SUSTAINABILITY INDICATORS FOR VILLAGES IN FORESTED MOUNTAIN WATERSHEDS: UPPER BEAS RIVER, HIMACHAL PRADESH, INDIA

47

By
COLIN E. DUFFIELD

A Practicum Submitted
in Partial Fulfilment of the
Requirements for the Degree,
Master of Natural Resources Management

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- Ancient 0289
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- English 0593
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Religion
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- Biblical Studies 0321
- Clergy 0319
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Theology 0469

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Anthropology
- Archaeology 0324
- Cultural 0326
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- Banking 0770
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Canadian Studies 0385
Economics
- General 0501
- Agricultural 0503
- Commerce-Business 0505
- Finance 0508
- History 0509
- Labor 0510
- Theory 0511

Folklore 0358
Geography 0366
Gerontology 0351
History
- General 0578
- Ancient 0579
- Medieval 0581
- Modern 0582
- Black 0328
- African 0331
- Asia, Australia and Oceania 0332
- Canadian 0334
- European 0335
- Latin American 0336
- Middle Eastern 0333
- United States 0337

History of Science 0585
Law 0398
Political Science
- General 0615
- International Law and Relations 0616
- Public Administration 0617

Recreation 0814
Social Work 0452
Sociology
- General 0626
- Criminology and Penology 0627
- Demography 0938
- Ethnic and Racial Studies 0631
- Individual and Family Studies 0628
- Industrial and Labor Relations 0629
- Public and Social Welfare 0630
- Social Structure and Development 0700
- Theory and Methods 0344

Transportation 0709
Urban and Regional Planning 0999
Women's Studies 0453

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Agriculture
- General 0473
- Agronomy 0285
- Animal Culture and Nutrition 0475
- Animal Pathology 0476
- Food Science and Technology 0359
- Forestry and Wildlife 0478
- Plant Culture 0479
- Plant Pathology 0480
- Plant Physiology 0817
- Range Management 0777
- Wood Technology 0746

Biology
- General 0306
- Anatomy 0287
- Biostatistics 0308
- Botany 0309
- Cell 0379
- Ecology 0329
- Entomology 0353
- Genetics 0369
- Limnology 0793
- Microbiology 0410
- Molecular 0307
- Neuroscience 0317
- Oceanography 0416
- Physiology 0433
- Radiation 0821
- Veterinary Science 0778
- Zoology 0472

Biophysics
- General 0786
- Medical 0760

EARTH SCIENCES
Biogeochemistry 0425
Geochemistry 0996
Geodesy 0370
Geology 0372
Geophysics 0373
Hydrology 0388
Mineralogy 0411
Paleobotany 0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
Palynology 0427
Physical Geography 0368
Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES
Environmental Sciences 0768
Health Sciences
- General 0566
- Audiology 0300
- Chemotherapy 0992
- Dentistry 0567
- Education 0350
- Hospital Management 0769
- Human Development 0758
- Immunology 0982
- Medicine and Surgery 0564
- Mental Health 0347
- Nursing 0569
- Nutrition 0570
- Obstetrics and Gynecology 0380
- Occupational Health and Therapy 0354
- Ophthalmology 0381
- Pathology 0571
- Pharmacology 0419
- Pharmacy 0572
- Physical Therapy 0382
- Public Health 0573
- Radiology 0574
- Recreation 0575
- Speech Pathology 0460
- Toxicology 0383

Home Economics 0386

PHYSICAL SCIENCES

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- General 0485
- Agricultural 0749
- Analytical 0486
- Biochemistry 0487
- Inorganic 0488
- Nuclear 0738
- Organic 0490
- Pharmaceutical 0491
- Physical 0494
- Polymer 0495
- Radiation 0754

Mathematics 0405
Physics
- General 0605
- Acoustics 0986
- Astronomy and Astrophysics 0606
- Atmospheric Science 0608
- Atomic 0748
- Electronics and Electricity 0607
- Elementary Particles and High Energy 0798
- Fluid and Plasma 0759
- Molecular 0609
- Nuclear 0610
- Optics 0752
- Radiation 0756
- Solid State 0611

Statistics 0463

Applied Sciences
Applied Mechanics 0346
Computer Science 0984
Engineering
- General 0537
- Aerospace 0538
- Agricultural 0539
- Automotive 0540
- Biomedical 0541
- Chemical 0542
- Civil 0543
- Electronics and Electrical 0544
- Heat and Thermodynamics 0348
- Hydraulic 0545
- Industrial 0546
- Marine 0547
- Materials Science 0794
- Mechanical 0548
- Metallurgy 0743
- Mining 0551
- Nuclear 0552
- Packaging 0549
- Petroleum 0765
- Sanitary and Municipal 0554
- System Science 0790

Geotechnology 0428
Operations Research 0796
Plastics Technology 0795
Textile Technology 0994

PSYCHOLOGY
General 0621
Behavioral 0384
Clinical 0622
Developmental 0620
Experimental 0623
Industrial 0624
Personality 0625
Physiological 0989
Psychobiology 0349
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Sustainability Indicators for Villages in Forested Mountain Watersheds: Upper Beas River, Himachal Pradesh, India

By

COLIN E. DUFFIELD

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfilment of the requirements of the degree of Master of Natural Resources Management.

Spruce lopped for fuelwood at 2700 m, Hamptah Valley, east of Manali.

ABSTRACT

The purpose of this research was to identify and select indicators to monitor the sustainability of human activity in the forested mountain watershed villages of Chachoga and Goshal, and to evaluate their feasibility. Data obtained from monitoring such indicators is required to guide natural resources practice and land-use policy, within the inherently diverse environment of mountain areas. The selection process for recommended indicators combines local input, background literature, a conceptual biophysical flow model, and feasibility selection in the field. Although the selected indicators may or may not be transferrable to other countries, the selection process is.

A conceptual model, created for the upper Beas River context, shows material flows (e.g. fuelwood) and services (e.g. landslide protection). It suggests that forests are the primary foundation of village sustainability. Agriculture, horticulture and pasture viability, the condition of soils, and tourism are also important components. This model, together with background literature and brainstorming with advisors led to the following preliminary (pre-fieldwork) indicator list: 1) Forest indicators of cover extent, cover density, diversity, and tree age-class structure; 2) changes in the relative mix of forest tree species and species preferred for use, as determined by village interviews, to watch for reverse succession caused by over-use; 3) frequency and magnitude of hazards and disasters such as landslides and floods; 4) soil measures of quality, and erosion; 5) comparison of the hypothetical primary productivity of an area with the extraction of photosynthetic products; 6) organization of indicators on spatial patterns of vegetation cover, soil, slope aspect, and altitude, and a focus on the watershed as a unit of study; 7) emphasis on verticality and biophysical flows between vertical zones; and 8) local input to identify further indicators which are considered most important.

For local indicators, 36 village interviews conducted in Goshal and Chachoga revealed 32 indicators ("signs or signals which should be monitored"). The most frequently identified indicators (by 15 or more villagers) were: 1) extent and quality of forest cover; 2) tree species diversity; and 3) adequate market access. Indicators identified by ten or more villagers also included: 4) forest density; 5) orchard area; 6) number of landslides and avalanches; 7) waterflow consistency (stable hydrology); and 8) reforestation and regeneration success. Indicators identified by more than five villagers further included: 9) family planning - population growth; 10) forest protection enforcement success; 11) clean water availability from the forest; 12) scenic beauty; 13) grazing and haying area; 14) availability of forest products - time to gather; 15) amount of erosion; and 16) cash crop area. Interviews with nine local natural resources

management professionals identified many of the same indicators, as well as two additional indicators: 1) access to credit and training; and 2) ability to set up cooperative businesses. The local professionals put more emphasis on management and enforcement indicators, and the necessity of diversifying cash crops to include vegetables and agroforestry.

Recommended indicators include the preliminary set, the locally identified set, and several additional indicators selected following the fieldwork and summarized in the final chapter.

In a distinct portion of the field research, data from Goshal and Chachoga were found to be available and accessible for several of the preliminary indicators - a summary follows:

Indian Forest Department records of the study area show forest cover and density have both declined since 1918. A recent inventory of tree age-class structure shows that three of Chachoga's six common tree species (spruce, chestnut and silver fir), and five of Goshal's seven (deodar, pine, chestnut, silver fir, and spruce) lack younger trees to replace mature ones. Observation of soil erosion characteristics showed that erosion occurs mostly in areas of high animal traffic which are concentrated in pathways close to the villages. Animal traffic, transport of timber down-slope, forest clearing, and the high energy monsoon rains all contribute to areas of massive erosion. The impact of orchards on erosion in Goshal and Chachoga, however, is low.

Apple orchard expansion has been into agricultural terraces, abandoned terraces, steep haying areas, and *Nautor* lands (village common lands which were allegedly redistributed to landless villagers in the 1960's and 1970's). New orchards on steep haying areas are usually surrounded by thick grasses, creating low erosion potential. However, the monocropping of only a few varieties of apple creates a different kind of high risk pertaining to loss of biodiversity and ultimately to apple production itself.

Thirty six interviews concerning changes in the relative mix of tree species revealed a perceived 30-year downward trend in the availability of preferred fuelwood, animal fodder, and timber tree species. Recent 2-3 year trends suggest a halt in decline of most of these species, and an increase in the relative availability of some other species. There was a high level of agreement between villagers and the local government forester regarding these trends. Increases in shrub species and declines in larger tree species suggest reverse succession may be occurring.

Resources management implications of these data findings are made in the final chapter, together with the recommended indicators for further data collection.

ACKNOWLEDGEMENTS

This practicum report would never have been possible without the input of many individuals in India and Canada, all of whom deserve thanks and recognition. First I must thank the people of the two villages, my consultants, who willingly volunteered their time and knowledge during a busy time of the year. Thank-you also to my translators and guides, Mehar-Chand Thakur (Meru) and Menorma Devi.

I must also thank the four members of my committee, Fikret Berkes, and James Gardner for providing the research opportunity, and for advice and guidance in the field, and Mary-Ellen Tyler and Naresh Singh for their insights and feedback, and all of them for their patience and help in creating an unparalleled learning experience.

I would like to thank Iain and Kerril Davidson-Hunt, Laurie Ham, and John Sinclair for sharing an extraordinary field experience, and for a steady diet of support and insight throughout the preparations, research, and writing of this report. Thank-you to my father and mother, James and Judy, for support and for instilling in me an appetite for learning. And a special thanks to Ms. Judy Zieske at the NRI for never-ending assistance during all stages of this research, and two years of courses.

For invaluable assistance in Delhi, and at the study site in India, I would also like to thank Dr. R.B. Singh, and his students, Mr. B.W. Pandey and Mr. G.S. Chauhan.

Finally, a big thank-you to Michelle Ninow for all your editing and on-going love and support.

The research on which this practicum report is based was funded by the Social Sciences and Humanities Research Council of Canada (SSHRC) through a grant to F. Berkes. The overall project "Sustainable Development of Mountain Environments in India and Canada," of which this research forms a part, was supported by the Canadian International Development Agency (CIDA) through the Partnership Program of the Shastri Indo-Canadian Institute, and undertaken in cooperation with the University of Manitoba, the University of Delhi, the Indian Institute of Science, and the International Institute of Sustainable Development. Additional and timely assistance in the form of a University of Manitoba Graduate Fellowship greatly helped during the writing stages. The sponsors do not necessarily endorse the views herein expressed.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF PLATES

(Photos: Colin Duffield)

...Lofty mountains are most worthy of deep study. For everywhere you turn, they present to every sense a multitude of objects and interactions to excite and delight the mind. They offer problems to our intellect; they amaze our souls. They remind us of the infinite variety of the world, and offer an unequalled field for the observation of the processes of humans and nature.

(Josias Simler 1574, *De Alpibus Commentarius*)

1 INTRODUCTION AND STUDY AREA

1.1 HISTORICAL CONTEXT: ISSUES OF SUSTAINABILITY AND RESOURCES MANAGEMENT

People of the villages of the Himalayan front ranges continue to maintain a direct relationship with upslope forests in order to meet their basic needs for fuelwood, animal fodder, animal bedding materials, minor forest products, and timber. These people also live by farming grains, fruit, vegetables, and grazing, as well as by wage labour and tourist industry. Ghaddis, nomadic sheep and goat herders, move through the area, and over alpine passes, while Gujjars, Muslims from further south, seasonally herd water buffalo at lower altitudes. As use rates increase and tourism grows, meeting basic needs is becoming more uncertain. Sustainability indicators are required to monitor changes in the factors which underlie people's livelihoods, to signal the need for new resource management practices, and to monitor the effects of old and new management policies. Sustainability indicators include biophysical, social, economic, and equity dimensions.

Local needs for fuelwood, fodder, food, fibre, and fertilizer (and medicinal plants and herbs), and the ability to manage locally for these needs, have been compromised by state forestry timber production in the recent past (Gadgil and Guha 1992; Damodaran 1990). The area has also seen an influx of people from other parts of India looking for service work in the towns to meet the growing ranks of tourists of the past two decades (Noble 1991). Villages which were formally stable and self-sustaining now require inputs of food from outside (Sangeeta 1987).

Today in the upper Beas, increasing cultivation on slopes, overgrazing, mega-engineering projects, overexploitation of village or community forests, unplanned land-use, tourism, and urbanization all deplete the forest, and its soil's water retention capacity. As a result, the forest which covered 60% of the Himachal Pradesh region in the 1950's, and 38% in 1977, now only covers 18% (Kayastha 1992; Shoumatoff 1991;

Chib 1977). The forests are essential for agricultural yield: Singh and Singh (1991) estimate that each energy unit of agricultural yield requires 12 units of forest and range land energy as input, while Robinson (1987) estimates that the inputs from 2.8 to 18 ha of forest are required to maintain 1 ha of agricultural land, yet the current forest/agricultural land ratio of Himachal Pradesh is one to one. The ability of both current and future generations in the upper Beas to meet their needs is thus threatened.

This depletion also increases the risk of landslides, erosion, sedimentation, floods, drying of springs, habitat loss, and species extinction (Ahmad 1993; Ives 1992; Sharma and Minhas 1990). The severity and frequency of these risks is likely related to the geological properties of the area (Gardner 1994, pers.comm).

Given these types of problems in mountain watersheds, several choices of response are possible: do nothing, do research, or take action through demonstration projects. This practicum follows the research route, research which may not only help people of the upper Beas by affecting policy, and legitimizing village perspectives, but also the people living in any mountain watershed of the world. This research will hopefully help guide future action.

Research on sustainable human use of the "products and services" of a watershed involves many fields. These include: (a) the ecological economics approach of assessing "natural capital stock" (Costanza 1991); (b) the combination of social sciences with biophysical elements in common-property research (Berkes 1989). This second perspective helps incorporate the institutional dimensions of policy, distribution, and equitable access to resources in the watershed (Sanwal 1989); and (c) an analysis of the frequency and intensity of risk events and daily drudgery faced by local people (Jodha 1993; Moench 1986). Most of the human/environment interaction in mountainous areas also involves movement within and between the altitude based vegetation zones of forest, meadow, glacier/rock, and agriculture in cleared forests at lower altitudes (Kayastha 1992; Bandyopadhyay 1992; Tyler 1988).

There is much interest in and research on sustainability in India, Canada, and the world, but development of practical measures of mountain sustainability is still in its infancy. Nine years have passed since the Bruntland Report put the political and developmental agenda of sustainability on the table. Yet little agreement on how to monitor sustainability, to tell whether or not we are progressing towards it, can be found

(NRTEE 1993; Kay 1991).

The present research recognizes that sustainability includes biophysical, social, cultural, and economic elements, but puts emphasis on natural resources - the bedrock of human society.

1.2 THE RESEARCH PROBLEM, PURPOSE AND OBJECTIVES

In order to be sustained, people of the study area rely strongly upon the endowment of their immediate natural surroundings. In turn, human activities in forests, pastures, and agricultural land depend on the way those resources are used and managed. However, the sustainability of the system of which these people form a part may be in jeopardy, indeed, there is a broad literature describing the increasing problems and risks faced by inhabitants of mountain watersheds, particularly in developing countries. A way to monitor the sustainability of people's activities on their natural surroundings is thus required. The method should tap people's knowledge and understanding in order to identify all the key variables which underlie local livelihoods. This monitoring process will make sustainable management possible.

The purpose of this research is to identify, evaluate, and select indicators to monitor the sustainability of human activity in forested mountain watersheds. The indicators should facilitate management for the sustainability of local livelihoods by being feasible to monitor. Such indicators would be applicable, among other places, to an upper watershed of the Beas River.

To fulfil the purpose, the objectives of this research practicum are:

1) To identify a preliminary list of indicators, based on a conceptual biophysical flow model and background literature, which respond to the forest, pasture, and agriculture sources of local livelihoods in forested Indian mountain watersheds.

2) To expose the preliminary indicators to the pragmatism of the study area, collect indicator data where possible, and determine which indicators are potentially feasible based on fieldwork and background literature. To make resource management recommendations based on the findings of collected data.

3) To use input from interviews conducted in the study site to identify indicators which are most relevant to local livelihoods, to compare the resulting indicators with the preliminary indicators and with indicator principles found in the literature, and to identify additional indicators selected after the fieldwork. To evaluate which of the externally and locally identified indicators are most feasibly used to assess the sustainability of human activities in forested mountain watersheds such as the upper Beas.

4) To recommend to policy-makers and other researchers what feasible and potentially feasible indicators, which contain external and/or local perspectives, should be monitored to help improve natural resources management and land-use policy decisions. To communicate the resulting indicators and concluding recommendations with other Shastri researchers in an on-going iterative process.

The present research also forms part of a larger project called *Sustainable Development of Mountain Environments in India and Canada*. Among the objectives of the larger overall project were the development of integrated methodologies best suited for comparative study of land resource management policies in forested mountain watersheds, and the development of cross-cultural indicators for assessing sustainability in mountain environments.

1.3 Scope and Assumptions of the Research, and Importance of the Findings

This study concentrates on renewable resource indicators, including forests, grazing lands, and agricultural areas which are assumed to underlie livelihood sustainability. Local input is used to help identify and weight the importance of indicators. Social and economic indicators identified by local input are also discussed. There is no formal economic analysis *per se*, as assessment of monetary incomes of individuals was difficult to obtain and of questionable accuracy given the area's underground economy. Social issues are covered by the other University of Manitoba researchers.

Much of the forest based field data is from secondary sources of government records and maps. Primary data analysis of aerial photos and remotely sensed images, and surveys of biodiversity were beyond the time and resources of the study. However, primary data from interviews in the field included locally identified indicators, local perceptions on changes in forest tree species mix over time, and preferred tree use. Primary data also included observations of land-use, and soil erosion potential characteristics.

