* 1996):

- selection of site where the map will be drawn (with a view of the area of the resource to be mapped)
- explain to the participants the purpose of the mapping
- decide on whether paper or the ground will be used for drawing the map (up to the participants)
- a key feature is drawn by the facilitator and named by participants
- more features are added by the participants (initially topographical features)
- resources are added (principally the forest), with key species, condition, planted areas, age etc.
- usage patterns are added, including seasonal usage patterns and locations (for fuelwood, timber, fodder, NTFPs and water)

Participatory sketch maps have been found to be more accurate than sketch maps produced by field workers in isolation from local forest users, and they are an excellent means of collecting essential farm-forest linkages (Jackson *et al.*, 1994). However, the spatial accuracy is still low. It has been found that the participants themselves have difficulty in identifying features they have drawn on the maps if they are shown them again six to twelve months later (Hunt, 1998 pers. comm.; Poudyal and Edwards, 1994). A number of workers have explored the possibility of incorporating aerial photographs into the participatory mapping process, to improve spatial accuracy. This has been discussed in section 3.3.2, and is discussed in more detail in section 5.2 in the results from this study.

3.7 Chapter summary

There are a range of tools and techniques applicable to CFRA. These come from the areas of geomatics (for gathering spatial data), traditional forest inventory and survey techniques (quantitative resource information) and participatory appraisal techniques (qualitative information). Applications of these techniques for forest and community forest assessment have been demonstrated, along with advantages and disadvantages. It has been shown that GIS has the best body of theory for integrating geomatics and participatory techniques, with a sub-area of GIS, PGIS, recently emerging. It has also been shown that there is practical scope for integrating some of these techniques: for example, using aerial photographs in a participatory context has been successful.

Chapter 4: The Study area

4.0 Chapter Overview

This chapter provides an overview of Nepal, the Dolakha District of Nepal, and the Yarsha Khola watershed, the area where most of the fieldwork was conducted. It progressively focuses on a smaller geographical area, examining local issues in more detail. Prior to this an explanation of why Nepal was chosen for the study is provided.

4.1 Why Nepal?

The fieldwork conducted for this research was conducted in Nepal, a landlocked country rising from the Gangetic plain, lying between India to the south and Tibet (China) to the north. Nepal was chosen as the research location because of a number of factors:

- it is the 'home' of community forestry (the Nepalese National Forestry Plan, 1976, was the first National Forest Plan to encourage community forestry explicitly, see NAFP, 1979, for translation)
- there is a wealth of forestry and development background information available
- community forest infrastructure (such as FUGs and forest rangers) is well established
- spatial information is freely available (unlike many less-developed nations)
- English is commonly spoken
- there is a great range of climate and cultures within a close geographical proximity
- there are a large number of developmental NGOs with an interest in community forestry, and many forestry professionals. This allowed a comprehensive consultative process to be conducted during the research.

4.2 An introduction to Nepal

Nepal has an extremely diverse range of habitats and societies, incorporating the highest Himalayan peaks, the Terai (an extension of the Indo-Gangetic plain), Buddhist, Hindu, Muslim and Christian societies, areas of dense urbanisation and virtually uninhabited high altitude deserts. Its diversity makes generalisations difficult, a point observed by academics (Thompson & Warburton, 1985: Ives & Messerli, 1989) and other visitors. The traveller and observer Dervla Murphy states that:

> 'Were I only allowed a single adjective to describe Nepal I would have to use 'varied'. No two villages are quite alike in language, dress, customs, attitudes, architecture or surroundings, and one could not possibly refer to 'a typical village' of this region' (Murphy, 1967, p.195)

Figure 4.1 illustrates an aspect of this variation, displaying the great range of vegetation types found within the 200km width of Nepal.

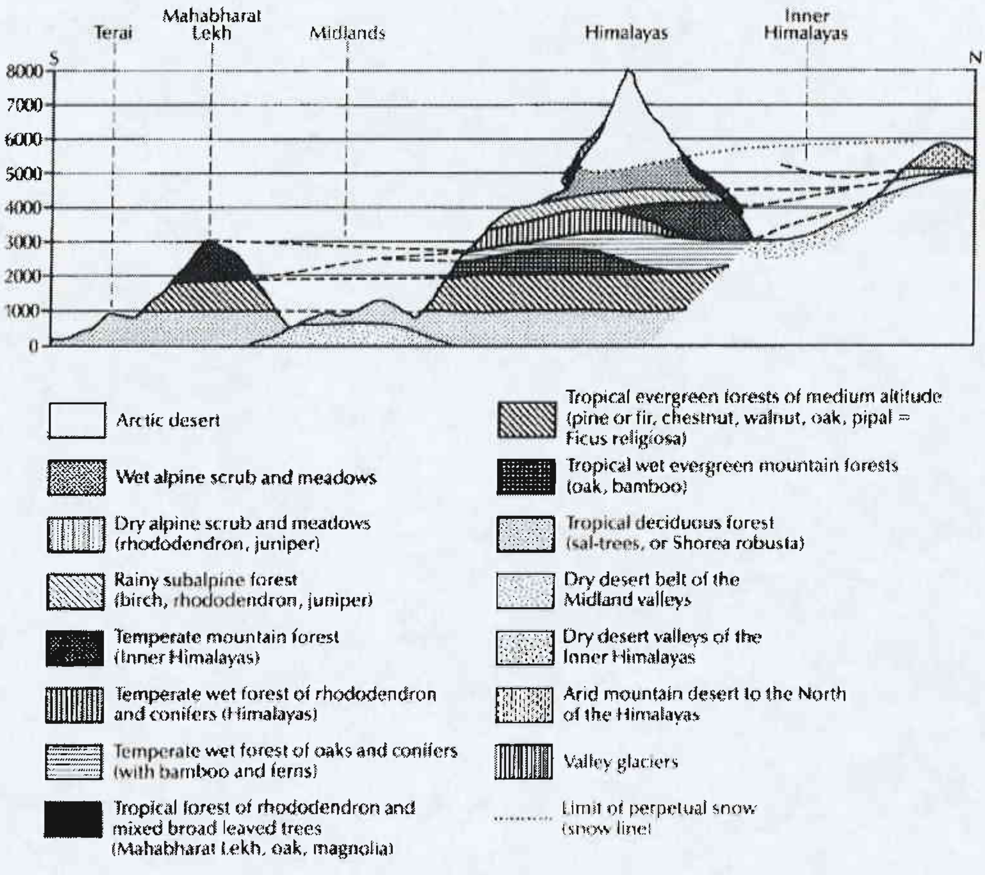


Figure 4.1 A cross-section of vegetation zones (source: Sill & Kirkby, 1991 p. 53)

4.2.1 Ecological zones

Nepal is often divided into five broad south to north ecological zones (see figure 4.2), delineated principally by rainfall. (Vuichard, 1986):

- The Terai. The southern part of Nepal is geographically (and socially) a continuation of the Indian plain, at an altitude of 100-200m. Traditionally a malaria infested region of dense sub-tropical vegetation, it is now largely agricultural.
- The Siwalik hills rise sharply from the Terai, and are effectively the southern-most foothills of the Himalaya, at an altitude of 120-2000m.
- The middle hills. These are separated from the Siwaliks by the Mahabharat hills, an uplifted zone at the south of the middle hills. The middle hills contain fertile valleys, the principal one being the Kathmandu valley. This zone lies at an altitude of 200-3000m.
- The high mountains or transition zone. A zone of high hills and deep river valleys bordering the Himalaya. The valleys descend to less than 1000m altitude, and the upper limit of this zone is regarded as being 4000m, the generally recognised treeline altitude for Nepal (although in reality the treeline altitude varies greatly).
- The high Himalaya. This extends from the treeline to 8000m+. Within Nepal this zone contains eight of the worlds fourteen highest peaks.

(Sill & Kirkby, 1991; Vuichard, 1986; Price, 1981)

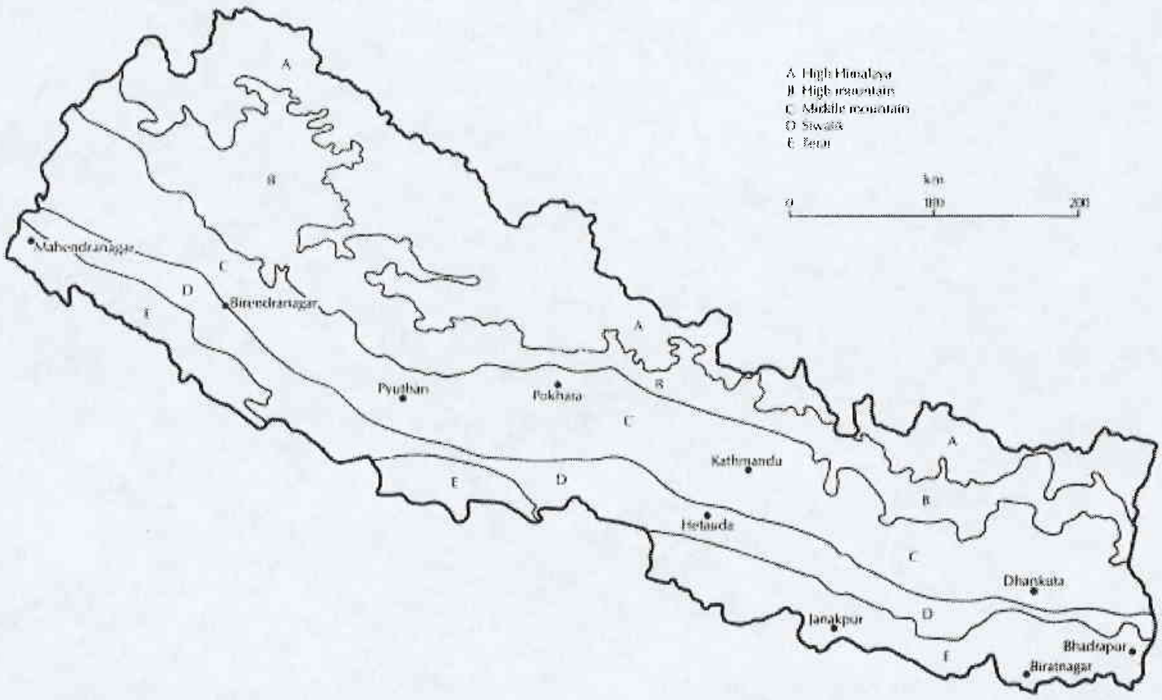


Figure 4.2 Ecological zones of Nepal (source: Sill and Kirkby, 1991 p. 52)

4.2.2 Climate

Average mean temperatures vary greatly for different locations in Nepal, mainly due to altitude variations. Nepal has strong seasonal climatic variations in temperature, being situated between 26° 30' and 30° 20' north of the equator. Rainfall decreases from east to west and from north to south, and with increasing altitude (once above 2000m). The high Himalaya act as a barrier to monsoon rains, resulting in the arid plateau of Tibet. Rainfall is highly seasonal, with the majority of precipitation occurring during May to September, the monsoon period. Within the high mountains and high Himalaya local topographical features, aspect, altitude and position within the mountain ranges have a profound effect on localised climate, particularly precipitation (Mani, 1981; Sill & Kirkby, 1991).

4.2.3 Socio-economic background

Some key socio-economic indicator values are presented in Table 4.1 below. It should be noted that no reliability information is associated with these values, and it is best to assume that they are indicative values only (Thompson & Warburton, 1985).

Key Socio-economic indicators for Nepal

Socio-economic indicator	Value	Year data from	Source
Population (millions)	22.6, 23.6	1997, 1998	World Bank, CIA
% Population growth rate	2.7, 2.52	1991-1997, 1998	World Bank, CIA
GNP Per capita $	210, 180	1997, 1993	World Bank, WHO
% Population below poverty line	52	1991-1997	World Bank
Life expectancy (years)	57	1991-1997	World Bank
% Poor in rural areas	60	1990	WHO
% Population with access to clean drinking water in rural areas	43	1991-1993	WHO
% of GDP from agriculture	41	1997	World Bank

Table 4.1 Key Socio-economic indicators for Nepal (Sources: World Bank, 1998; CIA, 1998; WHO, 1996)

Nepal is a densely populated country, 1998 figures give a population of approximately 23 million (World Bank, 1998) and 1991 figures give an average density of 102 persons per km^2, greater than Bangladesh (Sill and Kirkby, 1991). Population annual increase is estimated at 2.52 – 2.7% (CIA, 1998; World Bank, 1998). This is due principally to a drop in infant mortality rates, and also due to immigration (much of it illegal) from India.

For more than a decade Nepal has been consistently ranked in the ten poorest and least developed nations in the world (World Bank, 1987, 1998). It is currently estimated that over 50% of the population live below the absolute poverty line, and this percentage has barely changed in the last three decades (World Bank, 1987). Agriculture is the key economic activity, and over 80% of economically active Nepalese are farmers (CIA, 1998). This is a significantly higher percentage than for most other least developed countries.

The above indicates that population density, population growth, reliance on the agricultural sector, and a lack of finance to purchase alternatives puts great demands on the natural resources of Nepal, for fuel, fodder, fertiliser and building materials.

4.3 The Dolakha District of Nepal

The Dolakha Distinct is in the east of Nepal, ranging from the mid-hills in the south to the high Himalaya in the north. It is one of 75 Districts in Nepal (see Figure 4.3), each with its own local Government administration, of which the District Forest Officer is a senior member, responsible for coordinating the forest strategy.

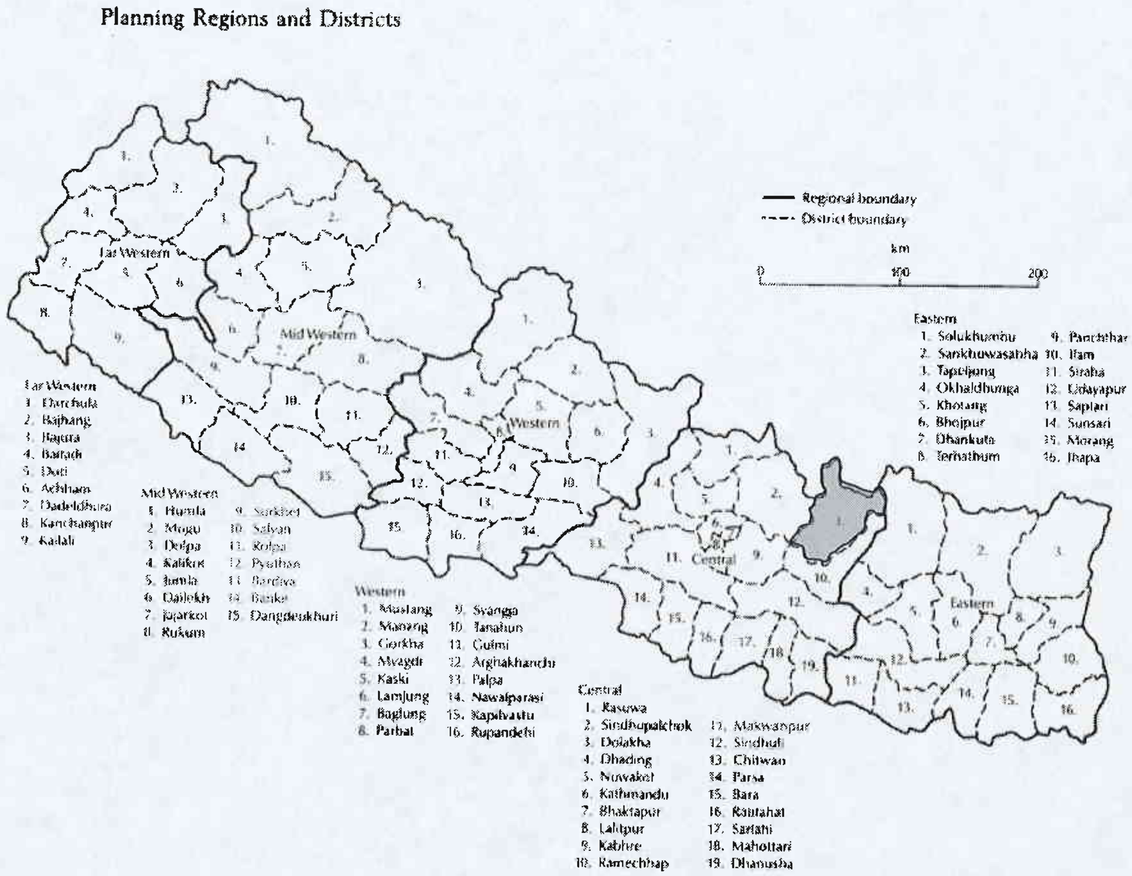


Figure 4.3 Planning Regions and Districts. (Source: Sill and Kirkby, 1991 p.36)

Dolakha is classified as one of the Nepalese mountain Districts (as opposed to hill or Terai), and infrastructure is limited due to the terrain. In the northern part of the District there is only one metalled road, and most towns and villages are only accessible by foot. Dolakha covers 2 200 km^2 and has a population of 174, 000, representing an average population density of 79 persons per km^2. This is significantly lower than the average figure for Nepal, but the topography is extreme, and there is little level land for conventional agricultural practices (see Table 4.2). Most arable farming is performed on terraced hillsides. This probably partially explains why the District is in the bottom 4 Districts for per capita food production (ICIMOD, 1997). The District has experienced an increase in agricultural land clearance over the last three decades, moving onto increasingly marginal land with steeper and less stable slopes and lower soil fertility (Shrestha, pers. comm.). This is illustrated by only 8% of the cultivated land being irrigated (*Khet* land): the rest is rain fed terrace (*Bari*). The main occupation is agricultural, with more than 90% of the working population in this sector. The major crops produced are maize, rice, wheat and millet (for brewing beer, *Chang*, and spirits, *Rakshi*), with potatoes being a key crop at higher altitudes. The District is famed for its potatoes, and these form one of the few cash crops. The main livestock are cow, buffalo, sheep, goat and yak at higher altitudes. The forest cover for the District is estimated at approximately 50% (DFO, 1997), although this figure is probably over-estimated and unreliable. Extrapolating the information from per capita forest area and total population for the District (in Table 4.2) gives 34% forest cover, probably a more realistic figure. The major tree species include *Schima wallichi, Terminalia tomentosa, Shorea robusta* (a high grade decorative and structural timber), *Castanopsis* spp, *Alnus nepalensis, Betula* spp, *Daphniphyllum himalense* and at higher altitudes *Rhododendron campanulatum, R. campylocarpum, R. cinnabarium* and *Juniperus recurva*. A number of *Pinus* species are important plantation species. The vegetation zones range from tropical deciduous forests through to arctic desert, largely depending on altitude.

Socio-economic and natural resource indicators for the Dolakha District, Nepal

Infant mortality rate (deaths under one year per 1000 live births	64
Child illiteracy %	38
% Landless and marginal farm (<0.5 ha) households	48
% area with slopes above 30^o	70
% households which are members of a Forest User Group	17
Per capita forest area (ha) with >10% crown density	0.43
% cultivated area	11
Per Capita food production (calories)	1164

Table 4.2 Socio-economic and natural resource indicators for the Dolakha District, Nepal (Source: derived from ICIMOD, 1997)

The major ethnic groups in the District are Brahmin, Chettri, Tamang, Sherpa and Newar. The District is principally Hindi, with Buddhists (Tamang and Sherpa, both from Tibeto-Burman stock) at higher altitudes.

4.4 The Yarsha-Khola watershed

This section presents background information on the Yarsha Khola watershed. Unless otherwise referenced, the information has been produced by PARDYP/ICIMOD (in Jordan & Shrestha, 1998).

4.4.1 Location

The Yarsha Khola Watershed is situated between approximately 27^0 33' to 27^0 40' latitude and 86^0 O5' to 86^0 11' longitude in the high mountains of Nepal, covering a total area of 5,400 ha. It is located about 190 km east of Kathmandu, along the Lamosangu-Jiri road. The watershed ranges from 930 to 3,030m altitude. Due to the wide variation in topography, it has a highly heterogeneous climate (covering subtropical to temperate), natural vegetation, land use, and ethnic group composition.

4.4.2 Land Use and Vegetation

Land use is determined by climate, topography, soil type, and population. The watershed is dominated by agricultural production, with double annual crop rotations on *Khet*, a single to double annual crop in dryland cultivation (*bari*), and triple crop rotations over a two-year period at higher elevations (*bari*). Photographs 1-3 at the end of chapter 6 provide an idea of the landscape.

A detailed land use survey was carried out by ICIMOD staff (Shrestha, 1998, pers. comm) using 1:20 000 aerial photographs and intensive field verification to examine the patterns of land use within the watersheds. GIS analysis determined the percentage land cover for each main land use. These are illustrated in Figure 4.4. The 'other' uses category covers landslides, rills, gullies, settlements, rock, quarries, and boulders.

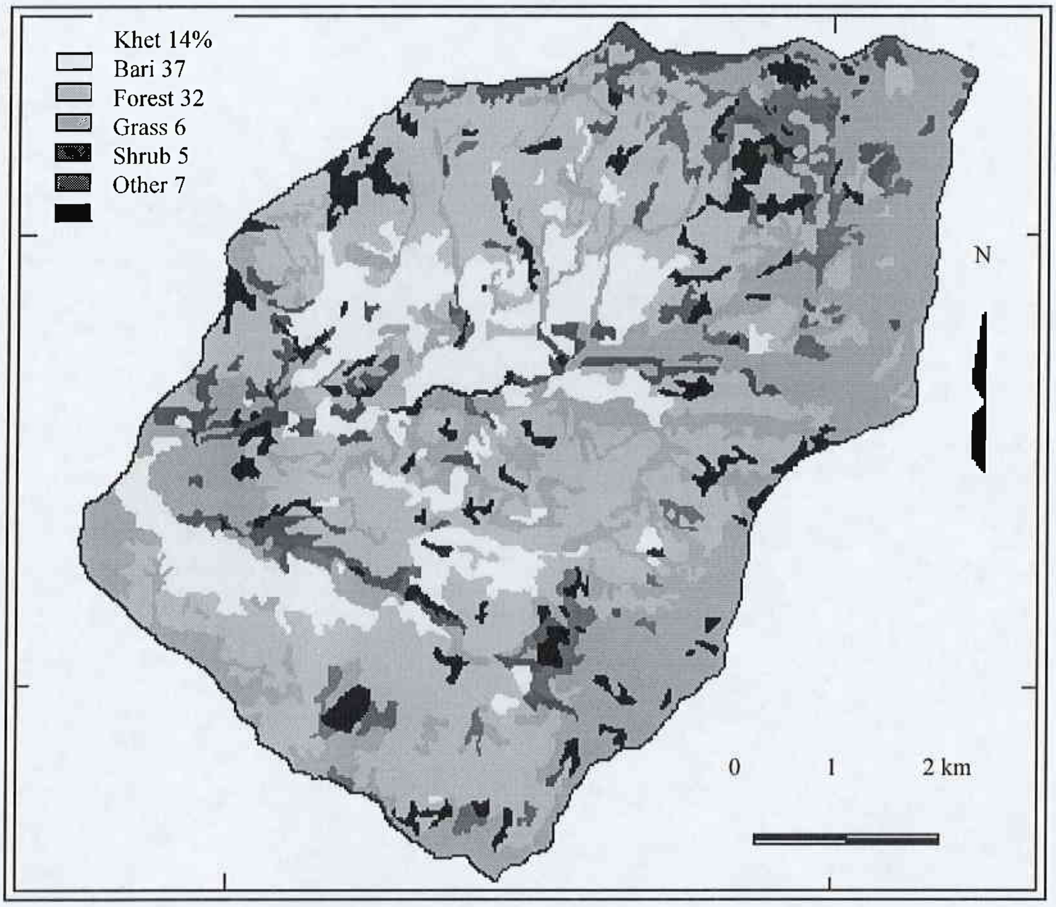


Figure 4.4 Land Use within the Yarsha Khola Watershed, 1996.

The area under forest cover within the watershed (32%)[1] appears extensive, but the forest condition in terms of crown cover, maturity, and species composition is generally poor. GIS evaluation shows that only eight per cent of the total forest within the watershed area has mature trees of logging size timber (with an average diameter at breast height (dbh) greater than 53 cm), and most of the forest resources are immature forest or in a fairly early stage of regeneration (See Table 4.3 and Figure 4.5).

[1] It is understood that little ground-truthing was performed to determine if the areas were correct (most concentrated on image-interpretation). No error estimates are associated with the data. All percentages quoted are best regarded as indicative.

Forest Type	Area (ha)	Area (%)
Mature (>53cm dbh)	136	8
Immature (28-53cm dbh)	1,210	72
Regenerating (13-28 cm dbh)	175	10
Plantation	160	10
Total	**1,861**	**100**

Table 4.3 Forest Maturity Classes in the Yarsha Khola Watershed, 1996

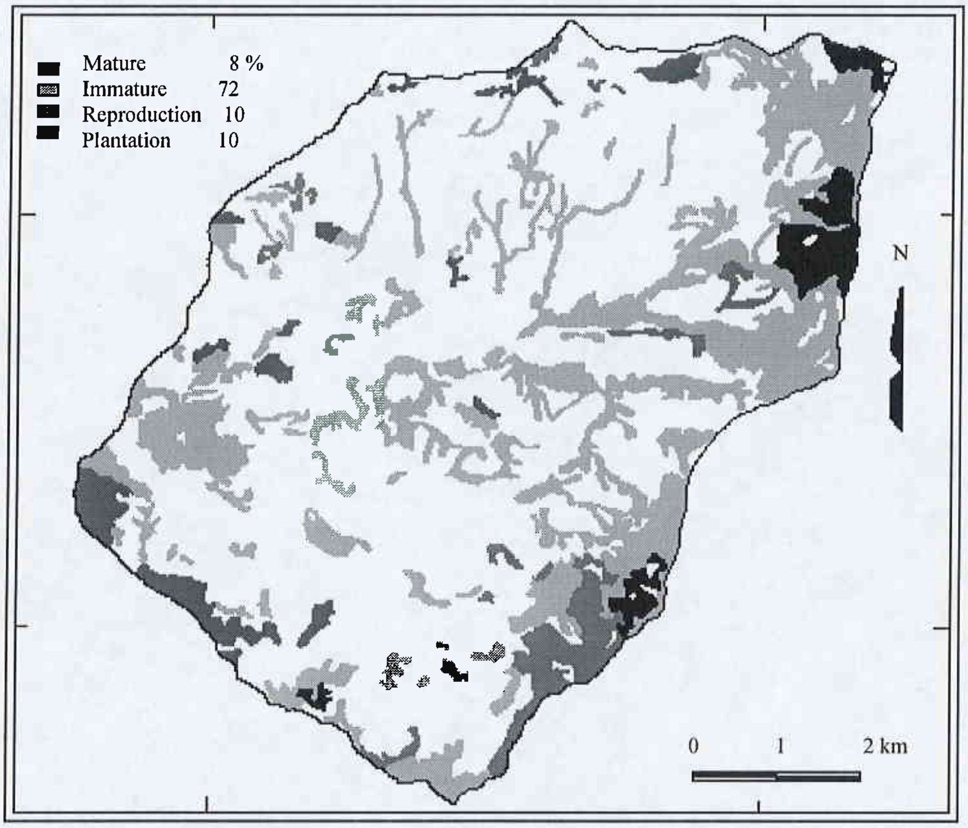


Figure 4.5 Forest maturity within the Yarsha Khola Watershed, 1996. (PARDYP/ICIMOD)

Very little (1.3%) of the forest has a crown density greater than 50 per cent, and a large portion of the forest (about 72%) has a crown density of less than 30 per cent (see Table 4.4). Generally, this relates to the maturity status of the forest resource.

Crown Density (%)	Area (ha)	Area (%)
<10	278	17
10-30	926	55
30-50	456	27
>50	21	1
Total	**1,681**	**100**

Table 4.4 Forest Crown Density in the Yarsha Khola Watershed, 1996

Aerial photographs and field investigation, coupled with a GIS for information analysis and output, were used to evaluate species composition for the watershed. This work determined that *Alnus nepalensis* is the most dominant species (comprising about 23% of the forest cover), and varieties of *Pinus* species make up about 31 % of the forest cover. The rest of the cover is composed of a range of principally broad-leaved species, with *Shorea robusta* being important at the lower altitudes and *Rhododendron* species becoming prominent at higher altitudes.

Much of the forest resource, particularly at lower to middle altitudes, appears very degraded due to excessive and uncontrolled harvesting of fuelwood, fodder, litter collection, and overgrazing in the past. The present community forestry policy in Nepal might improve bio-diversity and lead to better management of the forest resource. RRA work indicates that this appears to be happening already in the forest areas returned to local community management, with FUGs reporting a greater abundance of fodder and fuelwood and less time required to collect these products.

4.4.3. Population

Population growth with only limited land space appears to be seriously affecting the sustainable use of natural resources. One of the main problems in the Yarsha Khola watershed is the apparently rapid population growth since 1961 (see Table 4.5), leading to increased pressure on agricultural land, land fragmentation, and cultivation of increasingly marginal land.

VDC	1961			1996		
	No. of Households	Family Size	Population	No. of Households	Family Size	Population
Khabre	84	4.74	398	1606	4.74	7,612
Mrige	38	4.64	176	706	4.64	3,276
Namdu	46	4.65	214	426	4.65	1,981
Gairimudi	117	4.85	567	902	4.85	4,375
Total	285	4.72	1,355	3,640	4.72	17,244

Table 4.5 Total Number of Households and Population of Yarsha Khola Watershed from 1961 and 1996 Based on VDC Census Data (family sizes for 1961 and 1996 are based on HMGN census data; HMGN, 1996a) & aerial photograph interpretation

Population information for each VDC is theoretically available once every ten years, although most data for Yarsha Khola watershed are unavailable. There are problems with this information, because VDC boundaries change frequently and the data are not georeferenced, so only summary data are available. Also, VDC boundaries do not coincide with watershed boundaries. To document the population dynamics within the watershed, VDC boundaries were overlaid with topographical maps on a scale of 1 :25 000 (HMGN, 1996b). Aerial photo interpretation and data on family size from the VDC census (HMGN, 1996a) formed the basis for analysis . A series of 1:20 000 scale aerial photographs of the watershed were enlarged to 1:5 000, enabling all houses to be counted. The number of houses was then multiplied by the average family size determined for each VDC.

This methodology proved to be the most reliable means for collecting population data for 1996. As no historical census data were available, the 1961 numbers were obtained from 1:50,000 scale topographical maps (Government of India, 1965) in which cartographers marked all houses present in the watershed. Again, the number of houses was multiplied by the average size of family. According to this data, on average the population has grown by approximately 7.3 percent per annum. This figure appears to be very high, and it should be noted that the 1961 figures, and any subsequent population change estimates, are reliant on the correct identification and labelling of all houses present in the Yarsha *Khola* watershed by the 1961 cartographers. Additionally, it would appear from Table 4.7 that family size was not recalculated for 1996, with the 1961 figures being reapplied. These types of assumption, which are hard to justify, have to be made when working with historic datasets in the HKH region (Thompson and Warburton 1985). It is possible that the population growth rate is significantly higher than the average for Nepal (about 2.6% - see Table 4.1) due to the Jiri road being constructed encouraging in-migration from less accessible areas in Dolakha. Discussions with villagers during RRA work indicated that entire new villages have appeared within the last two decades.

4.4.4 The FUGs and their forest resource

The work conducted in this study used FUGs as the main stakeholder group. There are nine FUGs in the Yarsha Khola watershed, some have been officially managing their community forest resources for several years, others are in various stages of the hand-over process. Four FUGs were selected for this study, based on their desire to be involved in CFRA, to cover a range of conditions, and accessibility for fieldwork. They do not represent all the physical and social conditions found in the mountains of Nepal, but do provide a good range. Additionally, another FUG was worked with, located 20km east of Kathmandu, to provide an indication of transferability of the method. Basic information about the FUGs and their resources is presented in Table 4.6

FUG	Location	Main ethnic group	Main Forest type	Comments
Baishakeswori	Yarsha Khola	Sherpa/Tamang	Natural	Very steep slopes and extensive resource. Not officially handed-over to FUG
Bhasuki	Near Kathmandu	Hindi castes	Mature conifer plantation	A lot of NACFP support, and market opportunities for selling timber in Kathmandu
Chuletro Pakha	Yarsha Khola	Mainly Hindi	Young plantation	A wide variety of forest types and terrain – useful for testing techniques
Dhungeswori	Yarsha Khola	Mainly Hindi	Young plantation	Fire damaged plantation, some older trees
Ningure	Yarsha Khola	Hindi castes	Mature mixed plantation	Young Sal and conifer plantations, with grazing problems

Table 4.6 Background information on the FUGs and their forest resources

4.5 Chapter summary

This chapter provided background information on the study area, giving an appreciation of the social and environmental context of the Yarsha Khola watershed.

Chapter 5: The research problem and methods

5.0 Chapter Overview

The previous chapters have provided background information on the study area, the development of community forestry, recent developments in community forestry, and the range of tools that are commonly used for forest resource assessments. This has provided sufficient contextual background to identify key problems with community orientated resource assessment, and to develop a research method.

This chapter details a scoping study to help identify research problems and develop a method for CFRA, and presents the three areas of research concentrated on in this study.

5.1 The increasing information needs for modern forest management

Chapter two ended by stating that recent developments in community forestry in Nepal have increased the need for natural resource management information (see section 2.5.2). This is just one example of a general increase and diversification of the information requirements for forest management as forestry has become more integrated and multi-objective. Additionally, the ability to process information has grown with the availability and power of computers. Table 5.1 illustrates the increasing information requirements for forestry over the last few decades.

					Other lands
				Ecosystems, Biodiversity, NTFP's	Ecosystems, Biodiversity, NTFP's
			Global warming	Global warming	Global warming
		Biomass	Biomass	Biomass	Biomass
	Multiple resources	Multiple resources	Multiple resources	Multiple resources	Multiple resources
Timber	Timber	Timber	Timber	Timber	Timber
1950s	1960s	1970s	1980s	1990s	2000+

Table 5.1 Increase in information needs for forest lands. From Lund and Smith 1997.

This increase in management information can be broken down into information requirements for different planning levels, and this has been performed for community forestry in Nepal (Ingles *et al.*, 1996):

- Global/regional level. To monitor the effect of forest management on the world's global biodiversity heritage and to assess the effectiveness of forestry for community development. The monitoring is based on aerial photograph interpretation, and also in the future from Permanent Sample Plots and Range Post Planning (RPP) exercises.
- National level. To formulate policy and monitor implementation. The information is obtained from aerial photographs, though again RPP information should/will be incorporated.
- District/Range post level. To assist with the effective and efficient allocation of resources, and to facilitate the empowerment of legitimate forest users. Operations must be linked with national level priorities and budget allocation. RPP and incorporated techniques are used to gather information at this level.
- Forest level. For DoF staff and forest users for hand over, and to provide the basis for technical advice to provide improved forest management. Forest level operations should feed into the planning of range post/district level activities. Information at this level is used for the drawing up of operational plans.
- FUG level. Information to assist FUGs in their forest management.

As this research focuses on local level information needs for community forestry it is mainly concerned with the last two levels, though the others will be considered, and influence the method. Increasing information needs at an FUG and ranger level are due to a number of reasons:

- assess responsible ('sustainable') forest management
- allow a calculation of sustainable yield of timber
- address specific needs of the FUG
- examine tenure rights and rights to resources
- assist with conflict resolution
- assist with compensation claims
- identify potential economic NTFPs

These increasing information needs generate a requirement for assessment to provide this information (see sections 2.5.2.1 – 2.5.2.4). As discussed previously, forest resource assessment for community forestry is a relatively new concept. Traditionally, efforts have been almost solely concentrated on the social aspects of community forestry, but this has had to start changing in response to these needs. The problem of increased information needs is exacerbated by the lack of time and resources available for conducting assessments. This is a significant constraint on the techniques tat can be employed and the amount of analysis that can be conducted.

5.2 Problems with resource assessment methods

Chapter three has illustrated the wide variety of existing techniques for forest resource assessment, and demonstrated a wide variety of applications. From the range and diversity of techniques available it would appear that there should be little problem with resource assessment, but few of the traditional approaches are suited to addressing current community forestry information needs, for Nepal or elsewhere. Traditional inventories are unsuitable principally due to their high cost, the length of time required and their focus on detailed data for timber production (Branney, 1994a). Surveys and appraisals, using traditional participatory tools, fail to provide sufficient spatial and quantitative data for forest resource management, though they provide valuable community and resource information, particularly regarding usage patterns, community priorities and conflicts. Geomatics techniques have tended to be used at District, National or regional levels, not for local level purposes. Their usage has also tended to be unimaginative and has failed to realise the potential of these new technologies.

CFRA (or participatory forest resource assessment) specifically addresses these limitations and attempts to combine best practices from existing resource assessment techniques. By combining these approaches, a workable methodology for collecting sufficiently accurate and detailed data within a reasonable time period and budget, that is of direct relevance to the FUG and local rangers, can be developed. A variety of CFRA techniques have, more or less successfully, been employed to gather resource information for community forests. These represent the best means of obtaining resource information for community forestry. However, there are limitations with current approaches.

5.3 The research problem

CFRA goes part-way to addressing the problem of obtaining resource information for community forestry. But the current approaches to CFRA are still fundamentally lacking in three key areas:

- recent developments in obtaining and analysing spatial information have not been widely integrated into resource assessment processes
- the methods of participatory inventories are still developing and need improving
- there is no systematic approach to them

Geomatics has only been used in a fairly limited way for CFRA, although its use is steadily growing. In Nepal, its potential has been commented on, but initial results proved disappointing (Ingles *et al.*, 1996). It has also been mentioned that the current methods for CFRA for Nepal need refinement (Hunt, 1998; Ingles *et. al.*,1996), and in general the approaches are either too simplistic to provide useful data, or too complicated to be practical (this is discussed in section 7.1).

Although CFRAs represent complex types of assessment - incorporating participatory processes, a variety of resource assessment techniques and feedback mechanisms - they are often poorly structured and lack a systematic approach. This is in contrast to other areas of modern multiple objective forest assessment and management. MRIs recognise the complexity of current resource assessment, and the method is firmly based around a framework (Lund, 1998). Systematic frameworks are being used for forestry environmental management, and are encouraged by the FSC approach (CSA, 1996a,b; FSC, 1994). Systematic framework approaches are being increasingly adopted for MRI and multiple objective forest management because they simplify the organisation of the process (Lund, 1998).

It is believed that systematic framework approaches to CFRA have not been adopted because they are perceived as imposing a rigid methodology on assessment, which is felt to be inappropriate for participatory methods. This is not the case. A systems based framework provides a structure which is highly adaptive, for example, ISO 14000 environmental management systems can be used for a forest in Asia or a paint manufacturer in Europe.

From the above, three inter-related areas for research into CFRA in Nepal can be identified:

- determining what potential role geomatics technologies have for CFRA in Nepal
- examining how existing resource assessment methods can be improved by combining existing best-practice, introducing appropriate geomatics techniques and developing new approaches
- developing an appropriate framework that provides a systematic method for integrating geomatics and CFRA

5.4 Initial stages in developing the methodological approach

The research topic was developed from current issues highlighted in the relevant literature, and the authors previous experience of participatory forest resource assessment (Jordan, 1996). However, the perceived value of research in this field needed to be investigated. Additionally, indications of the information requirements for community forest management, and institutional and operational limitations for forest resource assessment in Nepal, needed to be evaluated. A scoping study was conducted in Nepal to consult with key players to determine the above. Contacts were made, both from previous work in Nepal and from 'Who's where in forestry in Nepal' (HMGN, 1995), and meetings arranged. A number of people were also consulted within the UK or by post. A list of contacts is in Appendix 1. Prior to the visit, a brief summary of geomatics, forest resource assessment and the proposed research was posted or faxed to the respondents, with an accompanying letter requesting that they took a few minutes to read through the document. The meetings took the form of semi-structured interviews (see Oppenhiem, 1992), based around four key questions:

- What are the key areas of community forestry where research inputs would be valuable?
- What are the current main information needs for community forestry?
- What are the operational and institutional limitations for CFRA?
- What do you feel is the potential role of geomatics in community forestry?

These questions are not impartial, and a number of assumptions were made in using them: research into community forestry in Nepal is of value; increasing information needs are an issue with community forestry; and that geomatics has a potential role for community forestry resource assessment. However, these areas were critically discussed, for example, negative views on geomatics were asked for from respondents.

In addition, the general response to the proposed research, and the potential for collaborative research, was ascertained[1]. The main findings from the scoping study are summarised in Table 5.2 below.

[1] Respondents opinions regarding the value of the research (and their general attitude to using geomatics for community forestry) were considered to be very important. Many of these respondents were decision-makers on the direction for community forestry research and development in Nepal. If they felt that geomatics had no role for community forestry there was little point in pursuing the work.

Key areas of community forestry where research inputs valuable	1. Determining how geomatics technology could aid the FUG, particularly with boundary mapping 2. Evaluating how community forests could meet the information requirements of the FSC 3. Examining how GPS could improve participatory sketch maps 4. Finding mechanisms for feeding information back to the FUG (limiting the extractive nature of resource assessment) 5. Developing effective and practicable means of collecting resource information
Main information needs for community forestry	1. Base-line data to allow determination of sustainable production levels 2. Accurate demarcation of forest boundaries 3. FUG training in resource assessment and basic forest management practices 4. Only those that are directly relevant to the FUG!
Operational and institutional limitations for CFRA	1. Resource assessment should use appropriate technology 2. Forest assessment needs to be participatory for practical & social reasons 3. Any workable methodology or framework has to be: low cost; rapid; geared towards the communities information needs; & empower the community through providing them with information, skills and knowledge
Potential role of geomatics	1. Boundary mapping 2. Organising and managing spatial data 3. Determining spatial location and attributes of community forest resources 4. Rapid collection of baseline data
General comments	1. Community forestry research should be primarily about empowerment and support of FUGs and District Forest staff (with findings perhaps being generalised and used to support policy level decisions) 2. Technical research and application should be geared to the needs of the FUGs and DFO staff 3. The first stage in developing technological applications is participatory work, to find out what FUGs, rangers etc. want, and to design field work around this 4. Methodological approaches should be realistic in terms of the resources (time, financial and skilled personnel) utilised 5. An appropriate application of geomatics technology has potential to provide useful resource information 6. Technological developments should be fed back to FUGs, rangers etc., for them to evaluate any benefits

Table 5.2 Summary of respondents comments from semi-structured interviews regarding community forestry. Source: responses from respondents listed in Appendix 1.

In general the respondent's information supported the supposition that there is a growing need for natural resource information for community forestry in Nepal, and that current methods do not provide it. The key reasons for needing resource information at a local level were believed to be for:

- calculating timber yields
- calculating fodder yields
- conflict resolution purposes (mainly boundary disputes)
- identifying types and quantities of NTFPs

Several respondents noted that calculating sustained timber yields was a perceived requirement. Traditionally, this has not been viewed as a major requirement for CFRA (Branney, 1994a; Ingles *et al.*, 1996). The recent policy changes in Nepal have made it (largely theoretically) possible for FUGs to produce timber commercially. Many FUGs in the mid-hills and mountains of Nepal have areas of conifer plantation under their control ready for thinning or harvesting. Respondents noted that a pre-requisite for felling or thinning operations in most districts is a management plan based on resource assessment.