Prior to this study few systematic attempts have been made to develop indicators of mountain watershed sustainability which incorporate both external and local input. The developed indicators can be used to monitor trends. For instantaneous feedback, the indicator can be compared with a desired condition or goal. The goal can be either a past condition, or a desired future condition. The choice of goal conditions, and the actual data required for most of the locally identified indicators are beyond the scope of this research.

This study increases knowledge of sustainability indicators for communities in mountain watersheds by creating a list of recommended indicators which combines local input, background literature, a conceptual biophysical flow model, brainstorming with advisors, and feasibility selection in the field. In short it identifies workable indicators which have an external and local input, and if compared with measures identified in future studies, could help identify indicators which are robust across other mountain watersheds in the world. Through the development and utilization of such measures of ecological systems and human reliance on those systems, people and external agencies can monitor progress towards sustainability by providing information on the effects of resource management policies. Although the identified indicators themselves may or may not be applicable in different countries, the selection process is. If similar future studies identify similar indicators in forested mountain areas of different countries, then those indicators are likely to be robust.

In addition to the identified indicators, the study provides descriptions of the forest and vegetative cover, forest tree age-class structure, village perceptions of trends in tree species change, and describes selected socio-economic conditions in the upper Beas watershed in 1994. The report is based on scientific and indigenous knowledge. The descriptions will help people and government in the area recognize problem trends in the future.

1.4 KEY CONCEPTS AND DEFINITIONS

The essential ideas underlying this research are those of sustainability, natural and human-made capital, sustainable livelihoods, and indicators of sustainability. Definitions of these terms and several others are described below. The term sustainability is used interchangeably with the term sustainable development, so long as development is a qualitative term referring to improved equity, efficiency, and wellbeing, rather than on-going growth in resource utilization.

Natural capital refers to "a stock [of natural assets] that yields a flow of valuable goods and services into the future" (Costanza and Daly 1992:38). The goods and services include yields, waste assimilation, erosion and flood control, and "life support services" such as consistent hydrological cycles and climate moderation. Maintaining a stock of natural capital has little to do with the conservation argument, rather, it concerns maintaining system processes through the maintenance of state variables and the relationships between those variables in order to provide the desired flows of products and services. Human-made capital, in contrast, refers to the stock of manufactured capital.

There is some uncertainty of whether sustainability requires passing an undiminished per capita stock of natural capital to the next generation (*strong* sustainability), or if passing on an equivalent per capita stock of the sum of natural and human-made capital together is sufficient for sustainability (*weak* sustainability). *Weak* sustainability thus implies that human-made capital is a substitute for natural capital. By contrast, *strong* sustainability posits that natural and human capital are complements, that is, natural capital is a prerequisite to human capital. Taking a strong sustainability perspective, Rees (1995) suggests natural and human capital be kept intact separately to be passed on to future generations.

Sustainability has often referred to the maintenance of ecosphere function and diversity (Opschoor and Reijnders 1991; Holmberg and Karlsson 1992); however, the definition used in this research is expanded to include the idea of sustaining people's livelihoods. Livelihoods refer to the capabilities, assets (stores and access to resources), and activities required to make a living. A sustainable livelihood is one which can cope with and recover from stress and shocks, maintain and enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation. It also contributes net benefits to other livelihoods at the local and global levels in the short and long term (Chambers and Conway 1992).

An indicator is simply "that which indicates or points out," thus a sustainability indicator is a measure which indicates or points out sustainability. To point out sustainability, indicators can take the form of a quantitative or qualitative variable which can be measured or described. The variable can either be compared with some desired condition, or observed periodically, to demonstrate trends in that variable, or both.

The term environment is used in the broadest sense, that is, the biophysical, social/cultural, economic, and spiritual realms in which human endeavour occurs.

Agroforestry refers to the use of woody perennials in the same area as crops and/or animals either in spatial or temporal arrangement, where there are ecological and economic interactions between the different components. An agrosilvipastoral system is one where mixed agriculture (crops and livestock) is integrated with, or dependent upon forests (Robinson 1987:108).

C.S. Holling et al (1994) provide a definition of resilience: "The magnitude of disturbances that can be absorbed before a system changes its structure by changing the variables and processes that control behavior" (quoted in Berkes and Folke 1994:4).

1.5 The Study Area, and the Villages of Goshal and Chachoga

The study site lies at the northern reaches of the Kullu Valley, close to the headwaters of the Beas River, in the province of Himachal Pradesh, NW India (Figure 1). The river and its valley run southward, bisecting the Pir Panjal Range of the Western Himalaya, it then flows west onto the Punjab plains. Manali is the commercial centre of the immediate vicinity. A burgeoning tourist town, Manali is situated near the valley floor at 2000 metres. Numerous smaller villages, most of which are very old, occur throughout the valley. As with most mountain environments, settlement and agriculture are found near the valley floor. The steep and forested slopes rise through to 4500 m alpine areas, with some 6500 m peaks. Glaciers and meltwater feed the

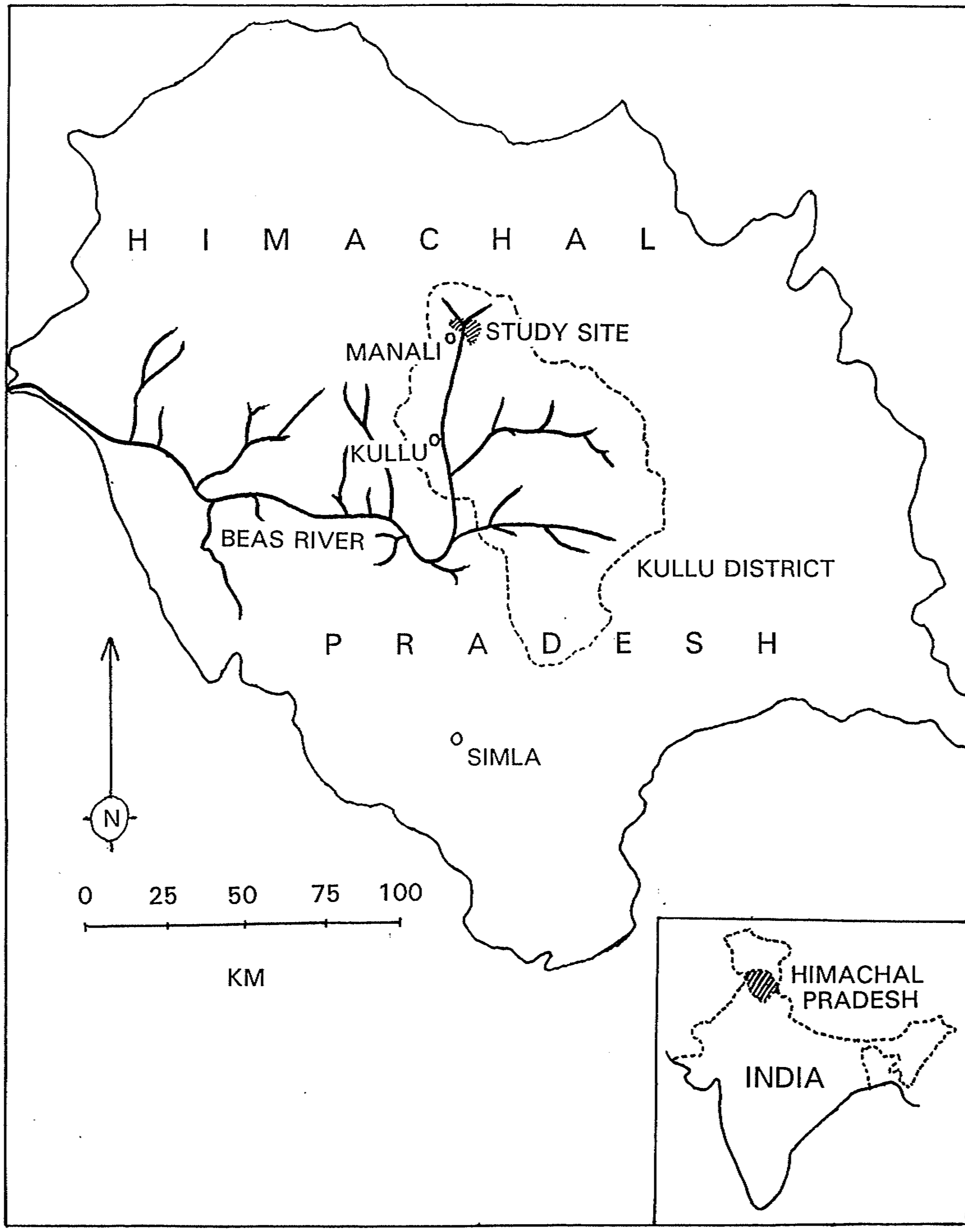


Figure 1. Location of the study site in Kullu District of temperate Himachal Pradesh state in the Himalayan foothills.

energetic Beas River and its many side streams - nallas. The area has a temperate monsoonal climate, and the high altitude slopes lead to a variety of ecoclimatic zones. The people of the villages are of the Pahari culture, which although Hinduized, is distinct from North Indian plains culture and from the high Himalayan Bhotian culture (for more detail see K.Davidson-Hunt 1995).

Two villages near Manali were chosen as case studies: Chachoga and Goshal. As well as including private agricultural land, each village has a defined resource (forest) use area, stretching from the valley floor, through forests, up to alpine areas (see Figure 2). Figure 2 provides an idea of the scale of relief in the area, although it does not show the other villages. Exclusive forest use areas for each village provide an ideal template on which to examine the sustainability of each village. The forest use areas are under the management of the Forest Department. Areas higher than the demarcated resource use areas are shared by the villages. The "DPF" areas, and the underlying map in Figure 2 were based on Manali Forest Department maps, private agricultural land, and "upf" land were determined through interviews and observation.

Chachoga has 155 ha of forest use area, while Goshal shares access to 1388 ha. The forest use area available per household in each village can be calculated given the number of households. Chachoga, with 80 households, has approximately 2 ha of forest per household. Goshal, with 130 households, has approximately 5 ha per household (since Goshal shares access to 1388 ha with two other villages). However, much of Goshal's forest is relativly unproductive alpine and sub-alpine forest and meadow. In contrast, over two-thirds of Chachoga's forest use area is highly productive deodar forest. Chachoga has approximately 83 ha of agricultural land, or about 1 ha per household. Goshal has approximately 107 ha of agricultural land, or about 0.8 ha per household. These figures are similar to the overall average of 1 ha per household in Kullu Valley, as estimated by ODA (1994).

Dynamism and biodiversity (based on micro-climatic diversity) inherent in mountain environments are often reflected in the variable ways residents make their livelihoods. Villages in the upper Beas watershed are no exception; indeed, many people of this region are strongly reliant on the variable natural and agricultural resources of the area. Other residents, more reliant on the growing flow of tourism, are still indirectly dependent upon the attractiveness of the area, an attractiveness which is in flux as well.

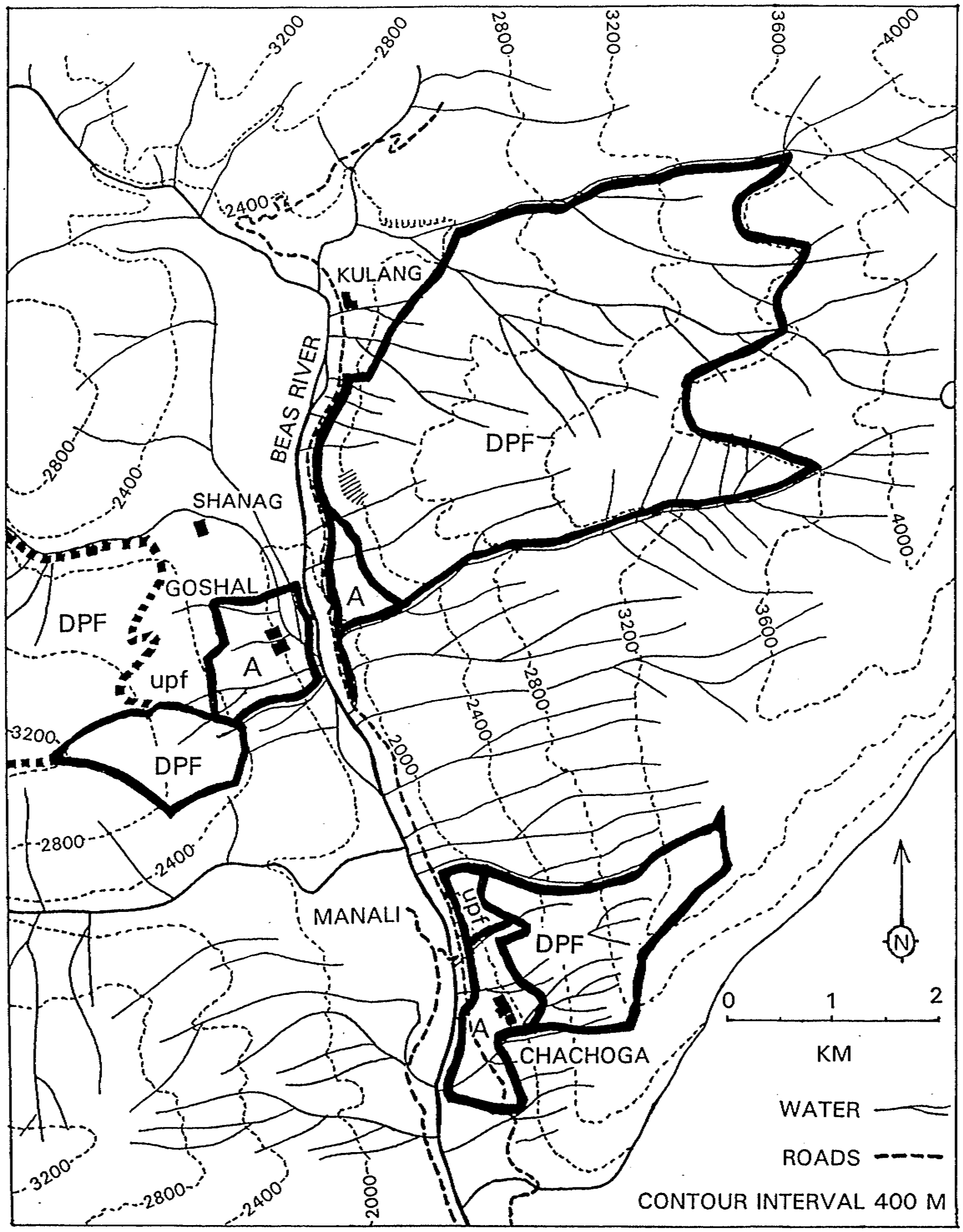
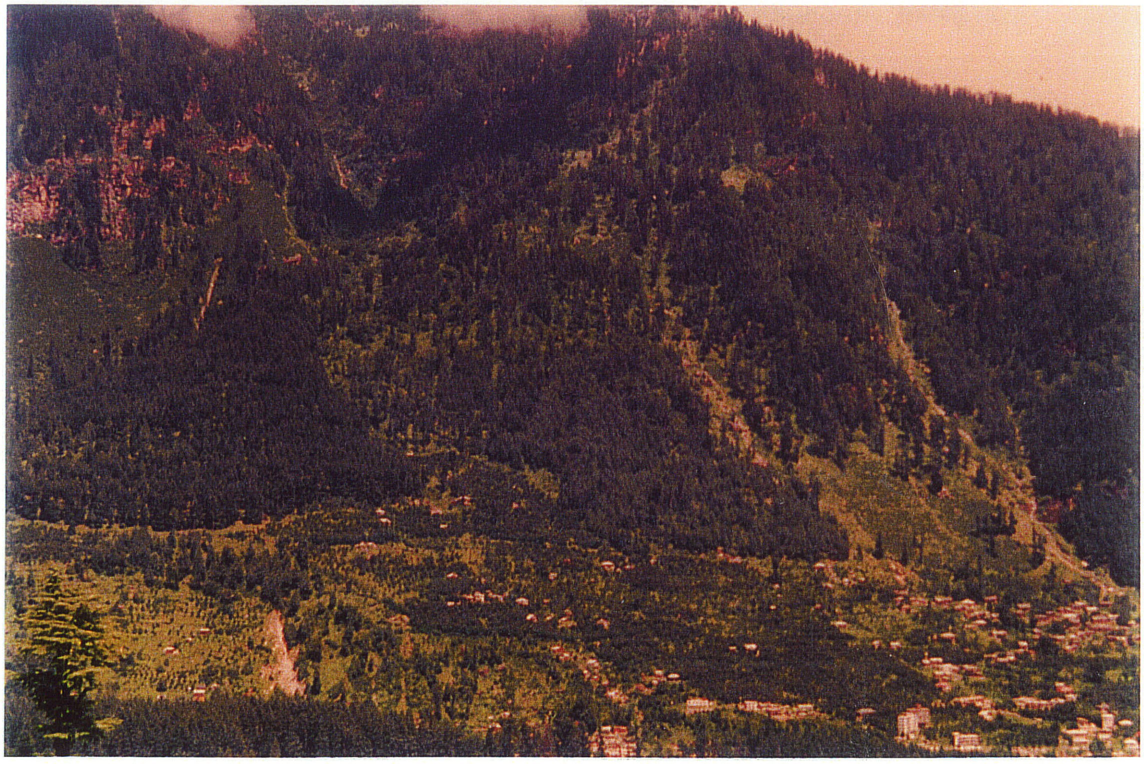


Figure 2. Village use areas of Goshal and Chachoga showing their respective demarcated protected forests ("DPF"), approximate undemarcated protected forests ("upf"), and approximate agricultural areas ("A"). Goshal shares its small south western DPF area with Shanag, and its large eastern DPF area with Kulang. Goshal also makes some *de facto* use of the dashed DPF area west of the village. The ("■■■") symbol denotes village sites.



Chachoga at lower right-hand corner, and Chachoga's forest use area. Note open and closed-crown forest, cleared area above village, and two gullies showing signs of erosion leading up to the left from the village (looking east).

These peoples' livelihoods are based in an environment prone to unpredictable climate and catastrophic events, where human induced changes are only a part of the environmental change.

An agriculturalist and pastoralist society in what has long been a trade route, the people of Kullu Valley have seen times dominated by export crops of tobacco and opium in the 1800's, periods of British settlement and the introduction of apple orchards, large-scale 1960's government clearing of some forests, and land redistribution (ODA 1994). Today, the conversion to a cash economy based on rapid expansion of apple orchards and tourism continues this historical evolution.