Respondents also noted that, contrary to popular belief, community forests in Nepal are generally managed in a very conservative way. Traditionally forests tend to be either utilised in an intensive way - often leading to degradation or fragmentation - or protected. Community forests are viewed as protected forests, and the utilisation of resources tends to be far below sustainable levels. It was felt that participatory resource assessment could introduce the ideas of sustained management and increase the yields of forest products for FUGs.

Biodiversity monitoring was generally felt to be of theoretical rather than practical interest at a local level, and there was felt to be limited potential for FSC certification. In the main, operational and institutional limitations had been correctly identified prior to the visit, but respondents noted that a genuinely participatory resource assessment that produced tangible benefits could strengthen the FUG by increasing its potential to present forest management proposals successfully to the DFO.

There was widespread support for using geomatics in community forestry, as long as it was part of a participatory process, appropriate, and added value could be demonstrated. This support was not universal: one respondent felt that all information gathering should be in direct response to FUG requests, and the use of geomatics was inappropriate. (Schuller, 1996, pers. comm). The underlying principles behind this are of interest. The respondent felt that if geomatics could directly aid the FUG through assisting their decision-making or providing information that would support management desires with the DFO, it was of benefit. However, the respondent felt that geomatics would not be used for this, but would centralise information, and perhaps disempower the FUG. The respondent cited a number of inappropriate uses of geomatics technology, particularly the centralising and non-participative use of GIS for preparing socio-economic data (ICIMOD, 1996). The respondent was not against geomatics, but against the way it had been used in Nepal, indicating that how geomatics is used is of great importance.

Respondents were supportive of the proposed research, and felt that it would be of practical benefit to the development of community forest assessment in Nepal. A number of respondents offered to collaborate with the research.
The scoping study provided an increased understanding of the current situation in Nepal, and allowed the assumptions made in the initial planning of the research to be verified and modified, and a detailed research approach to be developed.

Collaborative research arrangements were made with ICIMOD and NACFP.

5.5 The method

The method used in this study can be divided into three discrete areas.

- A technical evaluation of geomatics technology for use in a participatory context for community forestry in Nepal. This involved:
    - examining the potential for GPS for community forestry in Nepal
    - examining the potential of Participatory Photo Mapping (PPM) for community forestry in Nepal
    - evaluating the potential of GIS as a tool to assist with local level forest resource assessment
- The development and testing of participatory inventory techniques.
- The development of a systems based framework for CFRA, based around the theory and application of PGIS. This included developing an evaluation methodology for a participatory geomatics forest resource assessment.

A technical evaluation of geomatics was required. Although the technology had been identified as being potentially useful in Nepal, there were reports of operational difficulties, particularly with GPS. A scoping study was conducted, which identified some technical issues that needed further evaluation. These were examined, along with the role of GPS for forest resource assessment. The two other areas within the field of geomatics that were felt to have potential for CFRA were PPM and GIS. PPM had recently been re-evaluated for CFRA in Nepal (Mather, 1998), and comparative work was felt to be of use. Additionally, GPS was used to georeference PPMs, and the PPM information was entered into a GIS. Work was also conducted to indicate the potential role of ortho and geo-corrected aerial photographs for CFRA. Finally, the role of GIS for local-level CFRA was assessed, as this is an unusual role for GIS, which is typically used for district or regional purposes.

Existing participatory inventory techniques for Nepal were critically evaluated, and a new method developed, based on best-practice from existing techniques and a re-evaluation of information needs and limitations. Additionally, the new method was designed to maximise the benefits from using geomatics for obtaining spatial information. A ten stage inventory method was developed, designed to integrate data collection and information gathering from initial participatory sessions through to feeding the information back to FUG members.

It should be noted that the use of geomatics is within the forest inventory method. It is presented here as a separate activity, and separate chapter, for clarity, but in reality it forms part of the inventory process.

The third area involved developing a suitable framework for an integrated CFRA. This was based around the inventory method, which was found to be lacking as an appropriate methodological vehicle for the integrated assessment. Although the inventory method worked for obtaining, analysing and feeding back information, it was a weak model for a systems-based approach to CFRA. A number of important areas were found to be entirely absent, principally a structured approach and evaluation. The framework addresses these issues, and provides a solid systematic method for CFRA.

Figure 5.1 provides an overview of the methods used in this study. Each of the sections in Figure 5.1 is examined in detail in the next three chapters, along with the specific method employed.

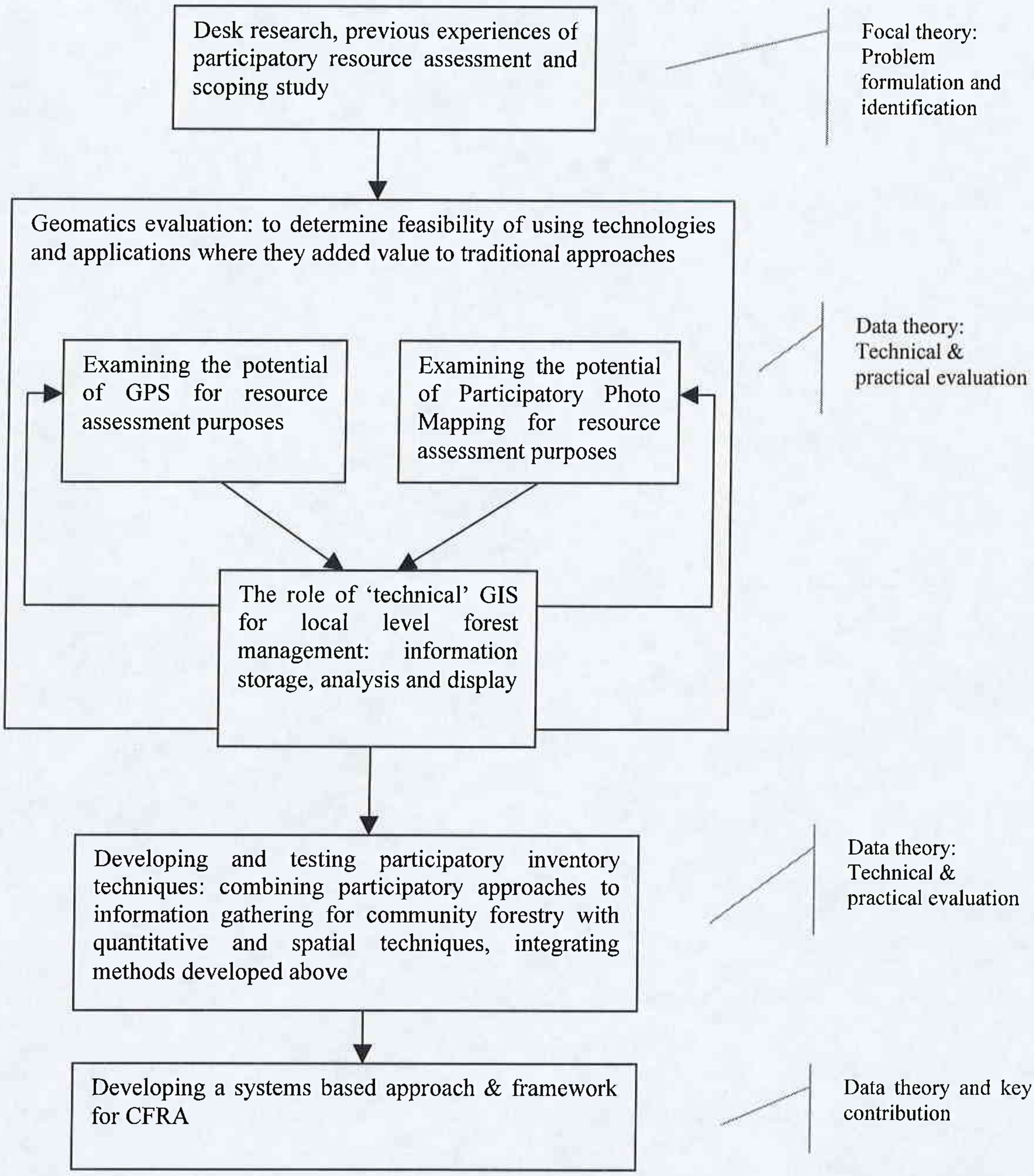


Figure 5.1 An overview of the methodology illustrating information flows

5. 6 Chapter summary

This chapter provided the context for the research, and developed a research method based on the needs identified by a scoping study. The method involves evaluating geomatics techniques for CFRA in Nepal, examining and developing CFRA techniques for Nepal, and then examining how best to organise and integrate the assessment processes.

Chapter 6: The role of Geomatics: results

6.0 Chapter overview

This chapter details the results of a series of evaluations of geomatics technologies to determine their effectiveness and potential role for community forestry resource assessment in Nepal. The applications of geomatics technologies tested and evaluated were based on responses to the scoping study interviews. Respondents identified the following as valuable research inputs and potentially useful roles for geomatics:

- boundary mapping purposes
- integrating participatory mapping techniques with geomatics (GPS and/or aerial photographs)
- organising and managing spatial data
- mapping the spatial locations of community forest resources, and georeferencing existing data
- collecting baseline spatial data

It was felt that the technologies with the most potential for the above were GPS, GIS and Participatory Photo Mapping. It should be noted that in this chapter GIS is evaluated for its technical applications: chapter seven details using PGIS theory and techniques for developing a framework for CFRA.

6.1 Examining the potential of GPS for community forestry in Nepal

Chapter three provided the background to GPS and the use of GPS for forestry. It was mentioned that GPS has had only limited applications for participatory forest management. Its use in Nepal is also very limited, with few serious attempts being made to use the technology. Attempts have either involved very basic trials with stand-alone receivers, or encountered serious technological problems that have halted evaluation (Hunt, 1996 pers. comm.; Schreier, 1997 pers. comm.; Fichtenau, 1996, 1998 pers. comms.). Owing to such limited applications of GPS, and problems being previously encountered, it was felt that an initial evaluation was required to examine the potential of GPS for community forestry in Nepal. The initial evaluation identified some areas that needed further technical examination, and once these were addressed the role of GPS for providing spatial information for community forestry was assessed.

6.1.1 An initial evaluation of GPS

The initial evaluation was conducted during the scoping visit discussed in section 4.4 (see Appendix 1 for itinerary). Five days were spent evaluating GPS under a variety of conditions around Pokhara. Pokhara was chosen because it has a fairly reliable power supply and rapid access to forest areas in hilly terrain. The evaluation had a number of aims designed to ascertain the potential of GPS for community forestry in Nepal:

- examine bureaucratic problems
- evaluate basic technical performance
- evaluate practical restrictions in the use of GPS
- produce a set of guidelines on the use of GPS in Nepal

Bureaucratic problems were expected due to the deep suspicion of customs staff in Nepal regarding electronic and computing devices, particularly if associated with mapping purposes. Nepal is sandwiched between two volatile Asian superpowers and tries to avoid offending either with perceived 'spying activities'. Visiting consultants and project staff frequently have equipment impounded by customs officers for lengthy periods of time (Allen, pers. comm. 1997). During the scoping study this was not found to be a problem, although project staff in Kathmandu suggested carrying letters of support from within Nepal, preferably from Government Departments. Getting the GPS battery packs onto aircraft was found to be a problem. Twice there was considerable doubt raised as to whether they were sealed batteries (which they were) or refillable lead-acid batteries (banned from passenger aircraft) and a set of batteries had to be abandoned to safety officers at Delhi airport.

The technical performance of GPS in Nepal was unknown. Previous researchers experience indicated that problems could be expected (Hunt, 1996 pers. comm.; Schreier, 1997 pers. comm.; Fichtenau, 1996, 1998 pers. comms.). An examination of possible causes was made and it was found that previous workers had used GPSs with a small number of channels (each channel fixes on an individual satellite), usually between five and six. Previous experience in upland forests in the UK found that using a 10 channel receiver allowed the rapid capture of reliable data while a comparable 5 channel receiver performed badly (Jordan & Carlisle, 1998). This is because when operating in a forest environment, four or more satellites are frequently visible, even in difficult conditions. However, the specific satellites comprising this set of four change frequently. Receivers with a small number of channels spend most of the time unsuccessfully trying to keep up with the changing array of satellites. Additionally, it was found that attempts to perform real-time differential GPS correction using information from a base station beacon, or another GPS using a radio or telephone link, failed due to poor signal reliability in Nepal (Schreier, 1997 pers. comm). Therefore differential correction by post-processing appeared to be the most satisfactory method.

Two Magellan GPS ProMARK X-CP receivers were used. These 10 channel receivers allow spatial data to be logged and down-loaded for correction and entry into a GIS. One of the receivers was used as a base station, the other as a mobile or 'rover' GPS. This allowed post-processing to be performed for differential GPS. The base station was established at a geographically unknown position on the roof of a guest house in the Pokhara valley. The view from the guest house roof was partially obstructed by nearby hills. For differential correction to work, all satellites used by the mobile GPS must also be recorded by the base station GPS. It would have been preferable to locate the base station at the top of a hill so it had a completely unrestricted view of all satellites. This was impractical due to rapid access requirements and security problems, and was felt to be representative of potential base station locations in the mountains of Nepal. The base station utilised a multi-path resistant antenna, which may have aided it in collecting data in carrier phase operation, essential for post-processing of GPS data (Magellan Systems Corporation, 1996).

When the GPSs were first used both receivers had approximate positions manually entered into them, and rapidly got positional fixes (1-2 minutes). It was found that the GPS's were usually tracking five to seven satellites, and the Positional Dilution Of Precision (PDOP) value was usually less than four in an unobstructed location. PDOP values indicate the spatial reliability that the GPS provides at that moment. If the PDOP value is greater than 10 the reliability of the positional data is low. A value of four is better than the situation usually encountered in northern Europe. The base station GPS was set to record differential data in a file, and the mobile GPS was taken to the study area.

The study area was hilly, in a valley system adjacent to the base station location. GPS readings were taken over a period of five days and designed to cover a range of different canopy covers. Paths through forest areas and forest boundaries were mapped. This aimed to ascertain how quickly locations could be obtained, and how spatially reliable the GPS signal was. The results presented in Figure 6.1 are not statistically valid, and are only indicative of the limited results of this scoping study. Some canopy cover classes are only based on five readings.

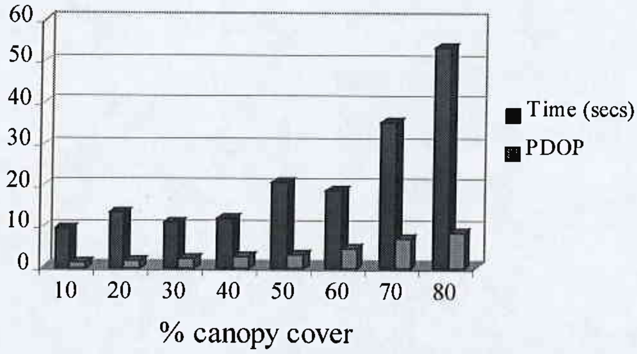


Figure 6.1 The Time taken to receive, and reliability of, GPS signals under various canopy conditions

The results shown in Figure 6.1, based on approximately 50 readings, indicate that the GPS worked effectively where there was less than 60% canopy cover (based on an ocular assessment). As the canopy cover increased, there was a rapid increase in the time taken to receive a positional fix and in the PDOP value. Above 80% canopy cover fixes could not usually be obtained rapidly, and if they could the PDOP values were unacceptably high (>10). It was found that signal obstruction was often only for short periods of time (<5 minutes). (The high angular velocity of GPS satellites means an obscured satellite often moves back into view, from behind a bole or branch.) Similarly, moving the GPS a few cm usually found a position where an acceptable PDOP could be achieved. Therefore data collection under denser canopies was possible, just taking longer than in a more open situation. It should also be noted that it was easier to get a positional fix under deciduous canopies when compared to a coniferous canopy with the same percentage cover, with fixes being more rapid to obtain and requiring less repositioning of the GPS aerial. This is a similar result to that found by other workers (Jasumback, 1993).

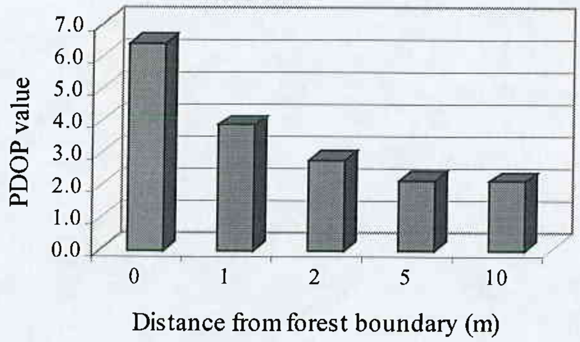


Figure 6.2 PDOP values for GPS signals at different distances from a forest boundary

Figure 6.2 indicates average PDOP values for GPS signals at different distances from a forest boundary. The values are based on averaging 20 readings in each class. The forest was an unthinned coniferous plantation of approximately 12m average top height. It can be seen that the PDOP values rapidly decrease as the GPS receiver is moved away from the boundary. It was found that by walking 2m out from the forest boundary it was possible to rapidly collect data with no loss of signal and low PDOP values. It was also found that paths through the forest could be travelled at normal walking speed with only short breaks in signal reception in particularly dense parts of the canopy.

The post-processing of the GPS data was generally successful, allowing differential correction to be performed. The differentially uncorrected files appeared to be of a reasonable spatial quality, and the differentially corrected files were of a high spatial quality. Back in the UK, the data was entered into a GIS and overlaid on a basemap of the area, but the basemap was of poor quality and was spatially unreliable. It was therefore not possible to evaluate the spatial accuracy in detail. A visual inspection indicated that the information was correct. With GPS data, it is usually immediately apparent if there are spatial errors - they are often dramatic.

The results above were only indicative, and did not address a complete range of forest conditions, but they did demonstrate that GPS could perform adequately in forest environments in the middle mountains of Nepal. Initial fieldwork indicated that the GPS receivers performed better in Nepal than they did under similar conditions in the UK. This may be because satellite configuration improves progressively as latitude decreases, and Nepal is at a lower latitude than the UK.

During the initial evaluation, a number of practical restrictions in the use of GPS were identified. These are listed in the guidelines for using GPS in Nepal, in Appendix 2, along with other practical suggestions for using GPS in Nepal.

The initial evaluation indicated that GPS worked effectively in the hills of Nepal. A number of areas were identified that required further study to determine whether GPS could be a useful research tool in the mountains of Nepal:

- the effect of base station location
- the spatial reliability of the GPS information
- the difference in accuracy between stand-alone and differential GPS in Nepal
- terrain limitations for using GPS

These areas are examined in more detail below.

6.1.2 The effect of base station location

A base station of known geographical location is required for post-processed differential GPS. This is the only type of differential GPS that appears to work in Nepal. There are very few secure known locations in Nepal. A secure location will often have an additional disadvantage in the mountains of Nepal: there may not be an uninterrupted view of satellites. Work was conducted to determine the likely effect of these two factors on the use of GPS in the mountains of Nepal.

6.1.2.1 Determining the geographical location of a base station

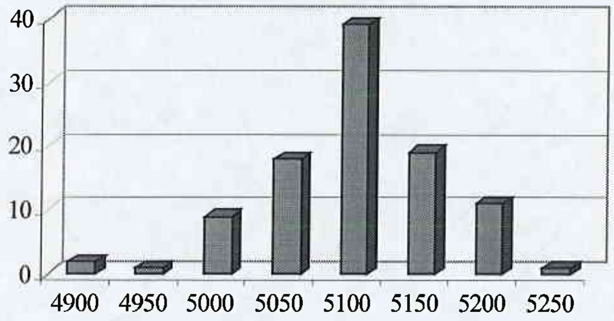
Two methods were used to determine the geographical location of the base station. The first of these was averaging a large positional dataset generated by the base station, and the second was by having a GPS at a known location, acting as a temporary base station, and using the usual base station location as the rover.

A dataset was generated from December 1997 to January 1998, designed to allow the base station position to be estimated. Although stand-alone GPS is only accurate to +/-100m for x and y co-ordinates for a single reading, accuracy can be improved by averaging a number of individual fixes. For example, five to ten minutes of fixes (300 to 600 readings) increases accuracy to +/- 50m (see section 3.2.1.1). The generated dataset contained 60 000 readings spread over ten days, recorded as 10 sets of 10-minute averaged fixes per day. The results are summarised in Table 6.1 below.

	Daily mean latitude 027° 38':	Daily mean longitude 086° 08':	Daily mean altitude:
	5086.2	4546.9	2031.2
	5073.5	4540.3	2025.4
	5104.3	4551.5	2029.8
	5042.5	4569.6	2021.9
	5100.1	4525.8	2000.7
	5073.4	4539.7	2034.2
	5092.8	4542.7	2011.6
	5078.5	4558	2008.1
	5068.7	4558.4	2019.1
	5039.1	4555.8	2028.8
Mean	5075.91	4548.87	2021.08
Range	65.2	43.8	33.5
Range in m	20.1	11.97	33.5
S. D.	21.9	12.43	11.09

Table 6.1 Summary of dataset used to obtain known location of GPS base station in Yarsha Khola. Note: values are seconds and decimal seconds e.g. 50. 862 seconds

It was anticipated that there may be an aggregation of fixes at a particular spatial location, which would indicate readings being recorded when selective availability was turned off, which is meant to occur for approximately 5% of the time (Wagner, 1998). This did not happen, with the distribution of fixes being fairly normal (Figure 6.3).



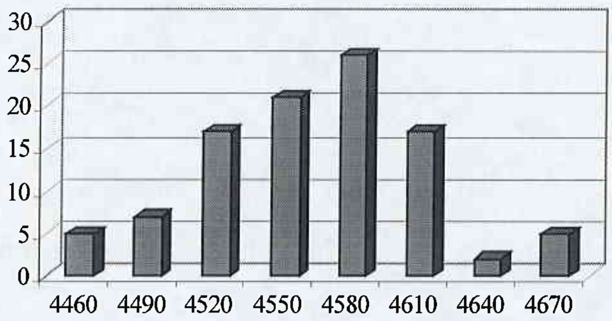


Figure 6.3 Frequency distribution of GPS positional fixes for latitude (top) and longitude

The above indicates that at the 95% level the true position of the base station lies within +/- 13.5m for the x co-ordinate and +/- 6.8m for the y co-ordinate.

The second method involved leaving a GPS receiver logging at the usual base station location. The new temporary base station was positioned at a geographically known location (a trig. point) at Hanumante monument, on a nearby prominent hill approximately 4.5km from the usual base station. The trig. point was located from a sketch map provided by the HMGN Survey Department, necessary as in Nepal trig. points are buried to prevent vandalism. Once the assumed position was located the trig. point was dug out from 0.5m of earth.

A carrier file was collected, which allowed carrier phase differential correction to be conducted, with the potential of sub-meter accuracy. Additionally, 5 averaging files were collected, each containing 300 fixes. These allowed the approximate evaluation of HMGN co-ordinates, which were found accurate to within ca. +/-50m (the level of accuracy a stand-alone GPS can achieve with averaging). After post-processing the usual base station location was obtained by this method. Table 6.2 compares the new location with the one obtained from averaging.

	Latitude	Longitude	Altitude
Position obtained by averaging	27° 38' 50" 759	086° 08' 45" 489	2021.08
Position obtained by using a geographically known position	27° 38' 50" 435	086° 08' 45" 104	2016.3
Difference (m)	11.86	8.85	4.78

Table 6.2 Differences in locational positions from two methods of calculating base station location

It can be seen from the results of Table 6.2 that the locations obtained by the different methods were spatially within 12m of each other. This indicates that the assumed base station location is very close to the true location. In subsequent work it was found that the accuracy of the differentially corrected GPS data appeared to be more accurate than the base maps that were being used.

6.1.2.2 Base station visibility

A second problem with base station location in Nepal is that ideal locations, with complete visibility of the sky and security, are scarce. Most base station locations have to compromise visibility in order to have the base station somewhere convenient and safe. The base station location for this work was on the roof of the PARDYP field office near Maina Pokhri, in the upper regions of the Yarsha Khola watershed. The office was located on a slope of 22° with some trees positioned to the north west. It was felt that visibility was restricted. The slope profile was recorded, and is shown in Figure 6.4 below. It can be seen that the view is somewhat obstructed except to the south and west. The slope obscured the sky up to a maximum of 18° from horizontal. However, GPS receivers use a mask angle, which prevents them using satellites which are very low in the sky and result in high PDOP values (principally due to atmospheric distortion). For mountainous and forested terrain typical mask angles are 10° for the base station and 15° for the rover (Magellan Systems Corporation, 1996). This ensures that any satellite data collected by the rover will have been collected by the base station. If mask angles are considered, this is a minimal obstruction of the sky. Little sky is obstructed above 10°, and the obstruction above 15° was minimal (represented by the dotted line in Figure 6.4). Mission planning software was consulted to see if the obstructions would effect the use of GPS at any time, but there was still 24 hour coverage for the base station. During GPS data collection there were no gaps in the base station data that were attributed to a loss of satellite visibility.

It is worth noting that a slope angle of 22° appears steep and to seriously obscure the sky. It was surprising to find that so little of the sky was actually obscured from the base station location. To minimise the effect of slope angle the base station must be mounted as high as possible. This necessitated climbing up the roof of the project buildings, requiring climbing equipment.

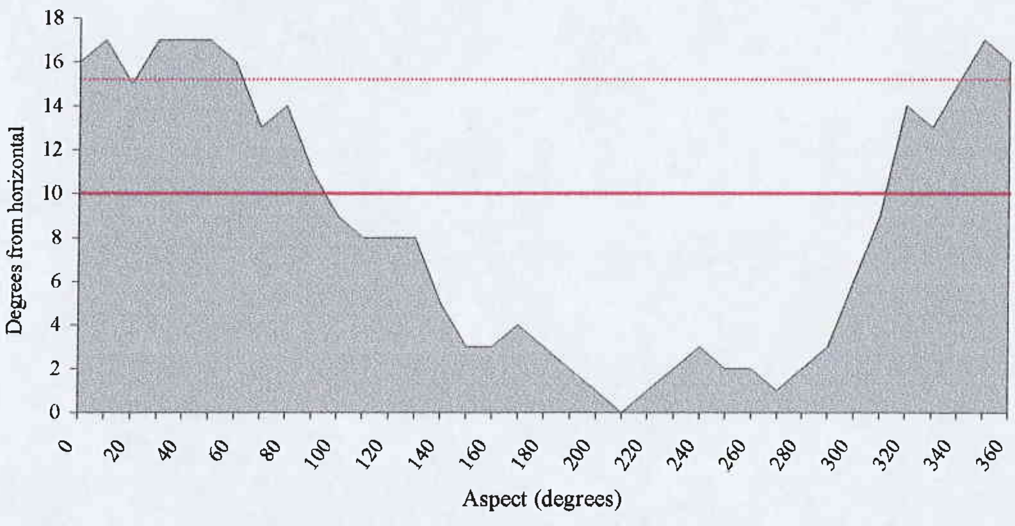


Figure 6.4 The base station Horizon

6.1.3 The spatial reliability of the GPS data

When using GPS in differential mode the accuracy is usually expected to be consistently within +/-10m of the true location, as long as there is a good satellite configuration and an unobstructed view of the sky. In Nepal it is fairly difficult to directly evaluate the accuracy of GPS readings. In countries with very accurate maps and accurately sited trigonometrical reference points it is easy to map these features with a GPS and compare the GPS readings with the true values. In Nepal the basemaps used (HMGN, 1996b) were of a lower spatial reliability than the GPS data. The basemaps (which are far more accurate than maps previously available for most of Nepal) were drawn from orthocorrected aerial photographs, which still had some spatial error due to using sample reference points and developing a Digital Terrain Model (DTM) for the correction (Harkinen, 1996, pers. comm.). Therefore other techniques were used to try to determine the spatial reliability of the GPS data.

The georeferencing work to find the base station position also provided some information on GPS accuracy. The GPS readings at Hanumante monument, once differentially processed, were within 7m (*x* and *y*) and 18m (*z*) of the official position of the trig. point. Although the trig. point position may not be exact, this is a good indication of reliable spatial data.

Repeat GPS readings were taken for the easiest feature to survey in the area, the road. These were used to see how much variation there was between GPS readings of the same spatial feature. These are shown in Figures 6.5 and 6.6, overlaid on the base map to aid visualisation. These illustrate a low level of variability between repeat readings, of the magnitude to be expected when using differential GPS correctly. The maximum difference between readings was approximately 20m (*x* or *y*), and the average difference was much lower than this. The variability was lower at Namdu than Maina Pokhri, probably because Namdu is more open and a better satellite configuration could be obtained.

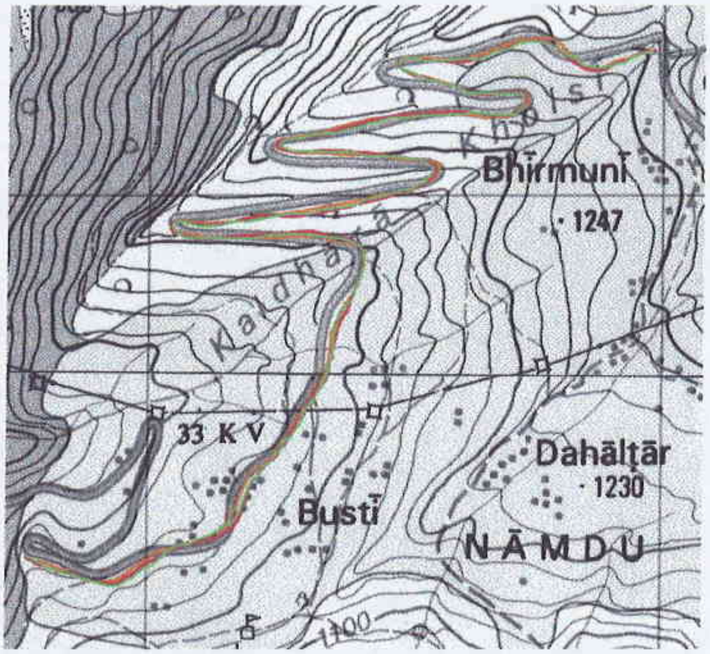


Figure 6.5 Repeat GPS surveys of the Jiri road at Namdu

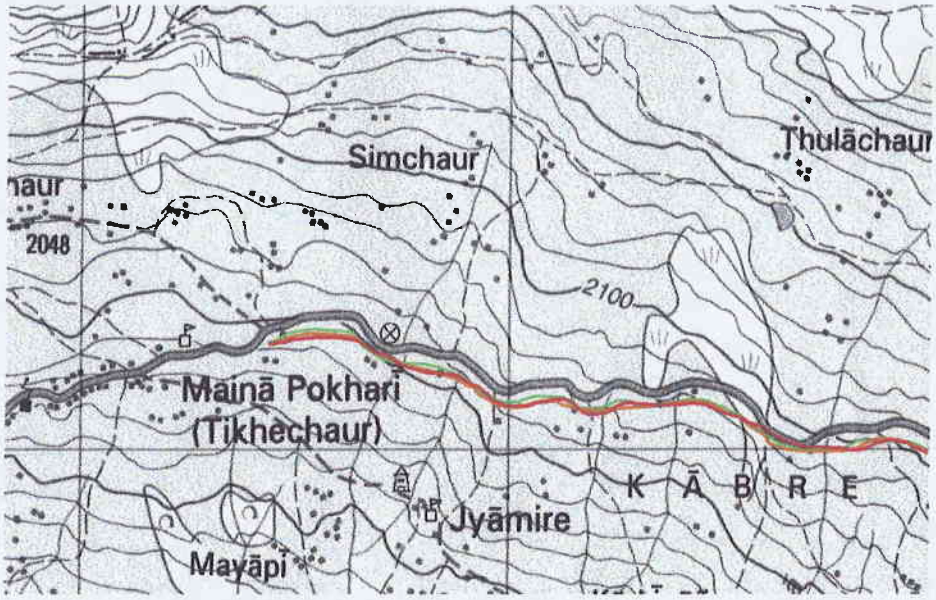


Figure 6.6 Repeat GPS surveys of the Jiri road at Maina Pokhri

Figures 6.5 and 6.6 also indicate that, as expected, there is spatial error associated with the base map. The Maina Pokhri GPS surveys are all much closer to each other than the line of the road, and the GPS survey constantly marks the road bends at Namdu slightly away from the mapped positions. The mapped road position is approximately 45m to the north of the GPS surveyed position at Maina Pokhri, and about 20m away at Namdu. Considering that UK Ordnance survey maps of the same scale have an error of +/- 5m, where the terrain is far less rugged, and there is a long history of accurate surveying, this is good accuracy (Ordnance Survey, 1996).

Whilst this work does not quantify the error associated with the GPS readings, it does indicate that the spatial accuracy obtained is within the normal limits expected for this type of GPS being used in differential mode (ca. +/- 10m). This is considered to be accurate enough for forest resource assessment purposes.

6.1.4 The difference in accuracy between stand-alone and differential GPS in Nepal

Differential GPS greatly increases the complexity and cost of using GPS. Two GPS receivers are required, and the post-processing is time consuming and complicated. There is a tendency to use stand alone GPS wherever possible, even though it is less accurate. Calculations were made, based on the usual errors associated with GPS, which indicated that stand-alone GPS would not be suitable for spatial assessment for community forestry (see Table 6.3)

Area (hectares)	Differential GPS min/max area ha[1]	% error +/- *ca.*	Stand-alone GPS min/max area ha[2]	% error +/- *ca.*
1	0.81 – 1.21	20	0 - 4.0	400
4	3.61 – 4.4	10	1 – 9.0	225
10	9.36 – 10.67	6.5	4.67 – 17.3	75
100	98.0 – 102.01	2	81 –121	20

Table 6.3 Expected errors for stand-alone and differential GPS

It can be seen from Table 6.3 that the percentage error of an area reading varies depending on the size of the area (perimeter/area ratios are not constant). With areas of one hectare differential GPS has a high spatial error associated with it and stand-alone GPS does not produce any meaningful results. Much CFRA is concerned with small areas of forest, almost always under 100 hectares, and usually much smaller than this.

[1] The variation in area is based on a differential GPS accuracy of +/- 10m.
[2] The variation in area is based on a stand-alone GPS accuracy of +/- 100m.

The figures in Table 6.3 are probably pessimistic, they represent the expected scatter of results under reasonable conditions. The Root Mean Square (RMS) is often used for measuring GPS error (Magellan Systems Corporation, 1996). This represents the average length of the error vectors computed for each fix in a stationary file. If the distribution of fixes around the true position is circular and normal, a RMS value implies that 63% of readings are within +/- this value of the true position. Typical GPS RMS values for the GPSs used in this study are an RMS error of 31m for stand-alone use, and an RMS error of 3m for differential use.

The above calculations combined with the results above (indicating that the GPS error was of the magnitude to be expected when using differential GPS correctly) indicated that stand-alone GPS would not provide sufficient accuracy for community forestry resource assessment. However, it was briefly evaluated through field trials, and the results are displayed in Figures 6.7 and 6.8.

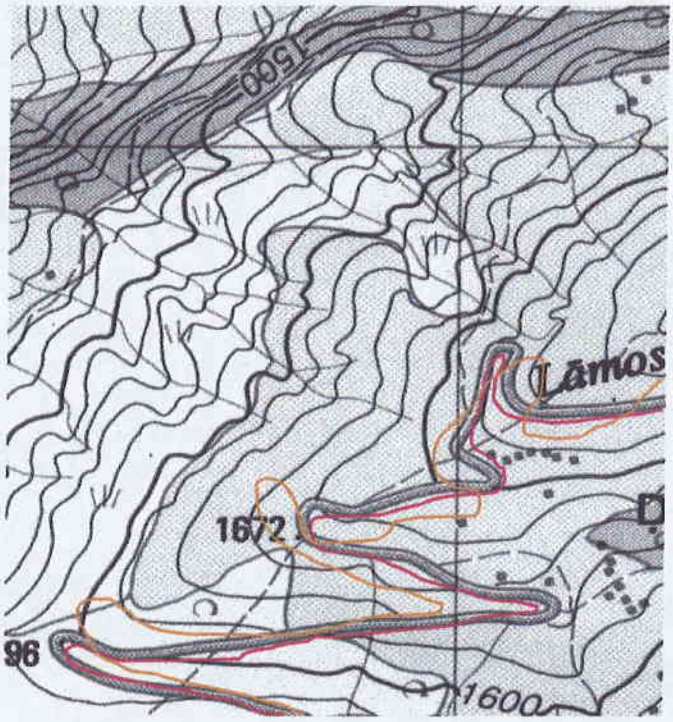


Figure 6.7 Stand-alone and differential (red) GPS surveys of the Jiri road above Namdu

Figure 6.8 Stand-alone and differential (red) GPS surveys of part of Chulettro Pakha community forest

Figures 6.7 and 6.8 illustrate that the stand-alone GPS survey results are far less accurate than the differential results, as expected. The positional results from the stand-alone GPS survey were often 60-80m from the true location, and in some cases over 100m away. This compares with the differential GPS results, which are consistently within 10m of the true position, and usually much closer than this. This further indicates that stand-alone GPS is inappropriate for surveying small community forests.

6.1.5 Terrain limitations for using GPS

The high mountains of Nepal have very steep slope angles (see Table 4.4, and photographs 1-3 at the end of this chapter), which means satellites are often obscured. This, coupled with a forest canopy reduces the effectiveness of GPS. A record was kept of the slope angles and vegetation types where GPS ceased to be effective (when the GPS lost its positional fix and could not regain it within 30 seconds, or the PDOP value was higher than 10 for 30 seconds). Summary information is in Table 6.4.

	Overall	Sparse canopy	Moderate canopy	Dense canopy
Mean (^{o})	39.9	42.1	40.5	31.8
N	51	21	18	12
Minimum (^{o})	22	34	28	22
Maximum (^{o})	53	53	52	48

Table 6.4 Slope angles and canopy cover where GPS ceased to be effective

From the above it can be seen that there was little trouble obtaining satellite fixes with slope angles less than 22^o. However, it should be noted that the canopy cover in the study area was generally sparse or moderate, and under denser canopies problems may occur on gentler slopes. It can also be seen that a dense canopy has a significant effect on the ability of GPS to function. It should also be noted that GPS worked effectively on slope angles greater than 60^o when there was little canopy. It also worked under cliffs as long as the remainder of the sky was visible (PDOP values tended to rise). The GPS worked very well even on demanding terrain. On slopes of 20-35^o it was possible to survey forest boundaries at walking speed with only occasional losses of signal, generally corresponding with denser canopy areas.

As well as the technical performance of GPS limiting its use on steep slopes, there are practical problems. Once slope angles exceed 45^{o} it is very difficult to safely move on the slopes whilst holding a GPS receiver. Accurate boundaries are hard to map due to having to avoid steeper sections, cliffs and loose vegetation. This effectively precludes the use of GPS on steep slopes. It is felt that GPS can be safely and effectively used on slopes up to approximately 40^{o}, after that its usefulness rapidly diminishes with increasing slope angle.

6.1.6 Mapping the spatial location of community forest boundaries and resources

So far this chapter has examined the technical evaluation of GPS for community forestry, and results have indicated that differential GPS is an accurate and practical means of collecting spatial data under a variety of conditions. This section examines case studies of mapping community forests using GPS.

During this study four community forests (fifteen compartments) were mapped using GPS. They were mainly conifer plantations, with quite wide spacing and generally young crops. In most cases the canopy was not closed. The terrain varied from less than 20^{o} to more than 45^{o}. Some areas of broadleaf plantation and natural forest were also mapped. This section will use a mapping exercise as a case study, referring to the other community forests for comparison.

6.1.6.1 GPS boundary mapping of Chulettro Pakha community forest

The initial stage of the surveying procedure involved informing the FUG of what the survey was for and what the GPS did. The operation of the GPS was described in fairly simplistic terms prior to demonstrating it, as the sight of the GPS caused much excitement. A detailed technical understanding of how it worked was felt to be inappropriate (for example, do you have to know how a fax machine works to understand what it does?) Participants were told how the GPS collected information from satellites, in the same way as satellite televisions work, and similar to how their radios work. It was explained that the information received from the satellites allows an exact position to be determined, and by putting the information into a computer, a map can be drawn of the forest area, or obtain the location of schools or meeting places. The

Magellan ProMark 10 used allows the status of each satellite and the satellite configuration to be viewed, which were of interest to the participants. The process of mapping the forest boundary was explained. The forest guard and six members of the FUG assisted with boundary mapping.

Initially the forest boundary was a distinct boundary between Bari fields and *Pinus patula* plantation, and the trees were quite small (<8m). Readings with an acceptable PDOP value were obtained rapidly, although the receiver had to be 2 - 3m from the actual boundary. However, difficult terrain was soon encountered, with the slope angle increasing greatly, and dense scrub and woodland, with no physical boundary between community and private land. Steep gullies with slope angles *ca.* 45^0, wet mud, and loose vegetation were found to be dangerous whilst trying to hold a GPS upright. Most of the participants stayed above on a trail. With the steep slopes, denser vegetation and a less favourable aspect, PDOP values were higher and there were gaps in the data collection. When the boundary again followed a clearly defined path the PDOP values improved again. The whole forest boundary was surveyed in approximately two hours (the area was approximately 15 ha). Internal partitions between FUG determined compartments were then mapped out. The GPS receivers functioned well unless the canopy or high scrubby vegetation was dense. Difficulties in maintaining satellite contact were again experienced on steep slopes, and in areas where the boundary was not defined. The GIS map obtained from this boundary mapping exercise is shown in Figure 6.9.

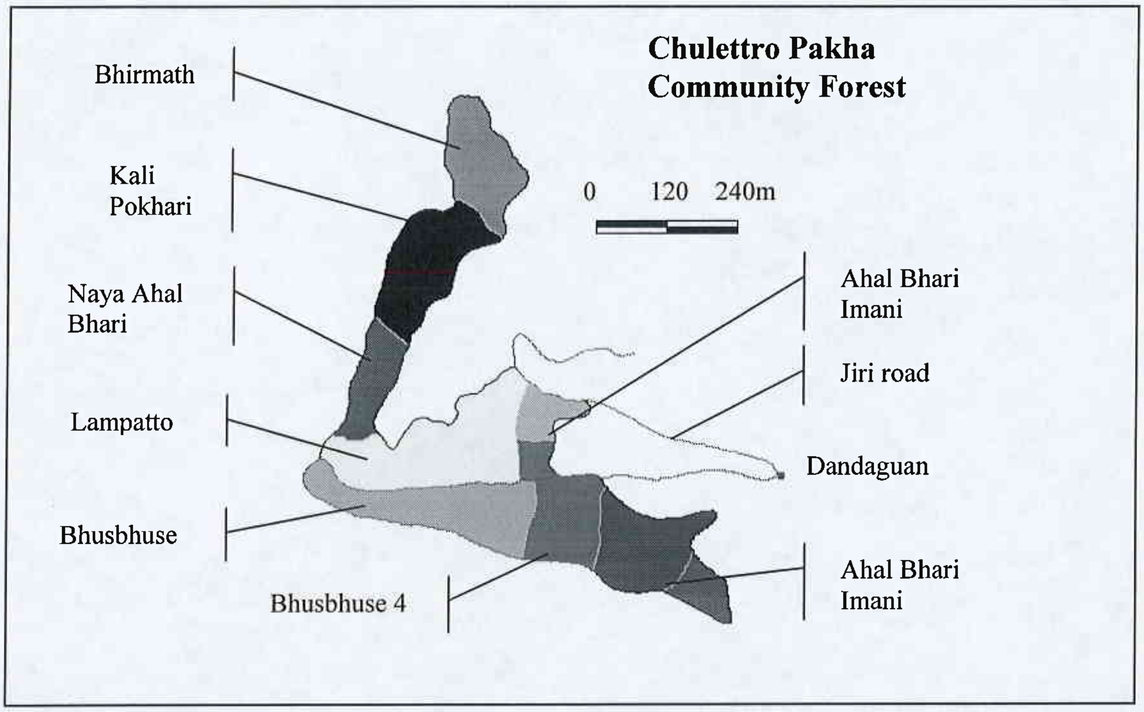


Figure 6.9 Chulettro Pakha boundary map

It is possible to estimate the error associated with a community boundary mapping exercise. Using the assumption validated above that the spatial error is the normal expected for differential GPS in this role (+/- 10m, or +/-3m RMS), the error associated with the estimated size of the community forest is shown in Table 6.5.

Estimated size of the resource (ha)	error (+/- 10m) ha		RMS error (+/- 3m) ha	
	Lower	Upper	Lower	Upper
14.82	14.06	15.6	14.59	15.05

Table 6.5 The estimated size of Chulettro Pakha community forest with reliability ranges

From the above it can be seen that GPS has potential as a useful tool for rapid boundary surveying for most terrain's, particularly where there is a distinct boundary to the forest. It ceases to be a useful tool on steep slopes, particularly if there is a dense canopy. It also makes the forest walk more interesting, and it takes the team and participants to areas of the forest that they may not otherwise visit. It became quite apparent that most users did not know exactly where the boundary was, the forest guard was the most knowledgeable. Additionally, as the whole forest boundary is traversed, a feeling for the surrounding land uses and terrain can be got that is difficult to obtain from aerial photographs. If the boundary survey is done with a group of participants, similar information can be obtained as from a 'traditional' group forest walk.

6.1.6.2 The value of GPS for mapping community forest boundaries and resources

The Chulettro Pakha case study illustrates a typical experience of using GPS for boundary and resource mapping. Table 6.6 summarises the use of GPS for boundary mapping for this study.

FUG	Canopy cover	Slope	Comments
Baishakeswori	Often dense	Often steep	GPS did not work well, surveying was impractical. Combination of steep slopes & high, fairly dense canopy meant PDOP values were high, or fixes could not be obtained
Bhasuki	Dense to sparse	Gentle	GPS very effective and rapid, except in limited places where the canopy closed
Chulettro Pakha	Moderate to sparse	Moderate to steep	GPS mainly very effective and rapid, except on steeper vegetated slopes where PDOP values rose, fixes could not be made and surveying was dangerous
Dhungeswori	Moderate to sparse	Moderate to steep	GPS very effective. There were no steep slopes with significant canopy cover. Also, forest at the top of the watershed and satellite visibility may be better
Ningure	Moderate	Moderate	GPS very effective. There were no steep slopes with significant canopy cover. In areas with large conifers had to move GPS slightly to obtain better PDOP values. In young Sal trees no problems with fixes

Table 6.6 The effectiveness of GPS for boundary mapping

GPS is an effective tool for boundary mapping unless the slopes are steep and covered in dense forest, as mentioned in section 6.1.5. In this situation the use of GPS becomes much slower, although still possible, but the advantages of speed and ease of operation are lost.

6.1.6.3 Comparison of methods used for boundary mapping

A comparative examination was made of the spatial reliability of different survey methods for a forest boundary. This was only done for one community forest and the results are indicative and only valid for Chulettro Pakha community forest. Four methods of survey were used: differential GPS; stand-alone GPS; PPM and the existing Forest Department chain & compass survey.

The participatory photo map and Forest Department survey map for were digitised and entered into a GIS. The GPS data were exported from the GPS post processing software and imported into the GIS. This allowed a spatial comparison, in terms of area and geographical accuracy, to be conducted. This information is shown in Figure 6.10.

Figure 6.10 Boundaries surveyed using different methods for Chulettro Pakha Community Forest

It can be seen that the participatory photo map border closely follows the differentially corrected GPS border. It can also be seen that the uncorrected GPS data is inaccurate. The Forest Department survey map also has a high level of spatial inaccuracy. The areas represented by these various borders are given in Table 6.7

Method used for obtaining the border	Total area (ha)
Differential GPS (Base-line data)	14.82
Participatory Photo map	17.0
Stand-alone (uncorrected) GPS	20.63
Forest Department Chain & Compass Survey	15.51

Table 6.7 Areas obtained for Chulettro Pakha community forest using different survey techniques

From this it can be seen that the chain and compass survey most closely approximates the area obtained from DGPS, followed by the participatory photo map. The chain and compass survey does not reflect the border very accurately, and the error in the spatial area could have been much greater. It can be seen that stand-alone GPS, without differential correction, has a high degree of error, as expected. All of the survey areas lie outside the range of values within the RMS error of the differential GPS results (see Table 6.5).

6.1.7 Georeferencing spatial data

In Nepal data is often collected which has a spatial component but is not georeferenced, so its spatial location is not known, for example Participatory Photo Maps or compartment data. Georeferencing infers obtaining an accurate geographical location for an identifiable feature (such as a bend in road, house, temple, or hilltop), which can then be used as a ground control point. Having georeferenced control points allows spatial information to be put into a GIS. DGPS was used to survey control points. As the receiver is stationary, the more accurate carrier phase differential correction can be applied. For this, five minutes of readings are required for an accuracy of *ca.* +/- 1-5m. Control points must be easily recognised from aerial photographs, and in positions where there is good satellite visibility. Control points should be situated a little outside of the area that is to be georeferenced, and spread around it. For georeferencing a polygon (such as a community forest) three or four control points are required.

The main role for control points in this study was for georeferencing PPMs, allowing them to be digitised and entered into a GIS. The following is based on the example of obtaining control points for the Dhungeswori PPM.

Once the PPM had been generated from participatory sessions, control points were collected. Features that could be identified from the aerial photographs were located, and the GPS was used to obtain spatial co-ordinates (see Figure 6.11). The most convenient features were sharp bends in the road that goes around the forest, and the site of an old Buddhist 'Chorten' on a ridge top. This process is quite rapid, and three control points were logged in about one and a half hours. The main problem is the interest generated by this procedure: if the control points are near a village it is difficult to prevent villagers crowding round and blocking GPS visibility!

Figure 6.11 Ground control points on an aerial photo to enable georeferencing

When all the control point data was collected, it was post processed and differentially corrected to obtain accurate geographical locations. The control point co-ordinates were manually entered into the GIS and digitized. The PPM was then digitized, and assigned topography.

GPS is an excellent tool for rapidly collecting ground control points for georeferencing spatial data. In the mountains of Nepal some of the control points may take some time to walk to, but recognisable features with good visibility in appropriate positions around the forest resource were always located.

6.1.8 GPS for participatory resource assessment – a useful tool?

GPS as a survey tool performed well under most conditions. It allowed rapid and accurate surveys to be conducted, and it is a cost effective mapping tool. It was also excellent for obtaining spatial information on ground control points. However, its appropriateness for community forest management requires addressing. Differential GPS is expensive and requires skilled operators for the data analysis. It is also difficult to use in a truly participatory capacity owing to the complexity of the surveying process.

6.2 Examining the potential of Participatory Photo Mapping for Community Forestry in Nepal

Background information on the use of aerial photographs for PPM was given in section 3.3.2. This section examines PPM conducted as part of this study. After a description of the process three areas of results are presented: PPM as a participatory exercise; PPM for obtaining spatial data and the spatial accuracy of aerial photographs.

6.2.1 The process of PPM

PPM sessions were conducted with each FUG in the Yarsha Khola watershed, but not with Bhasuki FUG, because aerial photographs of a suitable scale and quality were not available. The main purpose of using PPM was to obtain spatial information about the resource, and to produce a PPM of the community forest with external and internal boundaries, although it was found that aerial photographs were also an excellent facilitation tool.

The general procedure for PPM sessions involved an introduction explaining that a map of the forest resource would be produced, and explaining what it would be used for, and how the information would be returned to the FUG. Aerial photographs were introduced into this participatory discussion In most cases 1:20 000 aerial photographs were used by the FUG members to get their bearings and identify major features, such as roads and rivers; then 1:5 000 photographs were used to identify further features. The 1:5 000 photographs were found to be far more useful for FUG members than the 1:20 000 photographs. The switch in photograph scales occurred spontaneously with no influence from the facilitators. In some cases the 1:5 000 photographs were used from the start, because the participants noticed them and grabbed them! One of the key aspects of this approach is its animation and excitement. It is important to have good facilitation; as villagers start examining the photographs they need to be informed what has been identified correctly, and have some of the key features pointed out to them. If this is not done the group may wrongly identify key topographical features, which leads to confusion when mapping starts, or lose confidence in their abilities and become hesitant. Villagers can generally identify features very rapidly. This is probably due to them living in mountainous terrain, and being familiar with viewing fields, houses, rivers and forest from an 'aerial' perspective. Photographs 4-6 at the end of this chapter illustrate PPM in progress.

Once the villagers were able to interpret the image correctly, and were confident in their abilities at interpretation, the mapping procedure began. The PPMs were drawn on acetate sheets sellotaped to the 1:5 000 aerial photographs. The features were drawn with water-based acetate pens, allowing the position of features to be changed by FUG members. It was found that the best approach was to commence with clearly delineated parts of the forest boundary (next to a road, track or agricultural land) and once the group had marked these, to move on to the less clearly defined areas. Usually the group nominated one or two people to draw the boundary, but the final boundary was definitely a consensus of all who were present. The mapping of the external boundary was found to take from twenty minutes to an hour and a half. It generally involved a lot of discussion and arguing amongst FUG members, and parts of the boundary were usually rubbed out and re-drawn several times before a consensus was reached. Internal boundaries were harder to define in many cases, as the distinctions between compartments were often not very apparent on the photograph. With most groups, attempts were made to separate men and women into two mapping groups after the initial discussion, to see if there was much difference in the map each group produced. This was in practice quite difficult, and the facilitator had to be firm in preventing the groups from coalescing back into one. A useful technique was to have two activities occurring simultaneously, for example the forest ranger would talk to the men about management issues whilst the women were mapping the boundary and *vice versa*. It was also useful to have the women map the forest first, otherwise they tended to leave the meeting prematurely. Once both the men and women had mapped the resource, the group was merged into one again, and differences between the maps compared. Usually a consensus was quickly reached on the correct boundary. Once the map was finalised the features were drawn over with a permanent acetate marker. An example of a PPM is shown in Figure 6.12.

After the PPM had been produced, while it was still sellotaped to the aerial photograph, easily identifiable ground control points were marked on the acetate sheet and then georeferenced using GPS. This allowed the PPM to be spatially referenced and entered into a GIS. Figure 6.13 shows a digitised PPM overlaid on an aerial photograph. This method provided a rapid and fairly easy means of converting community spatial resource information into a format that allowed it to be spatially analysed and combined with other data for management planning purposes.

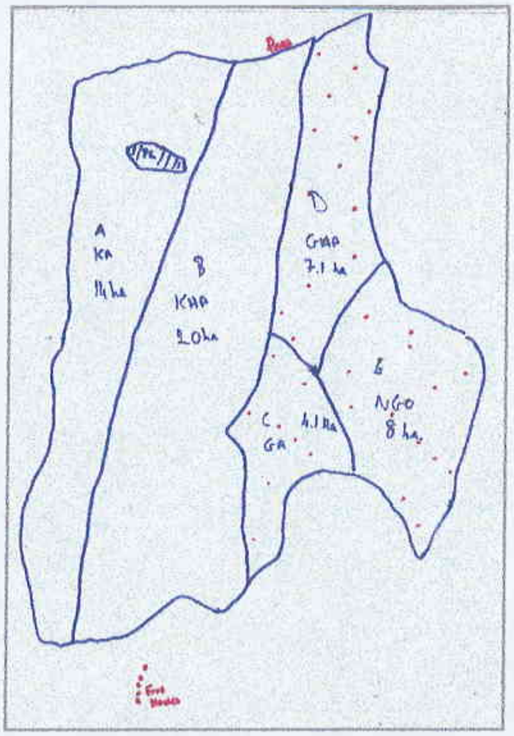


Figure 6.12 A PPM showing internal and external forest boundaries for Baishakeswori Community Forest

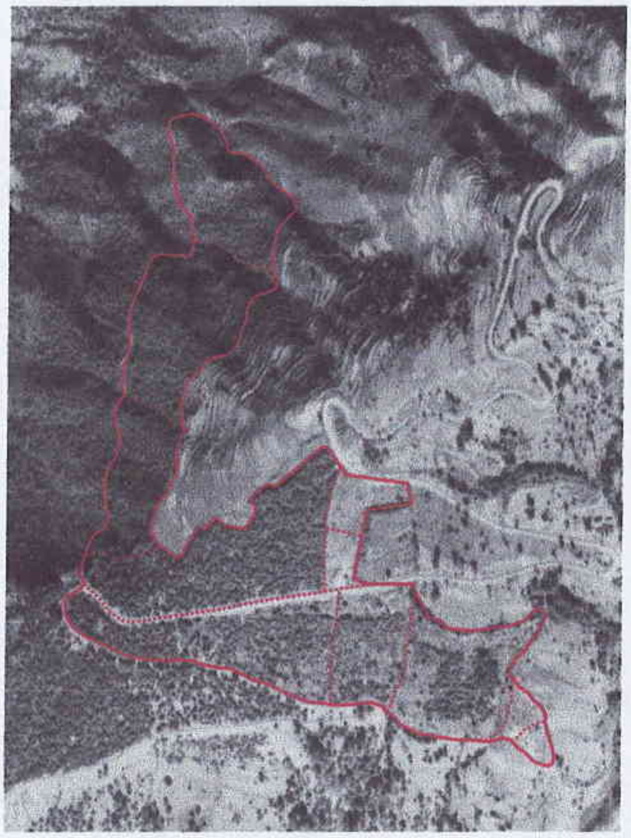


Figure 6.13 A digitised PPM of Chulettro Pakha Community Forest overlaid on a 1:5 000 aerial photograph

6.2.2 PPM as a participatory exercise

PPM was found to be excellent participatory tool and a useful addition to the rapid appraisal toolkit. Although the main objective of the PPM sessions was to obtain boundary information, it became apparent that PPM is an excellent tool for obtaining a variety of resource information with a spatial component. Areas where information was obtained included usage patterns, access, areas where there are conflicts and the condition of the resource. Other information was collected during this process, such as ranking of the quality of each area of the forest, and the criteria the FUG used for this ranking process. In one case (Baishakeswori FUG) it became clear during the PPM exercise which part of the forest was scheduled for imminent handover, and which part would be handed over in a year or so, owing to conflicts over private/community land. It had been impossible to determine this accurately from traditional participatory sketch maps, and the DFO had been unable to determine exactly which part of the resource was for immediate hand-over. It was found that integrating this type of focussed RRA activity with PPM provided the facilitators with a much greater level of spatial awareness of these issues than a standard topical RRA session allowed. It was also found that, as with traditional participatory sketch mapping, better results were achieved when the forest resource being mapped was visible. This allowed the FUG members to compare what was on the photograph with the resource.

Participant feedback indicated that the process was quite simple to understand, and participants also said that the process was easier to understand and conduct than participatory mapping sessions they had performed with DFO staff. They also said that they had an excellent and entertaining morning!

PPM was found to be a good facilitation tool, as Mather (1998) also found. The sessions were very participatory and vocal, with men and women freely joining in, gesticulating wildly, and influencing proceedings. The non-literate nature of PPM meant that no one was prohibited from participating. All the participants were highly enthusiastic, and it some cases it was impossible for the facilitator to split the group by gender. The process *became* the communities.

Mather (1998) identified a number of other ways in which aerial photographs contribute to participatory and other community forestry processes (see section 3.3.2). In general the results from conducting PPM exercises in this study confirm Mather's findings. However, it is not felt that authenticity was demonstrated, a lot of subsequent PRA work would have to be conducted to determine if all participants felt that the PPM reflected the distribution and condition of their resource. It has not been demonstrated that this information is captured by the PPM from the aerial photograph. Likewise, it was not felt that the information was always consistently interpreted by different groups: men and women usually identified slightly different boundaries that were only resolved by group discussion. However, it is agreed that aerial photographs and the PPM process are excellent facilitation aids and they provides a non-literate medium similar to a participatory sketch map, but easier to understand.

6.2.3 PPM for obtaining spatial data

PPM is a good process for obtaining community resource information. Participants appear happy with the process and seem to be able to confidently mark the forest boundary in most cases. Where there was a clearly visible boundary (such as different land uses) the boundary was rapidly marked. Where the boundary was less distinct, such as through an area of forest which was partly community and partly state-owned, there was a lot more discussion about where the boundary should be drawn. Additionally, with the younger plantation areas it was often difficult to identify where the community forest began and privately owned grazing or bari began. It should be noted that during boundary surveys it was found that these difficulties often occur on the ground, not just during aerial photograph interpretation. The implication of this is that the boundaries are community forests are perhaps not as defined as is commonly thought, and different members of the FUG have different opinions as to where the boundaries lie. Adjacent landowners probably have different opinions again. Internal boundaries were often difficult to accurately map, particularly when dividing areas of similar species, age and spacing. It appeared that sometimes the internal boundaries were drawn in a fairly arbitrary manner. This is discussed further in section 6.4.3.

Despite the above comments, PPM is regarded as an excellent method for mapping boundaries. It is rapid, participatory and the boundaries are accurately placed, where this is possible (most of the external boundary).

6.2.4 The spatial accuracy of aerial photographs

Mather identifies aerial photographs and PPMs as a potential base for survey maps, if they are geometrically restored. Geometrical errors are only one source of spatial error in a PPM. The boundary drawn by the FUG, and a boundary surveyed on the ground will differ slightly, maybe substantially where the boundary is poorly delineated or there are hidden agendas. An example is Chullettro Pakha Community Forest. Section 6.1.6.3 compared the results of different methods of mapping the boundary. It was found that the GPS survey gave an area of 14.82 ha and the PPM gave an area of 17.0ha, a difference of 13%. This was based on an uncorrected aerial photograph. The only part of the error budget which could be quantified was the amount due to geometrical error. To be able to calculate this the aerial photograph had to be geometrically corrected and the difference in area calculated.

Two methods of geometrical correction were attempted. The first was orthorectification, which involves draping the aerial photograph over a Digital Terrain Model (DTM). To do this georeferenced control points are required on the aerial photograph (generated by GPS and/or identifiable features from a map) to reference it to the DTM, and sufficient georeferenced *x, y and z* co-ordinates to produce a DTM. Additionally, information was required about the aerial photography. Information was obtained on the camera calibration (providing details of focal length, fiducial markers and internal distortions) and the photograph flight (height and type of aircraft). *Orthoengine v.6.0* was used to orthorectify the photographs[3]. Unfortunately the orthocorrection, although working, was not felt to be very accurate, because the DTM was based on too few reference points for the highly variable terrain. Although the aerial photograph was draped over the DTM, the DTM failed to reflect the finer variations in topography. Therefore a second method of geometrical correction was used, georectification ('rubbersheeting'). This procedure uses the same control points as required for orthorectification, but instead of draping the image over a DTM the

[3] The geometrical correction was performed by the author with assistance from Wildgoose Publications, a professional surveying Company.

aerial photograph is distorted so that all the control points on the aerial photograph are at their correct georeferenced position. The procedure fits polynomial equations to the control points, and uses least square criteria to model corrections to the image. The advantages of this approach are that it eliminates the need for an accurate DTM, but it only corrects for *x/y* co-ordinates, not height. Essentially the aerial photograph is turned into a map (and a specified projection can be applied if required). The RMS error for the worst 5% of control points was 10.1 m, probably similar to the topographical maps available for the area.

Uncorrected photographs and PPMs were already in the GIS, without any georectification having been performed. These showed geographic area on the original photographs. These uncorrected PPMs were overlaid on the orthorectified and georectified aerial photographs, with easily identified spatial reference points added, marked by red arrows. These are shown for part of Chulettro Pakha community forest in Figure 6.14.

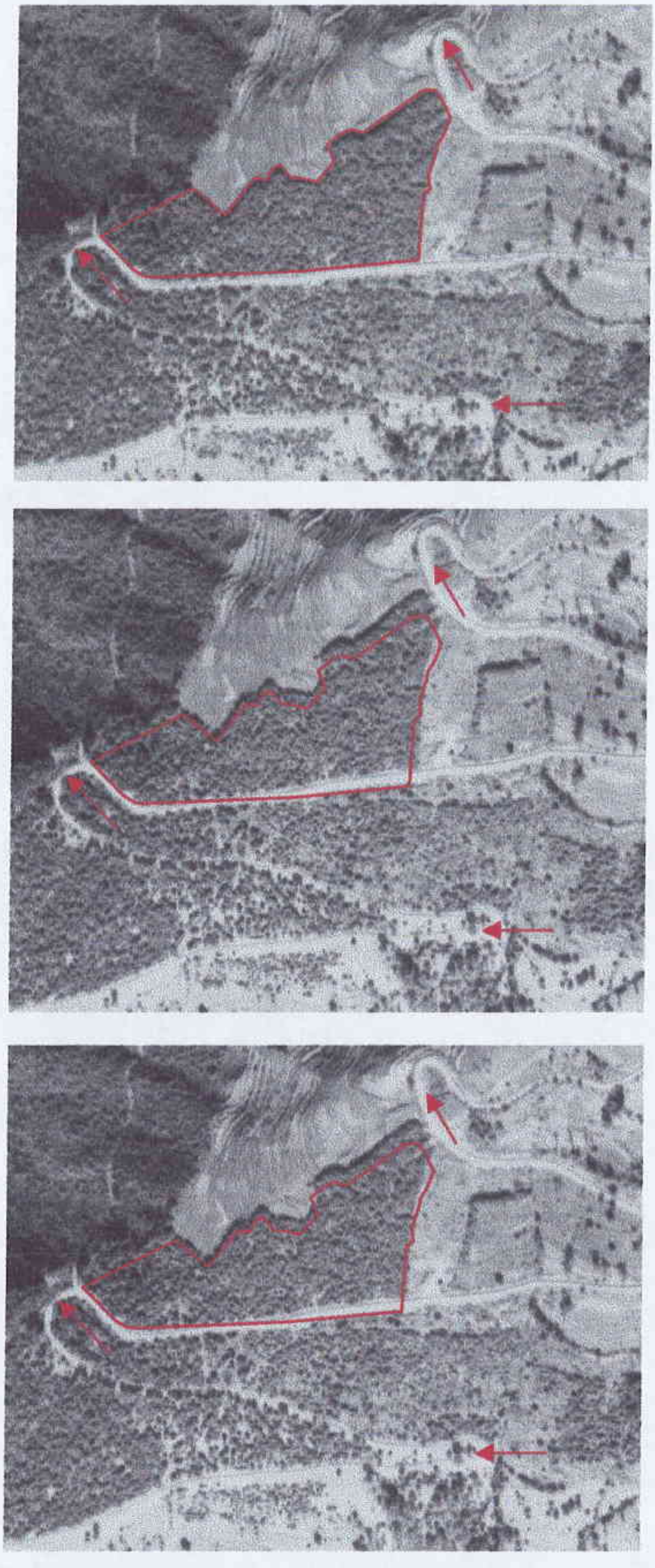


Figure 6.14 Spatial differences between uncorrected (top), georectified (middle) and orthorectified (lower) aerial photographs: Chulettro Pakha Community Forest. The boundary and control points from the uncorrected photograph have been overlaid on the georectified and orthorectified photographs to illustrate the spatial differences.

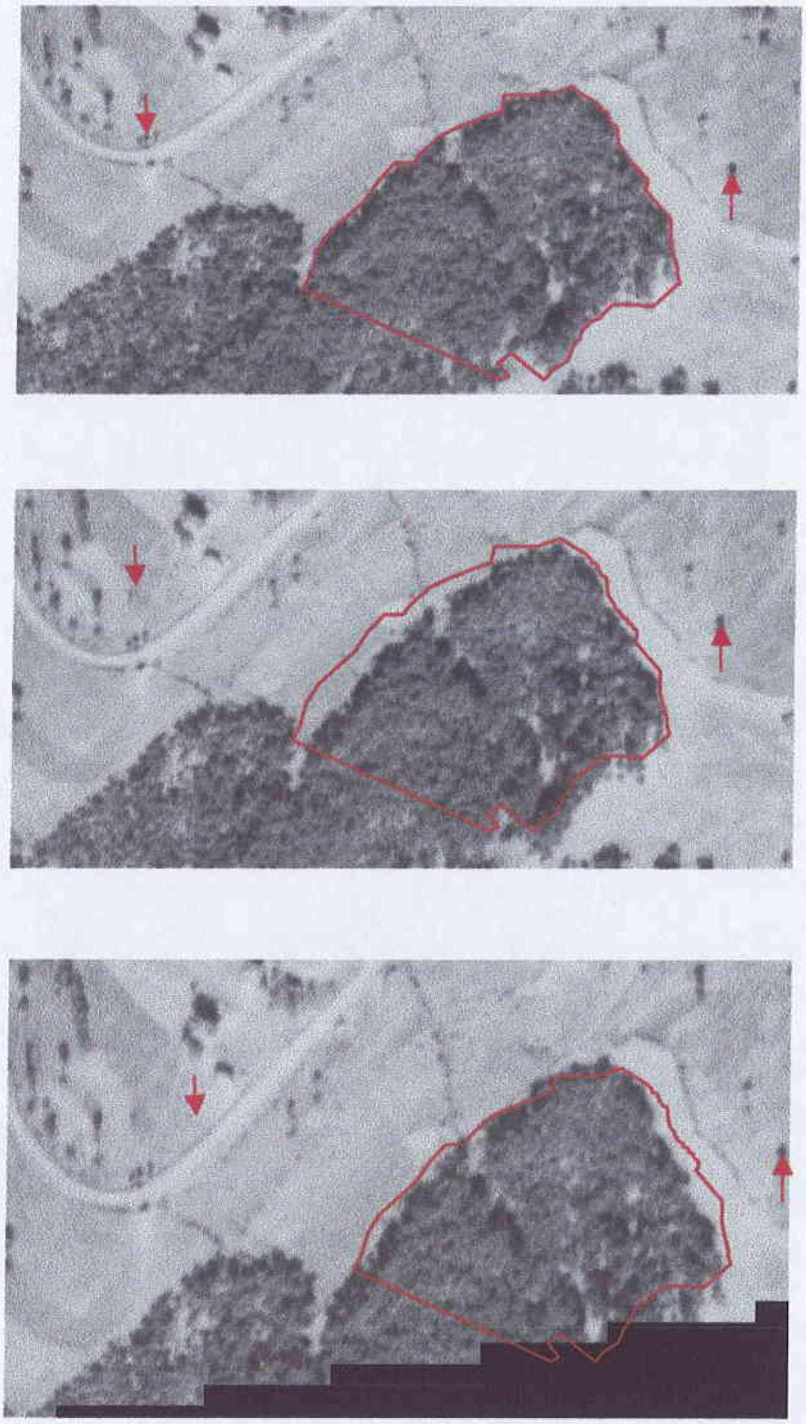


Figure 6.15 Spatial differences between uncorrected (top), georectified (middle) and orthorectified (lower) aerial photographs: Ningure Community Forest. The boundary and control points from the uncorrected photograph have been overlaid on the georectified and orthorectified photographs to illustrate the spatial differences.

It can be seen that the uncorrected aerial photograph is spatially inaccurate. The true boundary lies approximately 23m to the north for the eastern end of the forest. The reference points have moved up to 30.8m when rectified. It will also be noted that the movement is not constant: it depends on the altitude and the horizontal distance from the camera. There is little difference between the ortho and georectified images. There was a 2.2% difference in the area of the forest between the uncorrected and georectified images, and 0.17% difference between the orthorectified and georectified images.

This single case study cannot be used to generalise on the error budgets for GPS and PPM surveys. It can be seen that about 2.2% of the error is due to uncorrected imagery, and 10.8% is due to surveying different boundaries. In this case the different areas portrayed by uncorrected and corrected images is fairly insignificant.

The same three types of image are shown in Figure 6.15 for part of Ningure community forest. The spatial errors are in Table 6.8, along with those for part of Dhungeswori community forest (the aerial photograph for Baishakeswori was not georectified).

Community Forest	Max. displacement of reference points (m)	Difference in area of forest compartment (Uncorrected/ georectified) %	Difference in area of forest compartment (Orthorectified/ georectified) %
Chulettro Pakha	30.8	2.2	0.17
Dhungeswori	6.0	6.1	2.3
Ningure	29.9	5.9	3.8

Table 6.8 Spatial errors between uncorrected and rectified GIS imagery

The georectified images are probably the most spatially accurate images, as Ningure and, to a lesser extent Dhungeswori, were at the edge of the aerial photographs, where the DTM was least reliable.

The difference in magnitude of the variation in area between the three community forests is probably due to their location on the aerial photographs. These areas were chosen because Chulettro Pakha was at the centre of the aerial photograph, and Dhungeswori and Ningure were at the edge (it can be seen from Figure 6.15. that the orthorectified image of Ningure is cut by the aerial photograph boundary). Spatial distortion of aerial photographs increases at greater radial distances from the centre of the photograph (Sabins, 1996), so it is to be expected that the error would be greater for Ningure and Dhungeswori community forests. The relationship between the edge of the boundary and spatial error cannot completely correlate as Ningure was closer to the edge of the photograph than Dhungeswori.

The polygon shape of the community forest differs from the uncorrected and rectified images. This is not considered to be of great significance in Nepal where, as demonstrated above, the maps have *ca.* 20 - 45m error.

The above indicates that using uncorrected aerial photographs does introduce spatial error into area calculations, but with the photographic scale used for this study (1:5 000 enlarged from 1:20 000 originals), the error appears to be less than 10%. This is further reduced by only using the central part of the photograph (standard remote sensing practice), where a conservative estimate of error would be 5%. It appears from the repeat boundary survey of Chulettro Pakha that most of the 'error' in boundary mapping is due to mapping slightly different boundaries.

6.3 Examining the potential of GIS as a tool to assist with local level forest resource assessment

Sections 6.1 and 6.2 have examined the two main sources of data for this study: GPS and PPM. Other sources included aerial photographs as basemaps, topographical maps as basemaps, and chain and compass survey information. The reason for entering this information into a GIS are to analyse the data, organise it, and to allow it to be prepared in a manner that maximises its use for FUGs and rangers.

Some of the results detailed in the previous two sections, such as areas, were calculated using GIS, this section explains how it was used. For the analysis work Idrisi for windows v 2.0 was used.

6.3.1 GIS for data analysis

The spatial information provided by GPS, and to a lesser extent PPM, is not particularly useful until it is fully processed. For GPS data, initial processing (post-processing) removes spatial errors (principally by differential correction). The next stage of processing involves entering the data into a GIS. GPS data is already spatially referenced, and is easily entered into a GIS as vector data by overlaying it on a basemap (which may be a georeferenced blank area, or a map or aerial photograph, for an example see Figure 6.8). This allows the data to be used for visual purposes, but does not allow spatial analysis to be performed for boundary surveys. For this, the GPS boundary has to be converted into a polygon representing the internal area of the mapped feature (such as a forest compartment). The area of the polygon can then be determined. The procedure for PPM data is similar, except the vector data representing boundaries is not georeferenced, and the boundaries have to be manually digitised using a digitising table. Georeferenced control points are first digitised, providing spatial location data, followed by the boundaries and any other spatial information required. This data can then be entered into the GIS and the process is essentially the same as described for GPS.

This process allowed the areas of forest compartments to be analysed, but further information was required for this study. A key feature of a GIS is the ability to overlay layers of spatial data. The georeferencing allows each layer to be referenced to other spatial data layers. For example, boundary information from two or three different surveys can be overlaid and spatial statistics determined, or a forest boundary can be placed on different basemaps to determine spatial differences between them. Figure 6.14 illustrates this. Additionally, the area of forest on each aerial photograph can be converted into a polygon, and differences compared (see Table 6.8*)*. The GIS analysis allowed the following information to be obtained:

- areas of the community forest compartments
- comparisons in boundary surveys
- accuracy of differentially and non-differentially corrected GPS data
- variability between uncorrected and rectified aerial photographs

Only a limited GIS capability was used for this study. Basic spatial analysis was performed and the modelling capability of GIS was not used. As this study represents an appropriate approach to participatory resource appraisals this has significant implications. The technical capability of a GIS is not important, although other GIS features are. This is discussed in more detail in chapters seven and eight.

6.3.2 GIS for data organisation

This section considers GIS as a spatial information system rather than a specific type of software. The GIS contained data in a number of software packages and formats: spatial information in Idrisi (also MSTAR, GPS post-processing software, and other GIS packages), data in spreadsheets, photographs in desk-top publishing packages and descriptive information. Within the GIS information for each community forest was in a large number of files (20-100). The processes involved in converting boundary information (which may be in 5-15 raw GPS files) into final GIS images involved creating 5-20 files for each original file, and information management and organisation became a challenge. The GIS provided a means of linking these spatial files with meta-data (non-spatial information relating to the spatial data), based around the GIS images. A master document associated with the images for each spatial feature (such as a forest or the road through the watershed) was created, allowing an overview of what was in each directory (in Idrisi termed the environment). This proved to be vital for keeping track of all data associated with a particular forest or spatial area.

GIS has great potential for allowing FUG level data to be aggregated into larger datasets. In this study this was only done to a limited extent, aggregating the DFO spatial data on community forests for the Yarsha Khola watershed. This allows watershed level analysis to be conducted, for example, what percentage of land is community forest or what percentage of community forest in a watershed is plantation forest.

6.3.3. GIS for feedback to the FUGs

GIS can be used to aid information dissemination for the FUGs and DFO staff. The information from the GIS analysis was essential for converting resource information from a hectarage into a compartment basis, the information required. It was also useful to have the GIS map of the forest resource in the management plan to make sure that all FUG members knew which compartment information related to. The name given to a particular compartment can vary between forest users, for example, does ‘big rock’ compartment refer to the forest to the left or right of the rock?

In addition to allowing the resource information to be disseminated in a format that could be used by the ranger and the FUG, the GIS image of the resource was found to be of great significance to the FUG members. This was the first ‘proper’ map that they had received for their forest resource. This appeared important in its own right. Additionally there was a general opinion amongst FUG members that having a map of their resource that was computer generated (as opposed to a hand drawn sketch or chain & compass survey map) would strengthen their case in boundary disputes and in discussions with the DFO. This illustrates a potential empowerment role that GIS can play when it provides information for the community. It also shows the dangers associated with computer generated maps: the product appears to be professional and reliable, and because of this the information tends to be easily accepted as the truth. This is discussed in more detail in section 8.1.3.

6.4 Discussion

The results presented in this chapter have provided information allowing the suitability of a variety of geomatics tools and techniques for community forestry in Nepal to be evaluated. Additionally, a number of other issues require consideration.

6.4.1 An evaluation of geomatics for community forestry

It was felt that the geomatics tools and techniques examined in this study needed to be evaluated against the following groups of criteria:

- participatory
- technical
- practical

Participatory sketch mapping is also included in the evaluation because it is commonly used for obtaining spatial information for community forestry. The evaluation is subjective, but the criteria are clearly shown in Table 6.9.

Criteria for evaluation	Stand-alone GPS	Differential GPS	PPM (Uncorrected aerial photograph)	PPM (rectified aerial photograph)	Participatory Sketch Map	GIS
Participatory:						
Empowering	?	?	✓	✓	✓	?
Non-literate	✓	✓	✓	✓	✓	✓
Aids facilitation	✓	✓	✓	✓	✓	✓
Easy to learn	✖	✖	✓	✓	✓	✖
Requires outside assistance:						
Always	✓	✓	✖	✖	✖	✖
For set-up	✓	✓	✓	✓	✖	✖
Complex/expensive Equipment	✓	✓✓	✖	✖	✖	✓✓
Decision-making with Community	?	?	✓	✓	✓	?
Provides FUG members With new skills	?	?	✓	✓	✓	?

Table 6.9. An evaluation of geomatics tools and techniques

Criteria for evaluation	Stand-alone GPS	Differential GPS	PPM (Uncorrected aerial photograph)	PPM (rectified aerial photograph)	Participatory Sketch Map	GIS
Technical:						
Spatially accurate Information	✖	✓	✓	✓	✖	✓
Can the accuracy of the Information be assessed	✓	✓	✓	✓	✖	✓
Practical:						
Cost	Moderate	High	Low	moderate/high	low	high
Time:						
Data collection	Low	Moderate	Low	low	low	N.A.
Data analysis/interpretation	Low	moderate/high	Low/moderate	low/moderate	low	moderate
Comments:						
	Spatially inaccurate, possibly of use for obtaining ground control points The data collection process is not truly participatory	Spatially accurate, suitable for boundary surveying and collecting ground control points The data collection process is not truly participatory	Spatially accurate (less so than rectified PPM) Rapid Highly participatory Dependent on the availability of good quality aerial photographs	Spatially accurate Rapid Highly participatory Dependent on the availability of good quality aerial photographs	Rapid Highly participatory Requires virtually no equipment Very low spatial accuracy, and impossible to assess accuracy	Largely outside of the village, role as a participatory tool entirely dependent on how the GIS is used & viewed Potential for empowerment or disempowerment

Table 6.9. An evaluation of geomatics tools and techniques (continued)

It can be seen that all the techniques have some advantages and disadvantages. Participatory sketch mapping is highly appropriate for village level work and is a good participatory tool. However, the spatial information provided is of low accuracy and the accuracy cannot be assessed. This is an important point: if accuracy is fairly low, but can be assessed, the information may still be of use. If the accuracy cannot be assessed, the information is of little value. As a technique for obtaining spatial information participatory sketch mapping is weak and should not be used when quantifiable data is required.

Differential GPS is the opposite of this. It is not a good participatory tool. Although it may help facilitation by raising interest and animating discussions, it is very difficult to teach FUG members how to use the GPS in any meaningful way, as other researchers have found (Stockdale and Ambrose, 1996). It is possible to train FUG members to operate the receiver, but the data post-processing and analysis requires lengthy training and an IT capability. GPS is expensive, and requires electricity. The level of spatial accuracy is very high, making it a useful tool for boundary surveying and obtaining other spatial information. The other tools and techniques lie between these two poles.

This creates considerable practical problems when using GPS. If GPS is to be used for participatory resource assessments this has to be considered. It was found that the processing time (from downloading the data to getting a polygon in a GIS) is two to three times greater than the data collection time. There are also practical problems associated with maintaining the GPS and ensuring that the base station is operating when the rover is logging data in the field.

PPMs are a very good tool for obtaining spatial information and if suitable aerial photographs are available this is probably the best spatial technique for participatory resource assessment. They are highly participatory and easily understood by the FUG members. The spatial error of the uncorrected photographs appears to be quite low for area calculations, although there is some additional distortion. This can be removed by using ortho or georectified photographs. Unfortunately there is limited availability of good quality aerial photographs of an appropriate scale. In Nepal it is possible to obtain these, although there are practical restrictions (the negatives cannot leave the Government Department, and the copying equipment is often broken). The availability of good quality rectified aerial photographs is even more limited. There is a project in Nepal exploring the possibility of producing these for projects and possibly FUGs (Mather, 1998 pers. comm.), but is unlikely it will get beyond the research stage. It is felt that rectifying aerial photographs as part of a participatory resource assessment is generally not advisable: it requires a lot of time and resources, for fairly minimal increases in accuracy, which could be better spent elsewhere. It is likely to invite (justified) criticism that a techno-centric approach is being used, masquerading as a socio-technical approach.

GIS is different to the tools and techniques discussed above. It is not designed for data collection, but is used to analyse, organise and display spatial information. It has potential for being an excellent participatory tool if used correctly, and it also has potential for being disempowering and exerting a traditional top-down influence on the assessment process. This is a complex issue, and lies at the heart of the discussion about geomatics and participatory approaches. Section 3.4.7 introduced some of the issues with using GIS in a participatory context, and this is explored in more detail in the next chapter.

The above indicates that there is a role for geomatics technology for participatory resource assessments. The technology can assist with gathering data that will assist communities with managing their forest resources. The success of the application of the tools and techniques will depend largely on how they are used: whether they are thoughtfully integrated into the participatory process. This strengthens the case for a need for a method or framework that encourages this.

6.4.2 The need for geomatics

It was mentioned in chapter three that geomatics has been criticised for being used as a means of showing that a project is state of the art and technically proficient, rather than the use of geomatics being demand led. The results from this chapter indicate that the spatial information requirements for CFRA are usually not very detailed. At the FUG and forest ranger level the only spatial information required by the five FUGs were for forest area, to determine the amount of forest products that could be used and for assisting with boundary disputes (see Table 7.10). This information may be obtained fairly easily by using PPM, or perhaps by using traditional chain and compass surveys. In this case, there may be no need for a computer based GIS. A manual GIS, using acetate overlays and grid squares to calculate area may be more appropriate. If GPS is used for boundary surveying or georeferencing, a computer based GIS is required. It has been demonstrated that very limited GIS functionality is needed to meet the FUGs information requirements and a basic GIS is adequate.

The results from this chapter indicate that approaches to CFRA have to view the use of geomatics from the perspective of minimum requirements. Geomatics techniques are relatively expensive, time consuming and create practical and organisational problems. Their use has to be justified by a demand for the additional information they can provide.

6.4.3 The need for accurate boundaries

Much of this chapter has been concerned with evaluating accuracy and determining the spatial error associated with different techniques. This is obviously of importance, particularly when spatial information is used for determining sustainable yields from a forest resource. However, it is felt that too much emphasis can be put on the technical accuracy of a technique. For example, differential GPS can map boundaries to +/-3m using quite simple techniques, and rectification of aerial photographs can eliminate most spatial distortion. But results from section 6.2.4 indicate that most error between accurate GPS surveys and PPM results were due to slightly different boundaries being mapped. This indicates that in many cases boundaries may be fuzzy. Unless there is a clear demarcation of a community forest boundary, as with some plantations, different FUG members may have different views on where the boundary lies. Accurate mapping of a hard boundary will not change this situation. The hard boundary will provide 'accurate' spatial statistics, but from a real-life management perspective this is of no more value (perhaps less) than having a less well-defined boundary with confidence limits or a probability statement (Kosko, 1993). What this indicates is that time and resources are better spent in participatory work with the community, to determine how hard or soft boundaries are, than in highly accurate mapping. This is controversial, and probably needs assessing on a case by case basis, but it needs consideration in the development of a CFRA.