Adaptive strategies used by the people of the villages to face the permanent changes occurring in the valley include: 1) diversification of activities and household inputs; 2) crop species and spatial diversity within the traditional agricultural system; 3) increasing the integration of the household with the market economy; 4) reliance on agricultural wage labour and employment in the larger urban centre; 5) building up and drawing down of food, fodder, and fuel inventories; 6) reliance on common property

Goshal, bottom centre, and part of Goshal's forest use area. Note the eroded pathway leading from left-centre up towards the left, the avalanche slope at centre, and the 1993 landslide at the right. Note pasture areas in forest (looking west).

resources; and 7) the development of community groups. These findings were identified in the study site during the summer of 1994 by Ham (1995), a University of Manitoba researcher.

The use of forests has long played an important role in village livelihoods; an importance recognized by the pre-independence colonial government which, in the 1886 Settlement Report, gave usufructuary forest rights (often exclusive) to each village (for more detail see I. Davidson-Hunt 1995). The legacy of caste structure is seen in the majority landholdings of the Rajput caste, who usually meet their needs from horticulture, agriculture, and inputs from the forests, thus making greater use of the village forest use areas designated in the Settlement Report. Although landholdings of the Scheduled castes (low caste) have increased as a result of the land reforms of the 1950's and 1970's, people with smaller landholdings generally do wage work, thus having less interaction with the forests as an input to horticulture and agriculture.

A view up the Kullu Valley showing agricultural areas and forest of various densities. Taken from above Goshal, looking northeast.

1.5.1 Climate, Soils, and Forests of the Study Area. The climate of the two study villages in the valley bottom at 2100 m is temperate, with monsoons occurring from the end of June until mid September. Temperate climate occurs from 2000-3500 m. While from 3500-4500 m there is a sub-arctic climate, and above 4500 m, the climate is arctic. From 700-2000 m the climate is sub-tropical. Average rainfall is 200 cm at 2000 m, 90 cm at 3000 m, and nil above 4000 m. Much of the waterflow during dry periods is maintained by glaciers, although these glaciers have retreated during this century (Negi 1990).

The soils of the study area include alluvial soils in valleys, red and black soils, the rare ferruginous red soils, brown soils (frequently found under oak forests), podsolic soils (found under deodar forests), mountain and hill soils, and high altitude meadow soils. Himalayan soils often contain high levels of potash, medium levels of phosphorous, and low levels of nitrogen. Levels of organic matter are high in agricultural fields and meadows areas, but not in other areas (Ghildyal 1990). Negi (1990) provides a detailed description of the characteristics of each.

Forests of the area are within the Himalayan moist temperate zone. The forest cover types, and their altitude ranges, include (Negi 1990):

- Moist deodar forest (also includes pine, fir, and spruce)(1700-2500 m);
- Temperate mixed conifer forest (2400-3000 m);
- Temperate moist mixed deciduous forest (1800-2750 m);
- Temperate secondary scrub;
- Kharsu (korsh) oak forest (2500-3500 m);
- Oak-fir forest (2600-3400 m);
- Cypress forest (rare)(1800-2800 m);
- Alder forest along stream and river banks (<3000 m);
- Sub-alpine high level fir forest (2900-3000 m);
- Sub-alpine birch-fir forest (>3000 m);
- Birch rhododendron scrub (>3000 m);
- Deciduous alpine scrub (>3350 m); and
- Dwarf rhododendron scrub (near snowline).

A forest type of particular interest is temperate secondary scrub. It is found in hot, dry, exposed areas, or in areas under heavy biotic pressure. It consists of various evergreens and thorny shrubs. The appearance of this type of scrub, when a site previously supported one of the forest types listed above, is indicative of seral change, and strongly suggests unsustainable use. A detailed description of the species composition of each forest type is provided in Negi (1990).

2 METHODOLOGY

2.1 OVERVIEW

The process underlying this research was comprised of two major components: The preliminary steps, and the field methodology (also comprised of two distinct parts).

The preliminary steps included research of background concepts in the literature, and the development of a conceptual flow diagram of the biophysical basis of sustainability in order to create an initial set of sustainability indicators. To determine which of these indicators were "workable," or "potentially workable," these indicators and their data requirements were exposed to the pragmatism of the field. What is "workable" refers to what one Canadian researcher could accomplish in a seven week field season in India, whereas what is "potentially workable" is a somewhat intuitive evaluation which considers the Indian context. The reality of a Canadian researcher in India, for example, the challenges of language, differences in culture, and differences in sense of time, shaped much of the field methodology.

Several of the preliminary indicators were found to be workable, data was collected, and management recommendations are made in Chapter 4 and 6. Workable and potentially workable indicators are discussed in Chapter 6.

In a distinct and separate phase of the fieldwork, sustainability indicators were identified and weighted in importance through interviews with the local people themselves. Asking local people was a very simple way of discovering which of the hundreds of indicators found in the background literature (see Appendices 2, 3, and 4) were most relevant and important to villagers and their livelihoods.

Finally, after returning from India, a third set of indicators was selected in addition to the first two sets (preliminary indicators and locally identified indicators). The third set was selected by revisiting the background literature, and using new perspectives developed by this researcher following the fieldwork. This third set is described in the final chapter, and recommendations on choice of indicators from all three sets are made in the final chapter as well.

2.2 Preliminary Steps

A preliminary (pre-fieldwork) set of indicators evolved as follows: First, in order to generate indicator ideas, a literature review of the background concepts behind sustainability indicators was done. Next, brainstorming with the thesis committee advisors was done. These two steps helped to start build an initial cluster of indicators. These initial indicators, deduced at the time to be the most useful and telling of village sustainability included: forest indicators of cover extent, density, diversity, tree age-class structure, and productivity; the frequency and magnitude of hazards and disasters; the amount of biomass resources used by people of the area; soil measures of quality and erosion; a focus on the watershed as a unit of study; and use of local input to determine which indicators were most relevant and important to villagers.

The initial cluster of indicators and indicator approaches was augmented following discussion with thesis committee advisors. The additional ideas included: basing indicators on spatial patterns of vegetation cover, soil, slope aspect, and altitude; emphasis on verticality and biophysical flows between vertical zones; estimation of the hypothetical primary productivity of an area as compared with the extraction of products of photosynthesis; and ascertaining changes in the forest species mix to watch for reverse succession.

Further discussion lead to the realization that a conceptual model of the human/environment system would help focus the development of indicators by identifying key system components to sustain. A conceptual model of the biophysical components and flows in the study area was thus created - drawing from background reading on the study site.

2.2.1 The Conceptual Model. Figure 3 shows the conceptual model of the flows of biophysical products and services upon which people of the two villages rely directly, or rely for income. The model shows that the villages are supported by materials, services, and income from system components of: forests, pastures, agriculture

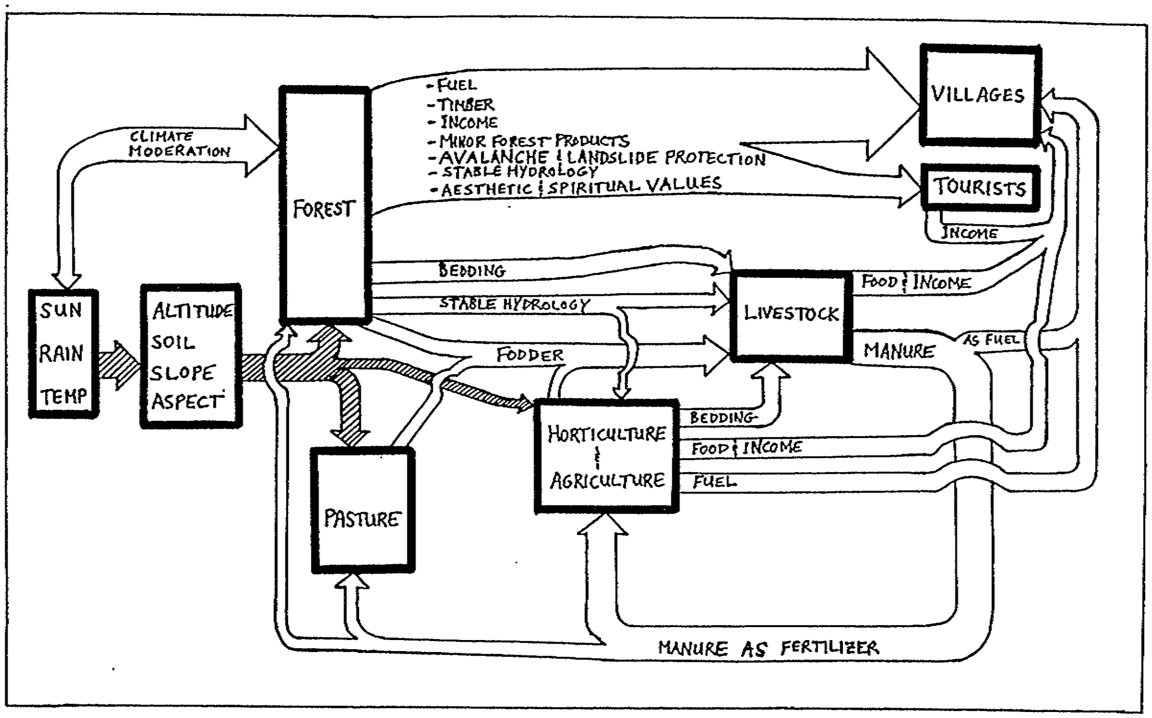


Figure 3. Village livelihood system: a conceptual illustration of the biophysical basis of sustainability and the importance of forests.

and horticulture, livestock, and tourists. The first three of these components are directly based on the inputs of solar energy and moisture, which are further shaped by factors of altitude, soil quality, gradient, aspect, and climate moderation linked to forests. Indeed, these latter five factors are profoundly important in mountain environments by creating high levels of species and micro-climatic diversity. To justify the biophysical focus of the model, it is assumed that people rely directly or indirectly upon biophysical components and flows as the basis for their livelihoods, the biophysical system thus forms a basic foundation for sustainability upon which social, cultural, and economic factors play their part.

Open spruce forest, upslope of Goshal (looking west).

In terms of importance to village livelihoods in the study area, the forest component is paramount, as can be seen in Figure 3 from the large number of products and services which originate from forests. Further, forests dominate the landscape, in particular the slopes. To seal the issue, a focus on forest indicators is also supported by village interviews. The indicators listed in the preliminary set thus emphasize the importance of forest indicators in assessing village sustainability.

The verticality of temperate forested mountain ecosystems largely determines where the most productive areas will be. In the Kullu Valley around Manali, the flat valley floor is the most productive, particularly with respect to agriculture. Most mixed-crop subsistence agriculture, and the increasingly important cash crop of apple orchards, are grown in the valley bottom. Agriculture and horticulture are important in sustaining people's livelihoods, an idea which is supported by the conceptual model, and by locally identified indicators.

(Left) Village flock of goat and sheep, en route to Rohtang Pass at the head of the Kullu Valley. (Right) Older orchards replacing mixed agriculture. Young orchard is evident in the middle of open areas in the middle foreground, Old Manali.

Key management considerations for the maintenance of the system and its components include the timing and intensity of biophysical flow appropriation. Management also impacts soil quality and erosion. As soil is an important factor in the productivity of the biophysical system shown in Figure 3, the research also focuses on soil erosion. Village interviews support the focus on soils, unfortunately, it was not possible to do soil quality analysis in the field.

The figure does not illustrate the direct flows of timber which historically went to government contractors. As well, it does not illustrate human waste flows, or the environmental service of waste assimilation. The latter two omissions may be a mistake considering the increasing impacts of tourism. Although, in the study villages, there was no observed waste impact on forest, pasture, and horticultural and agricultural areas.

Traditional household, living quarters above, animals below, drying grass for storage.

Most wastes simply end up in the Beas River, to be carried downstream.

Although the conceptual model (Figure 3) does not directly illustrate it, the village community, and the resources they use, are in a two-way mutual causal relationship with respect to management. If the figure were to illustrate management, there would also have been arrows from and to resource management agencies, including the village.

In sum, the conceptual biophysical flow model supports and provides a mental framework for all the preliminary indicators and indicator monitoring approaches selected from the literature and from discussion with thesis committee advisors. The preliminary (pre-fieldwork) indicators are also referred to as the externally identified indicators to distinguish them from the locally identified indicators. The preliminary indicators and their feasibility are described in more detail in the final chapter.

2.2.2 Indicators Carried into the Field. Although all the preliminary (externally identified, pre-fieldwork) indicators were carried into the field, the conceptual model and further brainstorming with advisors helped predict information collection approaches which were most likely to be workable by one researcher in the Himalayas. These included: change in the relative mix of tree species, and species preferred for use, as determined by village interviews; a walking survey of soil erosion characteristics mapped using a Global Positioning System (GPS); and interviews with villagers and local natural resources experts to identify indicators which were considered most important to monitor. It was assumed that local knowledge and understanding of the area and human/environment interactions would help screen the hundreds of indicators found in the literature (again, see Appendices 2, 3, and 4).

The initial plan for the local interviews was to ask "what good or bad changes are occurring in the valley." The term "good or bad changes" was used for simplicity of translation, and to encourage people to speak about implied sustainability indicators. It was not known whether forest cover, or any of the other preliminary indicators would be workable in the field. Methodology of the approaches was adjusted in the field, for example, a five page questionnaire for the interviews was reduced to only a handful of questions (described below) in response to the busy schedules of interviewees.

2.3 FIELD METHODOLOGY

2.3.1 Setting Up in the Field. The first week in the field served mainly as orientation. Accommodation was selected in the regional centre of Manali as a base from which to access the villages. Tours and hikes around the area brought the realization that the scale of the region would prohibit working with a watershed unit. Meetings with local natural resources professionals brought forth plenty of advice, and perspectives on sustainability, as a result, villages and their designated forest use areas were determined to be the most workable units of study. The entire region around

Manali, including dozens of villages was too large, and a single village was thought to be too unrepresentative. Probably the single most important step during the set up was finding a translator who was accepted and trusted by the villagers.

The village of Chachoga was selected first, partly because of the role of the Mahila Mandal (a local women's group) in halting forest depletion caused by the sale of fuelwood to Manali. This information was provided by the Forest Department in Manali. The Mahila Mandal provided a contact for entry into the village for interviews. Goshal was selected for comparison, and was chosen because it was the home of the senior translator involved in the study, and it was thus an opportune place to arrange interviews.

A village consultant (left), and the senior translator, Goshal.

The choice of which villagers to interview was largely opportunistic. In both villages, the people who were available were interviewed. In attempting to be representative in the range of people interviewed, interviews were conducted at various times of the day, from early morning to late evening. Many interviews were arranged either by members of the Mahila Mandal in Chachoga, or by the senior translator in Goshal. As the two major castes lived in distinct areas of the two villages, interviews were done in both caste areas.

2.3.2 Obtaining Forest Cover, Quality, and Tree Age-Class Data. Once the field set up was complete, the preliminary set of indicators was held up to the pragmatic light of culture, government records, and the abilities of one Canadian researcher in the Indian Himalayan front ranges.

Information on forest cover change over time, forest quality and species, and the tree age-class structure for each village's forest use area was found to be obtainable (it was a happy day). As the validity of these indicators and their importance in sustaining the lives of villagers is supported by both the conceptual model and by village interviews, they are presented in Chapter 4 of this research as workable indicators for villages in forested mountain watersheds of the upper Beas River. Assessment of the data is used to make several recommendations in Chapter 4, which presents data from both secondary sources, and direct observation (Chapter 5 presents local perceptions and perspectives).

Photocopies of original forest cover maps, and forest stand descriptions for Chachoga and Goshal forest use areas, were obtained from Manali's Forest Range Office. Tabulated tree age-class data from a 1979-1980 inventory were obtained from the same office. The age-class data was stored on a compartment basis; several compartments make up a forest use area. The information was thus compiled for the forest use areas of each of the two villages, and the results graphed for the more common species (greater than 100 individual trees). Observations from walking were also made, and recent reforestation (plantation) sites were added to the forest cover maps.

2.3.3 Observing Soil Erosional Characteristics. Of all the naturally occurring energy and material inputs into system components of forest, pasture, and horticulture & agriculture, only soil erosion and quality can be readily impacted upon by people. The other inputs of solar energy and moisture, as shaped by factors of altitude, soil type, gradient, and aspect, are less likely to be changed, other than by massive physical works or climate moderation (see Figure 3). Village interviews, literature based indicators, and the conceptual model, all support the use of soil quality and erosion as relevant indicators. Unfortunately, a survey of soil quality and the laboratory work required to determine soil quality proved unfeasible.

An attempt to survey the entire village forest use area was initially made. At each of the hundreds of survey points, data for the universal soil loss equation (USLE) was collected. Such data includes a rain intensity factor (from a nearby weather station), a soil erodability factor (from in-field techniques to determine soil characteristics of type, permeability, and structure), a slope length factor (paced and estimated), a slope gradient factor (using a clinometer), and a cropping management factor (estimating percent vegetation cover). The data collection methodology was from the Canada-Manitoba Soil Survey. The survey points were not random, but done in patches of generally uniform conditions. The size, shape and orientation of each patch was noted. The points were spatially referenced using a GPS with the hope of creating a map showing areas of differing erosion potential.

Surveying the entire forest use area, and creating a soil erosion potential map, proved unworkable, the area was too large to survey, and data transfer of hand written GPS points and creation of a map was too unwieldy. As a result, the erosion potential focus was narrowed to orchards, forests near the villages, and the agriculture-forest interface - key areas of activity and erosion concern. Estimation of the percentage of soil exposed to direct rain was qualitatively recorded for these areas to gain insight on the relative level of soil erosion. Observations along the interface were made approximately every 20 m. Several random observations were made in forest and orchard. Soil erosion potential is described in Chapter 4 as a workable indicator. Management recommendations are also made in that chapter.

2.3.4 Interviews: Local Perceptions of Tree Species Change and Preferred Use. Changes in the relative mix of different tree species, according to local perceptions, was identified in the preliminary stages as a workable indicator of possible reverse succession, and thus unsustainability. The only way to ascertain trends in the relative mix of tree species was to ask the villagers and the area's forest range officer. It was not possible to determine trends from Forest Department records, as only a single 1979/80 forest inventory was available. Long-term (30 year) and short-term (2-3 year) time frames were used in the interviews to identify trends which may have changed or turned around. The 30 year time frame was selected so that many of the interviewees could remember, or would know about changes. Questions on preferred use of different species were also asked, as decline in preferred species would be undesirable, and would indicate the possibility of unsustainable use rates of those species. The importance of forest products to people's livelihoods, as identified by the conceptual biophysical flow model, supports the use of tree species change as an indicator. In addition, the "just ask approach" to interviews was simple, and seemed enjoyable for the interviewees. It became evident that all villagers had a high degree of knowledge and familiarity with changes in their respective forest use areas, especially long-term residents involved in the agrosilvipastoral system (for discussion on intra-village differences see K. Davidson-Hunt 1995).