Linked with this is the need to consider the agendas in boundary mapping. FUG members may not wish to survey the exact boundary of the community forest, but may survey what 'should' be the boundary. During GPS surveys, there is a tendency for FUG members to include 'doubtful' areas within the surveyed FUG area, in case this at some stage legitimises their claim. This, of course, has important implications, as the GPS 'true' boundary can be seen to be just as subjective as any other method. The GPS may be impartial, but the hand that holds it is not. There may be disputed areas, or disused Bari or scrubland that FUG members feel should be part of the community forest. Therefore it is important to realise that maps are highly political, and they are far from being an objective portrayal of reality (Monmonier, 1996; Wood and Fels, 1992). A CFRA can easily become part of a power struggle or village dispute. There is no easy way of assessing this. It is important to realise that hidden agendas in boundary surveying may exist, and to ensure that there is adequate participation to allow multiple views and realities to be demonstrated. Again, this shows that the emphasis should be on the participatory process.

It is felt that in some cases the boundary derived from a PPM may be as or more accurate than GPS surveyed boundaries. In PPM, boundaries that are difficult to identify tend to be drawn fairly straight between identifiable boundary markers, the same way that the forest is surveyed by the DFO, whereas with participatory GPS the FUG may walk the boundary they feel should be the community forest.

6.4.4. A decision tree for selecting geomatics techniques

The discussion above indicates that it is not possible to select a single geomatics technique and use it for all situations. However, it is possible to provide decision trees to assist with selecting geomatics techniques, based on the findings of this study. Two decision trees have been developed, one for spatial data capture, and one for spatial data organisation and analysis. These are shown in Figures 6.16 and 6.17 respectively.

6.5 Chapter Summary

The results of the evaluation of a number of geomatics techniques in Nepal have been presented. The initial evaluations determined that GPS functioned effectively, and its role for CFRA was studied. It has been found to be a useful tool, and except in the harshest of terrain, operates effectively. Previous problems are thought to be due to either using the wrong receivers or using them incorrectly. PPM was used with FUGs, and found to be an excellent tool. GIS was used for simple mapping tasks, and found to be useful for this, and for organising data using the Information Systems capability.

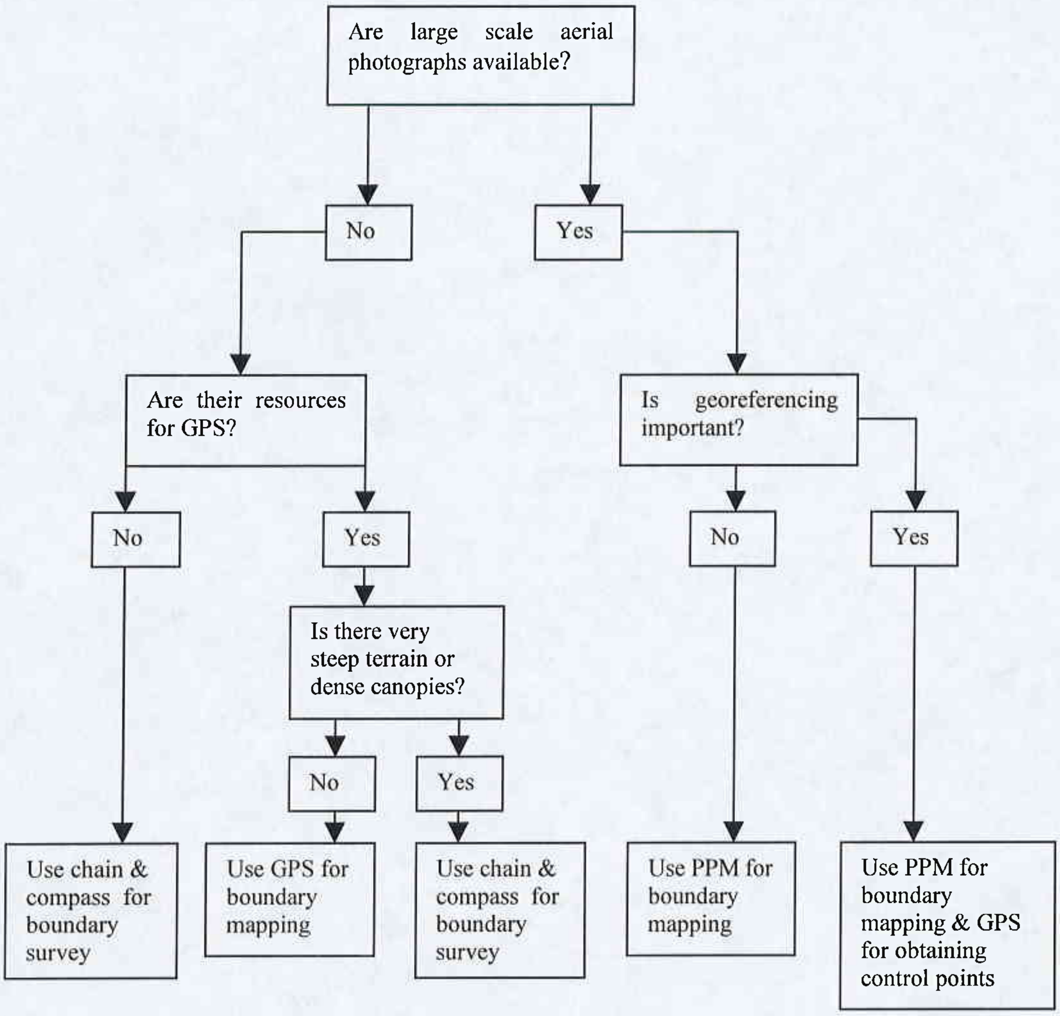


Figure 6.16 Decision tree for spatial data capture method

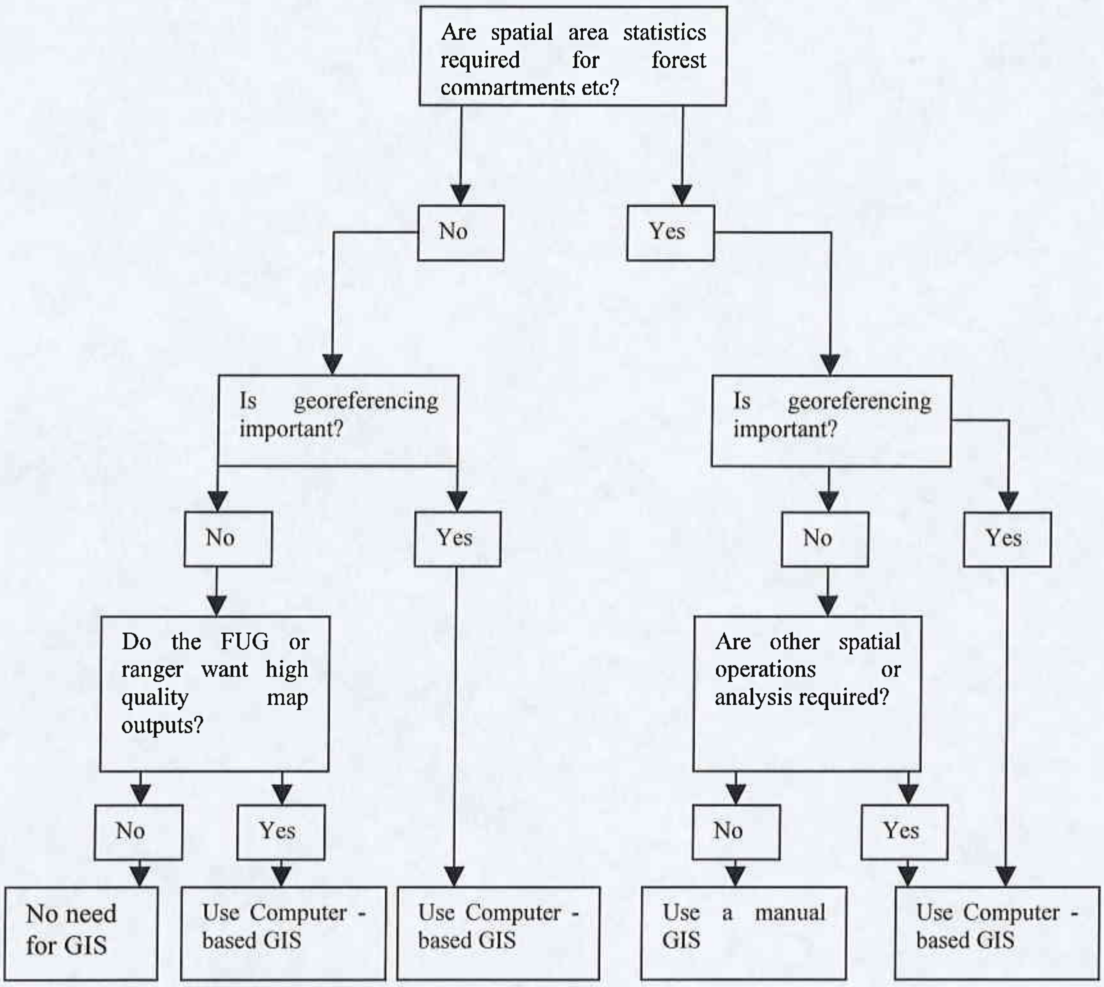
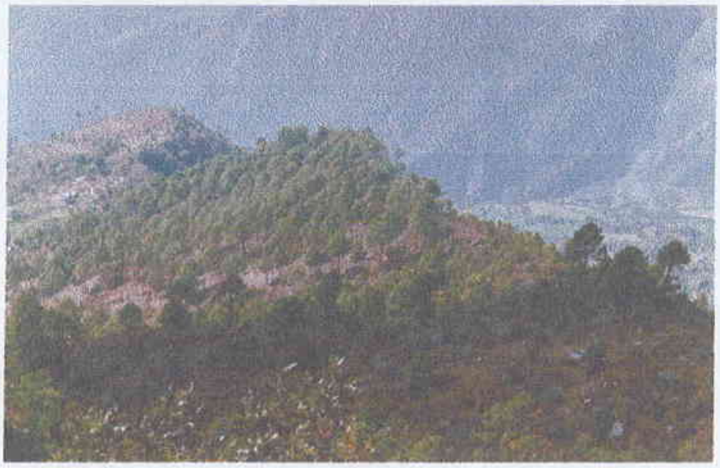
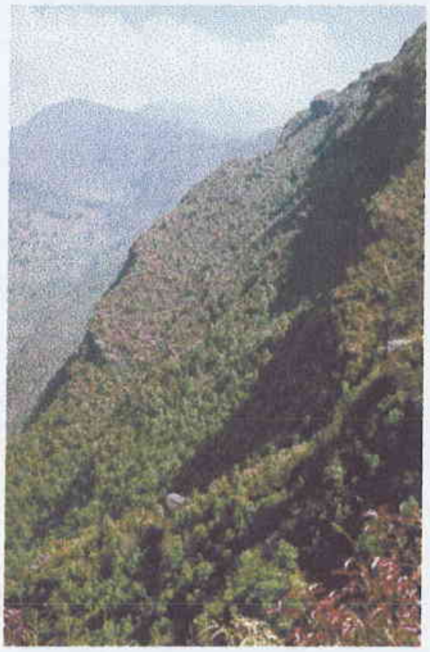


Figure 6.17 Decision tree for spatial data organisation and analysis method





Photographs 1-3: Forest and terrain in the Yarsha Khola watershed. These photographs indicate the steep slopes angles commonly found in the watershed. *All* the land in the top image is community forest – the term does not imply dense tree cover. The area in the lower image is too steep for GPS to be used.

Photographs 4-6: PPM sessions in Yarsha Khola watershed. These images attempt to convey the highly participatory and dynamic nature of the process.

Chapter 7: Participatory Resource Assessment: a new method and results

7.0 Chapter overview

A major part of a participatory CFRA is some form of forest survey or inventory[1]. This is essential to provide quantitative data about the forest resource, which can be used for management planning purposes. Forest resource assessment is a fairly new development in community forestry in Nepal, although limited work has been conducted in this area for several years (Branney, 1994a,b; Ingles *et al.* 1996; Jackson *et al.*, 1996, Metz, 1991). This work provided a basis for a new, updated resource assessment method. The methodological development involved examining previous methods for resource assessment in Nepal, identifying best practices and limitations, considering recent developments in participatory resource assessment, and incorporating the concepts of Multi-Resource Inventories. The method developed was trialed with five FUGs, and the results are discussed.

7.1 Existing methods of CFRA in Nepal

Section 3.5.4 has presented some examples of CFRA. This section looks at this development in the context of Nepal.

A number of approaches to CFRA have been developed in Nepal, principally by donor funded projects. Of these, the most advanced, and participatory, approaches have been developed by the Nepal-Australia Community Forestry Project (NACFP), The Nepal UK Community Forestry Project (NUKCFP), and SDC, a Swiss funded donor. SDC has not published any guidelines or suggestions on resource assessment, but has developed some novel highly participatory methods (Ostravee, pers. comm, 1998). Both NACFP and NUKCFP have developed two sets of resource assessment methods, one being very simple, for practical management purposes, and the other being more detailed, for research and learning applications. SDC have also developed a resource

[1] There are a number of definitions of a forest inventory. Carter (1996) states that an inventory can be distinguished from a survey by providing data allowing a standard error to be calculated. For this study the term refers to a systematic forest resource assessment, but no statistical validity is inferred, following the precedent set for Nepal by the NACFP 'Simple Forest Inventory'.

assessment approach. These are briefly outlined below. Much of the information is from Ingles *et al.*, 1996, who assessed the current state of CFRA in Nepal.

7.1.1 Simple resource assessment methods

The NACFP approach to rapid forest assessment is termed Range Post Planning (RPP). This utilises a number of rapid diagnostic tools, principally participatory mapping and informal surveys. The overall aim is to link the capacity and interests of local people with the capacity and interests of the nation for forestry development. The objectives of RPP are to:

- generate and prioritise a list and schedule of tasks to be undertaken within the plan period (usually 1 year)
- maintain information about the present status of forests, forest use and forestry activities
- review progress made in implementing community forestry

RPP is now adopted by the Community and Private Forestry Division of the Forest Department, and is promoted in all Districts. Only a few Districts had been implementing it, but recently its use has become more widespread, due to increasing information needs (Hunt, Pers. Comm. 1998).

The key resource assessment parts of RPP involve participatory mapping and rapid appraisal: preparation of forest profiles by asking questions, drawing sketch maps, and estimating forest characteristics by eye (ocular assessment); and measuring a small number of temporary plots to calibrate ocular estimates. Additionally site occupancy, abundance of useful species, regeneration and number of seed trees are also recorded within these plots. The tools used in RPP planning are listed in Table 7.1.

Tools used in Range Post Planning in Nepal	
Tool	**Information that can be obtained**
Semi Structured Interviews/Transect walks with key informants	1, 2, 3, 4, 5, 6
Participatory mapping	1, 2, 3, 4
Participatory analysis of aerial photographs	1, 2, 3, 4
Secondary data sources (e.g. DoF/VDC records)	1, 2, 4, 6
Forest profile by rapid appraisal	2
Workshops and group meetings	2, 3, 4, 5, 6
Interest groups	3, 4, 5, 6
Direct observation	3, 4
Time charts (seasonal diagrams)	3
Wealth ranking	4

1 = Forest names and location
2 = Forest types, sizes, and biophysical condition
3 = Forest use
4 = Local forest management systems/silvicultural knowledge
5 = Community interest for participation in community forestry programmes
6 = Current status of community forestry activities

Table 7.1 The Tools used in RRP. Adapted from Ingles *et al.*, 1996

For RPP, participatory mapping is usually viewed as the most important process (Jackson *et al.*, 1996). Table 7.1 indicates that aerial photos can be used in a participatory manner for similar purposes, and reduce problems associated with spatially unreliable areas and boundaries. However Jackson *et al.* (1996) state that this is only at a rudimentary stage in Nepal.

The forest profile preparation can be regarded as a 'quick and dirty' forest assessment (Ingles *et al.*, 1996). It provides a broad overview of the resource, but not enough detail for management planning. It is mainly performed by forest rangers. It involves an ocular assessment of the area, type, main species, overall condition (soil cover, crown cover, extent of natural regeneration and the presence of seed trees). The accuracy of the assessment information is improved by a calibration of the ocular assessment. Plots 5m by 20m are set out along the contour, at least two for each forest type (more if the forest is highly heterogeneous). The species and dbh are recorded for all trees over 2m and the total abundance by species is recorded for all other shrubs, seedlings and saplings. The ranger may go on to make more detailed records of occupancy to monitor condition (discussed in detail in Jackson *et al.*, 1996, section 7.3).

The NUKCFP approach to basic resource assessment is termed Operational Plan preparation. This is fairly similar to the NACFP approach, but is more integrated into the process of setting up the FUG. Again, emphasis is placed on the participatory mapping exercise. Most of the resource information is gained from rapid appraisal processes; there is less emphasis on physically calibrating this information. A key aim of the NUKCFP approach is to provide information on the type and condition of the forest resource, and the desired management objectives. These are used to determine appropriate forestry operations and yields of forest products, by applying thumb rules based on previous research and experiences (Branney, 1998, pers. comm; Branney, 1994a).

7.1.2 More complex methods of resource assessment

There is an appreciation in Nepal that the above methodologies do not provide enough information to evaluate the sustainability of forestry operations, or provide much management input. There are three recent approaches to obtaining better resource information for community forests. The first has been developed by SDC. This methodology is not published, and was obtained from SDC staff (Ostravee, Pers. Comm. 1998). It is unusual because it attempts to quantify the amount of fuelwood and fodder that can be obtained. It has a number of discrete stages:

1. Needs assessment: participatory work to determine how much fuelwood, fodder and timber is required per household, and how much is obtained from private sources. The balance is required from the community forest.
2. Boundary survey and internal compartmentalisation: locally defined sub-units of the forest are identified, and then sub-divided to allow for rotational practices to be performed. The survey is performed with chain and compass, to provide an accurate estimate of the forest.
3. Each sub-compartment has a plot surveyed in it, the plot representing 'average' conditions (defined by FUG). Each sub-unit is then classed as good, medium or poor.
4. Timber assessment: species, dbh, height and basal area are recorded. This provides basal area per diameter class/ha, number of trees per ha and volume. Calculated as:

   *v = basal area * av. Height of dbh class * 0.5* (form factor)

   Additionally, total wood volume is calculated as:

   timber volume (v above) * *1.3* (to include branch material)

The timber volume is calculated as:

$$total\ wood\ volume * 0.5$$

The annual increment is calculated as 1-3% of the timber volume (dependent on species and site condition).

5. Fuelwood assessment: A 100m^2 circular plot is laid out, and FUG members are asked to stand around the plot boundary. The FUG members calculate the total amount of fuelwood that can be obtained from the plot. The fuelwood increment is estimated at 5% *per annum*, allowing a sustainable yield to be calculated. If the amount of fuelwood available is less than the need identified in stage one, this becomes a focus point for the operational plan.
6. Fodder assessment: the assessment is divided into two areas: ground grasses and shrub/tree leaves. The same 100m^2 plot is used, with the FUG members calculating the amount of fodder that can be collected, and the time intervals between collection. The available supply is compared with the need identified in section one above. If the need is greater than the availability then agroforestry systems are incorporated into the operational plan.

Additionally, NTFPs and regeneration are assessed. Section five and six above are highly participatory ways of calculating fuelwood and fodder requirements, something that is notoriously difficult to do. The method developed from a previous method where the fuelwood, grass and leaves from a known area were weighed. It became apparent from FUG members that not all species were equally preferred or utilised, and the results were not in a form most suited to the FUG, who prefer *bari* measurements (a carrying basket) to weight measures.

The SDC method ends up with management information based around a map of the resource, detailing how much fuelwood, fodder and timber can be collected from each sub-compartment of the community forest each year.

The second method has been developed by NACFP, termed Simple Forest Inventories or Simple Shrubland Inventories (SFI/SSIs). This is a forest inventory method designed for use by forest rangers, using temporary sample plots. Table 7.2 summarises the information collected during SFI/SSIs.

Summary of NACFP SFI/SSI monitoring records

	Simple Forest Inventory (SFI)	Simple Shrubland Inventory (SSI)
Plot form	• Plot identification information • Trees > 2m height: species, dbh, Basal Area • Valued tree species < 2m height: number of each species • Other tree species < 2m height: number of each species	• Plot identification information • Trees > 2m height: species, dbh, seed trees or not • Regenerating plants and shrubs: number of each species • Crown separation (gaps and sizes in cm)
Calculation form	• Site occupancy by tree species (BA) • Total site occupancy by trees • Forest structure (size-class distribution) • Stocking • Total tree species regeneration	• Site occupancy by regeneration, shrubs, seed trees and non-seed trees • Site occupancy by trees only (based on BA) • Site occupancy by shrubs only (based on crown separation ratio)
Summary form	• Forest identification information • Species summary (dominant 5 species by BA, regeneration, species diversity) • Site occupancy summary • Comments	• Forest identification information • Shrubland summary (dominant 10 plant species, dominant 4 tree species by BA, species diversity • Site occupancy summary • Comments

Table 7.2 A summary of the information collected during SFI/SSIs. Source: modified from Ingles *et al.*, 1996

It has been found that SFI/SSIs have been used in very few situations (Hunt, pers. comm. 1998). This is thought to be due to them being time consuming, academically demanding, physically difficult and requiring a high level of motivation. Forest users are only involved to limited degree, principally in species identification and a lot of the information is not relevant to them.

The NUKCFP has a programme and method designed to collect baseline forest resource information, allowing changes in forest condition to be assessed over time. The methodology is a collection of standard inventory techniques based on permanent sample plots (Branney, 1994b). The methodology is not designed to be participatory, and the work is undertaken by project staff rather than rangers or FUG members, although the assessment has been used as an extension exercise (Ingles *et al.*, 1996).

7.1.3 A critique of existing methods

The above methods are examples of global best practice in CFRA. Table 7.3 critically analyses each of the methods.

Simple Resource assessment	Advantages	Disadvantages	Comments
NACFP – RPP	Fast Ranger doesn't require specialist backup Fairly high level of FUG participation Specifically designed to provide information for FUG level forest management	Low level of spatial accuracy – makes determining sustainable yields difficult Accuracy of information uncertain as little physical sampling – mainly based on ocular estimates	Workable and being implemented Little quantifiable information
NUKCFP – Operational Plan Preparation	Integrated into FUG establishment procedure Ranger doesn't require specialist backup Fairly high level of FUG participation Specifically designed to provide information for FUG level forest management	Low level of spatial accuracy – makes determining sustainable yields difficult Accuracy of information uncertain as little physical sampling – mainly based on rapid appraisal	Workable and being implemented Little quantifiable information

Table 7.3 Existing methods of CFRA used in Nepal (continued overleaf)

Complex Resource Assessment	Advantages	Disadvantages	Comments
SDC approach	High level of participation Training element involved Produces quantifiable information on timber, fuelwood and fodder Information fed back to FUG as understandable management proposals Spatially accurate	Time consuming Requires external input for ranger/DFO Little systematic collection of information, varies from FUG to FUG	Workable with donor support – currently not workable without this Good level of spatial and quantifiable resource information
NACFP SFI/SSI	Produces quantifiable information Some FUG participation	No accurate spatial information collected – difficult to convert sample plot information into forest information Requires a lot of ranger input and academic ability Fairly low level of FUG participation Not all information for the FUG and may not be fed back to them Different methods for shrubland and forest – increases complexity and no real delineation between the two in many forests	Very low levels of uptake by DFOs Good concept, but NACFP acknowledge the approach is too time consuming and complex for rangers/DFO staff
NUKCFP Baseline forest resource assessment	If widely adopted, will provide essential information for assessing sustainable forest management practices Produces detailed quantifiable information	Very limited or no FUG participation PSP monitoring outside of DFOs' activities Requires external inputs No accurate spatial information collected – difficult to convert sample plot information into forest information Not all Information for the FUG and may not be fed back to them	Donor initiative outside District community forestry activities May provide information essential for a more detailed evaluation of community forestry management practices

Table 7.3 Existing methods of CFRA used in Nepal (continued)

From the above the following criticisms can be made of existing methods:

- they tend either not to collect enough information to allow forest management planning or monitoring, or they are too detailed and complex (this is less true for the SDC approach)
- they do not collect sufficiently accurate spatial information for the forest resource, or employ surveying which is time consuming

- the more complex approaches lack participation (this is less true for the SDC approach)
- the more complex approaches do not feed information back to the FUG (this is less true for the SDC approach)
- some of the approaches lack structure and little comparative data is collected (particularly the SDC approach)

From the above it appears that there is potential for improving methods used for conducting resource assessment for community forestry in Nepal. Ingles *et al.* (1996) notes that:

'There is scope for refinement of some of the methods (*of forest resource assessment*), and many unanswered questions remain with regard to the most appropriate means of monitoring the condition of community forests. These will be interesting issues for future development' (In Carter, 1996, p. 167).

7.2 An improved method for CFRA

It is felt that any improved method for forest assessment should attempt to provide the following:

- a fairly accurate determination of the forest area
- sufficient data collection to allow management activities to be planned, condition to be assessed, and a basic biodiversity assessment to be conducted
- enough community and resource based information that sustained yield forestry can be practiced
- a focus on providing information on the forest rather than plots
- enough data for changes in the forest resource to be monitored
- easy to understand management plans based on the resource assessment that FUGs can understand and implement

Additionally the following needs were considered during the method development:

- increase time and cost effectiveness
- increase data reliability
- improve empowerment, participation, and involvement of the non-literate
- keep techniques and analysis as simple as possible

- assessment system should be transferable to FUG, and they should be capable of independently conducting the assessment (with help from a forest ranger)

A significant part of the method involved incorporating new geomatics developments into the assessment process. These were felt to have advantages over the traditional approaches of participatory sketch mapping or chain and compass surveys, in terms of accuracy, speed, ease of use, cost-effectiveness and participatory potential. Lund (1998) comments that:

"To reduce field costs, incorporate available technology (GPS, Landsat/thematic mapper, aerial photography or videography/image processing etc.) into the data collection process as appropriate. Based upon our questionnaire survey, nearly 60% of the countries having MRIs use remote sensing in one form or another." (Lund, 1998. P.49)

The resource assessment method can be divided into a number of discrete stages (see Figure 7.1). The method is loosely based on MRI methods, using NACFP SFI/SSI techniques (see Table 7.2) and incorporating some SDC ideas (the NUKCFP approach with PSPs and negligible participation was felt to be inappropriate). There were some important modifications.

- Collecting reasonably accurate spatial information was a priority.
- Rather than viewing approaches to forest assessment as being either profiling by rapid appraisal or more detailed inventories, these two approaches were combined as different stages of the assessment. Profiling by rapid appraisal was performed during stage two of the assessment, and modified simple inventory methods form the basis of the inventory work described here.
- Only one approach was used for both shrubland and forestry to simplify the task for the FUG and ranger.
- Sample plots were located by pacing and compass rather than chain and compass, to save time and simplify the process. If the size of a compartment cannot be determined, and a sampling strategy devised, then the SDC approach of sampling areas the FUG regard as good, average and poor for the compartment is used.
- Training the FUG was a major aim.
- Analysis of the information was not performed by range post staff. It was too time consuming to be performed manually. It was more efficient to enter it into a spreadsheet for analysis.

It was anticipated that the method would provide nearly as much information as the NACFP SFI/SSI approach and that it would be faster, simpler to analyse and easier for the FUG to understand.

The above method was trialed on five FUGs between November 1997 and April 1998, to provide comparative case studies. Each FUG was either already formally recognised as an FUG or in the final stages of handover. This meant that an operational plan and constitution had already been agreed, there was background information available on the FUG, and the forest ranger had an existing relationship with the FUG.

Owing to the method being flexible, and a range of rapid appraisal and resource assessment tools being used, each application was slightly different. The method was intended to provide enough similarity for comparisons to be made, but also to allow different approaches to be evaluated. The method for the forest assessment is described in detail below, with the results from the five applications.

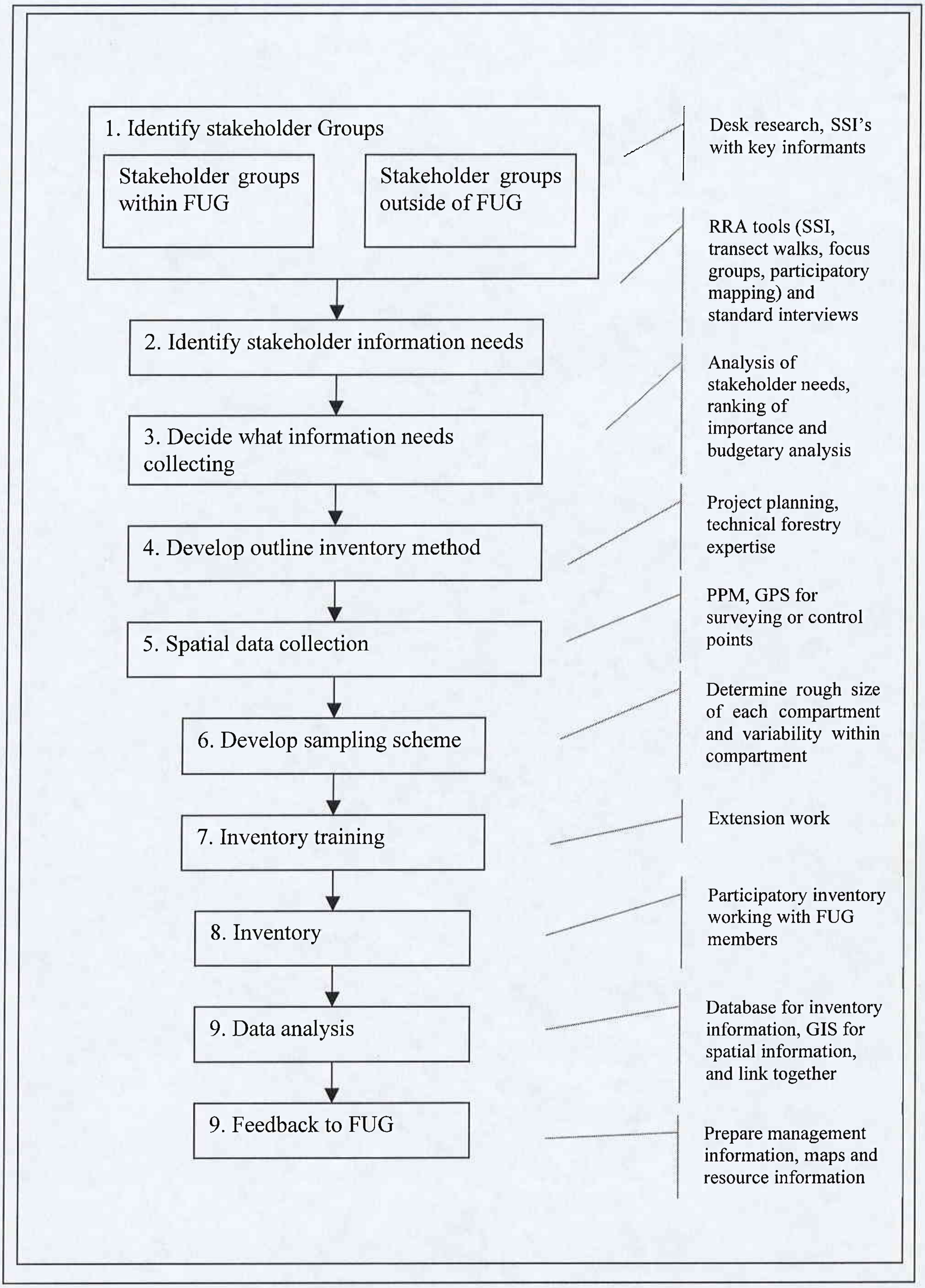


Figure 7.1 The Resource Assessment method

7.3 Results from the participatory resource assessment

7.3.1 Identifying Stakeholder Groups and Their Information Needs

A similar method for identifying stakeholder groups and their information needs was used for each case study. As indicated in Figure 7.1, stakeholder groups were identified within the FUG and outside of the FUG. Stakeholder groups within the FUG were identified from previous participatory work conducted by forest rangers and DFO staff. The limited rapid appraisal used in the forest resource assessment method did not replace the lengthy participatory work required for successful FUG establishment. Therefore this information was taken from the FUG constitution and from discussions with the forest ranger. There are a wide range of potential stakeholders and information needs from outside the FUG (see section 5.1). The method allows any of these stakeholder information needs to be incorporated into the resource assessment procedure. To simplify the research, the only stakeholders outside the FUG formally consulted with were forest rangers, as the method was specifically aimed at providing resource information for local level forest management. Additionally, some basic biodiversity information was recorded, to determine whether the method of resource assessment had potential for providing this.

Identifying stakeholder information needs involved an introductory participatory meeting, and examination of the resource, with as many of the FUG members as possible. This ranged from about ten to over sixty. The key objectives of the group meeting were to:

- establish a rapport with the FUG
- explain the work to them
- set them at ease regarding the nature and aims of the work
- identify key ways they interact with the resource
- identify key problems associated with the resource
- determine the level of interest for the work
- identify key features of the resource
- initiate the mapping process
- identify potential problems with the rapid appraisal approach

Three key actions were performed during the identification of stakeholder information needs:

1. Rapport establishment

Meetings were arranged with representatives of the FUG, through the forest ranger. Three or four days advance notice was given to allow news of the meeting to be spread. It was specifically requested that male and female representatives from all ethnic groups attended if possible.

It was explained that the aim of the work was to assist FUGs with forest management by providing them with information about the resource, and knowledge about how to obtain this information. To be able do this, information was required regarding what their key issues were regarding community forestry, and what their needs were from the forest. It was explained that information could be provided for the FUG, such as accurate maps, and information about the resource that could help them to manage it to meet their needs. The use of GPS and aerial photographs were discussed, and the potential role of these in providing the community with information was also mentioned. It was also explained that part of the work would involve using simple methods for obtaining base-line data about the forest resource, and that participants in this work would receive training to allow them to repeat the work themselves.

The timescale for the work was explained, along with the time commitment required by the FUG. The FUG representatives were then asked if they were interested in the proposed work, and willing to commit themselves.

Invariably the above involved a two-way flow of information, with questions being asked, and key problems and issues being raised.

2. Focus group semi-structured interviews

Focus groups were composed of representatives of specific interest groups, such as lower caste women or landowners. The focus group interviewing commenced with repeating and discussing some of the key information given earlier, and explaining the main areas that the interview/discussion would cover: examining existing management systems; and discussing problems with the forest resource. The key topics covered are in Table 7.4.

Topics addressed in group Semi-Structured Interviews
Major products obtained from the forest
Uses of the forest products
Gender divisions in the collection of forest products
Seasonal breakdown of time spent collecting forest products (labour and activity sequence calendars), see Limpinuntana, 1987
Changes in time taken to collect forest products
Which areas of the community forest were used for what products, and when
Restrictions on where users can go
Restrictions on quantities of forest products households can use
Systems for allocating quantities of forest products to households
Cash crops obtained from the forest
Key problems and issues with the forest resource and use of the forest resource
Problems with the size of the resource
Changes of the resource (size and quality)
Conflicts over the use of the resource (within user group/between user group)
Area of the resource
How yields in the operational plan were determined

Table 7.4 Topics addressed in group Semi-Structured Interviews

It should be noted that the structure of the SSIs was not as rigid as Table 7.4 indicates, and this list was rarely gone through in this order, or in its entirety, and other areas for discussion were often identified. This is one of the reasons for using SSIs rather than formal interviews or questionnaire based approaches (Oppenheim, 1992).

3. Group walk through the forest (Direct Observation)

This allowed an ocular examination of the resource to be made, and the FUG to demonstrate types and locations of forest products and characteristics of the resource.

This did not provide quantifiable information, but it did give an increased understanding of the resource. Usually 10 to 20 ha of the resource were examined, in two to three hours. The walks were very useful for visualising the resource, for RRA triangulation purposes and for obtaining additional information from FUG members.

7.3.2 The information needs for the FUGs

The information obtained from the initial participatory sessions, and the FUG needs identified from this, are presented for each FUG in Tables 7.5 – 7.9. Species are referred to by their local name, botanical names (where known) are listed in Appendix 3.

Baishakeswori FUG

Background Information from desk review

FUG information	None available (DFO should have this)
Resource information	Estimated at 53 ha, area has been surveyed, but area not officially calculated

Background Information from participatory sessions

FUG information	115 households in FUG The FUG has been established for 7 years, and hand-over is imminent. The approximate caste breakdown of households is Sherpa (100), Chettri (9), Newar (5), Tamang (1), lower caste (1) The FUG committee has 13 members, 10 Sherpa, 2 Chettri and 1 Newar. There are 5 women on the committee
Resource information	Natural forest, situated at 2000-2500m. The main species are salla spp., uttis, Ghorans, Kharane, Ungari, and Rakdatendon. There is no plantation. The resource is large enough for the FUG
Key products obtained from C.F.	Fodder, fuelwood, timber, leaf litter, grass and dry grass
Cash crops/NTFPs	Variety of NTFPs obtained, little FUG interest in examining them. None are sold or planned to be sold
Conflicts and Problems	Boundary disputes between private landowners and the FUG in the southern part of the forest, caused handover to be delayed. Problems: landslides, poor condition of the forest (not much grass or firewood), Illegal gathering of forest products
Changes in the resource conditions	Women spend approximately 2-3 hours per day collecting forest products (fuelwood in winter, grass in summer). This is less time than they were spending five years ago
Existing forest management	Grazing is allowed in the forest. Each household can take 0.5 bari of grass and 0.5 bari of leaf litter a day, and approximately 100 bari of fuelwood a year. This is approximately half of their requirements, the rest coming from private land. All FUG members have private land, but some have very little. These people graze their animals in the forest. The FUG assembly has agreed to stop this practice, but it is difficult as many households land is fragmented, and animals graze in the forest when going between land areas. Timber is felled as necessary for house construction, 100 cubic feet of timber is allowed for each new house. The resource is improving at present, due to more stringent management and control. There are no boundary disputes with the northern part of the forest.
Additional information	There are two parts to this proposed community forest, one which is ready for imminent hand over (northern part), and one where handover is expected in two –three years (southern part). This information is only concerned with the area for immediate handover (northern part), unless otherwise specified. The group walk showed that the resource was largely natural forest, generally in a very good condition. Slope angles tend to be very steep

Information needs

Information needs identified by FUG	How much timber they can sustainably cut what species they should use
Other Information needs identified	Area needs checking

Table 7.5 Information needs for Baishakeswori FUG

Bhasuki FUG

Background Information from desk review

FUG information	85 households in FUG
Resource information	Predominantly Khote Salla forest approaching maturity. Average age of trees 26 years Approximate area 21.7 ha Chilaune is also an abundant species

Background Information from participatory sessions

FUG information	76 households in FUG, 150 households in FUG area Eleven committee members The predominant caste is Newari, with Brahmin, Chettri, Magar and Nepali. Committee represents all these ethnic groups 5 women members of the committee
Resource information	The FUG regards the resource as being adequate for all their needs, and they regard it as improving. It is starting to produce good sized timber, and they have a surplus
Key products obtained from C.F.	Grasses, leaf litter, fuelwood and timber.
Cash crops/NTFPs	No NTFPs are considered important at present, but the FUG members believe there might be a commercial market in Kathmandu
Conflicts and Problems	Currently a boundary dispute with Bhagaban Thumki FUG over water access for livestock. This is a long running dispute
Changes in the resource conditions	The women spend approximately 2-3 hours per household per day collecting forest products throughout the year. Fuelwood is collected principally in the winter months, grass is mainly collected in the summer, and leaf litter is collected all year. The time spent collecting forest products has increased, but this does not indicate the resource has worsened, because they now collect material more slowly, as they are not doing it illegally and rapidly, as they had to when it was a state forest. The general opinion is that the resource has improved, for both fodder and timber
Existing forest management	The FUG do not have any limits on the amount that can be collected by a household. The forest management involves dividing the forest into 3 blocks, only one of which is used per year They are felling timber commercially, and the amount they fell is based on what they think is correct Grazing is not allowed in the forest, livestock is stall-fed
Additional information	The resource is entirely plantation. The terrain is fairly gentle for Nepal, with no very steep slope angles. The resource is at a harvestable age for timber production

Information needs

Information needs identified by FUG	They are interested in the possibility of harvesting herbs to sell. They want more broadleaf trees, particularly multi-purpose broadleaf's How much timber can be sustainably cut from the forest
Other Information needs identified	The area needs checking – it is thought that the area is based only on participatory sketch map information. This is a large community forest – only selected compartments can be surveyed. FUG prioritised Sunshito Tuumko for the inventory.

Table 7.6 Information needs for Bhasuki FUG

Chuletro Pakha FUG

Background Information from desk review

FUG information	92 households of mixed castes/ethnic groups
Resource information	Estimated at 14 ha (believed to based on chain and compass survey) divided into 0.88ha rangeland, 12.54ha plantation and 0.62ha grassland Key species Patle salla (*Pinus patula*)

Background Information from participatory sessions

FUG information	The FUG is composed of 92 households (approximately 500 people) Informal FUG was established in 1983 to work with the Forest Department (developing a nursery), the forest was officially handed over to the FUG for management in August 1995 There are 9 FUG committee members - 3 are women. Household composition is approximately Brahmin (40-45), Karni (blacksmith) (15-16), Pujel (farmer) (5-6), Chettri (4-6) and Sarkhi (shoemaker) (4-6)
Resource information	Principally a plantation forest, of mainly young trees (most of the trees were planted in 1985). The trees were planted by the DFO, originally as a state owned forest, but with the idea of transferring it to FUG as soon as it was established and working plan/operational plan agreed. The principal species is Pate salla (*Pinus patula*), with some Khote salla (*Pinus roxbirghii*), and natural regeneration of Painyu (*Prunus cerasoides*), Chilaune (*Schima wallichii*), Falant (*Quercus* spp.), Gurans (*Rhododendron* spp.) and Kangiyo (*Paveta indica* ?).
Key products obtained from C.F.	No timber products (fuelwood or other) come from the community forest yet, FUG members have to get this from their own land or buy from others. First fuelwood harvest will be obtained from pruning next April. Pine litter is collected, there is no limit on how much can be collected, its collection is actively encouraged as it inhibits the regeneration of grasses. Litter is collected from February to July, up to 3 times a day per household, representing a considerable workload
Cash crops/NTFPs	Collect *Epoterium identiforum* (banmara, small invasive shrub used as bedding/compost material, and fodder for goats) in September – October. There is equal distribution between FUG members of 1 doko per day for 7 days Amola (*Phyllanthus emblica/Emblica officianalis*) is collected but not sold
Conflicts and Problems	Problems with protecting the forest from grazers (group walk illustrated lopping widespread near village). Problems paying the guard (probably causing above) Problems with villagers protecting the forest – trying to have people from each household working 1 day every couple of months to look after forest. 6 - 7 years ago there was a big fire that damaged most trees (on walk it did not appear that 'most' of the trees were fire damaged) There are no conflicts over boundaries or use of the forest within the FUG. The community forest area is not big enough to supply all grass/shrub needs and users have to supplement it from their own private resources
Changes in the resource conditions	The resource is getting better – soon they will be able to get fuelwood. The amount of fodder material has been increasing, principally due to controls on grazing, which has allowed an understorey to develop (this had been largely destroyed due to excessive grazing pressure). There is significant natural regeneration of *Prunus*, *Capsinopsis* and *Quercus* spp., which are all good fodder species

Table 7.7 Information needs for Chuletro Pakha FUG

Background Information from participatory sessions (continued)

Existing forest management	Usage patterns: any FUG member can go anywhere to harvest products, but they must obey restrictions for the quantities that can be harvested. It is planned to start pruning fodder species in 6 years time, and it is anticipated that a lot of fodder will be available. Fuelwood will be obtained from April 1998, and rotation blocks have been delimited which will be rotated on a 3 year cycle. (Is this so? The DFO has no records.) Have an idea of how much to prune, remove up to 0.25 of the crown (SDC/Forest Department advice). livestock are all stall fed
Additional information	Have employed a forest watchman who works from 7am - 7pm, every household pays 10 rupees a month. This is difficult for some of the poorer households, and there have been some problems with paying the guard Other work that has been conducted includes planting seedlings (2000 in total) for *Prunus cerasoides* and walnut (*Juglans regia*), in July. Most of these have died.