The trend and preferred use information was gathered using non-scheduled structured interviews with a translator. At their convenience, villagers were asked *"how do you use the forest, what species are best for those uses and why, and what 30-year and 2-3 year trends have you perceived in the availability and area cover of those species?"* The part of the question which addresses trends was also asked of the area's forest range officer for comparative purposes. Agreement between villagers and the forester would strengthen the reliability of the responses. A list of 28 utilized tree (and shrub) species was compiled during the course of the interviews, and used to aid discussion of trends (see Table 1). During the initial part of the interviews, villagers typically spoke spontaneously of five to twenty preferred species (median range of nine to fifteen). Some of the interviews took place with groups of two to five people who would put forth single responses (not necessarily agreed upon). Twenty interviews were conducted in Goshal, sixteen in Chachoga, and one with the forest range officer. The number of spontaneous responses on type of forest use was used as a rough proxy for strength or importance of that use. Tables 1-3, and Figures 10 and 11 were generated. These same interviews were also used to ask about village identified sustainability indicators (see the following section). The results on trends in tree species change are described in Chapter 5.

2.3.5 Interviews: Locally Identified Sustainability Indicators.

Drawing from the background literature, discussion, and logic, it was decided that the easiest method to determine which indicators were locally relevant was simply to ask.

This approach constituted an entirely different perspective on the research. Whereas the field methods described above cover indicator data collection, this portion of the fieldwork covers local identification of indicators, but not actual data collection. The relative importance, or weighting, of the locally identified indicators is assumed to correlate with the number of responses on each indicator.

During the same non-scheduled structured interviews described above, villagers were asked through a translator: *"what signs and/or signals should be watched to predict a good or bad future for you, your children, and your grand children?"* This question was asked in general, and more specifically concerning natural resources. The first few interviews posed the question as "what are the good or bad changes happening in this area," before the "signs and signals..." question was formed.

The resulting signs and signals are used as a proxy for locally identified sustainability indicators. The question was asked in an open-ended manner; no list of possible indicators (signs and signals) was provided to villagers, thus responses were spontaneous. The technique was informal, and as interviews progressed, responses which were interesting or unclear were followed up. The median range of suggested indicators was from four to seven. Prompting, using recent interview responses, did occur during some of the interviews. The raw results from each village are shown in Appendix 5.

In addition, nine non-village local professionals, whose work concerned natural resources management in the Manali and Kullu area, were interviewed early in the field season. These interviews were later compared with the village interviews. The local professional interviews focused on issues of sustainability in the region, and on what indicators would be most important to monitor. These interviewees spoke English, and a summary of their raw responses is shown in Appendix 6.

The responses for each village, Goshal and Chachoga, were clustered in what seemed logical manners. Given their similarities, and for simplicity, the responses for the two villages were then combined. The combined indicator clusters are shown in Figure 12. A comparison of the relative weighting of the indicator clusters from the villager perspective and from the perspective of local natural resources professionals is shown in Figure 13.

The identified indicators, and some discussion of their relevance to the area, are presented in the latter half of Chapter 5.

2.3.6 Indicators Selected After the Fieldwork. After returning from summer 1994 fieldwork in India, a third set of indicators was selected in addition to the first two sets. It was thought that perspectives gained by this researcher in the study site would cast a new light on indicators from the background literature. Thus, the third set was selected by revisiting the background literature whilst drawing from perspectives gained in the field. The third set is described in the final chapter.

2.4 PUTTING THE RESULTS TOGETHER, AND THEIR COMMUNICATION

The identified indicators can have any combination of possible qualities: they may have been selected during preliminary stages of this research; they may have been found workable by this researcher in the field; and they may be identified by most respondents, or by only a few respondents. The resulting indicators, with different combinations of these qualities, and an interpretation of the importance of these different combinations, are presented in the final chapter.

Indicators which were selected during the preliminary stages, which emerged as workable by this researcher during the 1994 summer field season, and which were also identified by a large number of local people, are of particular interest for monitoring efforts, and may also have potential for application in different forested mountain environments. Indicators which were selected during preliminary steps and identified by many local people, but were unworkable, have potential for future sustainability monitoring. Indicators which were selected in preliminary stages, or by local people, but not by both, show the importance of including both external and local perspectives in indicator selection. Such differences illustrate differences in perspective, and possibly in understanding, and require further research.

The approach taken is essentially a three sided one, in that indicators are drawn from three perspectives: An external "objective" perspective; an internal local perspective; and a "workability" perspective (in this case, by this researcher). All three are important elements in the creation of a set indicators which are objective, relevant, and feasible.

To communicate the findings and recommendations, a technical report of findings was published and distributed among Shastri researchers, other researchers, local Indian NGO's, and selected policy and decision makers in India. Findings were also presented at a conference on Community Based Natural Resources Management, April 27-29, 1995, at the University of Manitoba.

3 LITERATURE REVIEW: A CONCEPTUAL BACKGROUND

The role of the literature review is to provide context and support for the research. In this case, the literature is also used as conceptual input for the development of preliminary (pre-fieldwork) sustainability indicators. Although sustainability indicator information is scattered in general (Friend 1992), and does not follow any agreed upon definition (Kay 1991), the literature does present some data specific to the study area. However, all the Himalayan specific studies take an ecological tact. Several authors recommend the need to consider the human side of sustainability, such as daily problems, risks, and amount of local control (Sharma and Minhas 1990; Agarwal 1987; Jodha 1993; Ostrom 1990; Berkes 1989).

Most of this literature review is devoted to background concepts which underlie sustainability and sustainability assessment. The background concepts are divided into four major sections. The first section presents an outline of: the idiosyncratic characteristics of mountain environments (i.e. those which lead to high biodiversity); threats to mountain environments in general; and specific information on sustainability in mountain watersheds of the Himalayan region. This first section points to the need for methods to monitor sustainability. The second section focuses on ecological concepts and studies of ecological sustainability. The third section takes a human perspective by discussing the importance of local knowledge, and incorporation of social, cultural, and equity elements in sustainability indicators. The fourth section looks at new approaches for the development of indicators based on guiding principles and selection criteria.

Insights from all the sections of this chapter were used to help develop a preliminary indicator list (outlined in the methods section, and described in the final chapter). Following completion of the fieldwork, this background literature was reconsidered again, in order to help select several additional indicators (shown in Chapter 6). Recommendations from the second, third, and fourth sections were also carried into Chapter 6.

3.1 Mountain Watershed Sustainability and the Upper Beas

Historically mountains have not been considered a "field of study" such as oceans and rain forests, yet mountain environments are some of the most complex, changing, and vulnerable ecosystems. Within this under-considered field, especially within the case study area of the Himalayas, there is a perceived lack of sustainability. Literature about mountain areas, sustainability in mountain systems and watersheds, and the situation in the Himalayan context is presented below.

3.1.1 The Mountain Template and Microclimatic Diversity. Mountain areas are elevated, and frequently dissected landscapes, with inclined surfaces of a steeper slope than lowlands. Formed of faulted or folded strata, metamorphosed rocks, and granite batholiths (large irregular mass of igneous rock that has melted or forced its way into surrounding strata), mountain landscapes are also defined by climatic and vegetational characteristics which change significantly at increasing altitudes (Price 1981).

> Clearly, one of the most distinctive characteristics of mountains, in addition to high relief and steepness of slope, is great environmental contrast within a relatively short distance (Ibid:3).

Many factors combine to shape the diversity of micro-climates in mountain environments. Latitude controls the angle (or directness) of incoming solar radiation. Slope affects the angle of the receiving surface, and controls the intensity of down-slope processes. Altitude affects pressure, which in turn affects water vapour content, both decrease as altitude increases. An example of these factors is that at mid latitudes, a surface inclined 20 degrees towards the sun receives fully twice as much energy as a flat surface, and a surface inclined away from the sun receives much less energy. Such difference are reflected in the different plant communities and habitats they support (Price 1981). Similarly, a 100 m increase in elevation is roughly equal to a 100 km increase in latitude (Denniston 1995). Micro-climatic diversity as a result of slope, altitude, and aspect variation affects plant diversity, primary productivity, energy balance, and soil type at a micro-regional scale. People living in mountain areas take advantage of micro-climatic diversity in mountain areas, to grow and use a diversity of crops and other products.

Numerous other biophysical factors are peculiar to mountain systems. These include barrier effects - the damming, deflection, and blocking action of mountains on flows of air; disturbance of upper air resulting in waves (much like the wake behind a ship); forced ascent of air resulting in rains (monsoon winds blowing north and up into the himalayas); and forced descent (adiabatic heating by compression). Temperature inversions also occur when cold air flows slowly down into valley bottoms, in such situations a thermal belt often forms where the valley floor is cold, a belt of warmer air sits above, and colder air is found again at higher altitudes. Daily temperature ranges actually decrease with higher elevation because at higher altitudes, one is further away from the fluctuating temperature of the earth's surface, this is also called the island effect, where the elevated area can be likened to an island in a sea of air of stable temperature. Humidity is lower at higher altitudes, however the drying effects of lower humidity are countered by lower temperatures at such altitudes. One also finds *slope winds* in mountain areas, caused by the heating action of the sun, these winds flow upslope during the day, then down again at night (Price 1981). A sum of the typical physical, biological, and evolutionary components of high mountain ecosystems by W. Dwight Billings (1979) is shown in Appendix 1.

3.1.2 Human Roles in Mountain Environments. A worldwide perspective suggests mountain environments are threatened by poverty, and population growth which leads to increased demands for fuelwood, crop-land, and demand for timber. Other threats include the control of village forest resources by external agencies, overgrazing, air pollution, and road building. The results are unsustainable livelihoods, vulnerability of the poor, as well as soil erosion, floods, siltation (Vollers 1990; Carpenter and Harper 1989). The ecological situation in Himachal Pradesh is described in similarly bleak terms by several authors. For example Shah (1988) describes the depletion and deterioration of grazing lands and associated forest lands as a result of sedentary and migratory nomads. Sen Sarma (1987) writes about forest degradation, deforestation, and environmental deterioration as a result of population pressures, fuelwood demand, and

Looking southeast from Solang Valley, across the top of Kullu Valley.

the practice of shifting agriculture. Focusing on energy flow from forests into the agrosilvipastoral system, Gupta and Joshi (1987) suggest that 65% of the region needs to be covered in dense forests to sustain inputs into that system.

Balances between arable and forest land are said to be unstable. Fuelwood, fodder, and manure (all dependent on forests, with the latter two being key inputs into arable land) are in such short supply that arable land can support only half the village's needs (Haigh 1988).

Azad and Verma (1993) assembled data showing the number of hectares of different land-uses available per rural person in all of Himachal Pradesh between 1966 and 1990. In 1966, with a rural population of 3.0 million, there was 0.28 ha of cropped area and 0.23 ha of forest area per person. In 1990, with a rural population of 4.7 million, there was 0.19 ha of cropped area, and 0.18 ha of forest area per person. Information at the scale of the case study regarding population and cropped area is uncertain.

Ahmad (1993) and Kayastha (1992) summarize some processes leading to perceived non-sustainability in forested mountain watersheds in Himachal Pradesh. These include: unplanned land use, cultivation on slopes, overgrazing, mega-engineering projects, over-exploitation of village or common forests, shifting cultivation, unplanned tourism, and urbanization. These processes lead to increased risk of landslide, sedimentation, changes in surface and ground water hydrology, eutrophication, drying up of springs, reduced animal habitat, and even the receding of glaciers. Changes in these measures over time in the upper Beas need to be monitored, and the measures of greatest local importance need to be identified. This research begins this identification process.

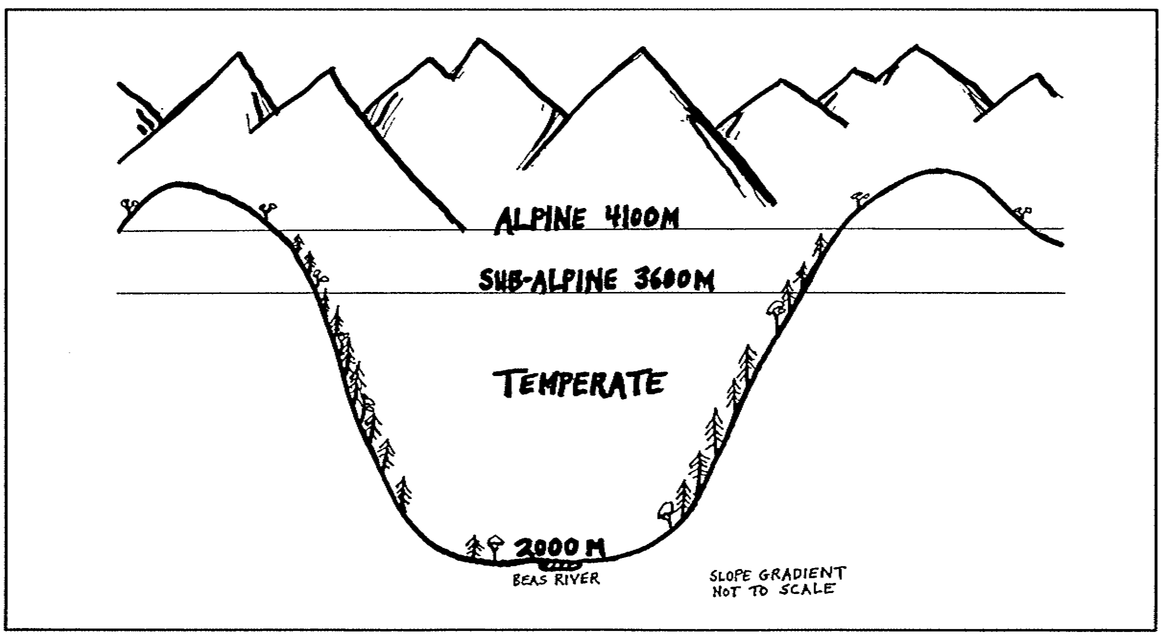
3.1.3 Summary. There is a wealth of general information describing "non-sustainability" in mountain watersheds in the Himachal Pradesh region and mountain watersheds. Interestingly, it always seems easier to recognize non-sustainability, and processes which lead to non-sustainability. Such processes include deforestation and overgrazing. For the purposes of this practicum, non-sustainability processes affecting forested mountain watersheds and the people living there need to be understood to gain insights on indicator selection. In particular, an understanding of the stage, the mountain environment upon which these processes take place, needs to be understood. The stage is described above. The challenge remains, how to predict a sustainable future, rather than recognize an unsustainable past and present.

3.2 Ecological Sustainability Indicators

There is a broad range of indicators of ecological sustainability from inventory and composite measures, to focused approaches such as energy flow analysis, to a few attempted holistic single measures. These can be based on elevation zones and soil type, and include total use of products from the watershed versus watershed primary production.

3.2.1 Using Indicators. Kimmins (1992) explains that sustainability indicators monitor a state of affairs which is compared with desirable conditions or goals laid out in principles. When indicators are compared with a past, or a desired future condition, they provide an instantaneous measure. Perhaps even more importantly, indicators can also show trends when monitored over time. The use of desired conditions or goals as a comparison, for ascertaining management success, raises the question of whose conditions or goals are chosen. This question is addressed later in the literature review.

3.2.2 Indicators by Vertical Zone. Literature on mountain systems suggest that analysis can logically focus on processes, within altitude based zones, and the interrelationships between the zones (Tyler 1988). In the study area in the western Himalayas, the valley bottoms are naturally forested up to a tree line of 3,500 to 4,200 m. Meadow occurs above the tree line, and glacier/rock occurs above the meadow (Kayastha 1992). Negi (1990) breaks down the area's verticality into the following zones: alpine >4100 m, sub-alpine 3600-4100 m, temperate 1650-3600 m, and tropical and sub-tropical <1650 m. Bandyopadhyay (1992) states vertical formation is the primary determining factor for mountain processes. Vertical zonation also has a profound effect on land productivity. In the study area, flat valley bottoms are highly productive for agriculture and horticulture, valley bottoms are also the location of all human settlements in the area.



A schematic representation of vertical zonation in the Kullu Valley near Manali, not to scale (after Negi 1990):

3.2.3 Inventory Approach to Indicators. Inventory indicators of ecosystem sustainability range from simple to complex. The simplest is a descriptive inventory. This indicator type is poor at assessing ecosystem integrity and sustainability, however inventories can be useful for identifying rare species, resources, or habitats, and especially for monitoring change over time. This study will compile some recent historical inventory information for the study village areas. A major drawback with monitoring inventory change as an indicator is that changes often occur "after the fact," that is, too late to prevent unwanted changes in the ecosystem (Kay 1991).

Inventories also include soil type, top soil thickness, and soil loss. Thus this study observes soil loss characteristics, and the possible ramifications for productivity. Kayastha (1992) describes a once forested area in the Himalayas which has become barren in living memory as a result of soil loss. He adds that 15 cm of top-soil is lost in 100 years of normal rotating cultivation, while the same amount of soil can be lost in 17 years if fields are left bare or continuously cultivated with maize. This study gathers specific, as well as anecdotal soil loss information from the study area of the upper Beas. Further, underlying soil and rock structure will likely have a large bearing on ecosystem stress responses, risks, and rates of soil depletion (Gardner 1994, pers.com). Consideration of the soil type is thus made.

As an inventory measure, changes in forest cover over time is assessed in this study, as is forest age-class structure. Changes in forest cover occur mostly near the villages, however a study done in the Modi Khola valley in the Annapurna range found that the tree line had lowered several hundred feet in the past two decades as a result of tourism (Pirazizy and Singh 1992). Changes in the forest cover, quality, and age-class structure are assessed.

3.2.4 Populations and Biodiversity. The study of species populations provides more detailed information than the inventory method. Populations can be modelled, and also provide a useful indication of the impact of environmental change on individual species, although a focus on populations does not provide as much insight on the effects of environmental change on the whole ecosystem (Perrings et al 1992, Kay 1991). A common type of population measure is diversity, referring to diversity of different species in the same area. However, the term biological diversity, or biodiversity, also refers to genetic diversity within a species, as well as diversity of trophic structures within a ecological community, and diversity of habitat type within an area. Measures of biodiversity reflect the number of, and the evenness (or dominance) of, the different genes, species, structures or habitats. High measures of biodiversity reflect both a large variety of gene, species, structure and habitat, as well as evenness (i.e. no single dominant type)(Perrings et al 1992).