Information needs

Information needs identified by FUG	Amount of fuelwood that can be harvested
Other Information needs identified	Standing volume of timber Check the area of the forest

Table 7.7 Information needs for Chuletro Pakha FUG (continued)

Dhungeswori FUG	
Background Information from desk review	
FUG information	174 households
Resource information	Natural forest and plantation 71 ha, believed to have been measured by chain and compass survey, but no records of how figure obtained Key species *Pinus roxburghii, Schima wallichii, Rhododendron* spp., *Quercus* spp., *Azadirachta indica* Heavily damaged by fire
Background Information from participatory sessions	
FUG information	FUG - used to have 206 households, now 197 - due to deaths, out-migration. Average household 5 persons, so 1000 people. 15 committee members, 6 female Village castes are Brahmin, Chettri and Sarkhi FUG established for 5 yrs, appears to very Brahmin dominated
Resource information	Key problem with forest used to be animal grazing. Now animals stall fed, litter collected from forest. Trees are still small, cannot use most of them for constructional timber
Key products obtained from C.F.	Leaf litter, green grasses, and some timber. A fire (about 7 years ago) damaged medicinal plants and other NTFPs. Also get litter, used for composting, and small amounts of fuelwood. Women collect: grasses, fuelwood and litter. Grass, 60 bari (1 bari = approximately 30kg) per household per year in total. Open the forests twice a year for the collection of grass and fuelwood. Each household is allowed to collect 1 doko (25kg) of fuelwood per year. Litter, 2-4 bari per household, only households near to the forest bother to collect this.
Cash crops/NTFPs	Get Amola (*Phyllanthus emblica/Emblica officianalis*), gooseberry like vitamin. C containing berry, approx. 2000kg collected and sold annually. Also get Ainselu (Rubus ellipticus) and kalo gujaghano (?)(like lychee), Pakhan ved (Bergenia ciliata), used for aches in bones, and Gothal sag (?) - edible grass. The fire seriously damaged the NTFP resource.
Conflicts and Problems	There is a conflict over the boundary. Fifteen years ago the Forest Department surveyed and mapped the forest boundary. The cadastral survey 6 years ago mapped part of the forest as private agricultural land, and it is being used as this. The disputed area is approx. 0.4ha The resource is too small to meet FUG needs There is no dead wood, and trees are too young to lop
Changes in the resource conditions	Time taken to gather grasses and litter has been getting shorter, due to no grazing and a controlled utilisation of the resource, and natural improvements since the fire

Table 7.8 Information needs for Dhungeswori FUG

Background Information from participatory sessions (continued)	
Existing forest management	Anyone in FUG can collect NTFPs Every year 140ft^3 of timber for construction can be harvested. This is divided between 7 'needy' households, decided on by FUG committee. The school may also get some timber. Key species for this is Chir pine (*Pinus roxburghii*) If people illegally graze their livestock in the community forest area there is a penalty system of fines Any member of the FUG can go and collect products (up to their limit) in any part of the forest Size of the resource: the resource is too small, they are trying to manage it to increase productivity, by enrichment planting of degraded sites. There is very little information available to the FUG on quantities to harvest, and they estimate how much can be removed based on their experience and knowledge.
Additional information	Buy timber from people with private woodlands within village. Fuel is mainly maize residues/grasses, richer people use some kerosene Want to plant bamboo and hardwood species There is a nearby area of state owned forest that could be converted into community forest, but there are disputes between existing FUGs over who should have it. The group walk identified some (fairly limited) areas of mature conifers and semi-natural woodland. A lot of the forest resource is shrub and rangeland. The majority of this resource is quite young and has not yet reached full production
Information needs	
Information needs identified by FUG	How much timber can be felled? How should they manage the resource?
Other Information needs identified	Area needs checking

Table 7.8 Information needs for Dhungeswori FUG (continued)

Ningure FUG

Background Information from desk review

FUG information	161 households
Resource information	Natural and plantation forest 94 ha, not known how it was surveyed Key species: *Shorea robusta, Pinus* spp., *Schima wallichii Alnus nepalensis, Terminalia tomentosa* Degraded forest, forest guard employed to watch the forest

Background Information from participatory sessions

FUG information	160 households, average of people per house Brahmin (80%), Chettri (10%), Tamang (5%), lower caste (5%)
Resource information	About 80% Sal (*Shorea robusta*), 15% Chir pine (*Pinus roxburghii*), 5% other species. About 20% of the resource is shrubland
Key products obtained from C.F.	Fodder (mainly ground grasses)and small branches for fuelwood, also dead diseased trees for fuelwood and small dimension timber (about 70-80 ft^3 per year)
Cash crops/NTFPs	Some scattered Amola (*Phyllanthus emblica/Emblica officianalis*), but not a cash crop
Conflicts and Problems	75% of FUG members have not any other source of fodder or fuel. Some members have no private grazing land. There is not enough fodder or fuelwood from the resource There is an internal conflict between landless FUG members and farmer members. Landless people graze animals in the forest, and use it as their source of water for livestock. At present, landless people can only bring livestock for water, not grazing, and have to stall feed their animals. 'Social fencing' of the plantation areas worked. There is a boundary conflict with an adjacent village, and within the forest there is an area (2 ha) which is being disputed in court regarding its status as community or private land.
Changes in the resource conditions	Improved over last 10-15 years, due to improved management – now only cut/collect dead wood and controlled pruning. Fodder collection still a problem because of open grazing
Existing forest management	No limits per household on litter, grass or small dimension fuelwood. One batch (360kg) of large dimension fuelwood per household per year, from pruning operations No restrictions on where FUG members can go to collect products. On the basis of experience they can remove approximately 100kg of green timber per user per year.
Additional information	The FUG identified more fuelwood as their main need, followed by fodder and grazing. They want to plant broadleaved species, and broom grass as a cash crop.

Information needs

Information needs identified by FUG	Information on quantities of products they can harvest Would like to learn how to assess the forest resource
Other Information needs identified	Area of the forest

Table 7.9 Information needs for Ningure FUG

7.3.3 Determining the data needing collecting

It can be seen from Tables 7.5 - 7.9 that although the circumstances of the FUGs are very different, the information needs are not very diverse. Table 7.10 lists the information needs that were identified.

Information need
Information on quantities of the forest resource that can be harvested: • how much timber can be felled • standing volume of timber • amount of fuelwood that can be harvested • sustainable yield of timber • NTFPs/herbs • what species should be used
Area of the forest resource
How to assess the forest resource
How to manage the resource

Table 7.10 Information needs identified for the five FUGs

From the needs identified in Table 7.10, discussions with forest rangers and consideration of biodiversity monitoring, the following data requirements were identified, using the system shown in Figure 7.2:

- aspect
- drainage
- slope
- fire evidence
- grazing intensity
- crown cover
- species
- basal area
- dbh
- tree form
- lopping intensity
- amount and type of natural regeneration
- soil exposure
- felling intensity

The systematic approach shown in Figure 7.2 was a useful tool for identifying information requirements and ensuring that adequate desk research was conducted to ensure that any existing information was utilised.

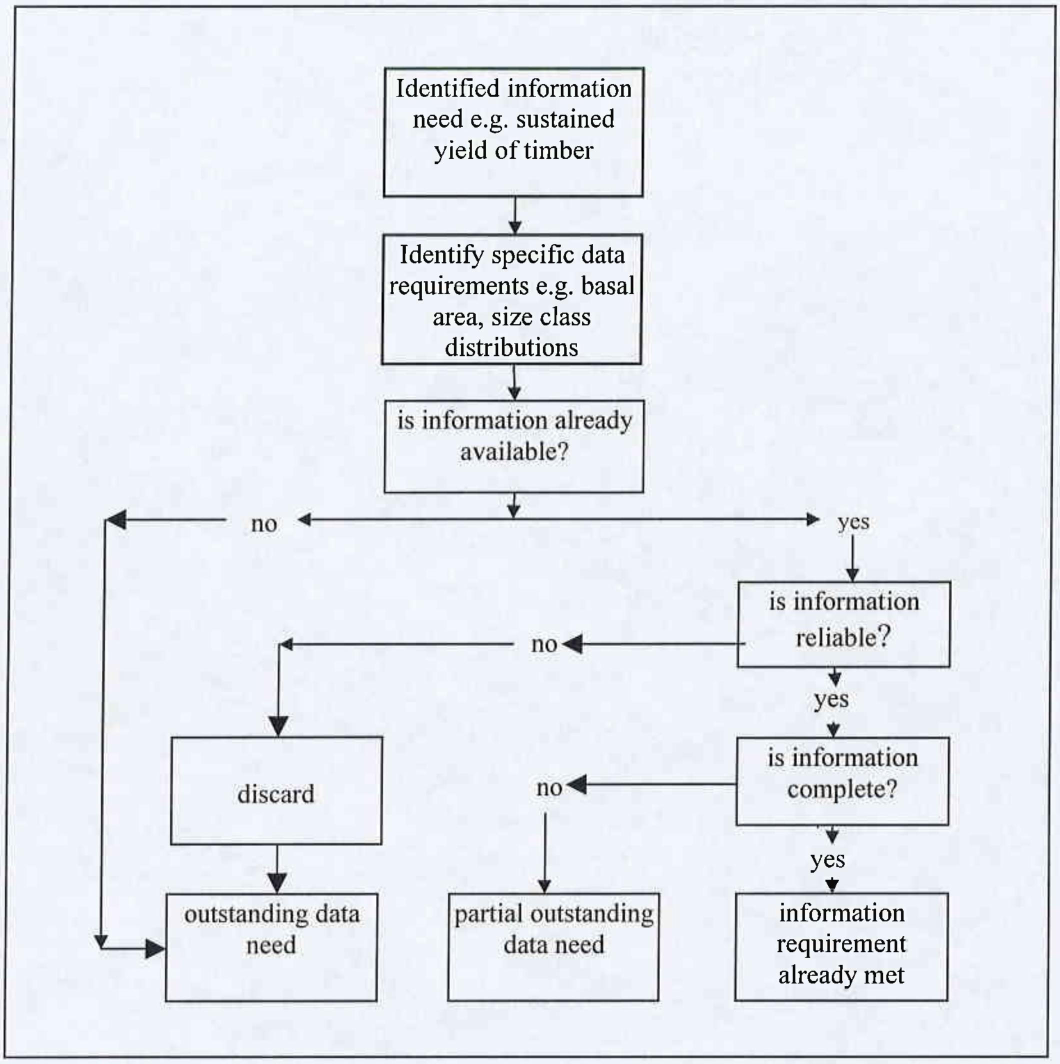


Figure 7.2 System for identifying outstanding information needs

It will be noted that height was not assessed. Previous experience had indicated that this was the most time-consuming variable to measure, and without accurate local volume tables the increase in accuracy of volume calculations based on dbh and height, rather than dbh, was not expected to be great. This is examined later in sections 7.4.3 and 7.4.4. It was felt that the data collected would allow the forest condition to be established, and determine the amount of timber and fuelwood that could be sustainably harvested. Attempts were also made to evaluate the amount of fodder that could be removed, although the SDC method, which appears to be a good approach for evaluating fodder quantities (see section 7.1.2), was only identified towards the end of the fieldwork period.

7.3.4 Developing the outline inventory method

The inventory method was based around Temporary Sample Plots. Permanent Sample Plots were felt to be innapropriate because of the difficulty of maintaining and accurately resampling them. The plots were 20m long and 5m wide (0.01ha), laid along the contour. All measurements were made with 20m and 2.5m ropes. Within this plot a 5m by 5m sub-plot was established for assessing natural regeneration (this was always the first five m of the large plot). The desired sampling intensity was 2%, but this was influenced by the variability of the resource and by time restrictions. The techniques used for forest assessment had to be fairly simple, rapid and utilise low cost equipment. Restrictions set on the inventory were that the resource assessment process (including training) should be completed within one week per FUG (both the forest rangers and FUGs felt this was the maximum time they could commit to the work). A financial limit of 500 rupees (about £5) was set for the inventory equipment.

7.3.4.1 Inventory equipment

Five hundred rupees buys a lot in Kathmandu. The equipment used for the inventory was:

1 20m rope
2 2.5m ropes
1 20m tape
1 compass
2 1m measuring rules (10cm gradations), homemade
4 marker poles, homemade
1 relascope, homemade
5 pens
1 notebook
50 forest inventory forms
Tape for dbh measurements

Additionally, a clinometer was used for calibrating ocular estimates of slope angles. The inventory forms were designed to provide a generic record of inventory data that was comparable across the FUGs. The form (a modified tally sheet) notes all the data that is required to address the FUGs information requirements. It should be noted that not all the information collected was always specified by the FUG or ranger, some of it addresses biodiversity monitoring needs. The form is in Appendix four.

7.3.5 Spatial data collection

All the inventories conducted involved some form of spatial data collection. The methods used were varied to allow comparison between different approaches. Spatial data was collected for four purposes: to design the sampling scheme for the forest inventory; to create maps of the forest resource for the FUG and rangers; to calculate yields from the forest; and to use in situations where there were boundary disputes. The methods used for collecting spatial information are outlined in Table 7.11.

FUG	Techniques
Chuletro Pakha	PPM, GPS boundary mapping
Dhungeswori	Participatory sketch mapping, GPS boundary mapping
Ningure	PPM, GPS boundary mapping
Baishakeswori	PPM, GPS control points
Bhasuki	GPS boundary mapping

Table 7.11 Methods used for collecting spatial data

7.3.6 Developing the sampling scheme

Once spatial data had been obtained for the community forests, sampling schemes could be developed. The initial stage involved getting a map of the community forest drawn onto an acetate sheet. The most useful spatial information for this were PPMs. These identified the external and internal boundaries of the resource. GPS boundary mapping was also useful, but necessitated entering the information into a GIS before spatial information (such as area) could be calculated. Although the PPMs, based on non-corrected aerial photographs, were probably less accurate than the GPS surveyed boundaries, they were of greater practical use. Participatory sketch mapping was found to be the least useful spatial information for devising a sampling scheme. This is due to the very significant spatial inaccuracies. The sampling scheme and inventory for Dhungeswori community forest was designed using a participatory sketch map for comparative purposes. A number of discrete stages were involved in developing the sampling scheme.

- Stratification. When the FUG marked internal boundaries onto PPMs or participatory sketch maps, information was sought regarding the homogeneity of the compartments. All the community forests were highly heterogeneous but were sub-divided to produce strata with fairly low internal variance. The FUGs generally sub-divided the resource by species, age, and to a lesser extent, condition.
- Deciding on systematic sampling. Although systematic sampling is not strictly statistically valid, it gives a better coverage of the area (samples tend not to cluster). An assumption has to be made that bias has not been created by the sampling pattern matching a variation in site factors. Additionally, it was decided to use plots rather than strip samples. This was due to the need to set up natural regeneration sampling sub-plots, and because it gave the participants a defined target of a plot to assess, rather than the appearance of a never ending task.
- Locating the sample plots. Each acetate compartment map (1:5 000) had a 5mm by 5mm grid laid over it and the area was calculated. The area of a 2% sample was calculated, and the number of 0.01ha plots needed for this obtained. At 1:5000 sixteen 5mm by 5mm squares gives 1 ha. Therefore for a 2% sample a plot was systematically positioned on every eighth square, with a random start. In reality the sampling intensity was influenced by time constrictions, and in most cases a sampling intensity of less than 2% was employed. Figure 7.3 illustrates sample plot locations for a part of Chuletro Pakha community forest.

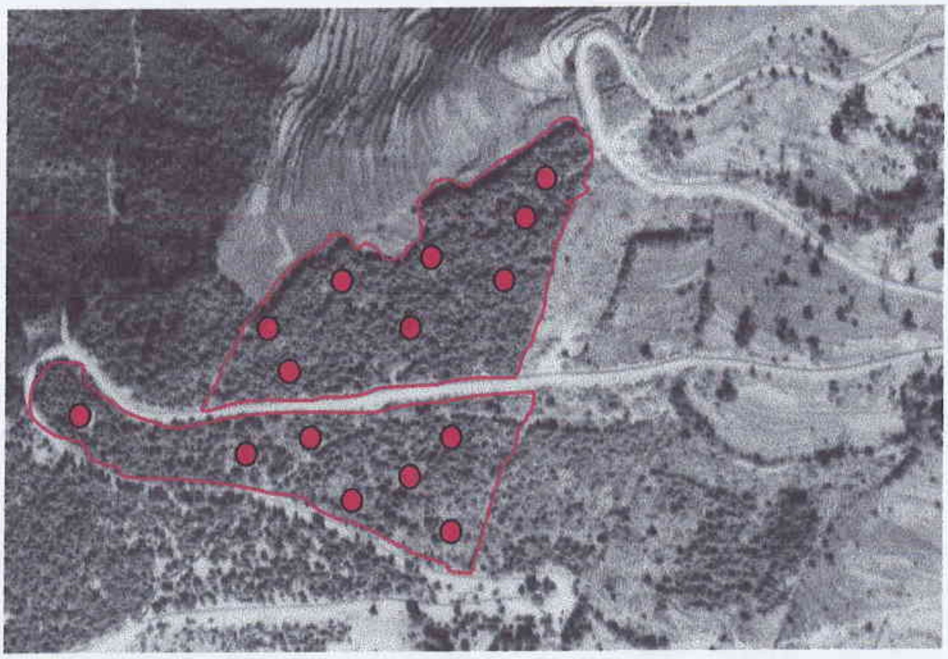


Figure 7.3 The location of sample plots for two compartments of Chuletro Pakha community forest

Once the sampling scheme for each compartment had been developed, a practical planning exercise was conducted to ensure that the work could be conducted in the appropriate time period. If this was not the case, either the sampling intensity or the number of compartments to be assessed was reduced (this was decided, after explanations of the implications, by the FUG).

7.3.7 Inventory training

The inventory was designed to be highly participatory. Prior to the inventory commencing, the practical skills required were developed. Initially, plots were laid out on shrubland for learning simplicity. The idea of sample plots was explained, as well as what to do with trees that were on the border of the plot. Compass bearings and pacing were explained, practiced and picked up very rapidly. The FUG inventory team then moved into the forest. Dbh measurements were practiced, and the usual conventions explained (these are detailed in Hamilton, 1975). Slope angles were estimated, and compared with clinometer readings. Fire evidence was explained, as needing visual evidence of damage rather than historical knowledge of fires having occurred in that area. It was hoped that an idea of grazing intensity would be gained from recording evidence of grazing animals, namely terracettes, dung or signs of grazed shrubs. Ocular estimates of crown cover were made until a consensus was reached for various canopy types. Attempts were made to estimate the amount of exposed soil, and finally the relascope was introduced. This was the hardest techniques for FUG members to conceptualise, and to use in practice. Usually, one or two members of the FUG inventory team picked up the technique, and could measure basal area quite accurately. The inventory training usually took a morning, including the complete sampling of one or two plots as part of the training. Within two days the FUG inventory team was usually fully competent in all the techniques, and could perform the entire process (including record keeping) themselves. Photographs 7-12 at the end of this chapter show examples of the CFRA in practice.

7.3.8 Conducting the Inventory

An inventory team of a minimum of three FUG members, (ideally five or six), conducted the inventories. On occasion more than twenty FUG members were involved, and things became somewhat chaotic. There was always one booker (usually a shopkeeper or teacher who was numerate and literate), and the measurers generally worked as a team of two, measuring trees and identifying species. All inventory results were directly recorded onto the forest inventory forms, as shown in Appendix four. Compass bearings and pacing were used to locate plots. Although this was less accurate than using chain and compass techniques, no problems with plot positioning were encountered. As long as the pacing was rigidly adhered to no bias was introduced by subconsciously picking good or bad parts of the resource. Depending on the forest type, terrain and enthusiasm of the inventory team, between three and ten plots could be surveyed per day.

7.3.9 The Inventory results and data analysis

Summary information for the inventory is presented in Table 7.12

FUG	Inventory type	No. of compartments sampled	No. of plots sampled	Plot area (ha)	Forest area (ha)*	Sampling %	Sampling scheme
Baishakeswori	Participatory	3	26	0.26	19.2	1.4	Stratified systematic
Bhasuki	Participatory	1	16	0.16	7.0	2.3	Stratified systematic
Chuletro Pakha	Participatory	7	22	0.22	14.8	1.3	Stratified systematic
Chuletro Pakha	Evaluation	2	14	0.14	6.3	2.2	Stratified systematic
Dhungeswori	Participatory	6	29	0.29	70.5	0.4	Good, average and poor condition plots
Dhungeswori	Evaluation	1	34	0.34	6.75	5	Stratified systematic
Ningure	Participatory	1	11	0.11	8.0	1.4	Stratified systematic

* Table 7.2.4 gives the methods for calculating the spatial areas

Table 7.12 Summary information for forest inventories

Table 7.12 shows that generally the sampling intensity is much lower than with a standard inventory, therefore the precision is likely to be lower (indicated by the confidence limits). The participatory inventory with Dhungeswori FUG used plots that the FUG deemed representative of good, average and poor conditions for the compartment. Two, more detailed 'evaluation' inventories were conducted to assist with determining the reliability of the participatory inventory data.

During the inventory the raw data for each plot was entered into the forest form. It was felt that a standardised form, addressing all the information needs identified by the FUGs, had a number of advantages over an approach solely addressing the information needs of individual FUGs:

- a standardised approach would be easier for forest rangers to understand and repeat
- methods could be easily replicated
- results from different FUGs could be easily compared and contrasted

The inventory data on the forms were initially entered into spreadsheets where basic analysis was performed on the data. This involved assimilating the plot data and converting it into data for the compartment, on compartment summary sheets. These are shown in Appendix five. The data is a mixture of descriptive data on condition and comments about the plots and compartments, and quantitative data about the resource. Descriptive information and standard errors allow an idea of the variability of the compartment to be obtained. In general it was found that most compartments were quite variable, which would be expected in natural forest, but the plantations also tended to have great variations in tree spacing and canopy cover. There were often open areas within the plantations due to deliberately maintaining some scrub or grassland, fires or the failure of young transplants.

A basic understanding of the compartment can be obtained from the compartment summary sheets. The first part of the sheet provides general information on the compartment. From a forest resource assessment perspective the key information is the canopy cover (and its variability), the amount of lopping, the number of stumps per hectare and the amount of natural regeneration. The second part of the sheet provides more detailed information on the timber resource. Main species are listed, and also any other species that had individuals >7cm dbh present in the sample plots. The number of stems per hectare was calculated, based on the mean number of trees per plot, converted to hectares. The number of stems per hectare does not by itself provide information on the stocking density of the compartment, but with another parameter such as dbh it does give a useful description of the crop (Philip, 1994). This was done for each key species. An indication of form was presented, based on the number of trees perceived by the FUG members as being of good or poor form. The basal area was the mean basal area for the plots within the compartment. The maximum dbh was for the compartment. The basal area and maximum dbh were then used to calculate the volume of standing timber per hectare, using a modification of procedure nine from the forest mensuration handbook (Hamilton, 1975). This involved a number of stages:

1. In order to determine the crop form the top height had to be calculated. Owing to the difficulties of accurately measuring top height with makeshift equipment and non foresters, it was felt that this could be better modelled. The correlation between dbh and height was determined from initial sampling, and found to be strong (see Table 7.13).
2. These figures were used to determine the appropriate tariff number for the trees, using single tree tariff charts (a tariff number reflects the slope of a straight-line relationship between volume and basal area, see Philip, 1994 or Hamilton, 1975). The general tariff number was found to be 12 (with a standard error of 0.23), using the tariff table for lodgepole pine (chosen for precautionary reasons because the form height values are low for this species).

3. Calculating the standing volume is done by multiplying the basal area by the crop form height. The form height is derived from the top height (Hamilton, 1975, Table 8. P.85). As mentioned above, top height was not directly measured. Instead, it was derived from the single tree tariff chart, where the tariff number and maximum dbh were known.

FUG and species		Correlation coefficient for dbh and height
Dhungeswori	*P. Roxburghii*	0.87
Dhungeswori	*P. wallichiana*	0.86
Dhungeswori	*P. patula*	0.87
Dhungeswori	*P. Roxburghii*	0.83
Chulletro Pakha	*P. Roxburghii*	0.78

Table 7.13 Correlation coefficients for dbh and height

It should be noted that a more usual means of determining tariff number is from the direct measurement of the volume by measuring sample trees. This involves felling them, which was not acceptable for this work, due to neither the FUG members or the DFO supporting this.

On sloping ground the basal areas derived from relascope measurements need to be multiplied by a factor appropriate to the slope angle (see Hamilton, 1975, Table 16 p. 133), to convert horizontal distances to the equivalent length along a uniform slope. The slope angle used was the mean slope angle for the compartment. These modified basal areas were used to produce modified standing volumes of timber.

Histograms of the size class distribution for the key species present in each compartment were also produced (these are also presented in Appendix 5.) Although these do not give a detailed picture of the diameter distribution (for which Hamilton (1975) recommends that *ca.*200+ stems should be sampled), they do give an indication of the structure of the crop for each species.

7.3.9.1 Deriving management information from the inventory data

A participatory resource assessment should not just present inventory information, but should also provide resource information and management suggestions that are of value to the FUGs and forest rangers. The next stage of data analysis thus involved converting this information into management information that would be of value to the FUG and forest ranger. A key part of this process involved converting plot data into compartment data. Until this stage the information related to plots, or was converted into hectares. The information was combined with the spatial data obtained from GIS analysis. This allowed the results per hectare (volumes, basal areas and stem numbers) to be converted into total volumes per compartment. The management information produced is presented in Tables 7.13-30.

Owing to the assumptions made in the calculations of yields of fuelwood and timber, monitoring of the resource is required to ensure that the management regime is sustainable.

It should be noted that the same information is provided to the FUGs, rangers and DFOs, but the way the information is presented differs to make it appropriate for each stakeholder group.

FUG: Baishakeswori Compartment: Gha				
Slope angle°	>40✓	20-40	<20	Area (from GIS): 7.1 ha Average slope angle° : 35 Area corrected for slope: 8.67 ha
Fire evidence	High	Low✓	None	
Amount of grazing	High	Low✓	None	Standing volume of timber (compartment, m^3): 2500
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 3500
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 1250
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+✓	50+	<50	Number of stems in compartment: 840
Nat. regeneration	Poor	Medium	Good✓	Form: Average
Average dbh	<10	10-20	20+✓	**Amount of fuelwood harvestable per annum**: 50 m^3
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** 25 m^3

Table 7.13 Management information for Baishakeswori FUG, Gha compartment

FUG: Baishakeswori Compartment: Ga				
Slope angle°	>40	20-40✓	<20	Area (from GIS): 4.1 ha Average slope angle°: 30 Area corrected for slope: 4.73 ha
Fire evidence	High	Low✓	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 355
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 497
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 177
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+✓	<50	Number of stems in compartment: 3650
Nat. regeneration	Poor	Medium✓	Good	Form: Poor
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum**: 7.1 m^3
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** 3.5

Table 7.14 Management information for Baishakeswori FUG, Ga compartment

FUG: Baishakeswori Compartment: Nga				
Slope angle°	>40	20-40✓	<20	Area (from GIS): 8 ha Average slope angle°: 30 Area corrected for slope: 9.24 ha
Fire evidence	High	Low	None✓	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 3380
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 4732
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 1690
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 1%
Number of stumps per ha	250+✓	50+	<50	Number of stems in compartment: 15940
Nat. regeneration	Poor✓	Medium	Good	Form: Average
Average dbh	<10	10-20 ✓	20+	**Amount of fuelwood harvestable per annum:** 67 m^3
Condition and resilience:	Poor✓	Average	Good	**Amount of timber harvestable per annum:** 17 m^3

Table 7.15 Management information for Baishakeswori FUG, Nga compartment

FUG: Bhasuki Compartment: Sunshito Tumko				
Slope angle°	>40	20-40	<20✓	Area (from GIS): 7 ha Average slope angle°: 20 Area corrected for slope: 7.45 ha
Fire evidence	High	Low	None✓	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 680
Canopy cover	<20	20-60✓	<80	Total wood volume (compartment, m^3): 952
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 340
Amount of lopping	High✓	Low	None	Annual increment (compartment, m^3): 3
Number of stumps per ha	250+	50+✓	<50	Number of stems in compartment: 5050
Nat. regeneration	Poor	Medium✓	Good	Form: Good
Average dbh	<10	10-20	20+✓	**Amount of fuelwood harvestable per annum:** 13.5 m^3
Condition and resilience:	Poor	Average	Good✓	**Amount of timber harvestable per annum:** 10 m^3

Table 7.16 Management information for Bhasuki FUG, Sunshito Tumko compartment

FUG: Chulettro Pakha Compartment: Lampatto 6				
Slope angle°	>40	20-40✓	<20	Area (from GIS): 3.6 ha Average slope angle°: 30 Area corrected for slope: 4.17 ha
Fire evidence	High✓	Low	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 403
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 564
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 201
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 6460
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum**: 8 m^3
Condition and resilience:	Poor	Average	**Good**✓	**Amount of timber harvestable per annum:** 6 m^3

Table 7.17 Management information for Chulettro Pakha FUG, Lampatto 6 compartment

FUG: Chulettro Pakha Compartment: Naya Aahalbari				
Slope angle°	>40	20-40✓	<20	Area (from GIS): 1.1 ha Average slope angle°: 30 Area corrected for slope: 1.27 ha
Fire evidence	High	Low	None	
Amount of grazing	High	Low✓	None	Standing volume of timber (compartment, m^3): 65
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 91
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m^3): 32
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 3
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 1727
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum**: 1.3 m^3
Condition and resilience:	Poor	Average	Good✓	**Amount of timber harvestable per annum:** 0.95 m^3

Table 7.18 Management information for Chulettro Pakha FUG, Naya Aahalbari compartment

FUG: Chulettro Pakha Compartment: Kali Pakhari				Area (from GIS): 2.3 ha Average slope angle°: 40 Area corrected for slope: 3.0 ha
Slope angle°	>40✓	20-40	<20	
Fire evidence	High✓	Low	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 84
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 117
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 42
Amount of lopping	High	Low	None✓	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 2100
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum**: 1.6 m^3
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** 0.84 m^3

Table 7.19 Management information for Chulettro Pakha FUG, Kali Pakhari compartment

FUG: Chulettro Pakha Compartment: Bhirmath				Area (from GIS): 1.8 ha Average slope angle°: 40 Area corrected for slope: 2.34 ha
Slope angle°	>40✓	20-40	<20	
Fire evidence	High✓	Low	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): N.A.
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m^3): N.A.
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m^3): N.A.
Amount of lopping	High	Low	None✓	Annual increment (compartment, m^3): N.A.
Number of stumps per ha	250+	50+✓	<50	Number of stems in compartment: N.A.
Nat. regeneration	Poor	Medium	Good✓	Form: N.A
Average dbh	<10	10-20	20+	**Amount of fuelwood harvestable per annum**: N.A.
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** N.A.

Table 7.20 Management information for Chulettro Pakha FUG, Bhirmath compartment

FUG: Chulettro Pakha Compartment: Bhusbuse 5				Area (from GIS): 2.7 ha Average slope angle°: 30 Area corrected for slope: 3.12 ha
Slope angle°	>40	20-40✓	<20	
Fire evidence	High	Low	None✓	
Amount of grazing	High	Low✓	None	Standing volume of timber (compartment, m³): 78
Canopy cover	<20	20-60✓	<80	Total wood volume (compartment, m³): 109
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m³): 39
Amount of lopping	High	Low✓	None	Annual increment (compartment, m³): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 2590
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum:** 1.5 m³
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** 0.75 m³

Table 7.21 Management information for Chulettro Pakha FUG, Bhusbuse 5 compartment

FUG: Chulettro Pakha Compartment: Bhusbuse 4				Area (from GIS): 1.6 ha Average slope angle°: 15 Area corrected for slope: 1.66 ha
Slope angle°	>40	20-40	<20✓	
Fire evidence	High	Low	None✓	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m³): 41
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m³): 57
Soil exposure %	>60✓	30-60	<30	Timber volume (compartment, m³): 20
Amount of lopping	High	Low✓	None	Annual increment (compartment, m³): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 1826
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum:** 0.8 m³
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** 0.4 m³

Table 7.22 Management information for Chulettro Pakha FUG, Bhusbuse 4 compartment

FUG: Chulettro Pakha Compartment: Ahal Bari Imani				Area (from GIS): 3.7 ha
Slope angle°	>40	20-40	<20✓	Average slope angle°: 20
Fire evidence	High	Low	None✓	Area corrected for slope: 3.94 ha
Amount of grazing	High	Low✓	None	Standing volume of timber (compartment, m^3): N.A (trees are fruit trees)
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m^3): N.A.
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): N.A.
Amount of lopping	High	Low	None✓	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: N.A.
Nat. regeneration	Poor	Medium✓	Good	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum**: N.A.
Condition and resilience:	Poor	**Average✓**	Good	**Amount of timber harvestable per annum:** N.A.

Table 7.23 Management information for Chulettro Pakha FUG, Ahal Bari Imani compartment

FUG: Dhungeswori Compartment: Dhunge				Area (from GIS): 26.5 ha
Slope angle°	>40	20-40✓	<20	Average slope angle°: 30
Fire evidence	High✓	Low	None	Area corrected for slope: 30.6 ha
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 1100
Canopy cover	<20	20-60✓	<80	Total wood volume (compartment, m^3): 1540
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m^3): 550
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 3%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 9790
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20	20+✓	**Amount of fuelwood harvestable per annum**: 22 m^3
Condition and resilience:	Poor	Average	**Good✓**	**Amount of timber harvestable per annum:** 16.5 m^3

Table 7.24 Management information for Dhungeswori FUG, Dhunge compartment

FUG: Dhungeswori Compartment: Khadan				Area (from GIS): 15.4 ha
Slope angle°	>40	20-40	<20✓	Average slope angle°: 15
Fire evidence	High✓	Low	None	Area corrected for slope: 19.94 ha
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 115
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m^3): 161
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m^3): 57
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 7580
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10✓	10-20	20+	**Amount of fuelwood harvestable per annum:** 2.3 m^3
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** None

Table 7.25 Management information for Dhungeswori FUG, Khadan compartment

FUG: Dhungeswori Compartment: Melchaur				Area (from GIS): 5.1 ha
Slope angle°	>40	20-40	<20✓	Average slope angle°: 15
Fire evidence	High✓	Low	None	Area corrected for slope: 5.28 ha
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 380
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m^3): 530
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m^3): 190
Amount of lopping	High	Low	None✓	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 1580
Nat. regeneration	Poor	Medium✓	Good	Form: Good
Average dbh	<10✓	10-20	20+	**Amount of fuelwood harvestable per annum:** 7.5 m^3
Condition and resilience:	Poor	**Average**✓	Good	**Amount of timber harvestable per annum:** None

Table 7.26 Management information for Dhungeswori FUG, Melchaur compartment

FUG: Dhungeswori Compartment: Bhasme				Area (from GIS): 10.6 ha Average slope angle°: 30 Area corrected for slope: 12.24 ha
Slope angle°	>40	20-40✓	<20	
Fire evidence	High✓	Low	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m³): 626
Canopy cover	<20✓	20-60	<80	Total wood volume (compartment, m³): 876
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m³): 313
Amount of lopping	High	Low✓	None	Annual increment (compartment, m³): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 1590
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10✓	10-20	20+	**Amount of fuelwood harvestable per annum:** 12.5 m³
Condition and resilience:	Poor	**Average✓**	Good	**Amount of timber harvestable per annum:** None

Table 7.27 Management information for Dhungeswori FUG, Bhasme compartment

FUG: Dhungeswori Compartment: Gagua Khaako Gairo				Area (from GIS): 6.1 ha Average slope angle°: 15 Area corrected for slope: 6.31 ha
Slope angle°	>40	20-40	<20✓	
Fire evidence	High✓	Low	None	
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m³): 131
Canopy cover	<20	20-60✓	<80	Total wood volume (compartment, m³): 183
Soil exposure %	>60	30-60✓	<30	Timber volume (compartment, m³): 65
Amount of lopping	High	Low✓	None	Annual increment (compartment, m³): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 6100
Nat. regeneration	Poor	Medium	Good✓	Form: Poor
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum:** 2.6 m³
Condition and resilience:	Poor	**Average✓**	Good	**Amount of timber harvestable per annum:** 1.3 m³

Table 7.28 Management information for Dhungeswori FUG, Gagua Khaako Gairo compartment

FUG: Dhungeswori Compartment: Thulodunga				Area (from GIS): 6.75 ha
Slope angle°	>40	20-40	<20✓	Average slope angle°: 8
Fire evidence	High✓	Low	None	Area corrected for slope: 6.81 ha
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 107
Canopy cover	<20	20-60✓	<80	Total wood volume (compartment, m^3): 149
Soil exposure %	>60	30-60	<30✓	Timber volume (compartment, m^3): 53
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 3%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 5584
Nat. regeneration	Poor	Medium	Good✓	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum:** 2.1 m^3
Condition and resilience:	Poor	Average	**Good✓**	**Amount of timber harvestable per annum:** 1. 5 m^3

Table 7.29 Management information for Dhungeswori FUG, Thulodunga compartment

FUG: Ningure Compartment: Salleri Ghardiri				Area (from GIS): 8 ha
Slope angle°	>40	20-40✓	<20	Average slope angle°: 30
Fire evidence	High	Low	None✓	Area corrected for slope: 9.24 ha
Amount of grazing	High	Low	None✓	Standing volume of timber (compartment, m^3): 1487
Canopy cover	<20	20-60	<80✓	Total wood volume (compartment, m^3): 2080
Soil exposure %	>60✓	30-60	<30	Timber volume (compartment, m^3): 743
Amount of lopping	High	Low✓	None	Annual increment (compartment, m^3): 2%
Number of stumps per ha	250+	50+	<50✓	Number of stems in compartment: 8131
Nat. regeneration	Poor	Medium✓	Good	Form: Good
Average dbh	<10	10-20✓	20+	**Amount of fuelwood harvestable per annum:** 29 m^3
Condition and resilience:	Poor	**Average✓**	Good	**Amount of timber harvestable per annum:** 14.8 m^3

Table 7.30 Management information for Ningure FUG, Salleri Ghardiri compartment

The key information derived from analysing the inventory data for the FUG and ranger were the condition and resilience of the compartment, and the amount of fuelwood and timber that could be harvested from the compartment.

Although in ecological terms resilience and condition are separate descriptors of a resource, here they were combined to provide a single description of what the resource was like and how much utilisation should be encouraged. Although the terms tend to indicate an entirely objective view of a resource, it is felt that the terms are partially subjective. The system of allocating a compartment to a condition and resilience class was not prescriptive (for example, one variable indicating particularly low resilience or poor condition did not automatically preclude the compartment being classed as good), but involved analysing the results for all the indicators and considering the descriptions for the plots and compartments. A combination of poor scores for certain indicators was viewed as indicating a particularly poor resilience and condition (such as a steep slope with high soil exposure, little natural regeneration and lopping occurring).

Calculating the amount of fuelwood and timber that was available for harvesting required making a number of assumptions. There is very little mensuration-based data available for Nepal, and little available for comparable areas in the Indian Himalaya. None was found which was considered to be of use for this study for predicting yields, although some was of general interest in terms of methods and results (Jackson, Nurse and Chhetri, 1993; Thompson 1990a, b; Thompson, Tamrakar and Mathema, 1990). The main assumptions were the values to apply to constants for calculations. The constants used were those developed by SDC, working in a variety of community forests in the Dolakha region (see section 7.1.2). A sustained yield of fuelwood and timber was calculated as following:

- total wood volume was calculated as: *standing volume * 1.4*, to include branch material
- timber volume was calculated as: *standing volume * 0.5,* to include processing losses and form considerations
- annual increment was calculated as: 1,2 or 3%, based on site condition

- the amount of fuelwood that could be harvested per annum was based on: *total wood volume – standing wood volume * 0.05*. This represents a conservative annual increment incorporating coppice and branch re-growth
- the amount of timber that could be harvested was based on: *timber volume * annual increment*. If the average dbh was <10cm then it was considered that no timber could be harvested

7.3.9.2 Producing the management plan

The final stage in converting the inventory information into practical information of maximum benefit to the FUG and forest ranger involved producing management suggestions and a management plan that the FUG could examine and comment on. GIS maps were combined with the management information, which was modified to be more accessible to the FUG (for example, yields were expressed in loads rather than m^3). The information was presented in two formats: one, for the forest ranger, was slightly more technical than the information for the FUG. An example, for Bhasuki FUG, is in Appendix 6. In addition, the forest ranger received copies of the forest form and the management information Table. It will be seen that the only new information from the inventory results is presenting the amount of forest products that can be obtained from the resource in Bari loads. The weight of the wood was estimated at an average of 1200 kg/m^3 (green softwood is usually slightly lighter than this, green hardwood slightly heavier), and an average Bari load as being 30kg. It will be noted that some basic management information and possible management strategies are also detailed. These were not documented in detail, because it was felt that it would be confusing to produce management information contrary to what the DFO or ranger had advised, and that potential management options were better discussed in participatory sessions. The yield of products from each compartment are presented in Table 7.31 below.

FUG	Compartment	Fuelwood yield (Bari per year)	Timber yield (Bari per year)
Baishakeswori	Gha	2000	1000
	Ga	284	140
	Nga	2680	680
Bhasuki	Sunshito Tumko	540	400
Chulettro Pakha	Lampatto 6	320	240
	Naya Ahalbari	52	38
	Kali Pakhari	64	34
	Bhirmath	N.A.	N.A.
	Bhusbuse 5	60	30
	Bhusbuse 4	32	16
	Ahal Bari Imani	N.A.	N.A.
Dhungeswori	Dhunge	880	660
	Khadan	92	N.A.
	Melchaur	300	N.A.
	Bhasme	500	N.A.
	Gagua Khaako Gairo	104	52
	Thulodunga	84	60
Ningure	Salleri Ghardiri	1160	592

Table 7.31 Yields in *Bari* and management suggestions for FUG management planning

7.3.10 Feedback to the FUG

The management plan was the final product of the information gathering process to address the FUGs' and rangers' needs. It was presented to the FUG for their comments. Feedback was sought on its usefulness, accuracy, presentation and acceptability. This was performed an in informal environment, generally in a teashop with the FUG chairman and as many members of the FUG present as possible. In general the feedback was very positive, and the FUG felt that the management information would help them with utilising their forests in a sustainable manner. Inventory participants often stated that they had enjoyed the assessment, and felt that they had learnt a lot. Every FUG stated that they would repeat the exercise and felt that the time-commitment had been worthwhile.

FUG members in general felt that the suggested yields were greater than what was currently being removed from the forest, particularly for younger trees. The idea of thinning crops to increase productivity and quality was new to several FUGs. There were no cases where compartments were being more heavily utilised than suggested by the management plan, at least, no cases admitted to.

The feedback exercise above is useful for getting information back to the FUG and discussing management options, but a poor way of evaluating the value of the information for the FUG and whether the management plan meets expectations. Nepali villagers do not like causing offence to visitors, it is unlikely that they would publicly vocalise disappointment with the information received. Additionally, the feedback was not structured to encourage participation from all interest groups; most feedback sessions tended to be the FUG chairman and other influential villagers planning how to use the information. It became apparent that participation for feedback purposes needs as much consideration and planning as participation in earlier stages.

Feedback from range post staff was very favourable. Forest guards have said that this information provides them with the first resource management data that they have had on a compartment by compartment basis. They felt that the information would be of great assistance in working with the FUGs in planning their forest management over the coming years.

Feedback comments from each FUG are presented in Table 7.32.

FUG	Comments
Baishakeswori	The FUG members appeared very satisfied with the maps, and the inventory information seemed of secondary interest. This may be because having poorly defined boundaries was slowing down the hand-over of the forest. They (rightly or wrongly) felt the GIS maps would assist with this. As they have a large resource and there is little pressure on it, the FUG members may have been less interested in determining sustainable yields.
Bhasuki	The FUG members will use the information in a presentation to the DFO, to persuade him to allow them to fell a little timber for sale in Kathmandu, to pay for a teacher at the school. The DFO has indicated that with a sustained yield based on inventory data he would let them produce timber commercially.
Chulettro Pakha	The FUG members were pleased with both the maps of the resource, and the management information. They were particularly pleased to receive quantifiable information on thinning compartments. In addition to providing the yields from these compartments, they were inspected during the feedback visit and advice was given on how to select trees and thinning intensities.
Dhungeswori	During the inventory this had been the least enthusiastic group, however, they appeared to be very pleased with both the management plan and with the inventory as a process. They felt the information would greatly assist with managing the resource, particularly in when to start removing produce from the areas damaged by fire. They also said it was the first time they felt that visiting foresters (apart from the ranger) had worked 'with' them.
Ningure	A useful process, the inventory members felt that they could conduct the inventory themselves. Felt that only working in one compartment limited the value for them, but they hoped to assess the other compartments themselves.

Table 7.32 Feedback from FUG members for the CFRA

7.4 Discussion

7.4.1 Evaluating the inventory method

The inventory method developed and tested in this study was evaluated against two sets of criteria, the initial objectives of an improved inventory method, and whether it delivered the information requirements of the FUGs.

Section 7.2 outlined a number of areas it was felt that an improved participatory inventory method needed to focus on. These are shown in Table 7.33 with comments regarding how they were addressed.

Objective	Achieved	Comments
An accurate determination of the forest area	✓	See chapter five.
Sufficient data collection to allow management activities to be planned	✓	Yield information, condition, natural regeneration combined with FUG participatory information on their objectives and needs.
Sufficient data collection to allow condition to be assessed	✓	Information on a variety of indicators of condition collected, allowing detailed assessment. Some problems with this, see below.
Sufficient data collection to allow basic biodiversity assessment to be conducted	✖	This did not work as expected. See below.
Enough community and resource based information that sustained yield forestry can be practiced	✓	Resource information was obtained that allowed sustainable yields of timber and fuelwood to be calculated.
A focus on providing information on the forest rather than plots	✓	Spatial data on compartments allows hectare based information to be converted into compartment data.
Enough data that changes in the forest resource can be monitored	?	Changes in age and species structure can be monitored, but subtler changes in vegetation, soil etc. would not be detected.
Easy to understand management plans based on the resource assessment that FUGs can understand and implement	✓	Feedback from FUG was very favourable. FUGs understood the information and it appeared that they would implement the management suggestions.
Increase time and cost effectiveness	?	The resource assessment increases the time required compared to traditional assessments based around participatory sketch mapping and ocular assessments. The process is faster than NACFP or NUKCFP inventory methods.
Increase data reliability	✓	The results (spatial and forest resource) are more reliable than with traditional rapid assessment techniques.
Improve empowerment, participation, and involvement of non-literate	✓	This is the most participatory inventory practised in Nepal.
Keep techniques and analysis as simple as possible	?	Techniques used are simple and easy to understand. Analysis is still time consuming and fairly complex.
Assessment system should be transferable to FUG, and they should be capable of independently conducting the assessment (with help from a forest ranger)	✖	At the end of the inventory the FUG inventory members could conduct the inventory and record the data entirely independently. However, the FUG members and ranger could not conduct all the analysis due to a lack of knowledge and a lack of time.

Table 7.33 Addressing the objectives of an improved participatory forest inventory

It can be seen from Table 7.33 that most of the objectives of the inventory method were achieved, and it is felt that this method represents a definite improvement in participatory CFRA in Nepal. However, some were only partially achieved, or the method failed to address them successfully.

Data was collected to allow condition to be assessed; this provided a better assessment than previous methods used by NACFP or NUKCFP (see sections 7.1.1 – 7.1.3), as a wider range of easily assessed variables are used. Some of the criteria used to assess condition were difficult to measure. Soil exposure was measured differently by FUG groups: some would remove leaf litter and measure the underlying soil exposure, others would measure it with leaf litter over the top. Additionally, this tended to be based on one small area, and was not always representative of the plot. Small natural regeneration (<2m in height) was difficult to measure. This was measured in a 5m by 5m sub-plot, and some FUGs would examine it in detail, recording tens or hundreds of plants, others would just note the names of four or five of the most abundant species. Additionally, for coppicing growth or multi stemmed plants some FUG groups would record all stems as one plant, others would record the number of stems. This meant the data sets could not be compared reliably. This problem also affected the information for biodiversity assessment. It is considered too unreliable to be of practical assistance. A better approach for assessing small natural regeneration, shrubs and ground flora, is to list all species occurring in the sub-plot, with perhaps a percentage occupancy for the most abundant species. This would be less prone to measuring bias and be more rapid. The information on number of stumps is of some value. It provides an indication of whether the resource is being utilised for timber. It does not provide much indication on the pressure on the resource as it cannot be determined which stumps are recent or historic.

Data was collected that allowed some temporal changes in the forest resource to be assessed. The level of information collected did not provide much ecological information about vegetation or site factors. It does not allow the true 'sustainability' of forestry operations to be determined, although it does provide information allowing sustained yield forestry to be implemented. This is considered to be an adequate level of information: the data requirements to assess change in a forest resource are very complex and would complicate the resource assessment and analysis procedures.

The method aimed to provide a similar level of information as the NACFP and NUKCFP simple forest inventories. As well as achieving that aim, it also significantly reduced the amount of time and resources spent collecting and analysing data (Hunt, 1998, pers. comm.). The data processing still takes a lot of time, and would be difficult without a computer based spreadsheet (or at least a scientific calculator). The time taken for the data analysis would prohibit this becoming a day to day activity for forest rangers. This is a major limiting factor in the adoption of the method by FUGs and rangers, and is discussed in the final chapter. The techniques used were kept as simple as possible, but further examination is needed to see if the data analysis process can be made more straightforward.

The second stage of the evaluation involved assessing whether the inventory method had addressed the information needs of the FUGs, shown in Table 7.34 below

Information need	Met	Comments
Standing volume of timber	✓	Information provided on how much timber there is, with a breakdown of species
Amount of fuelwood that can be Harvested	✓	Provided on a compartment by compartment basis in appropriate units
Sustainable yield of timber	✓	Provided on a compartment by compartment basis in appropriate units
NTFPs/herbs	✖	Not adequately addressed
What species should be used	✓	Information supplied
Area of the forest resource	✓	See Chapter five
How to assess the forest resource	✓	Provided in the inventory training
How to manage the resource	✓	Provided as management feedback with resource assessment information

Table 7.34 Addressing the information needs of the FUGs

The information needs of the FUGs were met with one exception. Not enough information about NTFPs or herbs were obtained from the assessment to provide practical guidelines. The quantity of NTFPs was not established so management guidelines could not be provided. It is felt that the complexity of NTFP inventory was underestimated, and a separate sub-inventory needs to be performed for specific NTFPs . It was anticipated that enough information would be collected from the natural regeneration data to allow NTFP volumes to be determined. This did not prove to be the case. This is an area that needs examining in more detail.

7.4.2 Transferability of the approach

The five FUGs involved with testing the method covered a wide variety of forest types with a variety of natural and plantation forests being assessed in different terrain. The inventory process worked well in all situations and the method and results are transferable between different forest types. The time taken to measure individual plots varies greatly depending on the terrain, forest type, tree density and amount of natural regeneration. Some plots were measured in less than ten minutes, others took over an hour. The time taken to locate the next plot also varied greatly: on gentle slopes with little ground flora it was easy to move from plot to plot; on steeper slopes it was much harder (particularly in natural forest).

It was harder to get representative samples for size class distributions in mixed natural forest as there was a wide range of species. This produced problems with data analysis because although there were a large number of individual stems recorded, the number for each species was much lower. Additionally the form of trees was more variable. This reflects a common situation with forest resource assessment: it is more difficult in a natural forest than a plantation situation.

The worst conditions encountered for conducting the inventory were open canopies with prolific scrubby ground cover. Thorns and small bushes made the inventory process very slow and difficult. Fortunately these conditions were rarely encountered. Where they are common, bias may be introduced, as it is hard to imagine FUG members or forest rangers willingly working in these areas.

7.4.3 Reliability of the results

The inventory results demonstrate that FUG members, with appropriate training and assistance, can conduct inventories of their community forests. The results include estimates of standard error, indicating how much variation might be expected among sample estimates, and confidence limits, suggesting how close results are to the parameter being estimated (Freese, 1984). Although these provide some indication of the reliability of the inventory data, there are potential sources of error that will not be shown by these. A key source, and one which critics of a participatory approach would quickly identify, is bias. Bias is a systematic error in results. It often occurs, to some extent, with highly skilled inventory teams using precision equipment, and some classic inventory techniques are known to routinely introduce slight bias, for example, using systematic sampling techniques may introduce bias (Freese, 1984). Using only recently trained members of an FUG to conduct an inventory, with cheap and home-made equipment, is likely to introduce some bias. Possible sources would include consistently sampling dbh too high or low, measuring every tree on the boundaries of plots, or misreading measurement tapes. Previous participatory inventories had identified some of these as causing bias (Lawrence and Roman, 1996).

To try to determine the reliability of the participatory inventory data, comparative inventories were conducted in three randomly selected compartments where the participatory inventory had been completed. The inventory was repeated, using a greater sampling intensity, trained foresters and commercial inventory equipment. The same parameters were measured, with the addition of height of trees, to help assess dbh/height relationships. The results of the inventories are presented in Appendix 7. Table 7.35 presents the standard error and confidence limits associated with the inventories.

	Mean (cm)	Standard error	Standard deviation	Confidence limits (95%)
Plot Bhusbuse 5, participatory inventory	13.3	0.6	3.47	1.33
Plot Bhusbuse 5, control inventory	12.6	0.60	3.59	1.21
Plot Lampatto 6, participatory inventory	14.3	0.44	3.57	0.89
Plot Lampatto 6, control inventory	15.24	0.41	3.76	0.81
Plot 'Thulodunga' participatory inventory	10.8	0.69	4.36	1.39
Plot 'Thulodunga' control inventory	10.67	0.37	3.38	0.73

Table 7.35 Error evaluation for dbh values for participatory and control inventory plots, Chulettro Pakha and Dhungeswori FUGs

It can be seen from Table 7.35 that the estimates for means obtained from the participatory inventories lie within the confidence limits of those obtained from the control inventory in two out of three cases. Lampatto 6 participatory inventory mean lies just outside the confidence limits. This indicates that there is some difference in the results, possibly due to bias, although it does not appear to be great. It is felt that these results provide support for participatory inventories, and indicate that FUG members are capable of conducting statistically valid inventories.

Another area of reliability needs examining. There are a number of stages involved in obtaining yields of forest products from the inventory data. These use models of the forest, largely based on Hamilton (1975). These models are specific to the U.K. and should not be directly applied to Nepal (no information is available for Nepal or found for the Indian subcontinent). Additionally, there is little information available on growth rates, and yield tables have not been developed. Growth rates were assumed, based on SDC experiences (Ostravee, 1998, pers. comm.). Assumptions had to be made to convert dbh and basal area information into yields of products. It was felt that an indication of reliability could be obtained by comparing the results obtained from the inventory data with results obtained by applying existing 'thumb rules' to obtain yields (Branney, 1994a). The thumb rules are based on the age, canopy density, amount of regeneration, forest condition and the type of forestry being practised. An annual yield in Tonnes/ha is derived. Table 7.36 below compares the results of this study with those obtained from applying the thumb rules.

Community forest compartment	Yield Results from 'thumb rules' (m^3/ ha)	Yield Results from study method (m^3/ ha)
Baishakeswori:		
Gha	8.0	8.65
Ga	5.0	2.24
Nga	8.0	9.09
Bhasuki:		
Sunshito Tuumko	4.5	3.15
Chulettro Pakha:		
Lampatto 6	3.5	3.55
Naya Aalhalbari	1.0	1.77
Kali Pakhari	1.0	0.81
Bhirmath	N.A.	N.A.
Bhusbhuse 5	1.0	0.72
Bhusbhuse 4	1.0	0.73
Ahal Bari Imani	N.A.	N.A.
Dhungeswori:		
Dhunge	2.5	1.26
Khadan	1.0	0.12
Melchaur	1.0	1.42
Bhasme	1.0	1.02
Gagua Khaako Gairo	1.0	0.54
Thulodunga	1.0	0.31
Ningure:		
Salleri Ghardiri	3.0	4.74

Table 7.36 A comparison of yield estimates using the study method and 'thumb rules'

It can be seen from Table 7.36 that both methods produce similar results, with a correlation coefficient of 0.92. This indicates that the assumptions made allow a reliable estimate of yield to be made, as the results have a strong association with those provided by existing methods. It is worth noting that a lot of the community forest resource assessed in this study was young, widely spaced plantation. For this type of forest the thumb rules generally provide a yield of 1.0 tonne per ha. The method used in this study allows a more accurate yield to be determined for low productivity sites.

7.4.4 Weaknesses in the approach

The main weakness was that the spatial data collection and the CFRA were not very integrated organisationally. It is a complex organisational task to integrate these activities, and one required more emphasis than was initially given. This resulted in a lack of organised feedback, and difficulties with conducting evaluation. This requires further attention, and is discussed in detail in the next chapter.

A major weakness was attempting to conduct the assessment for local level needs (FUGs and forest rangers) and to attempt to obtain biodiversity information simultaneously. The collection of biodiversity information was attempted to determine whether the requirements of diverse stakeholder groups could be met by a single simple approach. It appeared to fail due to viewing the problem in a simplistic way. It is believed that participatory inventories are well suited to conducting biodiversity assessments, and are more practical than other approaches currently being advocated (for example, see Rondeux, 1999). Providing information for local level use and for what is essentially a global stakeholder is difficult, and insufficient consideration was given to the problem. It is now felt that at this stage of developing an improved method of participatory CFRA it is better to address the needs of a solely local level stakeholders.

Top height was not measured for every sample plot. There is a good justification for this, as it is complex for FUG members to conduct and the error was found to be high. But the data would have been useful in establishing the strength of the relationship between top height and dbh and in determining the best single tree tariff chart and tariff number to use. In retrospect this information should have been collected even if it was not intended to measure top height as part of the participatory method, for evaluation purposes.

The FUG feedback was positive, but the mechanisms for receiving feedback were felt to be quite poor. There was no thorough evaluation, and the feedback was mainly at the end of the process, rather than being integrated throughout. This is a serious limitation, and both feedback and evaluation are explored in the following two chapters.

The amount of fodder available for FUG members was not determined. This was not listed as an information need by the FUG members, but it may have proved useful or interesting for them. The SDC method for determining fodder yields (see section 7.1.2) was not identified until close to the end of the fieldwork. It was trialed with Ningure FUG, and the FUG members found it to be a useful and easy method of determining fodder yields. Insufficient information was collected to be of any quantitative interest.

7.4.5 Value as a participatory exercise

Although the method has been mainly evaluated for its quantitative results, it is a participatory exercise. It was found to be a valuable participatory tool, and FUG members participated with genuine enthusiasm. The following points demonstrate the value:

- Empowerment. The process and the results had an empowering effect on the FUG as they realised that they could increase their management involvement with the resource.
- Confidence building. Conducting what were initially perceived as complicated tasks with relative ease gave FUG members more confidence in their abilities to manage the forest resource.
- Removed 'expert' view. Until the FUG members started the assessment all forest measurements had been conducted by skilled personnel from the Forest Department or development organisations. They soon realised that the techniques were not as complex as they initially thought.
- Greater understanding of the resource. The FUG members got a different perspective on their forest resource as they considered how trees grow and the structure of the resource. Ideas of sustainable use of the resource were also introduced to FUG members.
- Team building – within FUG and ranger/FUG. The FUG inventory teams included different castes, wealth and gender. These individuals would rarely, if ever, work together normally. Being in a completely different setting to normal allowed this to happen. Additionally the FUG members spent a lot of time with the ranger, who informally discussed many different aspects of forest management with the FUG members.

- Gender equality. As all the tasks were new to the FUG members there were no pre-defined gender roles, and activities were evenly split. It was noticed that the men were surprised by the capability of the women to perform all the functions, often better than the men.
- New skills. All inventory members learnt new techniques and also passed them on to other members. All the FUG inventory teams could conduct the forest assessment tasks without external assistance by the end of the inventory.

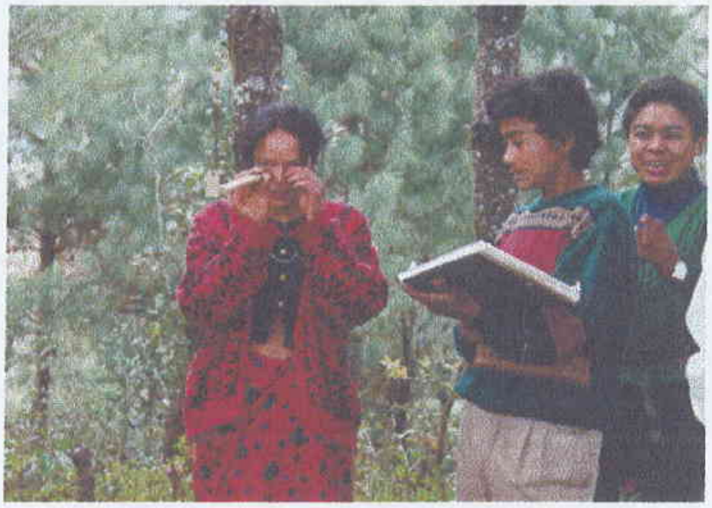
7.5 Chapter summary

This chapter has presented a new method for CFRA, based on previous methods used in Nepal. The method was trialed with five FUGs and the results analysed. It was found that the new method met most of the objectives for an improved inventory method, and provided most of the information required by the FUGs and ranger. The new inventory method has a number of advantages over previous methods:

- it is statistically valid, with error estimations provided
- it breaks the yield of wood down into timber and fuelwood
- it requires less analysis
- it is highly participatory
- it has a training component
- the FUG are provided with the inventory equipment at the end to enable them to conduct further work themselves
- it utilises the best available spatial information for calculating forest area

However, a number of areas were not successfully addressed: biodiversity could not be assessed; it was not wholly transferable to the FUG; and NTFPs were not adequately assessed. The chief weakness was the lack of a structured framework, resulting in a lack of systematic participation. It is felt that the method needs further modification. Additionally, the inventory needs to sit inside a more structured framework and decision support system to provide a strong resource assessment method.

Photographs 7-9: Top – Forest User Group Inventory Team, Dhungeswori FUG.
Middle: learning to take dbh measurements (group learning plays an important role).
Bottom: Taking dbh measurements in difficult terrain – Baishakeswori FUG.



Photographs 10-12: FUG members conducting CFRA activities: Top, measuring natural regeneration; middle, using a relascope; bottom, laying out the long axis of a 20m by 5m plot.

Chapter 8: A framework for participatory resource assessments

Chapter Overview

Gathering information for forest resource assessment is a complex procedure, involving a number of discrete stages. It requires integrating information and methodologies from different domains and disciplines, including the natural sciences, social sciences and business management. Having a framework and systematic approach is essential for effective integration (Clayton and Radcliffe, 1996).

Organised approaches to resource assessment involve either a systems based approach or a prescriptive methodology, detailing exactly what variables should be recorded and how. Whilst a prescriptive methodology is suited to assessments obtaining information for a specific objective (such as a timber inventory), it is less suited for a multiple objective assessment (Lund, 1998). It is difficult to envisage how a prescriptive approach could be applicable for CFRA. The nature of a participatory approach provides mechanisms for stakeholders to influence plans and methodologies (Hobley, 1996). This chapter argues the need for a framework that is flexible enough to be widely applicable for CFRA, but provides a consistent conceptual approach.

8.1 The need for a framework approach

CFRA involves information management of both quantitative and qualitative data, within a complex participatory resource assessment process. Once spatial data is included within the assessment, this becomes a difficult organisational problem. To maximise the benefits from using geomatics and new inventory methods a framework needs to be developed that provides a systematic approach to planning, conducting and evaluating the work. This idea is not new: Husch (1968) talks about systematically planning a forest inventory and more recently Management Information Systems (MIS) approaches have been applied in the area of MRI (Lund, 1998). It is becoming increasingly apparent that to manage complex information effectively some form of systematic approach is essential. Reynolds and Busby (1996) state that:

'.. it has become clear that the major obstacles to increased use of information in decision-making are *organisational*, not *technological* in nature, meaning that investments in information technology alone will not provide a solution.' (Reynolds and Busby, 1996, p.4, their italics).

Conducting good quality participatory work will not guarantee that the information obtained will be used for decision-making purposes. In response to this the Information Systems research agenda has changed emphasis from technical to management and organisational issues (Lee, Liebenau and De Gross, 1997). Placing the participatory work within a systematic framework, where the entire process can be analysed, improves the likelihood of it being used. For example, if there is systematic feedback to and from the FUG it will become apparent whether they feel the correct information for their management needs is being collected and presented in the best way.

A critical area that needs to be built into a framework approach is evaluation, and the two cannot (and should not) be completely separated (Allen, 1997; Bosch, Allen and Gibson, 1996). Incorporating geomatics and forest resource assessment in a participatory process is a new approach, with limited experiences of either the process or the outputs, and the evaluation of CFRA incorporating geomatics is in its infancy. The evaluation must by necessity be complex, involving participatory monitoring, spatial data analysis and more traditional methods, such as Cost-Benefit Analysis (CBA).

The theory supporting the design of the organisational framework approach is taken from a number of areas. The key area is participatory GIS. This was discussed in detail in section 3.4.5. – 3.4.7. This is the best body of theory and experience currently available that attempts to combine geomatics and participatory approaches. It also incorporates appropriate ideas from MRI design (see section 3.5.3) and the Canadian Standards Association systems based approach to forest management (CSA, 1996a,b). The framework for the forest resource assessment is termed a PGIS framework, and this is discussed below.

8.2 The CFRA framework

8.2.1 Conceptual Background

A body of theory has been developing, mainly in the USA, for designing frameworks for PGIS (see section 3.4.5.) Much of the practical experience of PGIS has been in participatory natural resource management, and some in community forestry Although, as previously stated, this is at present the best theoretical basis for the framework, it should be emphasised that PGIS is a new topic, and many issues still need considering. The approach in this study goes beyond the existing PGIS knowledge base, and brings in ideas from other areas, such as Information Systems Development Methodology (ISDM) and prototyping.

Before examining the framework a brief explanation of PGIS in this context is required. Although the management of spatial information is an integral part of PGIS, this is not the conceptual basis for it. The concept is based around the management of information: greater emphasis is placed on the means of collecting and disseminating information than on the technical design of the GIS database, as it believed that a PGIS is fundamentally dependent on obtaining community needs, perceptions and ideas. Information management and participation should both be systematic, to allow for the operation of a transparent, efficient and accountable system, that can be evaluated (Alspach, 1999). The emphasis is on the information system, and a PGIS could be defined as an information system utilising spatial data. It is important to differentiate between a GIS and a PGIS: the former is a component of the latter (see section 3.4.6).

Other background theory to the framework approach used here comes from the ideas of ISDM. This is not a single approach but a number of tools and techniques that can be used to translate information and organisational needs into a system or framework (Avison and Fitzgerald, 1998). The idea of ISDM is to provide a conceptual framework uniting what may otherwise be disparate elements, such as user needs analysis and cost-benefit analysis (Reeve and Petch, 1999). ISDM is more of a concept than a method, but it helps with the development of a logical, integrated framework, and is of obvious relevance to CFRA. The only example of ISDM being applied to forest inventory work is the recent approach taken to MRI by Lund (1998). Although this approach is not directly transferable to local level CFRAs - they are principally aimed at National level or regional level surveys with a large number of stakeholder groups - there are elements that are of relevance. The two most pertinent are the need for the participation of local communities (Hassan *et al.* 1996), and the necessity to design resource assessment methods around information needs and information systems (Lund, 1998). The new MRI approach puts great importance on a systematic approach to forest resource assessment, and it is felt that this is also entirely appropriate to community forest participatory resource assessment.

The bodies of theory outlined above all share similarities: they are highly interdisciplinary; they attempt to learn by looking at other applications and disciplines and applying or modifying approaches; operations are approached in a logical and integrated manner; and they involve feedback and evaluation to provide constant improvement. Between them they provide a wealth of knowledge and experience to design a framework for integrating geomatics and CFRA.

8.2.2 Components of the framework

The resource assessment method detailed in chapter seven (see figure 7.1), was generally effective, but three key areas were not fully addressed by it:

- the spatial data collection and the CFRA were not fully integrated
- data problems were not picked up until the end
- the evaluation did not work well

The new framework needed to address these issues in a systematic manner.

The first of these was addressed by ensuring that the examination of information needs and data to be collected occurred as a single process for spatial and inventory information. These had to be closely co-ordinated, and spatial data collection should be based on the needs of the CFRA, not as an objective in its own right. The second of the areas above indicated that there were insufficient feedback loops within the resource assessment method (information flows were uni-directional and linear). Additionally, there were no trials or pilots of inventory or data analysis methods. The final area was evaluation. This was inadequate, and there was no systematic approach in place to facilitate improvement.

The framework for a CFRA PGIS is shown in Figure 8.1. It attempts to unify the procedures for conducting the resource assessment and the geomatics approaches within a single organisational process, and put the work into a more robust organisational model. The framework is a type of rapid development method incorporating the ideas of prototyping by actively encouraging participant feedback and using this to modify the system (Bestebreurtje, 1997). Prototyping assists users views of the system and products to be reviewed and acted on (Reeve and Petch, 1999). This is achieved through feedback loops: these allow both the information given to the FUGs to be modified; and also the framework and process to change. This is important, as the framework is proposed as a system to be modified as more experience is gained. Additionally, end users often do not know what they want until they realise what is available (Giddings, 1984). It may be difficult for FUG members to articulate their information needs in terms of GIS or management plan outputs until they have seen examples.

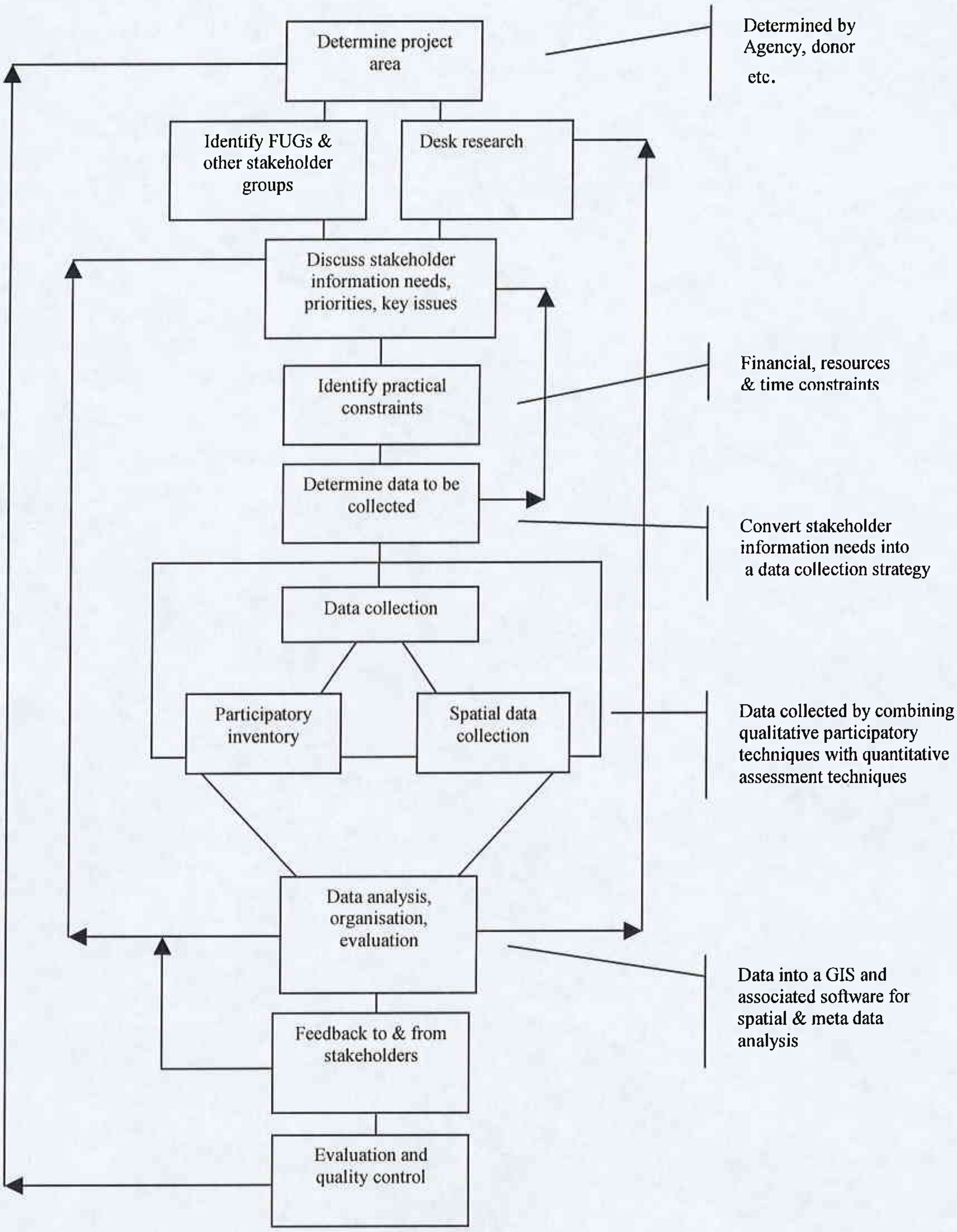


Figure 8.1 A systematic framework for a CFRA PGIS

Each stage in the framework is discussed below, and practical approaches considered.

8.2.2.1 Determining Project area

The initial stage involves determining the project area. This may be set by external agencies such as a donor or, more desirably, by the FUG themselves. They may have identified an information need, such as information about the sustained yield of timber, to meet their own requirements, such as the harvesting of timber. It is important that the extent of the project area is defined at the beginning so that appropriate information can be obtained in the next stages. In the case of this study the project area was determined by an agency (the PARDYP project) who were already operating in the Yarsha Khola watershed.

8.2.2.2 Identifying stakeholder groups and desk research

The next stages can occur in parallel. Once the project area is determined the FUGs and other stakeholders need to be identified. Even if the resource assessment procedure has been triggered by a request from an FUG it is important to identify other stakeholders, for example, nearby FUGs and the DFO may wish to be involved in the resource assessment procedure. Support from the DFO and forest ranger is essential to avoid institutional resistance that will limit effectiveness of the assessment. The DFO and forest rangers can supply information on the FUGs in the area. Initial focussed RRA work may be required to identify other potential interest groups such as village development committees. The other exercise that needs to be performed is desk research. This aims to identify what information is already existing. Established FUGs will have management plans lodged with the DFO. The DFO or donor agencies may have conducted RRA exercises and reports may be available. There may be some existing inventory information available or data from permanent sample plots. Some spatial information may be available. This could include accurate topographical maps, participatory sketch maps or chain and compass surveys of community forests or cadastral information. Attempts should be made to locate aerial photographs of the area. If dia-positives can be located it may be possible to produce high quality large scale photographs for use in PPM sessions. Locating this information may reduce the need for some fieldwork or provide alternative information sources that can be used for triangulation purposes.

8.2.2.3 Determining Information needs

In PGIS terms, this is User Needs Analysis. It is probably the most important part of the framework (McLaren, 1992). It is important that information needs are fully explored and identified, and that the PGIS is constructed to deliver this information (Chrisman, 1987). The methods used in this study offered an effective approach to this. In this instance it is best to address only local-level stakeholder information needs otherwise the data collection and information dissemination tasks become too complex. It is important that this stage is conducted thoroughly as the data to be collected will be based on these needs, and the specific design of the PGIS dependent on them (Falloux, 1989; Nossin, 1982).

8.2.2.4 Identify practical constraints

It is important to define the constraints on the resource assessment procedure. These will obviously include financial and time restraints, but also the availability of FUG members, professional foresters, translators, electricity, computers, inventory equipment and other resources. Seasonality may have an impact: in Nepal it is difficult to conduct inventory work during the monsoon, and FUG members are busy in October and early summer with agricultural activities. It may be appropriate to conduct a risk-analysis operation at this stage, to determine what externalities may affect the forest resource assessment. For example, the current DFO may be supportive of the assessment work, but doubts that his replacement will be.

8.2.2.5 Determining data to be collected

By considering the information needs in conjunction with the practical restraints, the data to be collected can be identified. The method presented in figure 7.2 worked well in this study. The practical experience from this study indicates that the ideas of optimal ignorance should be followed, attempting to collect the minimum data required to meet the information needs of the FUG and ranger. This will keep the resource assessment as simple as possible and require the least resources. Experiences from this study indicate that this stage could usefully contain a trialing of techniques to assess their suitability as practical methods and in obtaining the information required. Additionally, if the statistical reliability of data can be determined, this might dispense with the need to validate the results of the main inventory statistically. The associated error could be determined from the scoping work. This would greatly decrease the amount of analysis required, and might make it feasible for this to be conducted by the FUG, or at least in the village. This would be a major advantage, removing some of the practical and conceptual problems of analysing the information remotely.

8.2.2.6 Data collection

The data collection process can be divided into two parts, which should be closely linked: collecting spatial information and collecting forest resource information. These two activities may be conducted as separate processes, or they may be linked. Specific methods need to be identified and documented at this stage. As a general rule the simplest method to meet a data collection requirement should be used. For example, a manual GIS may be more appropriate than a computer-based GIS. There may be a need to trial techniques to ensure that they produce the desired results and remeasurement of some areas may be performed for quality control purposes. It is advisable to collect the spatial information prior to collecting the forest resource information, as the spatial data (principally the area of compartments) can be used for planning the inventory. Figure 6.16 is a decision tree to assist with identifying what geomatics applications are most appropriate. Again, it is important to try to use the simplest and most suitable approach to collect the data requirements identified. It is also necessary to consider how participatory this part of the data collection is going to be. The only geomatics approach which can be considered truly participatory is PPM. However, the other techniques can provide useful data for a participatory process, and this is discussed below. The resource assessment method developed and evaluated in this study is probably the best model currently available for CFRA in Nepal, and appears to be transferable to other areas. The specific method used needs to address the data needs and the practical constraints for the individual resource assessment, and the method developed here may require modification for local circumstances.

Similar considerations need to be given to the organisation, storage and systematic record keeping for fieldwork and data as with traditional inventories. These are well documented elsewhere (Philip, 1994; Husch, 1971). Additionally, information on the reliability of data should be obtained as part of the quality assurance procedure. Spatial and inventory data is of little use without an indication of reliability (Freese, 1984).

8.2.2.7 Data analysis, organisation and evaluation

As with data collection, data analysis should be kept as simple as possible in order to address the information needs identified earlier. Data analysis should involve converting inventory data into information on the forest resource which allow management decisions to be made. In order to do this spatial information needs to be combined with the inventory data to allow information to be based on compartments rather than hectares. It was found that even when attempting to keep data analysis as simple as possible it became a time consuming and complex task. This is a significant problem with CFRA and is discussed in more detail below. The method of analysis described in this work produces satisfactory information and allows management decision making to be performed.

Once the data has been analysed it needs to be organised into a format that will maximise its usefulness to stakeholders. This is information about the forest resource that is of use from an FUG and ranger perspective. It was found that it is best to present the information in different formats for the ranger and the FUG, as they have different information requirements. It is also important that the resource assessment information is presented in a way that assists the FUG with informed decision making for their forest resource. The information should not be used to develop management plans that are strongly suggested to, or imposed, on the FUG. Instead a number of possible management options that appear appropriate from the results of the assessment should be presented and discussed. The information fed back to the FUG should include summary information about the resource in a format that can be understood, for example, number of trees per compartment and the amount of fuelwood that can be harvested sustainably from a compartment. Complex information must be fed back in formats that are easy to understand and visualise, such as size class distribution. GIS maps of the resource should also be included in the resource information.

8.2.2.8 Feedback to the FUG

Section 7.3.10 describes the feedback conducted in this study. There are two types of feedback: feedback of information to the stakeholders; and feedback from the stakeholders on the information they received and their perceptions of the process. Although the feedback from FUG members was very positive, it was not felt that this allowed for evaluation, as there were no criteria for evaluation or systematic approach.

It is felt that feedback has to be closely associated with evaluation – it is effectively the data for a part of the evaluation process.

8.2.2.9 Evaluation

Evaluation is a key part of participatory processes, PGIS methods and ISDM. It is a circular argument to say whether evaluation should be part of the framework or whether the framework should be designed to allow evaluation (Allen, 1997). Evaluation covers a great range of operations, in the context of this study there are three areas that are considered, which together form an evaluation structure for a community forestry PGIS. They are Participatory Monitoring and Evaluation (PM&E), Cost Benefit Analysis (CBA) and data accuracy assessment.

PM&E is a subject in its own right, with its own body of literature (for examples see Anon, 1999; Estrella and Gaventa, 1998; IIED, 1998). It attempts to involve beneficiaries (or stakeholders) in the decision-making process, specifically in a critical analysis of methods used. There are a number of types of PM&E, three most relevant for this study are process (or systems-based) evaluation, outcome evaluation and impact assessment. Process evaluation measures the implementation of activities (and the effectiveness of this), outcome evaluation measures the tangible (immediate and observable) effect of activities and impact assessment ascertains the long-term consequences of activities (Anon, 1999). A range of tools are used within PM&E: many come from RRA and PRA and have been mentioned in section 3.6.6. The underlying concept is to encourage participation in the critical analysis of the project, to allow improvements to be made through feedback mechanisms. Surprisingly, there are no examples known of PM&E being used for PGIS.

CBA is a traditional decision-making and evaluation tool:

'Virtually every GIS project seems to have been subject to some form of Cost Benefit Analysis' (Reeve and Petch, 1999).

Whilst this may be an overstatement, its use is very common, despite the widespread awareness of serious limitations (Reeve and Petch, 1999: Alter, 1992; Price, 1989). The principle of CBA is to allow all costs and benefits generated over the lifetime of a project to be accounted for on a consistent monetary basis. This allows a net benefit-cost ratio to be calculated. Although this is attractively simple, producing comprehensive and meaningful monetary values for a PGIS is very difficult. Even the 'hard' GIS areas, such as procurement costs, start up costs and data conversion costs are notoriously difficult to value (Korte, 1996). Social CBA attempts to include traditionally non-monetary values into the CBA process (Price, 1989). In PGIS this is very important, but even harder to quantify in monetary terms. How much value should be put on FUGs having a computer generated map of their forest resource compared to a sketch map? It may be possible to identify all of the social costs and benefits, but quantifying them is probably little more than guesswork. However, this does not mean the CBA process is of no value: it may help provide a more detailed examination and understanding of the objectives, needs, processes and desired outcomes of the assessment. It is felt that the value of CBA for PGIS for CFRA is with the process rather than the result.

Data accuracy assessment is an important part of evaluation. This has been discussed for forest resource assessment information (where standard statistical techniques are used to indicate data reliability), but only in passing for spatial data. There are a number of errors that affect spatial data (Goodchild, 1993; Openshaw, 1989), and it is important to try and quantify this. Although the GIS literature acknowledges that spatial error must not be ignored (Kiiveri, 1997, Goodchild, 1993), there are no standard methods for assessing error (Goodchild, 1993). Whilst this is a serious problem for the GIS user after high spatial reliability, the methods for approximating error detailed in sections 6.1.2 and 6.1.5 are considered adequate for CFRA, and are certainly better than those commonly used for assessing spatial accuracy.

The thorough evaluation of a PGIS is complex, involving an integration of the three areas mentioned above. Areas that require consideration during the evaluation are presented in Table 8.1 below. This evaluation method provides for a thorough assessment of the community forest PGIS, and in addition would provide the information required for rapidly evolving the framework to meet the needs of the participants better.