Maintenance of sufficient biodiversity assures the resilience of ecosystems which deliver ecological services (Perrings et al 1992). It is thus vital to identify the autopoietic (self sustaining) features of an ecosystem to determine how species are supported and sustained across generations. Biodiversity could thus be used as an indicator of the functioning of autopoietic features (Norton and Ulanowicz 1992).

Use of biodiversity as an indicator depends on available information. Local and outside expertise are both required for study work. Information on trophic structures, successional stages, and dominant species, add to the utility of diversity as an indicator. Perrings et al (1992) suggest there is a relationship between biodiversity, standing biomass, and primary productivity.

Steady levels of diversity, or diversity levels which fluctuate within a certain range, give some indication of an ecosystem which is not overtaxed (Holling 1986). Drawbacks to this indicator approach include the difficulty and time involved in diversity studies, particularly in the high diversity of mountain areas, and a lack of predictive ability; by the time diversity changes are recorded, major ecosystem change may be well under way. In addition, the jury is out on whether the increase of biodiversity signals an improved ecosystem. Unfortunately, management for the increase of species diversity remains a popular approach, an approach which is not fully supported by the literature (Kay 1991).

3.2.5 Resilience Theory, Stress-Response Theory, and Ecosystem Health. More complex types of sustainability indicator are those which attempt to assess the resilience of entire ecosystems. Until recently the term resilience referred to ecosystem stability at a presumed steady-state, and stressed resistance to disturbance and speed of return to equilibrium. However, C.S. Holling et al (1994) describe a new definition for resilience. This new perspective emphasizes conditions in which <u>disturbances can flip</u>

a system from one equilibrium to another. Thus the measure of resilience becomes the scale or magnitude of disturbance that can be absorbed before the system changes in structure through changes in the variables and processes that control behaviour (Berkes and Folke 1994). This new multi-equilibrium approach is Holling's (1986) "science of surprise." From Holling's perspective, managing a system for a particular steady-state by preventing small perturbations allows larger potential perturbations to accumulate, and which will ultimately occur in a less predictable manner. When such larger perturbations finally occur, they can move ("bifurcate") a system into an altogether different, perhaps less desirable equilibrium. In short, a system frozen by management in a particular state, becomes "brittle", ready to shatter into a new and unpredicted state.

Another example of ecosystem analysis is the stress-response approach. Perrings et al (1992) state that the resilience of an ecosystem's self organizing ability determines the system's ability to handle stress. Using stress indicators however, requires a lot of information, furthermore, there is no consensus about what constitutes a stressed versus a healthy ecosystem. Kay (1991) cites a table of various indicators of ecosystem stress, which draws from several authors, please see Appendix 2.

Stress indicators are analogous to symptoms of poor ecosystem health. Schaeffer et al (quoted in Kay 1991) suggest criteria of how to use measures of ecosystem health. Such measures could also be used directly as indicators of ecosystem sustainability. Criteria for selecting the health measures (which could also be used as criteria for ecosystem sustainability indicators), are that they:

> a) do not depend on the presence or absence or condition of a single species; b) do not depend on a census or inventory of a large number of species; c) reflect our knowledge of normal succession; d) are not a single number; and e) they are related and hierarchically appropriate for use in ecosystems.

In looking at trends in the relative proportions of different types of tree species (as distinct from genus or family), this study attempts to assess environmental responses to stress which are relevant to livelihoods of the people in the two study villages. Locally identified environmental responses to stress may also be easier to obtain than the ecological measures suggested in Appendix 2.

3.2.6 Energy Flow and Recycling. The most complex type of ecosystem indicator is "flow analysis." This type of assessment is based on H.T. Odum's energy and mass flow diagrams, where the important functional attributes are the amount of recycling within the ecosystem, the use of nutrients and energy by the ecosystem, and throughput of energy and materials. The structural attributes of this analysis include the degree of interconnection between ecological components, the trophic level of the components, and the number of trophic levels in the ecosystem. A stressed ecosystem can be summarized as follows: it is smaller (in terms of throughput of energy and materials), more of the system biomass is comprised of lower trophic levels as compared to a non-stressed ecosystem, it recycles less energy and materials, and it leaks energy and materials (Kay 1991).

The drawback to using flow analysis to determine ecosystem sustainability, is the data requirement, however, several authors agree that flow analysis, in conjunction with species population and biodiversity studies, will lead to understanding of ecosystem development and integrity. Another problem with flow analysis lies in the proposed application of flow analysis; it has a purely ecological focus. However, there is no reason why flow analysis could not ultimately include human use and recycling of material and energy, other than increased data requirements.

Several examples of specific flow analyses of ecological sustainability have been attempted in regions similar to the case area. In the Gharwal region, an ecologically and socially similar area to the upper Beas, an example of energy and material flow analysis concluded that each energy unit of agroeconomic yield is dependent on about 12 units of forest and grazing land energy for fuelwood and animal fodder. Unfortunately forest cover is decreasing, thus the sustainability of agroeconomic yield is in jeopardy (Singh and Singh 1991; Singh et al 1984). In the Gharwal region, Singh and Singh (1991) conclude that in terms of primary energy and matter, forests are ten times more productive than agricultural production of the same area, likely as a result of the greater quantity of photosynthesis (however, the authors fail to describe how much of this forest productivity can ultimately supports humans). Singh and Singh promote afforestation to provide inputs into agriculture, and thereby increase regional profits and aid recovery of ecosystems.

In a similar study, Ralhan et al (1991) found that organic compost, mostly from the forests, accounted for over 90% of the energy input into village crops, and that from 2 to 9 units of forest energy were required for each unit of agronomic yield. Much forest energy is provided to crops in the form of fodder and bedding material (fodder is converted to manure, and mixed with bedding, which is then used as compost).

Previous work by Robinson (1987) supports Ralhan et al. Robinson describes how the main agricultural inputs of fodder, bedding material, and direct use of leaves as compost, primarily originate in the forest. Given the interconnections between forest, livestock, and type of agriculture, changes in any one component will affect the other two.

In an area of Nepal with similar altitude and rain to the study site, animal fodder was found to be supplied from crops 14%, grassland 27%, forest grass 15%, forest leaf fodder 39%, and private tree leaf fodder 5%. The important forest contribution supports Robinson's assertion. Recent Himalayan evidence suggests that there are insufficient nutrient inputs into agricultural land. In other words, the major source of those inputs, the forest, is no longer sufficient for agricultural requirements. Not only is full agricultural productivity is not achieved, but agricultural land productivity is thus in danger. Robinson (1987) further suggests that fodder harvest is too high to sustainably maintain forest inputs into agriculture.

Robinson cites seven studies which calculate the amount of forest and scrub land required to provide the necessary agricultural inputs in a sustainable manner. The assumptions behind the calculations vary, thus the amount of forest and scrub land needed to sustainably support 1 ha of agricultural land ranges from 1.1 - 40 ha. Robinson revisits the calculations used in the seven studies, and estimates 2.8 - 18 ha of forest and scrub per 1 ha of agriculture. Looking at Figure 2, it can be seen that the ratios for the two case villages are within this range. Robinson recommends stall feeding, as stall fed cattle require less forest in order to input the same amount of manure into agricultural land. He also cites several examples where total crop production is increased when woody perennials are intercropped, even though the actual area devoted to the crop is thereby reduced. The reason for this increased production is the addition of mulch (compost) from the woody perennials, either directly, or through cattle manure, and even from bird droppings which roost in the trees. Such studies as described above suggest the ratio of different land-uses in the actual study area could be included among recommended sustainability indicators, however this approach is very general, and is affected by differences in forest productivity.

Additional research related to flow analysis is cited by Sharma and Minhas (1990). For example, in a study of the use of wood for packing crates for the fruit and vegetable industry, it was found that about 3 ha of spruce/silver fir forests are cleared to support 1 ha of apple orchard. Likewise 10 ha of chir pine forests are cleared to provide packing for 1 ha of tomatoes. Unfortunately these studies do not make clear whether this amount of wood is required every year, or for the average total life of the orchard or tomato field.

Flow analysis of fuelwood use has also been undertaken. For example Negi et al (1986) did a survey in the upper hills of Shimla near to the upper Beas, and found fuel wood was the only source of energy for cooking. Villagers depend on forests for 84% of their fuelwood, and rely on their own sources such as orchard prunings and farm trees for 16%.

In Nepal, tourism pressure is seen as largely responsible for the reduction of Nepal's forest cover from 60% in the 1950's to 17% in the 1990's with resulting erosion and landslides (Shoumatoff 1991; Kayastha 1992). Such deforestation has serious consequences for Nepalese people, who rely on wood for 98% of their cooking and heating needs.

When fuelwood supplies decrease, increased use is made of manure for fuel, thereby removing manure from use in farming. This is the case in Phalabang (Zurick 1987). This study also makes observation of the use of manure for fuel, and whether villagers are satisfied with the amount of manure available for agricultural and horticultural inputs. Change in forest cover, density, and trends in tree species indicate the sustainability of fuelwood use.

3.2.7 Ecological Economics. Ecological economics is an approach which links the laws of thermodynamics to economics. As described in Pearce and Turner (1990:362), the relevance of the laws of thermodynamics to economics was first demonstrated by Kenneth Boulding (1966), expanded on by Nicholas Georgescu-Roegen (1971), and further clarified by Daly (1980). The theory is based on the first and second laws of thermodynamics. The first law states that matter and energy can be interconverted, but the sum cannot be destroyed. The second law states that in changes in closed systems, low entropy products are changed into high entropy products in an irreversible manner.

The approach likens productive renewable resources to a form of capital stock - natural capital - from which can be drawn a certain amount of income in the form of products and services from the resource. The approach attempts to measure the capital stock, and the income flows (Victor 1991a, 1991b; Costanza 1991). The thermodynamic school argues for the maintenance of a constant physical stock of natural capital (Daly 1980; Daly and Cobb 1989; Rees 1992). Natural capital includes natural systems which provide products (eg. fish and wood) and services (eg. flood control and climate stability) to the Earth. A larger stock of natural capital provides communities with more options to respond to shocks - a form of resilience. Furthermore, a constant stock of natural capital is demanded by intergenerational equity and the rights of other species (Victor 1991a). There is uncertainty concerning the size of stocks of natural capital; there is also uncertainty due to the risk of "irreversibility" if stocks are depleted too far. As Pearce and Turner suggest, *risks of irreversibility, indeed, uncertainty about the quantified amount, should make us more circumspect about giving up natural capital* (quoted in Victor 1991a:13).

As with flow analysis, the problem of actual measurement is a major drawback. Herman Daly however, provides four theoretical principles which could be considered as the basis for indicators of sustainability, depending on whether the data is available:

> a) keep within the carrying capacity of the region; b) use technology to increase use efficiency of ecosystem products and thus decrease social or ecological throughput of matter and energy; c) harvests and emissions should not exceed regenerative and assimilative capacities respectively; and d) non-renewables should be exploited at a rate equal to the creation of renewable substitutes (quoted in Victor 1991a).

One branch of ecological economics, sometimes called the London school, is concerned with the first law, in particular how all energy and matter are ultimately returned to the environment, thus causing degradation, and reducing its capacity to support future generations. The solution lies in taking the waste matter and energy, known as externalities, and internalizing them in the economic decision making of individuals and firms, by making those individuals and firms accountable for the waste matter and energy (Perrings 1987; Pearce and Turner 1990).

Another ecological economic technique is to place a monetary value on ecological functions (Pearce and Atkinson 1993). This approach has the same problem of measurement, but further problems of ecological thresholds, and the possibility of irreversible and undesired ecosystem change, make pricing ecological functions a very difficult task.

A recent approach based on the entropy law focuses on the individual consumption of resources by people living in an area. The idea is to determine the amount of natural products and services each person uses, and translate this amount into the area of land required to provide these products and services sustainably. The flow of products and services used by each person, or village community, is called their *appropriated carrying capacity*. The area of land required to sustainably provide the products and services used is described as the *ecological footprint* of the person, or village (Wackernagel et al 1993).

This approach poses difficulties on a regional basis when the local people use products imported from outside the watershed, and products and services of the watershed are exported. Secondly, the question remains of what is the sustainable amount of products and services which can be appropriated? This method is more useful at a national level because information on import and export of matter and energy flows is then available.

One author attempted to estimate the carrying capacity of common property resources in Himachal Pradesh, but failed to obtain results (Dalbir 1989). Clearly such estimations require too much information to be undertaken in this study.

3.2.8 The Prototypical Watershed Approach. A theoretical approach is to compare the total amount of watershed products used by humans with the *hypothetical* primary productivity of those products from each of the various elevation zones within the watershed. The underlying idea is that human use of watershed products should not exceed a certain percentage of hypothetical primary productivity; this percentage would change depending on the various stress resilience abilities of the different elevational zones. Vitousek et al (1986) suggests human appropriation of the products of photosynthesis worldwide is about 40 percent, a figure which might be used as a first estimation. In essence, this indicator approach is analogous to the ecosystem health and stress approach, where a higher appropriation of primary productivity constitutes an increased level of stress, and an increased risk of ecosystem change. Levels of appropriation above a certain level required for basic ecosystem function would indicate unsustainability. However, as levels of appropriation increase, there is much uncertainty about how the ecosystem will respond, or how much warning there will be before ecosystem change.

However, this approach holds promise to provide a robust, and instantaneous, indicator of sustainability. Hypothetical primary productivity can be obtained by either the red and infrared spectrum of remotely sensed images, or less expensively by basic, inputs such as area, elevation, temperature, moisture regime, aspect, soil type, and vegetation cover type (Tyler 1994, pers.comm; Dale et al 1993). Surveys of the quantity of resources used by villagers could be done, and compared with the hypothetical production. Future attempts with this method are recommended, as long as the villagers agree to the monitoring of their resource use.

3.2.9 Other Approaches, and Multi-Criteria Analysis. Some other measures are available such as Karr et al's *Indicator of Biological Integrity* (IBI) (in Kay 1991). Cocklin et al (1992) outline several other approaches: the *checklist approach*, which usually provides a qualitative assessment, the *matrix approach* looks at activity and effect, where the effect might indicate non-sustainability, and the *component interaction approach*, a set of matrices which looks at source of the problem, interactions, effects, and the link between the source and the effect. Cocklin et al (1992) suggest combining the *component interaction approach* with the use of GIN.

Multi-criteria analysis provides a method of weighting, and perhaps combining the various indicators of sustainability. Such indicators include not only the ecological approaches discussed above, but also social indicators discussed below. Combining efficiency and ecological sustainability measures with social and equity measures is recommended (Pelt 1993). Multi-criteria analysis has proved useful on a project by project basis, but remains un-tested for combining measures in a general analysis of watersheds.

3.2.10 Summary. This section discussed a range of theories which form the conceptual background to the assessment of ecological sustainability in mountain environments. The concepts included: indicators by vertical zonation, inventory approaches, measures of biological diversity, ecosystem resilience, ecosystem health and stress response, energy and matter flow, ecological economics and the laws of thermodynamics, appropriated carrying capacity, and the prototypical watershed. Unfortunately there has been little or no experience in applying these to actual measurement of sustainability, nor a comparative evaluation of the different approaches. The concepts described above were carried into the field portion of the research, where the pragmatics of the case study site were used to screen the concepts and develop workable approaches.

This section summarizes several studies which demonstrate the current dependence of mountain village agrosilvipastoral systems on the forest inputs of fodder, bedding material, compost, and fuelwood in Himachal Pradesh. These studies support the conceptual model of village dependence on forests presented earlier.

A balance between time and resources, and the minimal level of detail and accuracy required must be struck in sustainability indicators, keeping in mind that indicators are just that - indicators, not exact measures. Furthermore, indicators which provide quick results are needed, as well as indicators which are more relevant in the long-term for the case area.

A selection of sustainability and related indicators is shown in Appendix 3, while ecosystem stress indicators are shown in Appendix 2. There has also been some more recent projects, which attempt to develop a range of sustainability indicators spanning biophysical, social, economic, and cultural realms using an indicator development framework of overall principles and selection criteria. These new integrative and composite approaches are outlined in the last section of this literature review.

3.3 Indicators, and the Importance of Local Perspectives

There are several attempts to include human aspects in measures of sustainability, such as amount of local control over resources, frequency and intensity of risks faced by residents, daily difficulties in meeting local needs, coping and adaptive strategies, and equity of access to resources. These all fall under the topic of livelihood sustainability, and provide helpful background concepts for indicator identification.

An important insight for indicators, is the idea that locally controlled natural resources management tends to be sustainable when: rules of resource use are developed locally; rules relate to local needs; non-locals can be excluded from the resource; and there are high degrees of participation and group ability to adjust rules (Chambers 1994; Jodha 1993; Ostrom 1990; Berkes 1989). Although the amount of local control over resources may or may not correlate with sustainability, the following quote provides some insight upon the effects of removing local control upon sustainability in the Indian context:

> When a person cutting wood in a severely degraded area, formally a locally controlled forest, was asked what she could do to help the reverse the degradation, she answered: "The forest? It's not my responsibility" (Balaton Bulletin, Fall 1993:13).

3.3.1 Integrating Biophysical and Human Sustainability Indicators. An integrated system of indicators which monitor the physical state of the environment (e.g. ecosystem integrity), and which links this to the changing conditions of human well-being, is essential in assessing livelihood sustainability (Friend 1992; Singh and Titi 1993). Given the high level of human dependence in developing countries on the products and services of nature, the present study can justify the evaluation and development of both biophysical and human indicators.

Dale et al (1993) and Cocklin et al (1992) suggest using a Geographic Information System (GIS) to combine spatial and elevation explicit ecological data with social, cultural, and economic factors, as a method of integrating biophysical and human measures in an accessible, and workable form. An additional methodology, with applications to both ecological and social sustainability measurement, is the Abiotic-

Biotic-Cultural (ABC) approach (Nelson and Serafin 1992).

3.3.2 The Importance of Local Definitions of Sustainability. Sustainability has a normative, or value judgement component. This normative aspect of sustainability occurs in the transformations which are permitted in preference to others in the pursuit of sustainability. The normative side of sustainability is also found in evaluating the desirability of trends, and in setting targets, or benchmarks, against which to immediately compare measures. As Jodha (1993) suggests, the identification of local perspectives and aspirations on sustainability is a key element in developing sustainability indicators, an approach which is used in the present research.