PGIS Data Issues:	Means of Evaluation:
Spatial accuracy	Spatial statistics through field work accuracy statements on maps and existing data
Relevance of data	Stakeholder feedback meetings
Quality issues	Data assessment and indicators of statistical reliability, even if low
Error budgets & sources	Statistical analysis, data assessment
PGIS Process Issues:	
Level of participation (at each stage of process)	RRA, PRA & social science techniques
Stakeholder satisfaction	Stakeholder feedback meetings Examine usage of data provided by PGIS
Ability to produce & organise data for stakeholder use	Examine usage of data provided by PGIS
Assessment of long-term empowerment	RRA, PRA & social science techniques Examine outcomes of meetings/discussions using provided data
Assess how stakeholder expectations have been raised	Stakeholder feedback meetings Examine outcomes of meetings/discussions using provided data
Value of GIS to the process	Cost benefit analysis of the added value contributed by using GIS
Overall value of PGIS	Social cost-benefit analysis

Table 8.1 Evaluation areas for a PGIS

8.3 Discussion

The framework shown in Figure 8.1 provides a systematic approach to CFRA, based on the work conducted in Nepal. It is a practicable framework allowing the wide number of disparate tasks required for a CFRA to be integrated effectively. During the development of the framework it became apparent that there are a number of issues with this approach to CFRA that need further consideration.

8.3.1 A community forestry PGIS as a process

Whilst a PGIS can produce information that is useful for the FUG, it can be viewed as extractive in nature, rather than achieving the Participatory Rural Appraisal (PRA) goal of utilising local peoples analytical capabilities as well as their knowledge base

(Chambers, 1994). This may seem academic, but it is important to note that any technology which requires data to be taken away for analysis rather than encouraging people to undertake their own investigations and analysis limits participation to some extent. This ties in with the consideration of whether GIS is appropriate technology for participatory development work, where access to GIS is severely limited. Does the use of GIS foster an alienation between participants and their information? Does it remove them from much of the decision making process? If GIS is viewed as software and hardware, this could be a valid interpretation. But it is felt that a PGIS should be a process embedded within a participatory framework; it starts with the public participation procedure and intrinsically involves feedback to, and from, the FUG. Decision making should not be made centrally, the PGIS should be a decision support tool for the FUG, providing information they can use for their management decisions. Although the software and decision analysis processes are outside of the sphere of access of the FUGs, with associated problems (Harris *et al.*, 1995), it can be argued that the decision making process can be brought back to the FUG. This is a central issue in making a PGIS genuinely people orientated.

8.3.2 Representing village level reality

There can be a loss of detail when entering descriptive information obtained by participatory methods into a GIS. Qualitative information is not easily entered into a GIS, and the rich social, economic and environmental fabric of resource management at a village level is impossible to replicate. A people orientated PGIS must have a capability for storing some of this descriptive information. This may not just be as textual and diagrammatic information; multimedia offers a variety of interesting ways to represent this more realistically. But it is important to realise that all the information will still not be obtained. What is necessary is to involve local people and incorporate their knowledge and decision making into the PGIS. The task is not to capture and replicate all the village information, but to organise and present pertinent information that was not previously available, using the technological capability of GIS, to assist the FUG in their decision making. Having a framework which encourages participation and two-way communication is essential for this.

8.3.3 The need for participation

It is felt that a fundamental requirement for the use of PGIS is having the emphasis on participation. Mentioned in the introduction, this work confirms the importance of this. GIS is a useful tool for enabling the participation and empowerment of FUGs, through providing them with increased information for decision making, but only if it is geared to their needs. The technical performance of the GIS, spatial accuracy and quality of output are all secondary to the need for a participatory approach. This can easily be forgotten, particularly as this is a reversal of the traditional GIS priorities.

All the discussion points converge with the need to view a community forestry PGIS as a systems based process. The focus is on participation. Although the system will vary greatly from situation to situation, it should be based around identifying user information needs, and providing this information to support decision making. Figure 8.1 indicates a workable system, but it should be noted that as this worked progressed, the emphasis switched from the technological considerations towards participatory issues. This is where the emphasis must be for development work.

8.4 Chapter summary

CFRA is a very complex management task. It is highly interdisciplinary, resources are typically difficult to organise, and it involves co-ordinating a number of disparate activities. To allow any form of quality assurance and evaluation – and probably to achieve the CFRA objectives - a systems based framework approach is required. A framework is presented here, parts of which have been tested during the fieldwork, other elements have been developed in response to weaknesses identified in the original method.

Chapter 9. Discussion and conclusions

9.0 Chapter overview

This chapter discusses a number of issues that this research has identified as important for the design and implementation of a CFRA. These issues are discussed within the context of changing information needs and problems with existing approaches, which stimulated this research. The research has also identified a wider range of issues relating to institutional issues, evaluation and data needs.

9.1 Discussion

At the start of this thesis it was argued that a model or framework for CFRA was essential to provide an integrated and systematic approach. It was suggested that without a framework approach the potential benefits from using geomatics and CFRA techniques for community forestry could not be maximised. It was argued that, certainly in Nepal, this was a method problem. Potential techniques had not been evaluated, and no integrated approach to forest resource assessment had been successfully presented. Although there were a number of methods for CFRA that had been developed, they all had some inadequacies, and failed to incorporate geomatics technology. The existing methods were reviewed, and used to develop a new method for resource assessment. A key feature of this was the need to obtain a reasonably accurate area for the forest resource. This, coupled with reliable resource information, allowed yields to be determined and planned management to be implemented.

Geomatics and CFRAs are powerful tools for obtaining forest resource information. They provide means to rapidly and cheaply obtain estimates of the area of forest resources, and the salient characteristics of the resource. Additionally, they allow information gathering to be directly geared towards the needs of the forest users and managers (the FUG and forest ranger), and this information to be fed back to them in the most appropriate way (as defined by the FUG/ranger). This work established that a number of geomatics techniques were appropriate and operable for community orientated resource assessment in Nepal, provided an improved method for participatory resource assessment, and integrated these into a methodological framework. However, problems and limitations in the use of geomatics and participatory resource assessments have become apparent through this work. These can be divided into four categories, which need further discussion:

- participation
- obtaining spatially referenced data
- reliability of data
- institutional issues

9.1.1 Participation

The emphasis on CFRA needs to be on the participatory process. This has been commented on previously (Abott, 1998; Carter, 1996; Van Gelder and O'Keefe, 1995), and this study confirms this view. By its very nature a CFRA needs to be geared towards the needs of the participants: otherwise it becomes highly exploitative, utilising a cheap, locally available, labour source. Participation has to be fully and comprehensively integrated into the resource assessment framework. The ideal situation is where the FUG and/or forest ranger identify and address their information requirements themselves with no external input (Cornwall, 1995). At present this is unlikely to occur in most of Nepal, as forest rangers have not the time, equipment or experience to conduct a CFRA. Cornwall (1995) identified the next most preferable level of participation as co-learning (also termed interactive participation, Hobley, 1996: see Table 2.4.1). Here, outsiders facilitate the local community. It is felt that there should be an addition to this: outsiders try to develop sufficient capacity within the community that they can in future conduct the work with no external input, therefore progressing towards a higher level of participation. This indicates that an integral part of participatory forestry resource assessment is training: not so the FUG members can assist with the inventory, but *so that they can in future do it themselves*. It also implies that evaluation is an important part of the participatory forest resource framework. The level of participation and learning by the community needs to be assessed to ensure that it is being maximised. How this is evaluated is complex: it is not enough to ask FUG members whether the exercise has been useful; some indicators need to be developed (Quinney, 1994; Davis-Case, 1990).

The use of geomatics and the framework for CFRA have some important participatory implications. Participatory techniques should be in the community, with as much participation as possible (Chambers, 1994b). Both geomatics and the framework encourage information to be isolated from participants, and remotely analysed by 'experts'. This is the antithesis of a participatory approach. This leads to a fundamental question, are geomatics appropriate for participatory resource assessments?

The argument to support an integrated approach is that as long as the decision-making lies within the community then the participatory approach is still being applied. The framework has to support this: there has to be feedback to the community regarding what happens to the information, how it will be handled, where it will be kept and how it will be returned. Ideally, the community can decide all these. But, as long as the community identify the information needs, and discuss the returned information and can modify it, the decision-making is theirs. An analogy is a small business in the UK setting up a web-site. The Company may know nothing about web design and contract a designer. The Company specifies what they want, the designer produces a prototype and the Company asks for modifications to meet their requirements. Although they do not do the work, the decision making is theirs and the designer is a facilitator. In Nepal the alternative to remotely analysing spatial and inventory data is not analysing it at all (it is considered entirely inappropriate to attempt to install geomatics and IT capabilities in villages: experts would still be required to work the systems, and the set-up would be highly unsustainable). It is believed that it would be disempowering to prevent FUGs and rangers from receiving the benefits of an integrated forest resource assessment, and this is also noted by Carter (1996, p. 275). It is also felt that the PGIS framework allows for a high level of participation even though the data analysis occurs remotely. The challenge is to provide FUGs and rangers with modern approaches to resource assessment, while allowing them to keep control of the decision-making processes. The framework proposed in this study represents a significant step in this direction. It is complacent to assume that it will happen naturally or through good intentions. Full participation and community ownership need to be assured through a systematic approach.

9.1.2 Obtaining spatially referenced data

A significant part of this study concerned evaluating the suitability of a range of geomatics techniques for community forestry participatory resource assessment. This work found that it was technically and organisationally possible to use a number of tools effectively. The most questionable techniques were the use of uncorrected (stand-alone) GPS, due to the considerable spatial inaccuracies of this approach, and the rectification of aerial photographs, due to the relative complexity of the task.

For small forests (less than *ca.* 50 hectares) stand-alone GPS should not be used. Its inappropriateness has been commented on (Carlisle and Heywood, 1997; Jasumback, 1993). Differential GPS is an interesting geomatics tool. It has great potential for CFRA, and also some serious drawbacks. Differential GPS has been identified as having great potential for CFRA, but there are few examples of its use being pertinent to local level needs (Carter, 1996). This apparent paradox is due to the problems associated with using differential GPS. It is expensive, highly technical and requires a significant amount of post-processing. It is not an appropriate participatory tool, although the products from it can be of immense benefit to the FUG and ranger. If it used it is felt best not to train the FUG to push the GPS buttons, which is purely tokenistic involvement, but to have experienced GPS users acting as service providers obtaining data for the community. The appropriateness of GPS needs to be evaluated on a case-by-case basis. Technically it works in Nepal, and should work in any location with a similar infrastructure and terrain. This study concludes that differential GPS is worth using for local level CFRA – just.

At present in Nepal there is interest in the rectification of aerial photographs (Mather *et al.* 1998; Mather, 1998). As mentioned in chapter five, it is felt that if rectified aerial photographs are found to be already available during the desk study, they should be used for PPM purposes, but it is recommended that resources are not spent correcting them as part of the assessment process. It is viewed with some apprehension that this approach is part of the NUKCFP research occurring in Nepal. There appears to be a danger of reverting towards a techno-centric approach to community forestry rather than focussing on the participatory process.

PPM is ideally suited for community forestry resource assessment. It is the best example of integrating the collection of spatial information with a participatory process, and if appropriate photographs are available it should definitely be used.

It should be remembered that one of the most appropriate discussions of geomatics for participatory use did not limit the term to computer based spatial technologies (Poole, 1995). This needs to be considered in designing the method: where there is no electricity a manual GIS produces far better information than a computer based GIS.

9.1.3 Reliability of data

The reliability of data is crucial to all forest resource assessment. Ignoring systematic bias, a 100% sample of a population provides entirely reliable data. As the sample gets progressively smaller, greater assumptions are made regarding the reliability of the data (Philip, 1994). These assumptions are often quantified as standard errors. With CFRA the sampling intensity will probably be lower than with a traditional inventory. The reliability of the information will probably be lower (again, ignoring bias). To allow the inventory results to be used with confidence, an assessment of error should be included. This type of statistical information is usually considered to be inappropriate for CFRAs. Freese (1994) states that:

> 'The fact is, however, that a sample estimate is almost worthless without some indication of its reliability.' (p. 17).

This study concludes that it is inappropriate to consider a level of sampling or reliability (the two are very different) that is appropriate for CFRA in Nepal, but some indication of reliability should always be included. This should cover the inventory data and the spatial data, for example, if boundaries have been surveyed by GPS quite accurate reliability estimates can be made. Some reliability regarding derived values should be made. A weakness in the inventory method for this work was deriving standing volumes from models based on UK forests (Hamilton, 1975). If the reliability cannot be quantified, some mention of possible inaccuracies should be made.

An interesting area that was discussed in chapter six is the reliability of community defined boundaries. The boundaries of community forests may not be 'hard' boundaries. Cadastral surveys may define one boundary, DFO chain and compass surveys another, topographical maps a third and the FUG has its own mental boundary, which may differ between users. The implications of this are interesting. It is possible that when grazing is in short supply, the boundaries of the community forest (where grazing is prohibited) get smaller. Perhaps, for fuelwood, the boundaries are slightly larger. It is feasible to imagine a community buffer zone, where removing trunks and major branches is prohibited, but twigs and leaves can be removed (this was observed in one forest). A 'fuzzy' boundary may prevent disputes between land-owners and the FUG regarding whether resources belongs to the individual or a community. A sliding scale can easily be imagined, perhaps over tens of metres, where resources progressively move from individual control to community control. If the tree is 'more' privately owned than communally owned the FUG members would not consider felling it, but may remove some branches. Likewise, the individual concerned may remove grazing material from the community side of the fuzzy boundary, but would not fell a mature tree. This type of pragmatic approach, with complex unwritten rules, is quite likely to be implemented in some Nepalese villages. This was borne out by some examples of PPM using large scale aerial photographs. With these it is possible to mark individual trees either as inside or outside the community forest. In some cases there was a reluctance to delineate the boundary so precisely, and some fuzziness was desired by participants. This again questions the relevance of producing highly accurate spatial information in order to produce spatial statistics based on hard boundaries.

It is important not to become too focussed on the scientific idea of voluminous, highly reliable quantitative data. The framework and approach to CFRA advocated here integrates social and natural resource approaches to assessment. Therefore the idea of 'acceptable' data needs to be integrated. The rapid/participatory appraisal ideas of optimal ignorance and triangulation need to be incorporated (Chambers, 1994b). There are precedents for forestry management planning in situations where there is comparatively limited resource assessment data available, for example, a study by the author prior to this work (Jordan, 1996). By applying precautionary principles (Soil Association, 1994) a management plan was developed meeting the requirements of the FSC. Even with very limited sampling, by using precautionary principles of planning yields at the bottom level of confidence limits, sustained yield management can be encouraged, if not assured. If the resource is periodically monitored, the yields can, if necessary, be modified accordingly.

9.1.3.1 The role of the researcher

The scientific method implies objectivity, impartiality and an inductive approach. With participatory research this cannot be the case, due to the very nature of the activities undertaken. This obviously has implications; the researcher becomes an actor rather than observer. At the start of the research the classic scientific method can be followed. As the research progresses, activities such as facilitating, rapport building and training are undertaken. Towards the end of the field research it is possible to again become an observer, as the FUG can conduct the work themselves. It is important to realise the implications of this: the researcher is actively involved in the process, and the outcome will be influenced by the activities and actions. This is fairly common in social science research, and is key to participatory research. It should also be noted that this is not such a radical departure from the scientific method as it may appear. The scientific method is not inductive, but is best viewed as hypothetico-deductive (Popper, 1972; Phillips, 1991). Scientific research is not impartial or unbiased, and it is a myth that this is the way 'proper' research is conducted (Kuhn, 1970).

9.1.3.2 The role of the interpreter

Interpreters are often overlooked in participatory research, but their role is fundamental. An interpreter's activities can range from verbatim translation through to facilitation and restructuring of approaches, and this influences the information obtained.

An interpreter may translate questions word by word, and do the same with answers. This is the best situation for an impartial, passive interpretation role, with least influence on the results. However, interesting avenues of thought and discussion may be missed by the interpreter developing discussions by further questioning. This starts to move into facilitation. The advantage with this interpreter role is that a greater depth of understanding may be achieved by both the researchers and the participants. An interpreter may effectively take over the discussion and the approach, entirely redirecting the approach. While this may be beneficial, it is often difficult for a non-speaking researcher to understand proceedings. It is not uncommon for an interpreter to conduct a discussion for many minutes, and translate with a one word answer!

It is often difficult to ascertain which role the interpreter is playing, and it is difficult to alter the role. It is largely dependent on the personality and training of the interpreter. The best way of approaching this is to ask the interpreter exactly what s/he asked, and to provide the responses as accurately and in as much detail as possible.

It should be noted that an ability by a researcher to speak the native language and dialect is of great value in avoiding the problems outlined above.

9.1.4 Institutional Issues

This study has been largely research orientated and has not considered institutional issues in any detail, but they are so fundamental to any implementation of community forestry participatory resource assessment in Nepal that a brief discussion is required. There is literature available that considers institutional issues and community forestry in a Nepalese context (Gilmour and Fisher, 1997; Hobley 1996a,c; Jackson *et al.*, 1996; Gilmour and Fisher, 1991).

Nepal is one of the most supportive countries for community forestry and has legislation encouraging the transfer of state controlled forests to the local community, via the FUG (HMGN, 1997). However, there is some reluctance to allow community forests to produce timber or other forest products (including NTFPs) commercially. It is perceived as creating a potential conflict of interest between the Nepalese forest department and FUGs. Carter (1996) argues that Nepalese institutional support of community forestry is demonstrated by official support for qualitative-based operational plans for FUGs. This may have been the case, but the Government (or certainly some DFOs) now argue that the lack of quantitative data means that commercial harvesting cannot proceed, because sustainable yields cannot be calculated. Therefore the current situation in Nepal is that, in certain Districts, there may be active resistance to CFRA that provides this information. This institutional resistance is likely to exacerbate existing problems of lack of financial resources and overworked forest rangers. Even with institutional support it is unlikely that many DFOs will be able to analyse the spatial and inventory data collected from a participatory resource assessment, and efficiently feed it back to the FUG (and perhaps modify it to better meet their information requirements). This presents a fundamental problem: who will conduct the assessments?

The framework for CFRAs provides an excellent method for conducting this work. However, it relies on individuals or an Organisation implementing and managing it. This is a complex task. Activities have to be conducted in a specified order, and some of them simultaneously. There is a lot of data analysis required, and other significant resource implications. At present there is no institution in Nepal that could provide this service nationally. Bilateral development projects could implement the framework in their focal areas, but as a national initiative it would not be sustainable. There are three possible approaches to providing an infrastructure to allow the framework to be implemented on a wider basis:

- through the Forest Department
- through FECOFUN or a similar co-operative
- through a processor

The Forest Department has already been discounted, due to a lack of capability, and possible institutional resistance. However, they may play a significant part, for example by encouraging rangers to assist with the resource assessments.

The Federation of Community Forestry Users in Nepal (FECOFUN) has already been mentioned. With capability building this organisation has the potential to provide a forest assessment and training service, implementing the framework approach and conducting the analysis. This may help keep the entire process within the FUG, as FECOFUN is essentially an extension of the FUGs. The third possibility is to identify a processor who wishes to purchase products from FUGs and is willing to finance the assessment operation in some form of partnership with the FUG. Both of these models have been successfully implemented for community forestry, principally with the aim of achieving FSC certification. In Zambia, a Company paid for a participatory resource assessment to be implemented and a management plan to be developed from it. The Company provides for the organisation, analysis and feedback of the data (Jordan, 1996). In Madagascar a co-operative has been established for village based community forestry groups, which conducts forest resource assessments and prepares management plans designed to meet FSC requirements.

This research work did not establish the feasibility of the approaches described above, or examine them in detail.

9.2 Potential future research

This work assumed that the reliability of PPMs was greater than with traditional participatory sketch maps. No work has been found which explores this. Poudyal and Edwards (1994) conducted work that indicated less than 50% of forests identified by participatory sketch mapping could be correlated with a comparative study conducted a year later. It would be of interest and value to examine PPMs using the same method.

It would appear that basic mensuration work has been lacking in Nepal. Very little information could be found. It is probable that information is available in old project literature and internal documents within the Forest department. Transferable information must be available in India. It would be of great value to assimilate this information and publish it in some format. Once this desk research has been conducted more specific information needs could be identified. Single tree tariff charts, crop form heights, stand volume charts and yield tables would assist inventory work in Nepal greatly. These would be of great value even if based on relatively few sample plots, if estimates of reliability were provided. Unfortunately this type of research is no longer popular.

This research work ended with obtaining feedback from participants. To gauge the value of participatory processes such as forest resource assessment it is necessary to determine how the information is used by participants (Quinney, 1994). This is a part of participatory monitoring and evaluation, but one that is often not conducted in short term studies such as this. A study of whether having the resource information and management plan influences how the resource is managed, and how the increased information affects discussion with the DFO, would be of great interest. It would also be of interest to determine whether any of the FUGs attempt to conduct resource assessments by themselves.

A number of geomatics techniques and a participatory resource method were tested in this study, and used as components of a framework. The framework itself needs testing to see how it works in reality. Key areas would include building it into the institutional environment and testing the evaluation method proposed. This ties in with another potential area for further work: investigating the transferability of this approach. At present the methods are known to work for a part of the high mountains of Nepal, and transferability appears to be likely as the method was successfully tested in the mid-hills of Nepal near Kathmandu. It would be of interest to test the framework and techniques in an area where there is existing inventory information, to compare the results of these methods with more conventional approaches. It would also be of interest to use the framework in other areas where the terrain was different: for example, could high resolution satellite imagery be used instead of aerial photographs for PPM exercises in flatter areas? Additionally, it would be interesting to see if PPM worked in flat terrain, as participants would have no experience of an aerial perspective.

A final area of interest would be to see whether the CFRA provided enough information to plan for responsible forest management. A possible way of assessing this would be to evaluate the information obtained with that required by the FSC for the preparation of management plans.

9.3 Conclusions

This research has shown that integrating geomatics and participatory approaches to CFRA has the potential to provide an improved process and improved information. As geomatics and quantitative approaches to forest resource assessment also have the potential to reduce participation this is highly dependent on the approach taken, and it has been argued that these benefits will only be accrued if a systematic framework is used to provide a rigorous method.

It was shown that most of the geomatics techniques tested and evaluated in Nepal operated effectively, in some cases contrary to previous experiences. Of the techniques used, PPM and differential GPS are considered to be the most promising. It was found that a combination of PPM with GPS for georeferencing allows participatory spatial information to be easily entered into a GIS. GIS was found to be beneficial, particularly for organising spatial information and producing maps for participants. The analytical capabilities of GIS were barely utilised, and the technological issues of GIS are tertiary to the participatory and organisational considerations.

An improved method for participatory inventories was developed, tested and evaluated. It was based on advancements of existing best-practice in Nepal, combined with techniques for obtaining spatial information. It was found to be less time consuming and simpler than some of the previous approaches, more participatory and to provide reliable information. Although this represents the best approach to CFRA in Nepal to date, this is an ongoing development, and the method should be viewed as a further improvement in an ongoing process of development.

To ensure that the process works in an integrated and effective manner, and remains truly participatory, it is felt that the geomatics and participatory inventory components need to sit inside a systems based framework. A framework was developed, based on information systems principles, and specifically the ideas of PGIS. This is felt to be the most appropriate body of theory for uniting participatory and spatial approaches and represents the method for integrating geomatics and participatory techniques.

It is believed that whilst this lack of a systematic approach to participatory resource assessment has led to much beneficial innovative development, it has also led to a methodological impoverishment. One of the key results of this is a lack of a strong evaluation base for participatory resource assessments. This is a complicated issue as it involves evaluation from a social sciences perspective (PM&E) combined with more traditional quantitative evaluation techniques.

This study indicates that a framework for CFRA must be in place to ensure that:

- decision making lies with the community
- there are tangible benefits from using geomatics
- the integrated participatory resource assessment is designed to meet the participants information needs
- quality assurance, in its widest context, can be conducted through evaluation
- participation occurs throughout the process

The comment below is perhaps the best way to end, illustrating that integrating geomatics and participatory techniques allows decision-making control to rest with and empower the community:

‘Thank you for the maps, thank you for the (management) plan. They are what *we* asked for. Now maybe the DFO will let us do what *we want to do* with our forest.’ Chairman, Bhusuki FUG, 1998.

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Personal Communications

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Jirel, M. (1997) Forest Ranger, Bhirkot Range Post, Maina Pokhri, Nepal. Series of discussions at range post

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Shrestha, B. (1998) GIS Land-Use specialist for PARDYP project. Meetings in Kathmandu and Yarsha Khola watershed

Appendix 1: Itinerary and schedule for scoping study

22 April 1997 - departed London for Delhi

23 April - arrived Delhi

24 April - flew to Kathmandu - finalised Kathmandu meetings

25 April - flew to Pokhara - finalised Pokhara meetings

26-30 April - GPS field work

01 May - Institute of Forestry, Pokhara. Met with Mr. A. K Das, Assistant Dean, Mr. Ridish Pokharel, Assistant Professor, Mr. Shree Dhoubhadel, Lecturer, Mr. Chiranjibi Upadhyaya, Lecturer.

02 may - International Centre for Integrated Mountain Development, Kathmandu. Met with Mr. Pramod Pradhan, Head of the Mountain Environment and Natural Resources Information Service (MENRIS), Mr. Basenta Raj Shrestha, systems specialist, MENRIS
Mr. Steven Keeling, VSO community forester
Mr. Richard Thomsett VSO Community Forester

03 May - Nepal Australia Community Forestry Project. Met with Mr. Steve Hunt, team leader.
CARE Nepal. Met with Dr. Balaram Thapa
Talked with Mr. Nick Roche, team leader, Nepal-UK Community Forestry Project

04 May - Nepal/Swiss Community Forestry Project (Swiss Agency for Development & Cooperation). Met with Mr. Karl Schuler, team leader.
SNV Nepal (Netherlands Development Organisation). Met with Sonja Zimmermann, Policy and Programme Coordinator (Deputy Director)
FORESC (Forest Research & Survey Centre). Met with Mr. Prem Pradhan.
FRISP (Forest Resource Information System Project). Met with Mr. Tuomo Pikkarainen.

05 May - depart Kathmandu

06 May - arrive London

Persons consulted with in the UK or by post

Anna Lawrence AERDD
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Peter Branney, LTS International

Appendix 2: Guidelines for using GPS in Nepal

Below are practical guidelines on using GPS in Nepal, based on a short period of fieldwork in spring 1997.

Introduction

GPS has had only limited usage in Nepal. Initial reports of its use were not encouraging, with it generally failing to operate effectively in the hills and forests of Nepal. However, the experience during the fieldwork mentioned above was positive, and it was found that GPS can be used effectively, with some prior preparation and using certain techniques. These guidelines assume a working knowledge of differential GPS.

Technical requirements

- Two professional GPSs, capable of data logging, differential correction and with ten or more channels. This last point appears to be important, and may be a key reason why previous attempts to use GPS in Nepal have been unsuccessful. Magellan pro mark 10 GPSs are recommended. One GPS should be used as a base station, the other as a rover, allowing post-processed differential correction to be performed.
- Computer (preferably lap-top) to act as a data logger for the base station, and for post-processing
- A multi-path resistant antenna for the base station (these assist with carrier phase operation) and 10m cable to allow it to go on a roof or similar
- Voltage regulators
- Extension leads and plug sockets from outside Nepal (those sold locally are unreliable)
- Short antenna cables so the GPS antenna on the rover GPS can be mounted above a backpack for hands free operation
- Spare battery power-packs
- A generator if away from a reliable power source
- Spare leads and connectors with tools to make minor repairs to cables etc.

Paperwork

- Letters of invitation/collaboration or MoUs from organisations in Nepal stating the GPS is for work with them. Preferably paperwork from Government Departments
- If appropriate, letters from research organisations from outside Nepal
- Letters from the manufacturers stating that the GPS and batteries are safe for commercial passenger flights (this is important or the battery packs may be confiscated at airports)

Practical Restrictions to be considered

It was found that power supply, even in a major city, was unreliable, both in terms of duration of the power supply and the voltage supplied. A generator has to be used, or it must be accepted that some working time will be lost due to power losses either directly causing equipment failure or preventing batteries being charged. It is also critical to use a voltage regulator to protect the GPSs and associated hardware.

Electrical extension leads and adaptors should be brought from outside Nepal, as those available in the country are unreliable.

Extension leads of at least 10m are needed to allow base station aerials to be located on roofs.

Don't use Chinese batteries for backup batteries, as they have a short life and data can be lost. Additionally they may leak causing catastrophic damage to electrical equipment. Bring Duracell type batteries from outside (or purchase in Kathmandu where they are widely available).

In Nepal the base station will probably have to be located at a geographically unknown location, and the location determined by secondary means (such as averaging GPS readings). The effect of this on the spatial accuracy of data has not yet been determined. Additionally, if working in the high mountains of Nepal it is likely that the position of the base station will not allow unrestricted visibility of the sky. This may effect differential processing.

The terrain in Nepal is very steep, and this provides a limitation on where boundary surveying can physically be performed. This is a genuine problem, and it is easy to get into potentially hazardous situations (e.g. 50^0 slopes with wet and loose vegetation).

Using a GPS as a data logger and then downloading the data to a computer is very time consuming, the downloading taking about 15 minutes for every hour of base station data recorded. Therefore it is preferential to use a computer as a direct data logger for the GPS, avoiding the need for any subsequent downloading.

Bring the GPS manuals, duct tape and insulation tape! Nepal is tough on electrical equipment.

Appendix 3: Local and Botanical plant names[1]

Ainselu	Rubus ellipticus
Amola	Phyllanthus emblica/Emblica officianalis
Angeri (Ungari)	Lyonia ovalifolia
Aru	Prunus persica
Arupate	Prunus cornuta, P. napaulensis
Asari	Lagerstroemia paviflora L. sp.
Balaya *	
Banjh	Quercus lanata
Banmara	Lantana camera (Shrestha), Eupatorium spp. (Jackson)
Bansi	Quercus lamellosa
Bayer (Bayar)	Zizyphus jujuba
Benso (Bansi?)	Quercus lanata
Bhabaya *	
Chilaune	Schima wallichii
Chulesi	Melastoma malabaricum
Chutro (Chuttro, Chettro)	Berberis Spp. (chitria, macrophylla, thunbergii)
Dabre	Quercus lamellosa
Dudhilo	Ficus neriifolia var. nemoralis
Ghangaru	Pyracantha crenulata
Ghunda Sugane *	
Ghurmiso (Gharmiso)	Leucosceptrum canum
Gobre Salla (Gorge& Khote Salla)	Pinus wallichiana
Gogane	Quercus lamellosa
Gurans	Rhododendron arboreum
Hadebayer	Ziziphus rugosa
Jasare *	
Jhigane (Jhigini, Jhingane)	Eurya acuminata E. cerasifolia
Kainyo (Khainyo phul)	Grevillia robusta
Kandar	Aesculus indica
Kaphal (Kafal)	Myrica spp.
Katus	Castinopsis indica
Khalme (Khalmi)	Ipomoea reptans (?)
Khar	Cymbopogon microtheca
Khareto (Khereto)	Phyllanthus parvifolius
Kharuki (Kharuni)*	
Khashru (Khasru)	Quercus semecarpifolia
Khote salla (Rani & Aulo Salla)	Pinus roxburghii
Kukurdiano	Smilax microphylla
Kutmiro	Litsea monopetala

[1] The information in this Appendix has been mainly sourced from Howland and Howland (1984), which is the best source of information currently available for foresters conducting field-work in Nepal. Additionally, Sandra Brown (Assistant Professor, University of British Columbia) kindly provided a list of botanical names compiled for her thesis.

Lokta	Daphne spp.
Mel (Mele, Malo)	Pyrus pashia
Mulu	Bauhinia vahlii
Nigalo	Drepanostachyum spp.
Nundhiki	Osyris wightiana
Oinyu	Dryopteris filix-mas
Painyu (Painyo)	Prunus cerasoides
Panhele (Panheli)	Litsea oblonga
Patle (Pate) salla	Pinus patula
Patpatay	Gaultheria hookaris
Pauli	Kidia calycine
Phalat (Phalant, Falant)	Quercus glauca or Quercus lamellosa
Pipiri*	
Pyauli (Payuli)	Reinwardtia indica
Raktachan (Rakta chandan)	Pterocarpus santalium
Rani salla (Khote & Aulo Salla)	Pinus roxburghii
Sal	Shorea robusta
Sim ghans (Sim bans)	Utricularia bifida
Siru (Seru)	Imperata cylindrica
Sottar (Sotter)*	
Ungeri (Angeri)	Lyonia ovalifolia
Utis	Alnus nepalensis
Yangari (Angeri)	Lyonia ovalifolia
Yasare*	

* The botanical name for these plants could not be determined

Appendix 4: The forest inventory form

FUG name:	
Forest/compartment name:	
Plot number:	
Date & information collected by:	

Plot characteristics: 20*5m plot								
Aspect:	N	NE	E	SE	S	SW	W	NW
Drainage:	Good				Poor			
Slope class:	Steep (>40^{0})		Moderate (20-40^{0})			Gentle (<20^{0})		
Fire evidence:	Yes (comment):						No:	
Grazing intensity:	Terracettes		Droppings			Grazed plants		
Crown cover:	Closed		Moderate(<80%)			Open (<20%)		
Comments								

Trees: (only above 16cm girth - 5cm dbh)						
Species:	Circumference cm:	Form:		Lopping:		
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High
		Poor	Good	None	Low	High

Forest form page 2

Forest/compartment name:	Plot number:

Natural regeneration: Whole plot (20*5m) - ONLY ABOVE 2 METRE HEIGHT	
Species:	Height cm:

Forest form page 3

Forest/compartment name:	Plot number:

Natural regeneration: Sub-plot (5*5m) - ONLY BELOW 2 METRE HEIGHT	
Species:	Height cm:

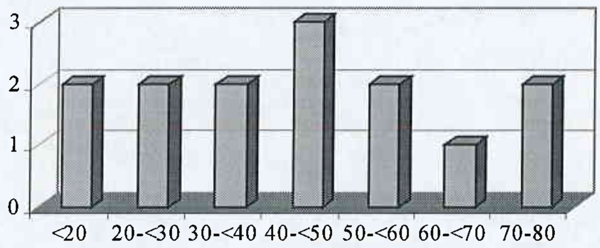
Soil exposure:	None	<30%	30-60%	>60%

Felling intensity (Number of tree stumps in plot):	

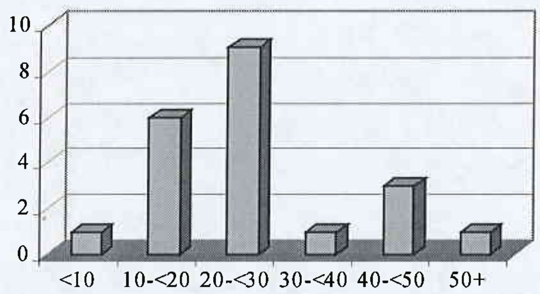
Basal area (No. of trees through viewing stick)	

Appendix 5: The inventory results: Compartment summary sheets for the participatory forest inventory

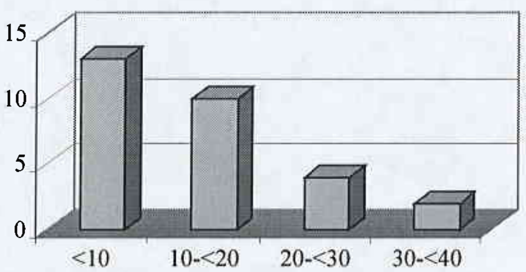
FUG:	Baishakeswori		
Compartment name/number:	Gha		
No. of plots:	14		
Aspect:	NW		
Slope (degrees):	20-40, some 40+ (av. 40)		
Fire evidence:	No		
Grazing evidence:	Some low intensity evidence (old droppings)		
Canopy (%):	Varied between <80% to closure		
Soil exposure (%):	All sites 30-60%, or 60%+		
Lopping:	Mainly none, one plot high incidence		
No. of stumps per ha:	270		
Natural regeneration:	Khalmi and Lokta		
Condition/comments:	Excellent natural forest with many large trees, lichens, epiphytes etc. Good regeneration. Used quite intensively at top (near teashops and small settlement), but still in good condition. Little grass, lots of leaf litter. Quite shaded on the forest floor in many parts, a fairly dense, high canopy. Some evidence of historic pitsawing in the forest		
Key species:	i. Khalmi ii. Gurans iii. Angeri Also: Panhele, Jhigane, Malo, Simbans, Raktachan, Yasare, Ghunda Sugane, Arupate, Ghurmisu		
No. of stems per ha:	840 total, Khalmi 207, Gurans 150, Angeri 100		
Form:	About 50% of trees poor form		
Average dbh per species (cm):		Standard error	Confidence limits (95%)
	i. 14.7	1.66	3.41
	ii. 27.0	3.42	7.13
	iii. 42	5.68	12.27
Max dbh for form factor (cm):	78		
Basal area M^2/ha:	Standard 16.3	Corrected for slope angle 19.9	
Total Volume M^3/ha	Standard 236	Corrected for slope angle 288	



Size class distribution for Angeri (dbh cm)



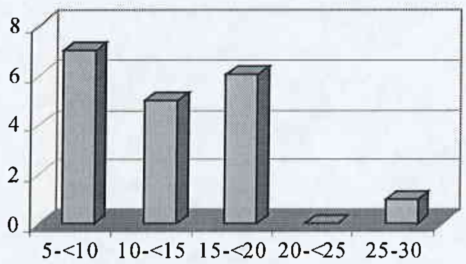
Size class distribution for Gurans (dbh cm)



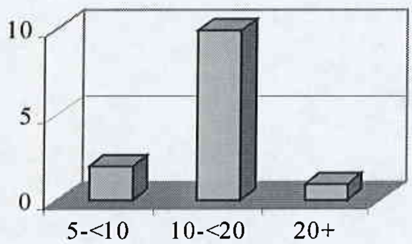
Size class distribution for Khalmi(dbh cm)

Table 1: Participatory inventory summary sheet for Baishakeswori FUG, Gha compartment

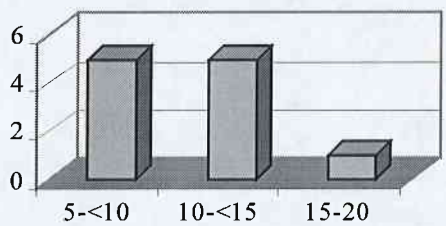
FUG:	Baishakeswori		
Compartment name/number:	Ga		
No. of plots:	8		
Aspect:	Predominantly NW		
Slope (degrees):	<20 to 20-40		
Fire evidence:	Only on one plot		
Grazing evidence:	No		
Canopy (%):	Mainly <20		
Soil exposure (%):	< 30 (3 plots), 30-60 rest		
Lopping:	2 plots high, 3 plots low, 3 plots none		
No. of stumps per ha:	225		
Natural regeneration:	Above 2 m, Yasare, Khalmi, Sottar; below 2m Ainselu, Utis, Gurans		
Condition/comments:	Compartment degraded, a fairly poor area of forest. High incidence of lopping, the compartment has only recently been managed. Accessible, so heavily utilised		
Key species:	i. Gharmiso ii. Gurans iii. Angeri Also: Yasare, Bhabaya, Ghunda Sugane, Jasare, Khalmi, Malo, Phalat		
No. of stems per ha:	Total 890, Gharmiso 240, Gurans 160, Angeri 140		
Form:	Predominantly poor		
Average dbh per species (cm):		Standard error	Confidence limits (95%)
	i. 13.4	1.14	2.39
	ii. 13.8	1.84	4.02
	iii. 11.4	0.94	2.10
Max dbh for form factor (cm):	31		
Basal area M^2/ha:	Standard 11	Corrected for slope angle 13.4	
Total Volume M^3/ha	Standard 62	Corrected for slope angle 75	



Size class distribution for Ghurmiso(dbh cm)



Size class distribution for Gurans (dbh cm)



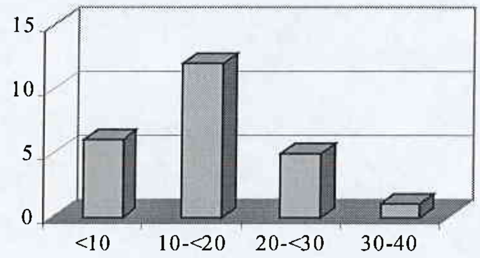
Size class distribution for Angeri (dbh cm)

Table 2: Participatory inventory summary sheet for Baishakeswori FUG, Ga compartment

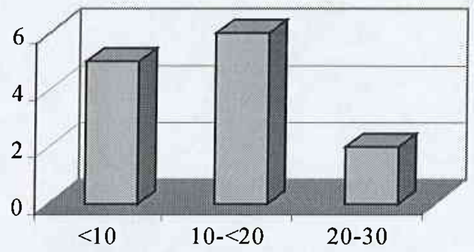
FUG:	Baishakeswori
Compartment name/number:	Nga
No. of plots:	4
Aspect:	NW
Slope (degrees):	20-40
Fire evidence:	No
Grazing evidence:	No
Canopy (%):	Mostly <80, one plot <20
Soil exposure (%):	30-60
Lopping:	All plots some trees with low levels
No. of stumps per ha:	370
Natural regeneration:	Large: Malo, Khalmi, Angeri, Yasare, Simbans. Small: Lokta, Pipiri, Khalme, Sotter
Condition/comments:	A lot of leaf litter present, but few grasses or shrubs. In general low levels of natural regeneration, and quite dense forest. It appears to be in good condition
Key species:	i. Gurans, ii. Angeri Also: Balaya, Chutro, Ghunda Sugane, Khalmi, Khasru, Malo, Painyo, Raktachan, Sim bans, Utis, Yangari, Yasare
No. of stems per ha:	Total 1725, Gurans 600, Angeri 325
Form:	Equal between good and poor

Average dbh per species (cm):		Standard error	Confidence limits (95%)
	i. 15.7	1.43	2.96
	ii. 13.7	1.93	4.17

Max dbh for form factor (cm):	53	
Basal area M^2/ha:	Standard 39.5	Corrected for slope angle 43.6
Total Volume M^3/ha	Standard 366	Corrected for slope angle 404



Size class distribution for Gurans (dbh cm)

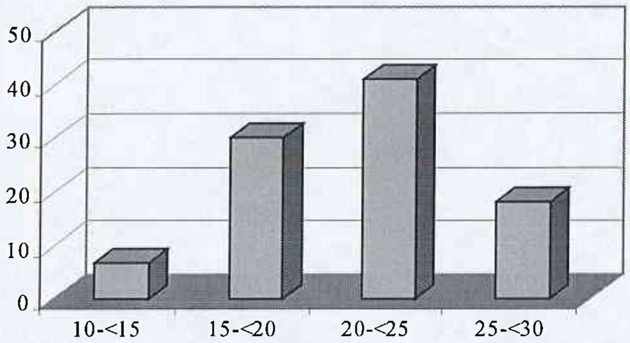


Size class distribution for Angeri (dbh cm)

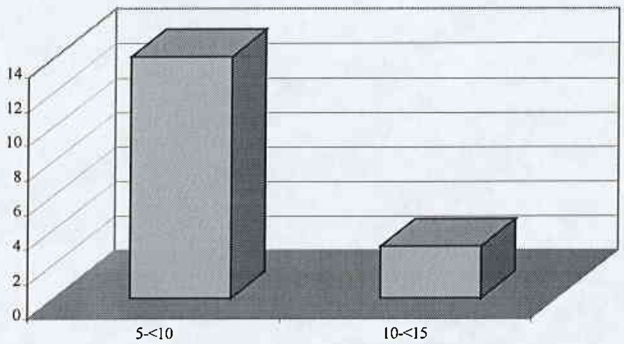
Table 3: Participatory inventory summary sheet for Baishakeswori FUG, Nga compartment

FUG:	Bhasuki
Compartment name/number:	Sunshito Tumko
No. of plots:	16
Aspect:	NW/W/SW
Slope (degrees):	Mainly <20, three plots 20-40
Fire evidence:	No
Grazing evidence:	N
Canopy (%):	Highly variable, from <20 to >60
Soil exposure (%):	Mainly 30-60
Lopping:	In most plots there was a high incidence of lopping
No. of stumps per ha:	75
Natural regeneration:	Abundant Chilaune, Ainshelu, smaller shrubs and a good herb layer. Some Khote Salla regeneration
Condition/comments:	A plantation forest that is close to a large village. When it was a state forest it was heavily (illegally) utilised for fuelwood and fodder, with some trees being felled as well. Now that it is managed as a community forest there is stricter management enforced.