In mountainous watersheds of developing countries, sustainability involves the very survival of many people (Bandyopadhyay 1992), thus sustainability indicators based on local values are the only legitimate measures (Bergstrom 1993). Moench (1986) identified the sustainable supply of fodder as the primary concern of people in a Gharwal hill village, followed by supply of fuelwood. In this study, the key measures of sustainability from a local perspective in the two case villages are obtained through interviews.

Available examples of livelihood sustainability measures in the Indian Himalayas include per capita availability of land, and per capita wood consumption. In 1961, each person had 0.43 ha of land available, while in 1981, the figure had dropped to 0.15 ha (Kayastha 1992). Annual wood consumption is 2 tonnes in the high hills, while on average, fuel wood harvest per ha of forest comes to 1.8 tonnes in Himachal Pradesh (Sharma and Minhas 1990). Azad and Verma (1993) showed the number of hectares of different land-uses available per rural person in Himachal Pradesh to be 0.28 ha of cropped area and 0.23 ha of forest area per person in 1966, and 0.19 ha of cropped area, and 0.18 ha of forest area per person in 1990. Such declines in land available per capita increase the challenge of maintaining sustainable livelihoods.

3.3.3 Risks and Daily Difficulties People Face In The Upper Beas. The frequency and intensity of natural disasters such as floods, landslides, and avalanches, are often assumed to be related to degradation processes such as deforestation, inappropriate farming techniques, and overgrazing. Damage to settlements, agriculture, projects and reservoirs has resulted (Kayastha 1992). Other risks and challenges suggested by Sharma and Minhas (1992), and Agarwal (1987) include:

- disturbed hydrological cycle:
  - -floods
  - -drought
  - -drying of springs;
- depletion of:
  - -fuelwood
  - -fodder
  - -food
  - -fibre and fruits;
- drudgery faced by women to collect fuel wood and fodder;
- reduced air and water quality; and
- life of uncertainty and exploitation.

Many other risks could be added, depending on the circumstances of the locale. In the case study site, one could add risk of resource-use conflict, risk of crop failure and decreasing agricultural productivity, risk of forest dieback, soil erosion, siltation, decrease in energy availability, infant mortality, and school dropout to this list, plus famine, starvation, and malnutrition is always a possibility. However, there has been little actual integrated analysis of the frequency and intensity of such risks. Some studies address the issue of daily difficulties. For example Agarwal (1987) found it may take a woman eight to ten hours per day to gather biomass resources like wood in arid Rajasthan, versus less than one hour per day in Kerala. But few if any studies gather this type of information over time in one place. Jodha (1993) recommends monitoring the time to gather biomass resources as an indicator of sustainability.

As discussed earlier, the amount of natural capital, and its productivity, determines the amount of goods and services which can be sustainably appropriated from the watershed. However, determining that physical amount, and its productivity is problematic. Assuming these problems could be solved, Pearce and Turner (in Victor 1991a) suggest that communities are more resilient to natural shocks, and hence more sustainable, when there is more natural capital upon which to rely. However, the amount of natural capital available is only one factor in community resilience; local institutions, resource use patterns, adaptive strategies, cultural values, and amount of natural capital

The Beas River after heavy rain, at Manali.

all interact to influence a community's resilience to natural shocks.

In the upper Beas, subsistence use of natural capital provides a non-cash means of survival; this is good insurance against the uncertainties of cash jobs (Girardet 1993). Ham (1995) identifies adaptive strategies observed in the two case villages of Goshal and Chachoga during the summer of 1994, these include: 1) diversification of activities and household inputs; 2) crop species and spatial diversity within the traditional agricultural system; 3) increasing the integration of the household with the market economy; 4) reliance on agricultural wage labour and employment in the larger urban centre; 5) building up and drawing down of food, fodder, and fuel inventories; 6) reliance on common property resources; and 7) the development of community groups.

As one facet in estimating the physical amount of natural capital, and the extent to which its flow of "interest" is being used sustainably, this study suggests monitoring the frequency and intensity of risks over the past decades in the upper Beas as an indirect measure. This thinking follows C.S. Holling's ideas about the increasing unpredictability and fragility of a stressed system. In a similar vein, a diversity of uses made of a mountain ecosystem (livelihood diversity), which draws from many trophic levels, or parts of the ecosystem, may be less likely to trigger risk events than narrow, focused, and technically aided use of just a few ecosystem products. The diversity of uses made of a mountain ecosystem could thus be used as a possible indirect measure of sustainability.

Assessing the sustainability of natural capital "services" of steady water regime, and soil loss prevention in the upper Beas through the indirect measures of intensity and frequency of risk events, and daily drudgery faced by people would fill a gap in ecological economic theory. Friend (1992) suggests an approach for the assessment of risk in mountain systems, which is similar to the pressure-state-response framework described in section 3.4:

(i) level of stress on the environment (degradation processes);
(ii) environmental response to (i) - (including risk events);
(iii) human response to (ii) - (long-term adaptive strategies, and possible short-term coping strategies in the face of disaster, see Ham 1995); and
(iv) inventory of environmental stocks (natural capital stocks).

3.3.4 Social Components of Sustainability. Sustainable development emerged out of the issues of ecology, poverty, development, women, peace, and equity, Singh and Titi (1993:5) provide an operational definition of sustainable development which incorporates all these concepts. They write that sustainable development means:

- ensuring self-sustaining improvements in productivity and quality of life of communities and societies including access to basic needs such as education, health, nutrition, shelter and sanitation; as well as employment and food self-sufficiency;

- ensuring that production processes do not overexploit the carrying and productive capacities of the natural resource base and compromise the quality of the environment, thus limiting options of the poor, the present and future generations; and

- ensuring that people have basic human rights and freedoms to participate in the political, economic, social and environmental spheres of their communities and societies.

Ideally, indicators of sustainability should include components of ecological productivity and assimilative capacity, vulnerability to natural disasters, entitlement to means of production (land), political and social organizations and social services, and access to basic needs (from Singh and Titi 1993).

Focusing on empowerment, Singh and Titi (1993:12) list the necessary conditions for empowerment, some of which could also provide be incorporated in social and cultural measures of sustainability. These include:

> 1) self-reliance and autonomy; 2) space for cultural assertion; 3) access to land rights; 4) food self-sufficiency; 5) access to income and credit; 6) access to knowledge and skills (both traditional and modern); 7) access to skills training; and 8) meaningful participation in decision making.

Unfortunately, certain subtle social effects such as "sense of community" cannot be measured quantitatively (Cocklin et al 1992).

On a different tack, Chambers (1994), and Chambers and Conway (1992) suggest that empowerment and poverty figure significantly in issues of sustainability. This sentiment is captured in the following quote:

> To be poor effectively means to be isolated, vulnerable, and powerless (Chambers quoted in Singh and Titi 1993).

Levels of isolation, vulnerability, and powerlessness, together with amount of local control, and frequency and intensity of risks are all aspects of sustainability, and have potential as indirect measures.

3.3.5 Summary. There is a strong argument to include both biophysical and human perspectives among sustainability indicators, even though it may not be possible combine them into a single measure. GIS has the potential to make the biophysical and human measures accessible and useable in a spatially stored form. Local input into the sustainability indicators needs to be included in order for the indicators to be valid and relevant to particular regions.

Higher levels of local control and empowerment likely correlate positively with sustainability, and could thus be used as indicators.

Vulnerability to risks, and amount of daily drudgery to meet basic needs, also have potential as indirect indicators of whether the natural capital of the watershed is being degraded. Such an approach could prove useful given the difficulties in measuring natural capital directly.

A combined list of ecological and social sustainability indicators is shown by NRTEE (1993) in Appendix 3.

3.4 APPROACHES TO SUSTAINABILITY INDICATOR DEVELOPMENT

To ensure consistency and utility of sustainability indicators, most recent projects on indicators start with overriding principles or goals, towards which management shall aim. In essence, principles are future visions. Criteria are then used to select workable indicators by providing descriptions of desirable indicator characteristics. Indicators monitor progress toward the principles. An indicator is "a quantitative or qualitative variable which can be measured or described and which, when observed periodically, demonstrates trends in that variable" (Montreal Process 1995:5).

The principles behind sustainability indicators are rooted within the various definitions of sustainability; sustainable livelihoods as supported by maintenance of: ecological and economic integrity, resilience, productiveness and diversity, and social and cultural wellbeing. Principles also delineate the scope of indicators, which should include equity and efficiency, as well as sustainability (Opschoor and Reijnders 1991). The major goals underlying indicators is that they provide analytical, communication, warning and mobilization, and coordination functions (Hardi and Pinter 1995). The Montreal Process (1995), and the Alberta Round Table (ARTEE 1994) provide examples of principles. A selection of these sustainability principles have been made for their applicability to the present study area:

- Maintenance and enhancement of long-term multiple socio-economic benefits to meet social needs;
- Maintenance of productive capacity of ecosystems;
- Maintenance of ecosystem health and vitality;
- Conservation and maintenance of soil and water resources;
- Conservation of biological diversity;
- Maintenance of air, water, and land quality;
- Legal, institutional and economic framework for conservation and sustainable management;
- Healthy living environment in communities;
- Citizens are educated and informed about the economy and the environment;
- Citizens are stewards of the environment and economy.

Various criteria may be used to select indicators that best fit a given situation. The nature of such criteria can be surmised from the following list, adapted from Alberta Round Table (ARTEE 1994), Opschoor and Reijnders (1991), Hardi and Pinter (1995), and Holmberg and Karlsson (1992). Criteria used in selecting indicators for policy and resources management applications should:

- Be measurable, relevant data should be available, and data gathering should be cost efficient gathering - in sum, indicators should be workable;
- Be responsive to change, and shows results of action to effect change;
- Reflect the concerns of people and institutions in the area through their input;
- Cover biophysical, social and economic realms;
- Be easy to understand and meaningful;
- Focus on crucial factors in the human/environment system;
- Relate to one or more principles by being integrative;
- Have predictive ability;
- Be sensitive to reversibility; and

- Be sensitive to changes in time, across space, and over social distribution.

After indicators have been screened through the preceding list, they remain normative in the sense that they monitor a state of affairs which is compared with desirable conditions or goals laid out in the principles (Kimmins 1992). Indicators are categorized several ways in the literature. They can be drivers of change in the form of environmental pressure, or they can show the results of change, or environmental effects (Opschoor and Reijnders 1991; ARTEE 1994), or they may have qualities of both within a linkage model of cause and effect. Measures of "potential for management toward sustainability" should be distinguished from factual measures of pressures and effects. Potential for sustainable management indicators include current and anticipated science and technology (relevant to products, processes, and inputs), and managerial tools such as appropriate institutions and policy (Opschoor and Reijnders 1991).

To be useful, the condition shown by various indicators must be compared with a past, or a desired future condition; indicators can thus provide an instantaneous measure comparing the present with the desired goal, when monitored over time, indicators can also show trends. Holmberg and Karlsson (1992), and Opschoor and Reijnders (1991) suggest it may be possible to aggregate different types of indicators by standardizing them into ratios of actual versus desired condition (e.g. rate of flow vs. stock, or rate of flow vs. goal), and compiling the ratios into a single number - so long as the different ratios can be weighted in importance. Both a single aggregate number, and separate indicators would be useful for adjusting policy and management.

Additional suggestions on the use of indicators include periodically revisiting the desired goals, and public input into choice and weighting of indicators so as to reflect driving social, economic, technological, and political trends (Hardi and Pinter 1995). In spite of regional differences, and the resulting differences in appropriate indicators, Carpenter (1994) suggests the need for several "standard measures" in the areas of: yield characteristics, hydraulic cycle, water quality, soil condition, atmosphere, and keystone and pest species.

Several international organizations have recently agreed upon the *Pressure - State - Response* framework to make indicators operationally useful by addressing causal linkages between actions, effects, and reactions (Hardi and Pinter 1995:13). In the PSR framework, indicators should signal:

1) the *pressure* that society puts on the environment (in the form of resource depletion and pollution);
2) the resulting *state* of the environment (especially the incurred changes) compared to desirable (sustainable) states; and
3) the *response* by human activity, mainly in the form of political and societal decisions, measures and policies.

The indicators developed in several recent regional projects, and which use the principles and criteria approach described above, are shown in Appendix 4.

3.5 SUMMARY OF BACKGROUND LITERATURE

This literature review can be summarized as an attempt to explore ecosystem models, theories of mountain ecosystem diversity, and social perspectives which provide the necessary theoretical underpinnings, as well as practical implications for the development of sustainability indicators applicable to Chachoga and Goshal. The literature ranges from general descriptions of forest cover decline, erosion, and over-grazing in the region, to other more detailed conceptual approaches, such as material and energy flow analysis of agrosilvipastoral village systems in the western Himalaya.

There is a broad literature on potential indicators of sustainability from both biophysical and human perspectives. This study incorporates both of these approaches by carrying the concepts into the field and exposing them to the pragmatic demands of a Canadian researcher working in a different cultural environment. The resulting data and local perspectives from the two study villages are developed into indicators of sustainability. Several of the approaches described in this literature review, in including the use of GIS, are recommended for use in the assessment of sustainability of mountain communities, but were unworkable during this study. Recommended approaches are summarized in the final chapter together with the research results.

4 NON-INTERVIEW DATA COLLECTION FOR FEASIBLE PRELIMINARY INDICATORS

In the field, it was found that several of the preliminary indicators were readily feasible. To create a document which may be of greater use, data for these feasible indicators was collected and is described below. The implications of these findings for resources management practice and land-use policy are described in the final chapter. Data collected from local interviews, and locally identified indicators are described in Chapter 5.

4.1 FORESTS: COVER, QUALITY, AND TREE AGE-CLASS

4.1.1 Forest Area Cover and Quality. Forest cover and quality (i.e. its extent, its density, and the mix of useable species), are the best indicators of livelihood sustainability in the Himalayan context. Observation and village interviews showed that the greater the area, density, and productivity of the forest use area (as shaped by tree age-class structure, mix of useable species, and abiotic factors), the more fuelwood, fodder, bedding material, timber, and minor forest products (MFP's) can be sustainably harvested. However, by hiking into the forest use areas of the villages of Goshal and Chachoga, by participating in fuelwood gathering, and through interviews, the field research uncovered that much of the forest is too distant for daily access. Clearly, cover and quality of forests within a days access of the village, relates to how easily needs can be met. In terms of erosion, forests and ground covering vegetation, like any dense cover, hold the soils on the steep slopes - particularly important in the monsoon climate. Forest maps dating back to 1918 show changing patterns of cover, and descriptions indicate changing quality. Unfortunately, the most recent map and inventory data are 15-18 years out of date; this is a serious shortcoming in a rapidly changing environment.

The forest use area available to Goshal's 130 households is 1388 ha, although this is shared with the neighbouring villages of Kulang and Shanag. In a rough calculation (assuming there are 10 people per household, and that Goshal has rights to half of the area), there are approximately 0.5 ha of forest available per person. Chachoga has exclusive use of 155 ha of forest use area for 80 households. Using the same household size estimation, Chachoga has approximately 0.2 ha of forest available per person. Unfortunately, this type of calculation ignores the importance of differences in forest productivity. In comparison, Azad and Verma (1993) calculated 0.18 ha of forest available per person in 1990 for the average rural villager in Himachal Pradesh. Kayastha (1992) calculated 0.15 ha per person in 1981. See Table 1 for a list of tree species mentioned in the following text.

4.1.2 Chachoga's Forest Cover Pattern. Figure 4 shows Chachoga's forest use area in 1918 had a healthy cover of mature spruce in its middle portions. Himalayan cedar (deodar) was either young (less than 40 years) in the northern reaches, or as described by the Forest Office records, "malformed" and sporadic. The existing pine was younger than the deodar. Broad leaf species were found in one valley, but were not described. A large area of cleared forest occurred upslope of the village on which no regeneration was described. Data for the upper portion was not recorded. The frequency of young trees in 1918 suggests some clearing of forests had occurred a little earlier. Harvest of the spruce from the southern mid-slope area was planned.

By 1949, the pattern of forest cover had changed dramatically. The middle portion of mature spruce had either been thinned to an open canopy of over-mature trees, or cleared. Previously cleared areas north and north-east of the village had become a "mass of woody undergrowth", while recently cleared areas directly east and south-east were not described. However, young deodar ("pole-age," of 15-30 years), often mixed with pine, was found regenerating over much of the lower areas, and older, 50 year old deodar was growing well north of the village. Some planting and thinning was undertaken. Broad leaf species were not noted. The upslope area to the far north-east of the village was described as rocky and precipitous, with a sporadic mix of spruce & silver fir (fir), interspersed with oak (korsh) higher up to the north-east, and with alpine grazing areas in between.

In 1977, the pattern becomes more similar to that found in 1918. The scattered

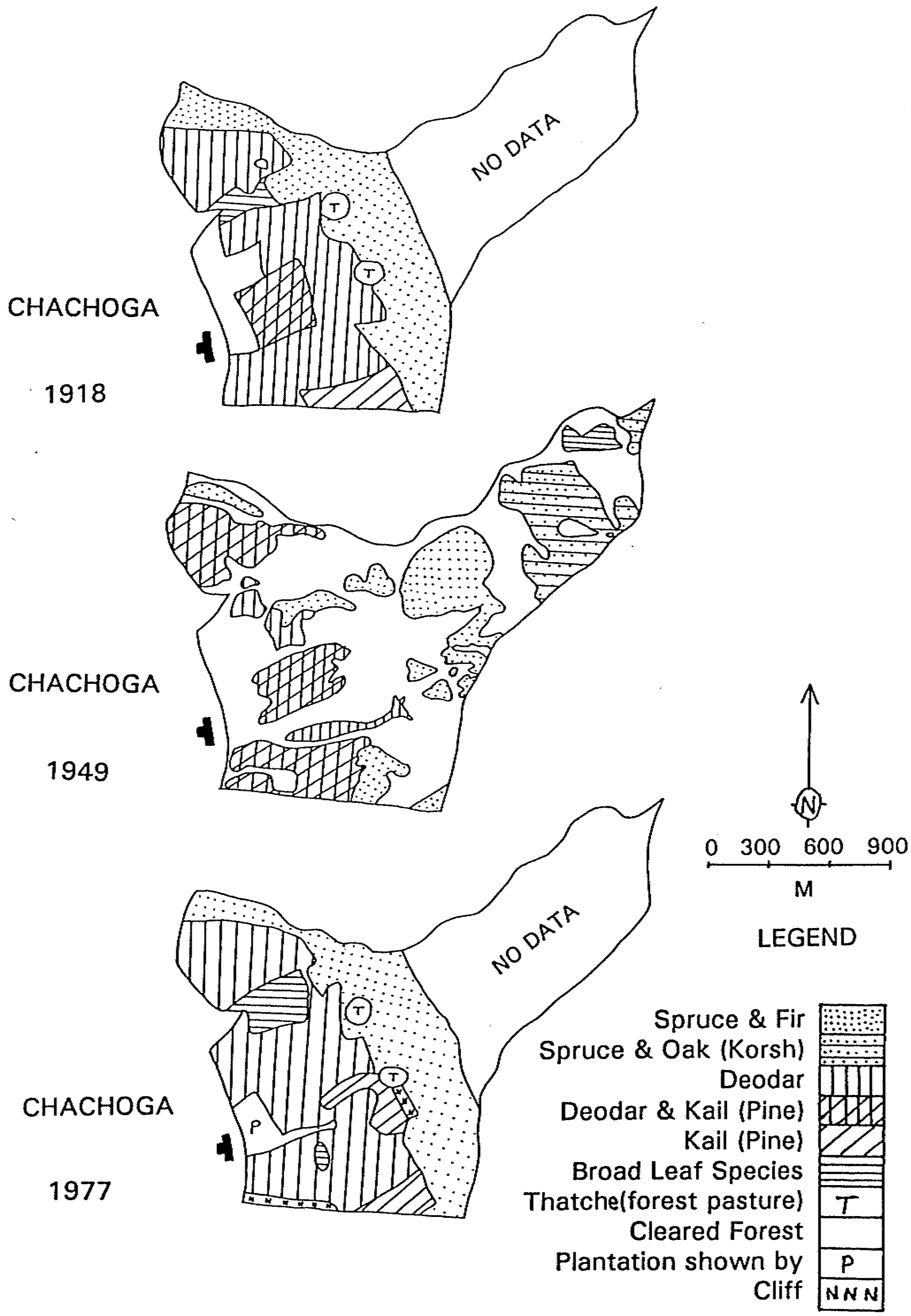


Figure 4. Chachoga's changing forest cover pattern: 1918, 1949, and 1977. Upslope is east (to the right).

over-mature spruce in the mid-slope areas remain, with more spruce growing up in open spaces. Areas of pine and broad leaf species to the east and north of the village are described as "doing well", some of these broad leaf species were planted. Deodar to the far north of the village is nearly 100 years old, and doing well, however to the north-east and east of the village, young deodar is either suppressed by over-mature trees, or absent underneath a patchy canopy (some deodar planting occurred in 1968-1969). The far up-slope area is described as unchanged since 1949.

4.1.3 Goshal's Forest Cover Pattern. Goshal has two forest use areas, the changing forest cover pattern of the larger area north-east of the village is described first, starting in 1949. In that year, most of the area indicated as spruce and silver fir in Figure 5 were undergoing "regeneration felling", that is, most of the mature spruce and fir trees were removed, leaving scattered mature trees as seed bearers and clusters of pole-age trees. Some unfelled areas of pole-age to middle-age spruce and fir were also described, but not delineated on the map. On some rocky areas, spruce, oak (korsh), deodar, and pine were found. Oak (korsh) and other broad leaf species were also left in the process. The mid-slope areas were characterized by oak (korsh), while the upper reaches were characterized by open mixed stand of oak (korsh) and birch, with sporadic silver fir and broad leaf species in nallas, and alpine grazing and massive rock at the uppermost areas to the east.

By 1977, as can be seen on Figure 5, much of the spruce and fir trees were clear felled under a "Mechanical Logging Scheme" during the first half of the 1960's. Natural regeneration was described as successful until a major fire in 1970 destroyed much of the forest, particularly seedlings.

An inspection of forest condition was done in 1972 after the fires of 1970 and 1972. Most of the forest was affected, however the intensity of the fire, and the resulting condition of the forest was not described. Killed trees were removed by the Timber Extraction Division. Subsequent planting of spruce and fir in the years from 1971-74 and 1976-77 (areas indicated by "P" in Figure 5) have had success ranging from less than 25% in the southern plantation to 70% in the north. Planting of broad leaf species of beech, ash, walnut, maple, and bird cherry in nallas (gullies) and depressions was more successful. The village of Shanag apparently has access to a portion of the

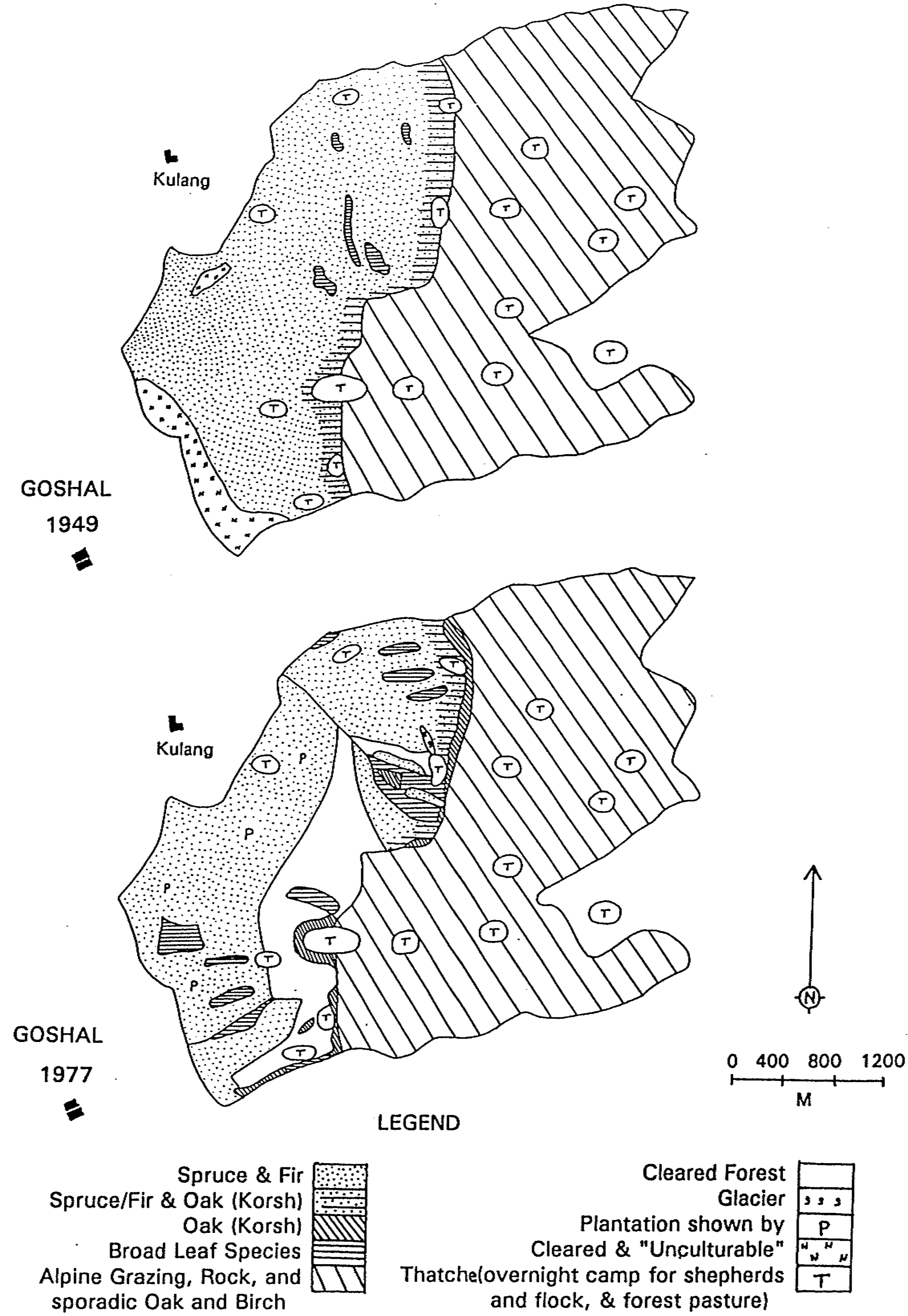


Figure 5. Goshal's (and Kulang's) changing forest cover pattern: 1949 and 1977. Upslope is east (to the right).

area, and grazing by Shanag's cattle was found to be killing seedlings. Fencing of the planation area was undertaken, but not mentioned later on. Heavy grazing and browsing is described as the cause of low planting success. Attempted plantings in the middle cleared area (the blank area in the lower map of Figure 5) have been a complete failure, probably as a result of a combination of factors including poor planting stock, poor planting technique, and grazing pressure.

Some mixed age-class areas of thin canopy spruce and fir with a few deodar and pine are found to the north and south - natural regeneration in those areas is reported as being suppressed by grazing in places. Oak (korsh) and other broad leaf species are found in depressions and nallas. A pattern of more spruce at lower altitudes, shifting to silver fir further upslope to the east, shifting again to oak even further up before reaching the upper areas of open oak (korsh) and birch, sporadic silver fir and broad leaf species in nallas, and alpine grazing and massive rock at the uppermost areas to the east.

Goshal's other forest-use area lies to the south-west of the village (Figure 6). In 1918, the south-east portion consisted of an open fir and spruce forest which was heavily lopped, and showed no regeneration. The area was described as "over-felled, over-grazed, and over-lopped". The portion to the north-west was the same type of forest although further away from the village and thus less heavily lopped. In 1949, no descriptive records were kept, however the site was mapped (Figure 6). An area to the south-east was clear felled, broad leaf species were noted in nallas (valleys), and oak (korsh) was found higher up to the west.

A fuller picture was provided in the 1977 description. In the south-east portion, there was mostly open (scattered) spruce and fir which had undergone "regeneration fellings", which means trees were thinned to provide more light for regeneration, and to meet saw mill demands. Some over-mature and damaged trees were left behind. Regeneration was poor due to grazing and browsing, and from dragging and rolling of logs to the saw mills. A report from 1963 said this portion once had excellent regeneration. Deodar and some spruce planted in 1931-32 to the south has become a good pole-age crop. The middle portion was described as a heavily lopped, thin to open, mixed-age spruce and fir forest. More fir was found higher up, with deodar on rock outcrops, pine on steep slopes and spurs, and broad leaf species (maple, chestnut, walnut, hazelnut, and bird cherry - jarainth) in nallas and depressions. Oak and birch

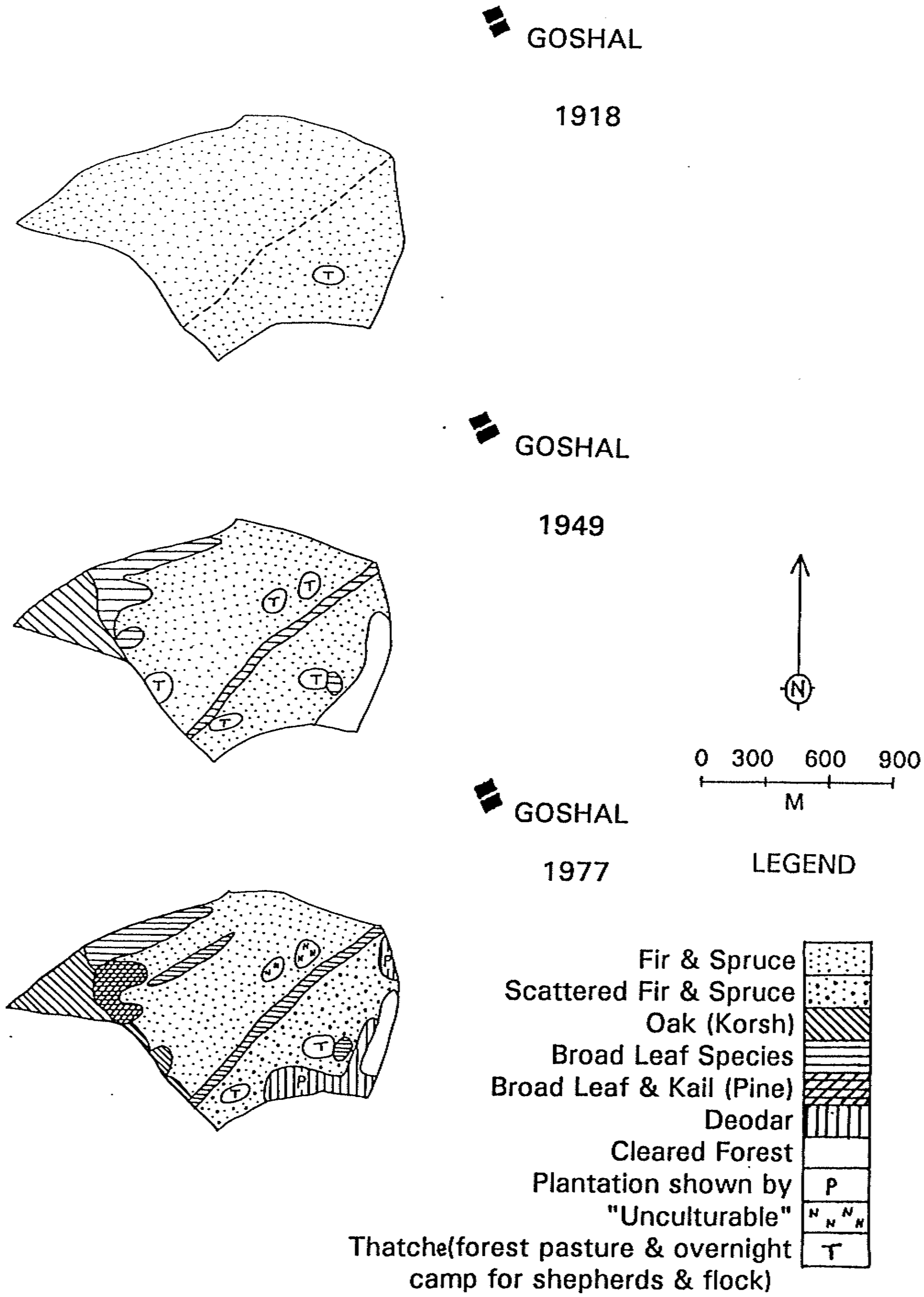


Figure 6. Goshal's (and Shanag's) changing forest cover pattern: 1918, 1949, and 1977. Upslope is west (to the left).

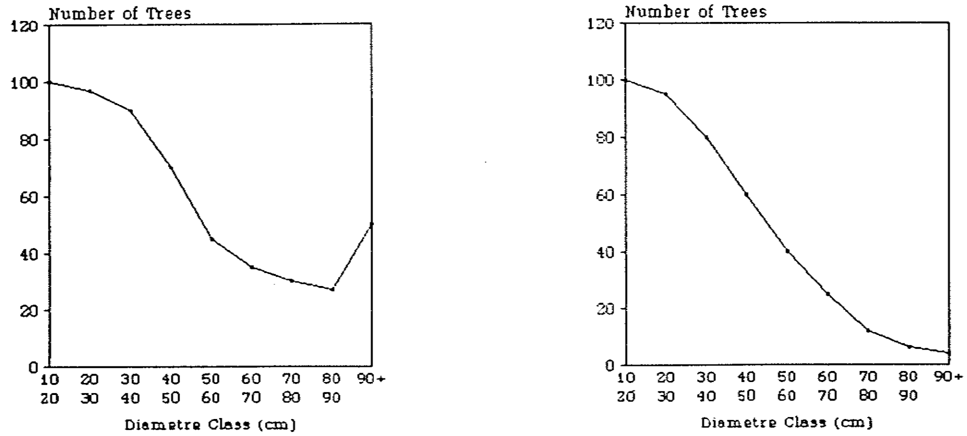
was found pure higher up. The north-west portion was a thin to open fir and spruce forest ranging in size from pole-age to mature (50-80 years) with density improving with elevation. Again, there was no regeneration, and the lower area was heavily lopped and very open.

In summary, there has been an overall reduction in forest cover and density in the forest use areas of both villages. Cover and density loss has occurred at the forest margins near both villages as a result of fuelwood lopping, from taking over-lopped and partially dead trees, and from both sanctioned and unsanctioned felling. In Goshal's case, large areas of forest were removed as a result of fires in the early 1970's, and from government cutting of spruce and silver fir in the 1960's. Forest Department records and observation suggest that poor choice and handling of planting stock, and overgrazing, are the causes of continued reforestation and regeneration failures. Sustainable management of the area would include improved choice of planting stock and technique, and village input in the development of a system of grazing management.

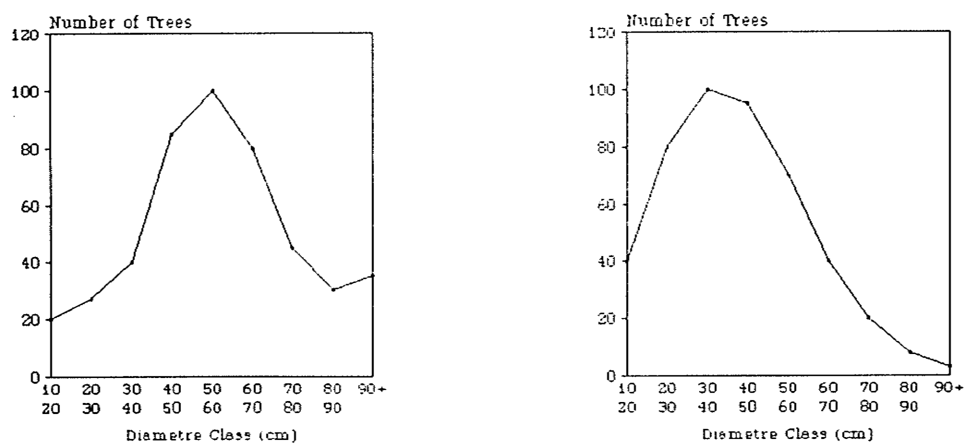
In Chachoga's case, government clear cutting of deodar at the turn of the century, and again after World War Two, has left their mark upslope from the village. Reforestation and regeneration difficulties in Chachoga's forest were also described in records and noted during observation.

4.1.4 Age-Class of Trees. The theoretical future yield of forests is based on the number, size, and species of the current stock of trees and vegetation, and on abiotic factors (Sheehy 1989; Clutter et al 1983; and Bickerstaff et al 1981). When multiple uses are made of the forest, it becomes important to know the number of trees of different age-classes (Clutter et al 1983). In order for the village forest to provide a sustainable supply of products and services, a mixture of all ages of the desired species are needed. Figure 7 contrasts theoretically sustainable tree age-class structures with unsustainable ones, the diameter values are "dbh" measures, or diameter at breast height.

The two top graphs in Figure 7 represent mixed-aged forests. They are theoretically sustainable because as the medium and larger trees are used, there are a greater number of young trees which will grow to take the place of the larger trees. The bottom two graphs show theoretically unsustainable tree age-class structures because there is a lack of young trees available to take the place of older ones.