Key species:	i. Khote Salla ii. Chilaune		
No. of stems per ha:	Total 720, 615 Khote salla, 106 Chilaune		
Form:	Good		
Average dbh per species (cm):		Standard error	Confidence limits (95%)
	i. 21	0.42	0.84
	ii. 7.7	0.68	1.45
Max dbh for form factor (cm):	32		
Basal area M^2/ha:	Standard 13.9	Corrected for slope angle 14.9	
Total Volume M^3/ha	Standard 85	Corrected for slope angle 91	



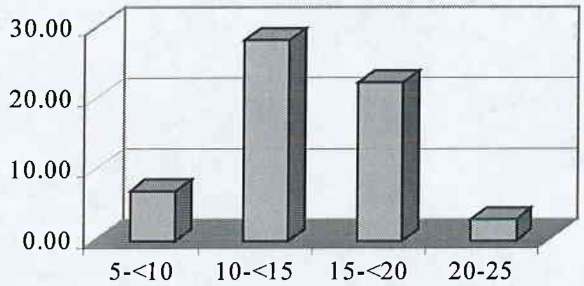
Size class distribution for Khote Salla (dbh cm)



Size class distribution for Chilaune (dbh cm)

Table 4: Participatory inventory summary sheet for Bhasuki FUG, Sunshito Tumko compartment

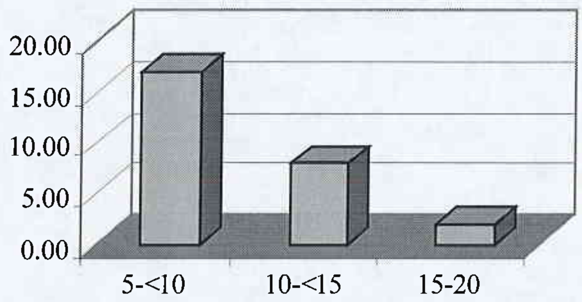
FUG:	Chulettro Pakha		
Compartment name/number:	Lampatto 6		
No. of plots:	4		
Aspect:	S		
Slope (degrees):	Varied, from <20 to >50		
Fire evidence:	Yes		
Grazing evidence:	No		
Canopy (%):	Average <80, quite variable		
Soil exposure (%):	60, variable		
Lopping:	Generally low		
No. of stumps per ha:	0		
Natural regeneration:	Banmara, Khareto , Siru		
Condition/comments:	Khote salla plantation, good shrub layer and abundant grasses		
Key species:	i. Khote Salla		
	Other: Chilaune		
No. of stems per ha:	Total 1550, 1500 Khote salla, 50 Chilaune		
Form:	Generally good, one plot where several trees were poor		
Average dbh per species (cm):	i. 14.3	Standard error 0.44	Confidence limits (95%) 0.89
Max dbh for form factor (cm):	23		
Basal area M^2/ha:	Standard 21	Corrected for slope angle 24	
Total Volume M^3/ha	Standard 85	Corrected for slope angle 97	



Size class distribution for Khote Salla (dbh cm)

Table 5: Participatory inventory summary sheet for Chulettro Pakha FUG, Lampatto 6 compartment

FUG:	Chulettro Pakha		
Compartment name/number:	Naya Aahalbari		
No. of plots:	2		
Aspect:	NW		
Slope (degrees):	20-40		
Fire evidence:	In one plot		
Grazing evidence:	No		
Canopy (%):	<80		
Soil exposure (%):	<30		
Lopping:	A little in one plot		
No. of stumps per ha:	0		
Natural regeneration:	A lot of small P. Salla and Angeri. Also Banmara, Khareto, Sotter and Gurans		
Condition/comments:	A fairly dense plantation, with some large open spaces with a good shrub layer		
Key species:	i. Khote Salla		
No. of stems per ha:	1360		
Form:	Good		
Average dbh per species (cm):	i. 9.6	Standard error 0.659	Confidence limits (95%) 1.35
Max dbh for form factor (cm):	18.14		
Basal area M^2/ha:	Standard 16.5	Corrected for slope angle 16.75	
Total Volume M^3/ha	Standard 49	Corrected for slope angle 50	

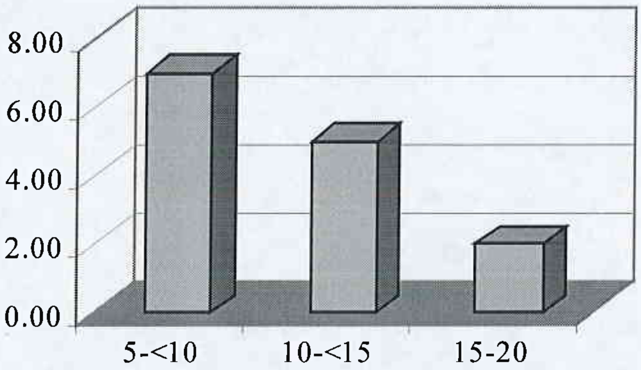


Size class distribution for Khote Salla (dbh cm)

Table 6: Participatory inventory summary sheet for Chulettro Pakha FUG, Naya Aahalbari compartment

FUG:	Chulettro Pakha
Compartment name/number:	Kali Pokhari
No. of plots:	2
Aspect:	NW
Slope (degrees):	One plot 20-40, other >40
Fire evidence:	Yes
Grazing evidence:	No
Canopy (%):	<80
Soil exposure (%):	30-60
Lopping:	No
No. of stumps per ha:	0
Natural regeneration:	Large: Ungari, Kainyo, P. Salla, Gurans, Amola. Small: Banmara, Khareto, Oinyu, Siru
Condition/comments:	A plantation with some natural regeneration. It is good for fuelwood. It has a good shrub layer.

Key species:	i. Khote Salla		
No. of stems per ha:	700		
Form:	Good		
Average dbh per species (cm):	i. 10.5	Standard error 0.90	Confidence limits (95%) 1.96
Max dbh for form factor (cm):	15.6		
Basal area M^2/ha:	Standard 11	Corrected for slope angle 11.1	
Total Volume M^3/ha	Standard 27.5	Corrected for slope angle 28	



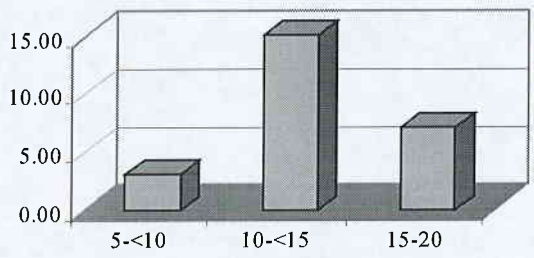
Size class distribution for Khote Salla (dbh cm)

Table 7: Participatory inventory summary sheet for Chulettro Pakha FUG, Kali Pokhari compartment

FUG:	Chuletro Pakha		
Compartment name/number:	Bhirmath 9		
No. of plots:	2		
Aspect:	SW		
Slope (degrees):	One plot 20-40, one plot >40		
Fire evidence:	Yes		
Grazing evidence:	No		
Canopy (%):	<20		
Soil exposure (%):	<30		
Lopping:	None		
No. of stumps per ha:	50		
Natural regeneration:	Large: Khainyo, Katus, Chilaune, Gurans. Small: Banmara, Sottar, Khareto, Kharuki, Siru		
Condition/comments:	Natural shrubland, with trees of a low height, and all <5cm dbh. Appears to be good condition rangeland, and the FUG value it for fodder products		
Key species:	i. N.A.		
No. of stems per ha:	N.A.		
Form:	N.A.		
Average dbh per species (cm):	N.A.	Standard error	Confidence limits (95%)
Max dbh for form factor (cm):	N.A.		
Basal area M^2/ha:	Standard N.A.	Corrected for slope angle	
Total Volume M^3/ha	Standard N.A.	Corrected for slope angle	

Table 8: Participatory inventory summary sheet for Chulettro Pakha FUG, Bhirmath 9 compartment

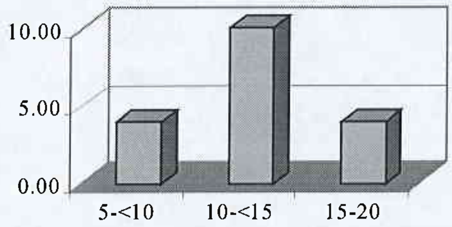
FUG:	Chulettro Pakha		
Compartment name/number:	Chulettro Pakha/Bhusbuse 5		
No. of plots:	3		
Aspect:	SE		
Slope (degrees):	<20, one plot 20-40		
Fire evidence:	No		
Grazing evidence:	On one plot terracettes, dung and grazed shrubs noted		
Canopy (%):	Highly variable, from <20 to 80		
Soil exposure (%):	60		
Lopping:	Some trees with a little lopping		
No. of stumps per ha:	0		
Natural regeneration:	Large: Bayar, Chuttro, Painyo, khareto. Small: Khareto, Chutro		
Condition/comments:	An open plantation, with evidence of heavy past grazing, and probably some continuing. There is a good shrub and grass layer, not overgrazed		
Key species:	i. Khote Salla		
	Also: Mele (very few)		
No. of stems per ha:	830		
Form:	Good		
Average dbh per species (cm):	i. 13	Standard error 0.65	Confidence limits (95%) 1.33
Max dbh for form factor (cm):	16		
Basal area M^2/ha:	Standard 8.3	Corrected for slope angle 8.4	
Total Volume M^3/ha	Standard 25	Corrected for slope angle 25.1	



Size class distribution for Khote Salla (dbh cm)

Table 9: Participatory inventory summary sheet for Chulettro Pakha FUG, Chulettro Pakha/Bhusbuse 5 compartment

FUG:	Chulettro Pakha		
Compartment name/number:	Bhusbuse 4		
No. of plots:	2		
Aspect:	SE		
Slope (degrees):	<20		
Fire evidence:	No		
Grazing evidence:	No		
Canopy (%):	<20		
Soil exposure (%):	>60		
Lopping:	A little light lopping in one plot		
No. of stumps per ha:	0		
Natural regeneration:	Chutro, Khareto, Amola, Hadebayer		
Condition/comments:	A plantation, with much of the planting having failed. The central area of the compartment has been successful, the rest has not, and has a good cover of shrubs and grasses		
Key species:	i. Khote Salla Also Chilaune and Hadebayer		
No. of stems per ha:	Total 1100, 900 Khote Salla		
Form:	Good		
Average dbh per species (cm):	i. 12.78	Standard error 0.71	Confidence limits (95%) 1.50
Max dbh for form factor (cm):	17		
Basal area M^2/ha:	Standard 8.5	Corrected for slope angle 8.5	
Total Volume M^3/ha	Standard 25.5	Corrected for slope angle 25.5	



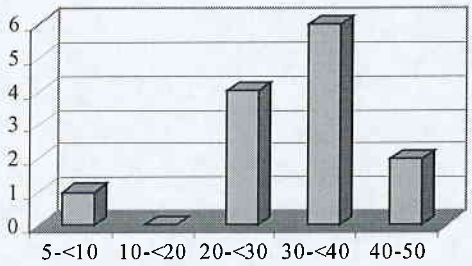
Size class distribution for Khote Salla (dbh cm)

Table 10: Participatory inventory summary sheet for Chulettro Pakha FUG, Bhusbuse 4 compartment

FUG:	Chulettro Pakha
Compartment name/number:	Ahal Bari Imani
No. of plots:	7
Aspect:	South (one plot SE, one plot SW)
Slope (degrees):	Mainly <20, two plots 20-40
Fire evidence:	No
Grazing evidence:	One plot with animal dung present
Canopy (%):	<20
Soil exposure (%):	<30 to >60
Lopping:	No
No. of stumps per ha:	0
Natural regeneration:	Chutro, Chilaune, Hade bayer, Banmara and a range of grasses
Condition/comments:	This compartment is terraced bari with a few scattered trees. There is a lot of grass present, the area is mainly used for gathering this. There are areas of serious erosion (several meters deep) caused by monsoon streams. There are also areas which have been recently planted.
Key species:	i. Mel ii. Khote Salla Also some Chilaune. All species are very scattered with few trees in this compartment
No. of stems per ha:	220
Form:	Mainly good
Average dbh per species (cm):	Standard error / Confidence limits (95%) i. 12.9 / 2.29 / 5.27 ii. 13.6 / 2.24 / 5.76
Max dbh for form factor (cm):	N.A.
Basal area M^2/ha:	Standard: N.A.; Corrected for slope angle
Total Volume M^3/ha	Standard: N.A.; Corrected for slope angle

Table 11: Participatory inventory summary sheet for Chulettro Pakha FUG, Ahal Bari Imani compartment

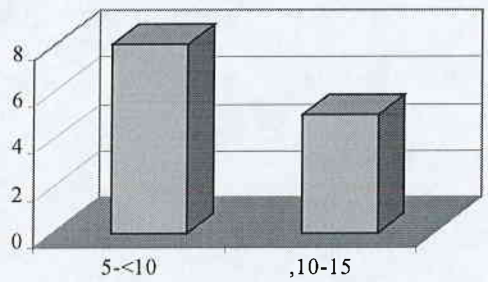
FUG:	Dhungeswori		
Compartment name/number:	Dhunge		
No. of plots:	5		
Aspect:	SW		
Slope (degrees):	<20 and 20-40		
Fire evidence:	Yes (all plots)		
Grazing evidence:	No		
Canopy (%):	Variable but sparse (<20-<80)		
Soil exposure (%):	0 to 60		
Lopping:	A small amount of light lopping		
No. of stumps per ha:	20		
Natural regeneration:	Large: Kainyo, Angeri. Small: Amola, Khareto, Banmara and a range of grasses		
Condition/comments:	This is an area of natural forest with scattered large trees. There is good natural regeneration. It appears to be in a good condition, with a lot of shrubs. It is used for fodder collection		
Key species:	i. Rani salli Also: Gurans, Chilaune, Khainyo		
No. of stems per ha:	Total 320 Rani Salla, 260		
Form:	Good		
Average dbh per species (cm):	i. 32	Standard error 2.9	Confidence limits (95%) 6.3
Max dbh for form factor (cm):	48		
Basal area M^2/ha:	Standard 4.0	Corrected for slope angle 4.1	
Total Volume M^3/ha	Standard 35	Corrected for slope angle 36	



Size class distribution for Rani Salla (dbh cm)

Table 12: Participatory inventory summary sheet for Dhungeswori FUG, Dhunge compartment

FUG:	Dhungeswori		
Compartment name/number:	Khadan		
No. of plots:	5		
Aspect:	Mainly S, one SW, one NW		
Slope (degrees):	<20		
Fire evidence:	Yes, in four of the plots		
Grazing evidence:	No		
Canopy (%):	Mainly <20, one plot <80		
Soil exposure (%):	0 to <30		
Lopping:	Light lopping in two plots		
No. of stumps per ha:	0		
Natural regeneration:	P. Sallo (a lot), Amola, Mel, Chettro, banmara, Jhigini, Seru, Ainselu, Chilaune, Gurans		
Condition/comments:	A young plantation, with areas of young trees interspersed with areas of rangeland. Most of the rangeland is in good condition, with good shrub growth. There are parts with dense shrubs which are virtually impenetrable, and made this some of the most difficult terrain encountered for conducting the inventory		
Key species:	i. Pate Sallo Also: Angeri, Chilaune, Mavo		
No. of stems per ha:	Total 380, P Sallo 260		
Form:	Good		
Average dbh per species (cm):	i. 9.62	Standard error 0.54	Confidence limits (95%) 1.18
Max dbh for form factor (cm):	14		
Basal area M^2/ha:	Standard 2.2	Corrected for slope angle 2.3	
Total Volume M^3/ha	Standard 5.5	Corrected for slope angle 5.75	



Size class distribution for Pate Salla (dbh cm)

Table 13: Participatory inventory summary sheet for Dhungeswori FUG, Khadan compartment

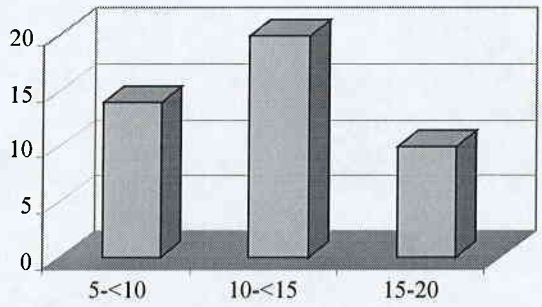
FUG:	Dhungeswori		
Compartment name/number:	Melchaur		
No. of plots:	4		
Aspect:	South (one plot SW, one plot NW)		
Slope (degrees):	<20 (one plot 20-40)		
Fire evidence:	Yes (all plots)		
Grazing evidence:	No		
Canopy (%):	<20		
Soil exposure (%):	<30		
Lopping:	None		
No. of stumps per ha:	0		
Natural regeneration:	Large: Gurans, Chilaune, Angeri, Banmara, Seru, Utis Small: a variety of grasses		
Condition/comments:	Mainly grassland under young plantations, most trees ,5cm dbh. This areas was badly burnt but is now starting to recover. It provides a lot of fodder and is a useful part of the forest. No size class histogram as all trees 5-10cm dbh		
Key species:	i. Pate Salla Also: Mel		
No. of stems per ha:	Total 300, p. Salla 250		
Form:	Good		
Average dbh per species (cm):	i. 6.2	Standard error 0.32	Confidence limits (95%) 0.73
Max dbh for form factor (cm):	8		
Basal area M^2/ha:	Standard 3.5	Corrected for slope angle 3.6	
Total Volume M^3/ha	Standard 7.0	Corrected for slope angle 7.2	

Table 14: Participatory inventory summary sheet for Dhungeswori FUG, Melchaur compartment

FUG:	Dhungeswori		
Compartment name/number:	Bhasme		
No. of plots:	4		
Aspect:	Two plots NE, two NW		
Slope (degrees):	20-40, one plot >40		
Fire evidence:	Yes		
Grazing evidence:	No		
Canopy (%):	<20		
Soil exposure (%):	<30		
Lopping:	Some trees lightly lopped		
No. of stumps per ha:	0		
Natural regeneration:	Seru, Kharuki, Angeri, Khareto		
Condition/comments:	This compartment is essentially rangeland. It has luxuriant grass growth, and the trees are very small, principally Gurans. This area was badly burnt and the trees are probably natural regeneration since the fire. All the trees are 5-10cm dbh		
Key species:	i. Gurans Other: Gobre Salla		
No. of stems per ha:	Total 150 Gurans, 125		
Form:	Good		
Average dbh per species (cm):	i. 8.3	Standard error 0.756	Confidence limits (95%) 2.1
Max dbh for form factor (cm):	10		
Basal area M^2/ha:	Standard 1	Corrected for slope angle 1.15	
Total Volume M^3/ha	Standard 1	Corrected for slope angle 1.15	

Table 15: Participatory inventory summary sheet for Dhungeswori FUG, Bhasme compartment

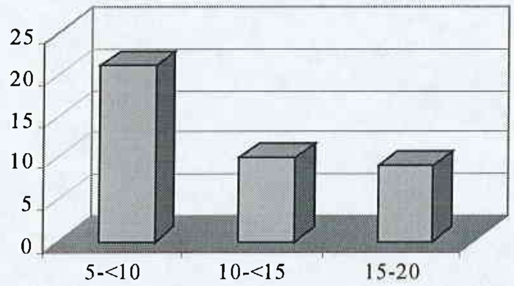
FUG:	Dhungeswori		
Compartment name/number:	Gagua Khaako Gairo		
No. of plots:	6		
Aspect:	South (two plots SW, one plot NW)		
Slope (degrees):	<20 (one plot 20-40)		
Fire evidence:	Yes (in three plots)		
Grazing evidence:	No		
Canopy (%):	Variable, from <20 to <80. Generally sparse		
Soil exposure (%):	<30 (one plot <60)		
Lopping:	Frequent light lopping		
No. of stumps per ha:	0		
Natural regeneration:	Large: Mel, Khareto, Chuttro, Ghangaru, P. Salla Small: Banmara, Angeri, Seru		
Condition/comments:	Plantation with some natural regeneration, a lot of shrubs and some treeless areas. Parts of the compartment have a lot of leaf litter, with few grasses. Some FUG members felt this was the best compartment of the community forest. There are also some medicinal herbs and grasses. There are areas which avoided the fire, with thicker vegetation and some larger trees. The area supplies a lot of fodder and bedding		
Key species:	i. Pate Salla Others: Chilaune, Gurans, Mel, Angeri, Kaphal		
No. of stems per ha:	Total 1000, P. Sallo 735		
Form:	A lot of poorly formed trees		
Average dbh per species (cm):	i. 12.4	Standard error 0.55	Confidence limits (95%) 1.11
Max dbh for form factor (cm):	19		
Basal area M^2/ha:	Standard 5.8	Corrected for slope angle 5.9	
Total Volume M^3/ha	Standard 20.4	Corrected for slope angle 20.8	



Size class distribution for Pate Salla (dbh cm)

Table 16: Participatory inventory summary sheet for Dhungeswori FUG, Gagua Khaako Gairo compartment

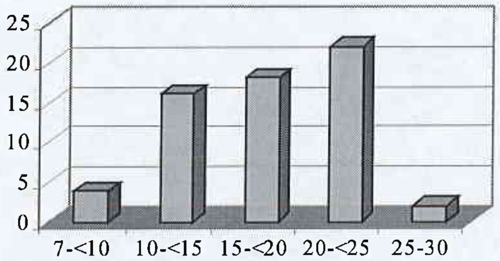
FUG:	Dhungeswori		
Compartment name/number:	Thulodunga		
No. of plots:	5		
Aspect:	South (one plot SW)		
Slope (degrees):	<20		
Fire evidence:	Yes (four plots)		
Grazing evidence:	N		
Canopy (%):	<20 - <80		
Soil exposure (%):	<30		
Lopping:	Some light lopping		
No. of stumps per ha:	0		
Natural regeneration:	Large: Khote Salla, Ainselu, Chettro, Utis, Mel Small: Banmara, Angeri, Khareto		
Condition/comments:	A good habitat with shrubs, grass and wild animals. Some small areas of mature trees. Also, fruit producing shrubs		
Key species:	i. Khote Salla Also: Utis		
No. of stems per ha:	Total 820 pate salla 800		
Form:	Good		
Average dbh per species (cm):	i.10.8	Standard error 0.69	Confidence limits (95%) 1.39
Max dbh for form factor (cm):	20		
Basal area M^2/ha:	Standard 4.4	Corrected for slope angle 4.5	
Total Volume M^3/ha	Standard 15.5	Corrected for slope angle 15.7	



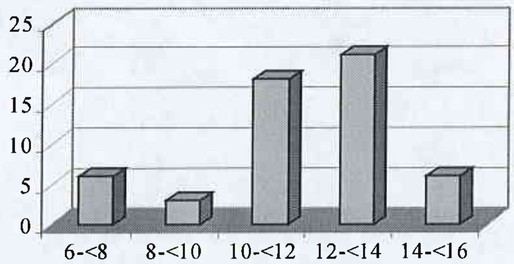
Size class distribution for Pate Salla (dbh cm)

Table 17: Participatory inventory summary sheet for Dhungeswori FUG, Thulodunga compartment

FUG:	Ningure		
Compartment name/number:	Salleri Ghardiri		
No. of plots:	11		
Aspect:	South (one plot SE)		
Slope (degrees):	20-40		
Fire evidence:	No		
Grazing evidence:	No		
Canopy (%):	<80		
Soil exposure (%):	30-60 to >60		
Lopping:	Some light lopping		
No. of stumps per ha:	0		
Natural regeneration:	Limited natural regeneration, principally Banmara, Khereto, Kharuni, Siru and Sal		
Condition/comments:	This is effectively two compartments, one of pure Khote Salla, and one of pure Sal. For some reason the FUG do not differentiate between these. The Khote Salla is well established but the Sal is still young. It appears to be doing well		
Key species:	i. Khote Salla ii. Sal		
No. of stems per ha:	Khote Salla 880, Sal 1800		
Form:	Good		
Average dbh per species (cm):		Standard error	Confidence limits (95%)
	i. 17	0.57	1.14
	ii. 11.5	0.25	0.50
Max dbh for form factor (cm):	Khote Salla 25 Sal 14		
Basal area M^2/ha:	Standard Khote Salla: 17	Standard Sal: 22	Corrected for slope angle Khote Salla: 18 Sal: 24
Total Volume M^3/ha	Standard Khote Salla 70	Standard Sal 84	Corrected for slope angle Khote Salla 73 Sal 88



Size class distribution for Khote Salla (dbh cm)



Size class distribution for Sal (dbh cm)

Table 18: Participatory inventory summary sheet for Ningure FUG, Salleri Ghardiri compartment

Appendix 6: Management information for rangers and FUGs

Management information for forest range post

Bhasuki FUG – Sunshito Tuumko compartment
Range post: Janakal

Approximate Location: 0.5km north west of Janegal, 25km east of Kathmandu

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Background information:

Approximate area: 21.7 ha

Currently a boundary dispute with Bhagaban Thumki FUG over water access.

The forest is predominantly Khote salla forest approaching maturity. The trees are approximately 26 years old.

FUG information:

76 households in FUG, (150 households in FUG area)

Eleven committee members

The predominant caste is Newari, with Brahmin, Chettri, Magar & Nepali. Committee represents all these ethnic groups.

Forest and management information:

The main products obtained from the forest are Grasses, leaf litter, fuelwood and timber. No other Non-timber forest products are considered important. Most of the forest related activities are performed by women, with men collecting timber. The women spend approximately 2-3 hours per household per day collecting forest products throughout the year. Fuelwood is collected principally in the winter months, grass is mainly collected in the summer, and leaf litter is collected all year.

The time spent collecting forest products has increased, but this does not indicate the resource has got worse, because they now collect material more slowly, as they are not doing it illegally and rapidly, as they did when it was a state forest.

The FUG do not have any limits on the amount that can be collected by a household.
The forest management involves dividing the forest into 3 blocks, only one of which is used per year.

The FUG regards the resource as being adequate for all their needs, and they regard it as improving. They are commercially felling timber, and the amount they fell is based on what they think is correct.

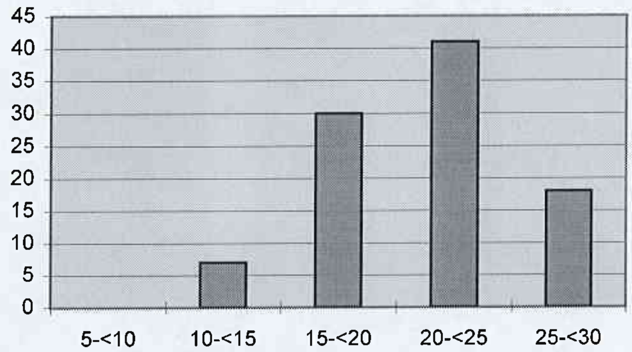
Interests/concerns of the FUG:

They are interested in the possibility of harvesting herbs to sell.
They want more broadleaf trees, particularly multi-purpose broadleaves.

Resource information: **Note - this information is only for Sunshito Tuumko**

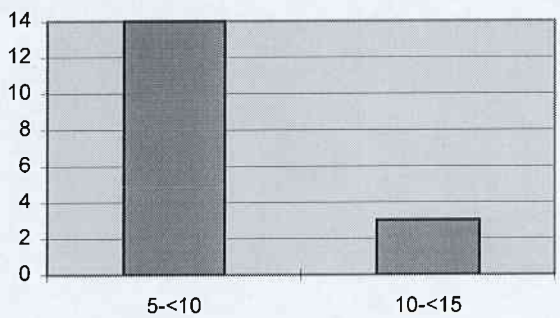
Size of compartment: 7 ha, surveyed using GPS

The two predominant species are Khote salla and Chilaune.



Size class distribution for Khote Salla

Average dbh = 21.3 cm
No. of stems per ha (greater than 5cm dbh) = 615
No. of stems in compartment = 4305
Form is predominantly good
There is a high incidence of heavy lopping



Size class distribution for Chilaune

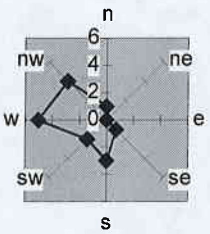
Average dbh = 7.7cm

No. of stems per ha greater than 5cm dbh = 105
No. of stems in compartment = 740
Form is predominantly poor
There is a low incidence of light lopping
The total number of stems in the compartment is 5050

The forest condition is classed as good.

Information about the forest:

Average aspect: West



Slope: mainly less than 20 degrees
There is no evidence of fire having occurred
There is evidence of a little grazing close to the village and fields
The forest varies in canopy closure, with a little closed canopy forest, but is predominantly open.
The soil exposure is on average 30-60% in the dry season.
Most natural regeneration is Chilaune, with some small Khote salla

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Management information:

The basal area of all species is 14 m^2/ha.

The number of observed tree stumps from felling was 75/ha

Standing volume of trunk material = 680 m^3

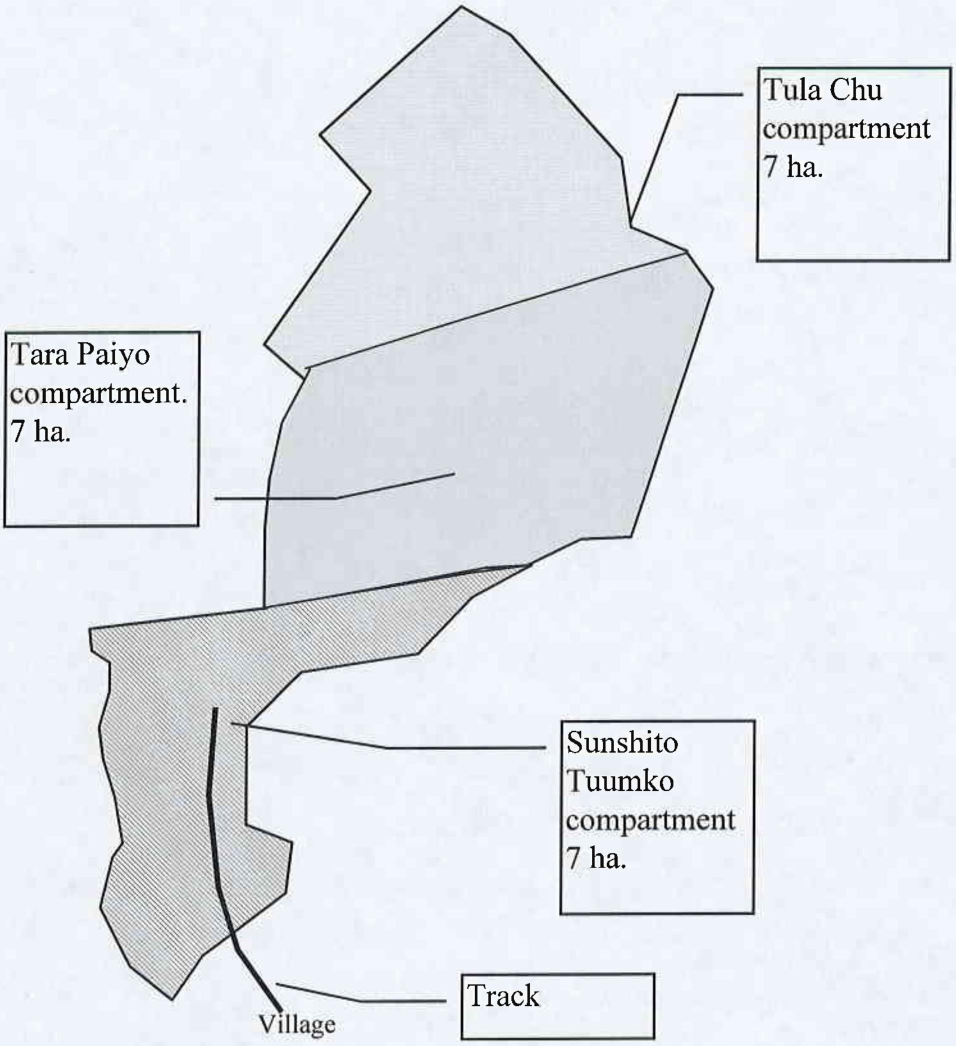
Total standing wood volume (including branch material) = 950 m^3

Timber volume (after felling & conversion losses) = 340 m^3

Amount of fuelwood harvestable per annum = 13.5 m^3

Amount of timber harvestable per annum = 10 m^3

Information for Bhasuki FUG regarding their forest management:



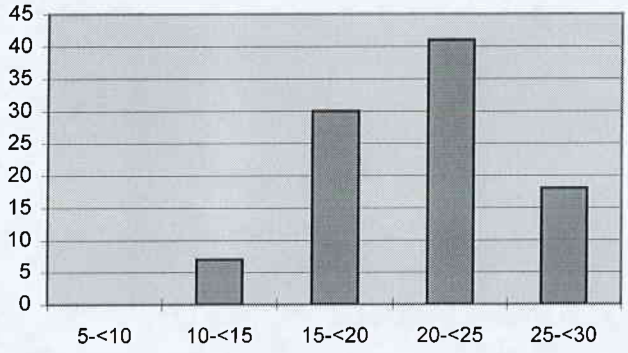
Bhasuki Ban Community forest

This information is for Sunshito Tuumko compartment only.

The forest is generally in good condition. The trees have been heavily lopped and pruned, but in most cases this has not slowed down the trees growth. In places there is a good understorey providing fodder materials, but a lot of the forest is quite bare. Too much fodder material might be being removed.

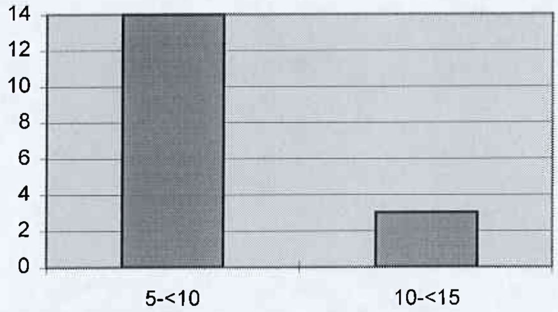
Below is some information about the forest resource, and after that some information to help you manage it successfully.

As you know, the main species are Khote Salla and Chilaune. Here is some information on how big the trees are and their condition:



Size class distribution for Khote Salla

This graph illustrates how big your trees are. Most of your trees are 20 to 25cm in diameter, big enough to produce some timber.
There are about 625 trees per hectare, about 4,300 trees in Sunshito Tuumka.
The trees are mainly a good shape (straight and round) for producing timber.
There is a high incidence of heavy lopping - this is not damaging the trees, and means the timber should be good



Size class distribution for Chilaune

Most of your trees are quite small, about 5 to 10 cm in diameter
There are about 105 trees per hectare, about 750 trees in Sunshito Tuumka
Most of the trees are quite a bad shape.

In total there are about 5050 individual trees in Sunshito Tuumko compartment.

Below is the amount of wood you can safely remove from this part of the forest without doing any damage to it. If you remove this amount of wood, there will always be more wood growing than what you have removed.

If you want to remove wood for fuel you can remove:

540 bari, about 7 bari per household every year.

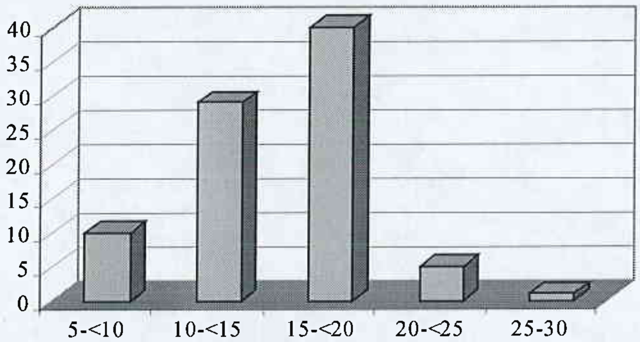
If you want to remove wood for timber you can remove:

400 bari, about 5 bari per household every year.

As the forest is divided into three equal areas, it might be good to remove wood from only one area each year. Then you would get from Sunshito Tuumko 1620 bari of fuelwood and 1200 bari of timber once every three years.

Appendix 7: Comparative Research inventory data

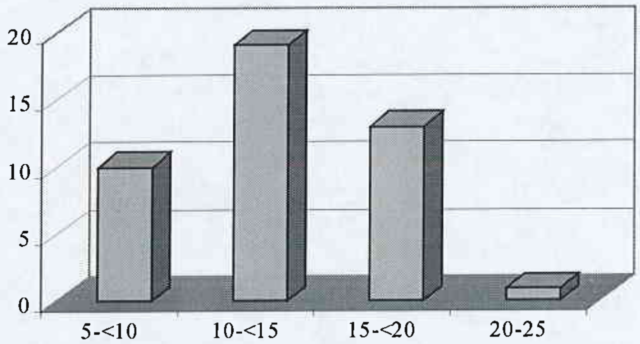
FUG:	Chulettro Pakha		
Compartment name/number:	Lampato 6		
No. of plots:	8		
Aspect:	All South		
Slope (degrees):	12, standard deviation 3.65		
Fire evidence:	Yes (all plots)		
Grazing evidence:	No (all plots)		
Canopy (%):	65, standard deviation 12.1		
Soil exposure (%):	36, Standard deviation 14.8		
Lopping:	Most plots light lopping, one plot none		
No. of stumps per ha:	0		
Natural regeneration:	Large: Ghutmero, Rani salla, Mel, Ainshelu Small: Banmara, Siru, Ainshelu, Khareto, Chutro, Poinyu, Dundilo, Hadebaar, Bhukiphel, Kuundo, Pipiri, Bhansu, Khar, Titipate, Ghutmero		
Condition/comments:	See participatory inventory		
Key species:	i. Rani Salla (Pinus roxbirghii)		
No. of stems per ha:	1065		
Form:	Good		
Average dbh per species (cm):	i. 15.24	Standard error 0.41	Confidence limits (95%) 0.81
Max dbh for form factor (cm):	25		
Basal area M^2/ha:	Standard 19	Corrected for slope angle 19.5	
Total Volume calculated from form factor M^3/ha	Standard 77	Corrected for slope angle 79	
Total Volume calculated from actual top height M^3/ha	Standard 106	Corrected for slope angle 109	



Size class distribution for Rani Salla (dbh cm)

Table 1: Comparative research inventory summary sheet for Chulettro Pakha FUG, Lampatto 6 compartment

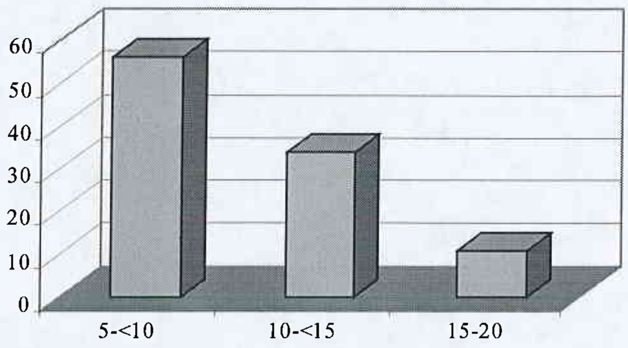
FUG:	Chulettro Pakha		
Compartment name/number:	Bhusbuse 5		
No. of plots:	6		
Aspect:	South (one plot SW, one SE		
Slope (degrees):	14 Standard deviation 2.7		
Fire evidence:	No		
Grazing evidence:	No		
Canopy (%):	20 Standard deviation 10.7		
Soil exposure (%):	30 Standard deviation 16.8		
Lopping:	Light lopping evident on all plots		
No. of stumps per ha:	0		
Natural regeneration:	Large: Ainshelu Small: Khareto, Chuttro, Banmara, Bhukiphul, Khareto, Gurans, Siru, Khar		
Condition/comments:	See participatory inventory		
Key species:	i. Rani Salla (Pinus roxbirghii) Also Pionyu		
No. of stems per ha:	Total 800, 720 Rani Salla		
Form:	Good		
Average dbh per species (cm):	i. 12.6	Standard error 0.56	Confidence limits (95%) 1.21
Max dbh for form factor (cm):	24		
Basal area M^2/ha:	Standard 10.3	Corrected for slope angle 10.55	
Total Volume calculated from form factor M^3/ha	Standard 41.6	Corrected for slope angle 42.6	
Total Volume calculated from actual top height M^3/ha	Standard 49.7	Corrected for slope angle 50.8	



Size class distribution for Rani Salla (dbh cm)

Table 2: Comparative research inventory summary sheet for Chulettro Pakha FUG, Bhusbuse 5 compartment

FUG:	Dhungeswori		
Compartment name/number:	Thulodunga		
No. of plots:	34		
Aspect:	South		
Slope (degrees):	7.3 Standard deviation 4.25		
Fire evidence:	No		
Grazing evidence:	No		
Canopy (%):	12 Standard deviation 12.2		
Soil exposure (%):	30 Standard deviation 19		
Lopping:	Mainly none, some plots with light lopping		
No. of stumps per ha:	3		
Natural regeneration:	Large: K Salla, Mel, Kapur, Ungari, Chilaune, Bhukiphul, Ghangaru Small: Banmara, Siru, Gangaru, Bhukiphul, Ungari, Khar, Chilaune, Khareto, Pipiri		
Condition/comments:	See participatory inventory		
Key species:	i. Khote Salla (Pinus roxburghii)		
No. of stems per ha:	300		
Form:	Good		
Average dbh per species (cm):	i. 10.67	Standard error 0.37	Confidence limits (95%) 0.73
Max dbh for form factor (cm):	19		
Basal area M^2/ha:	Standard 4.2	Corrected for slope angle 4.2	
Total Volume calculated from form factor M^3/ha	Standard 13.7	Corrected for slope angle 13.7	
Total Volume calculated from actual top height M^3/ha	Standard 14.8	Corrected for slope angle 14.8	



Size class distribution for Khote Salla (dbh cm)

Table 3: Comparative research inventory summary sheet for Dhungeswori FUG, Thulodunga compartment