Theoretically sustainable tree age-class structures



Theoretically unsustainable tree age-class structures

Figure 7. Theoretically sustainable and unsustainable tree age-class structures (From Sheehy 1989; Clutter et al 1983; and Bickerstaff et al 1981).

To illustrate with an example, evergreen trees between 40-60 cm dbh are lopped for fuelwood and bedding. The trees do not provide enough fuelwood when smaller, and cannot be climbed when larger. In the bottom left graph of Figure 7, current need for these products are hypothetically being met, however in 25 years, when the 10-30 cm dbh trees have grown to size, there will be far fewer trees available for lopping given the current age-class structure. This sort of analysis can be used to assess sustainability of the age-class structure of Chachoga's and Goshal's more common trees, given their use.

The upward trend at the right side of some graphs indicate the existence of large trees which reach diameters greater than 90 cm. The taper on the other two graphs suggest smaller trees with a maximum size of 100 cm dbh (if the scale went to 200 cm, the left hand graphs would also taper to zero). The downward turn in number of older and larger trees suggest the size at which trees are felled; for example, between 40-60 cm dbh in the top left graph.

Age-class structure can indicate whether desired tree species will be available in the future; data on overall wood volume change, and number of trees at each size-class over time, are required to assess whether the forest is being maintained. Total volume figures from the 1979-1980 inventory are also presented as baseline values for future comparison.

The following two sections assess the forest age-class structures of the forest use areas of Chachoga and Goshal. It can be argued that this is a limited view, that assessment of the district would show very different conclusions (J.S. Walia 1995, pers.comm). This study, however, takes a village perspective. As a village only has use rights to particular forest use areas, assessment of the age-class structure of those particular areas, and their potential for sustainability, is the relevant perspective for villages.

4.1.5 Chachoga's Forest Age-Class Structure. (Figure 8) Deodar is Chachoga's most common species, reflecting the suitability of deodar to Chachoga's lower altitude growing area, it is also the most valuable commercially. Plantations account for the high number of 10-30 cm deodar trees. A historically heavy use of large trees (over 70 cm) is reflected in the graph, such use is for timber. This species normally grows very large (150-200 cm) and one would expect an upward tail on the

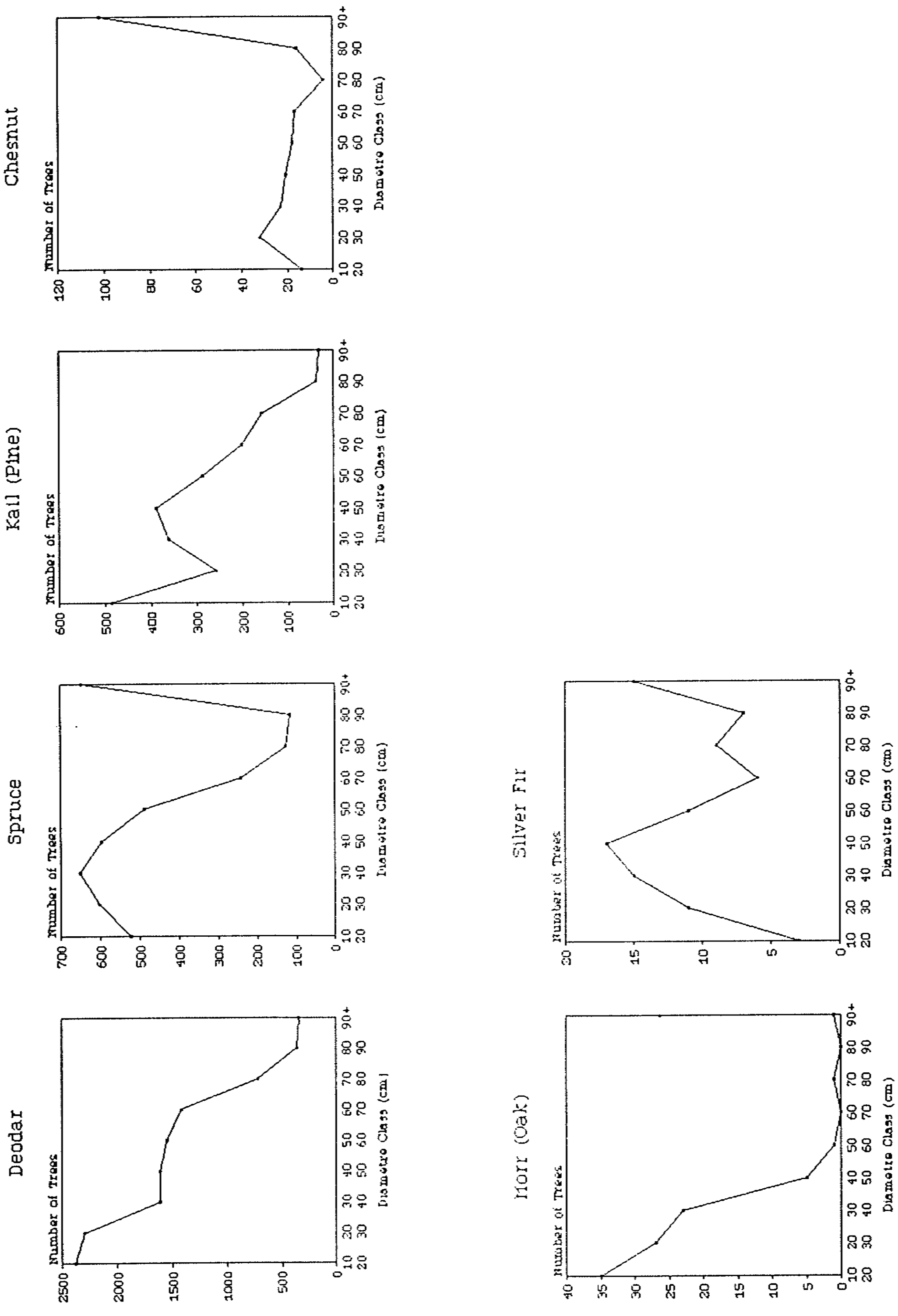


Figure 8. Tree age-class structure of Chachoga's more common species (1979/80 Forestry Department Records, Manali).

right side of the graph, thus historical depletion of larger age-classes is shown.

The age-class structure of spruce, used for fuelwood, timber, and bedding, is mixed, but evidently 50-70 cm size trees were, or are, heavily used. Availability of young trees (10-30 cm) is lower than in earlier years, indicating a decline in regeneration, unfortunately the 0-10 cm size class was never recorded. Thus, there is a 7-10 year lag in information before trees reach 10 cm in diameter (which can be added to the 15-18 year age of the records). The upward tail on the graph indicates larger age-classes remain.

Pine (kail) presents an apparently sustainable age-class structure with some deficiency in the 20-30 cm size. Pine is also a large tree, preferred for timber, as well as for bedding and fuel. The graph reflects heavy use of the larger age-classes by depletion of trees over 80 cm.

Chestnut is the next most frequent species, its graph suggests a relative paucity of smaller age-classes in comparison with the number of large trees. This species is preferred for fuelwood and fodder, and the graph suggests smaller trees are overused for this purpose.

Oak (morr) is preferred for winter fodder and fuel, and would normally grow to 100 cm+. The graph suggests heavy use and depletion of larger (>40 cm) trees. More numerous smaller trees have the potential to eventually increase the larger age-classes.

The last species, silver fir, is generally uncommon and lacks smaller age-classes, it is used for fuel and timber.

The total wood volumes in cubic metres, provided in the forest range office inventory are: deodar 8814, spruce 8729, kail (pine) 1228, chestnut 545, morr (oak) 28, and silver fir 381.

4.1.6 Goshal's Forest Age-Class Structure. (Figure 9) Oak (korsh) is the most common species. This high altitude species reflects the large proportion of high altitude grazing area in Goshal's forest. The age-class graph shows korsh oak to be mixed age, as this is not normally a very large tree, there is good representation in the larger age-classes. Severe fires in 1970 and 1972 probably caused the current number of 20-50 cm trees to be fewer than they might otherwise be (larger trees are more likely to survive fire). This species is desirable for fodder and fuel, however its high altitude makes

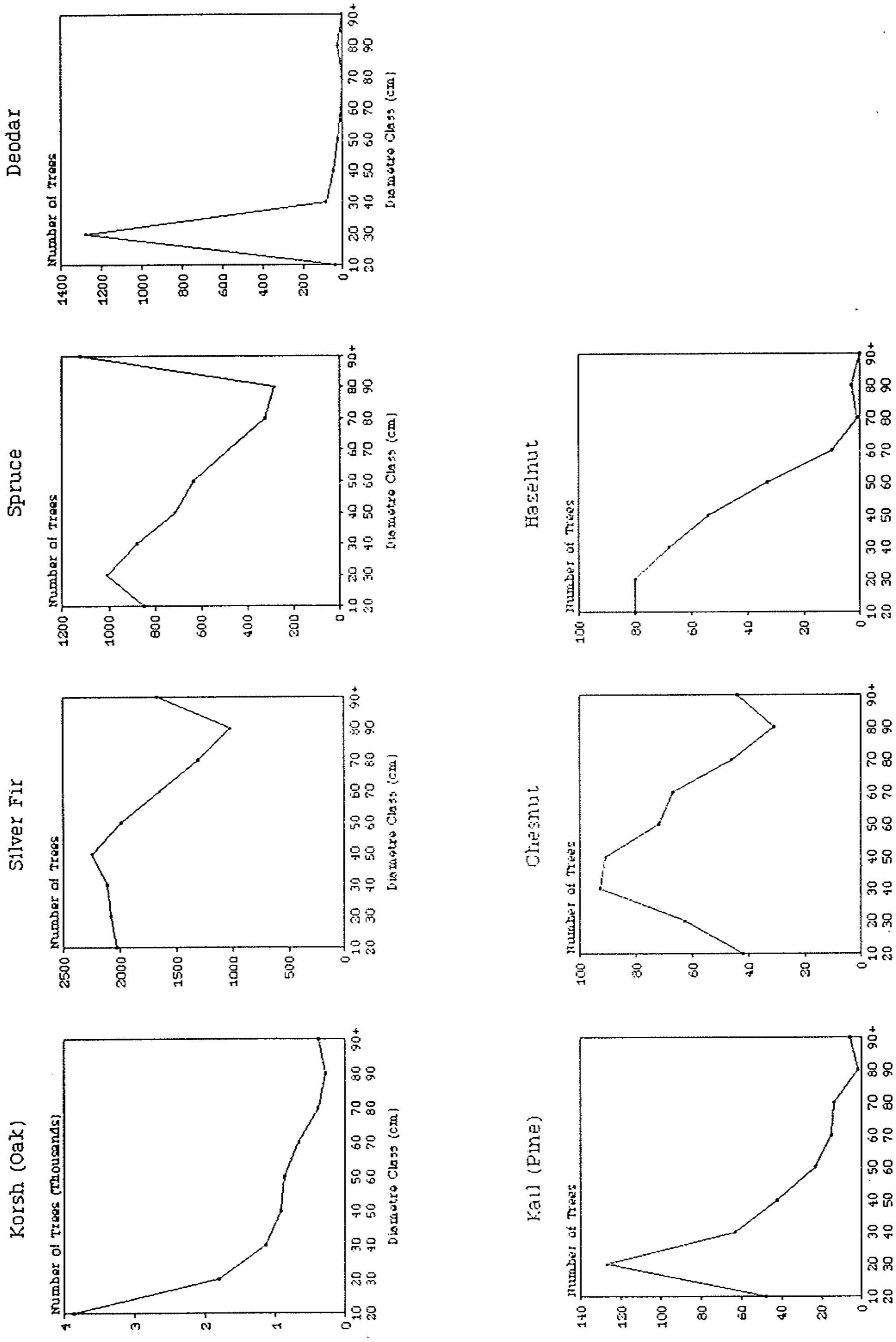


Figure 9. Tree age-class structure of Goshal's more common species (1979/80 Forestry Department Records, Manali).

access difficult.

Silver fir, the next most common tree, is also a high altitude species. Regeneration is lower in the last 30-40 years as evidenced by the slightly reduced numbers of trees in the 10-40 cm class. Overgrazing, described in the forestry records, may be the cause of lowered regeneration, and thus potential unsustainability.

The age-class structure of spruce appears as if it may be moving towards potential unsustainability, as regeneration is reduced in the 10-20 cm class, and regeneration of 0-10 cm trees is not recorded.

The shape of Goshal's deodar graph indicate a deodar plantation was created about 30 years prior to the inventory. Deodar had either been depleted in the past, or was never present.

Pine (kail) has insufficient regeneration of young trees (10-20 cm), and being a large tree, the graph shows larger age-classes have been used (this is a valuable commercial timber species, second to deodar).

Chestnut also has insufficient regeneration of young trees (10-30 cm), while Hazelnut shows a pattern of sustainable use with heavier use of larger trees.

The total wood volumes in cubic metres, provided in the forest range office inventory are: korsh (oak) 18,287, silver fir 50,685, spruce 29,734, deodar 952, kail (pine) 366, and chestnut 1467.

In summary, three of Chachoga's six common tree species (spruce, chestnut and silver fir) have unsustainable age-class structures in that they lack younger trees. Whereas deodar (Chachoga's most common species), kail (pine), and morr (oak) have potentially sustainable age-class structures.

Three of Goshal's seven common tree species (deodar, pine, and chestnut) have unsustainable age-class structures, while two others (silver fir and spruce) show signs that during the next forest inventory, a lack of younger trees may be apparent. Korsh oak (Goshal's most common species) and hazelnut have potentially sustainable age-class structures.

There is nothing that can be done to actually correct a lack in the numbers of 10-20 cm, or 20-30 cm trees. Even if the number of successfully planted trees today is great enough to return the number young trees to desired amounts in the near future, the lower number of young trees today means a lowered number of mature trees in the future. This present and future lack could be compensated somewhat by planting an even greater number of young trees. The result in the future would be, for example, a lack of 50-70 cm trees, and an over abundance of 30-50 cm trees. The ability of villagers to adapt to using smaller trees in the future would determine the success of an over-planting of young tree compensation strategy.

4.2 Soil Erosion Potential in Orchards, Forests, Fields, and Forest-Agriculture Interface

Humans are dependent upon the productivity of soils, and the productivity of soils depend on humans (Ghildyal 1990:185).

Not every soil can bear all things (Virgil 30 B.C., *Georgic II*).

Soil erosion potential in any one place is a function of rain intensity, the amount of soil directly exposed to rain (a function of the type of cover), the steepness of the slope, soil characteristics, and soil conservation measures. Soil was mostly of one type, in Chachoga's forest there was micaschist overlain by clay, or overlain by shallow boulders. In Chachoga's forest there is a deep layer of humus in most places, little in others. In Goshal's forest, micaschist is overlain by clayey loam and shallow loam, and humus is thick and undecomposed, although patchy in places. The presence of humus, particularly undecomposed humus, reduces soil erodability. As slope analysis was beyond the scope of this report, the focus is on percentage soil exposure. It should be noted however, that the predominantly clay and clayey loam soils have a low natural erodability (as opposed to sandy soils), thus reducing the negative impact of soil exposure to rain. The soils of the small forest use area to the west of Goshal however are micaschist overlain by shallow loam, this soil type has a slightly higher erodability.

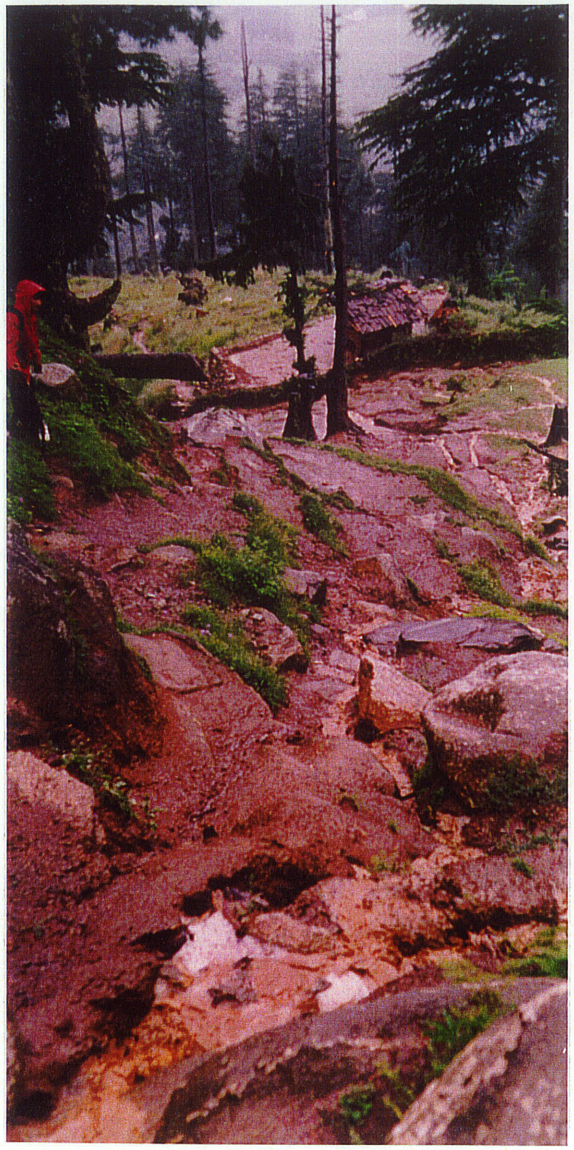
The percentage of exposed soil in older orchards (usually found on flat well maintained terraces formally used for agriculture), and orchards planted on steep haying areas, was zero because of thick grass cover. When orchards are planted in steep haying areas, a small (50-75 cm diameter) terrace is typically created in which to plant the tree. However the exposed soil of this terrace is flat, covered with manure, and quickly grows over with grass, and thus poses little erosion threat. This new type of orchard is encroaching on steep grassed haying areas, and will eventually result in improved holding of the soil, improved slope stability, and improved snow avalanche protection and prevention, as opposed to grass alone. This assumes that apple trees have deeper roots than grasses, that apple tree-trunks can play a role in avalanche protection and prevention, and that a two-tier cover of both apple-tree crowns and grasses leads to improved slope hydrology (Tejwani 1994).

New orchards are also being planted into terraced agriculture found higher upslope. In this case, the new, and some mid-size trees are surrounded by mixed agriculture of legumes, greens, and vegetables. As the trees grow, the mixed crop around their bases will be replaced by grass, providing a nearly zero erosion risk. However, in the future, some of the orchards may be of the miniature tree variety, thus mixed agriculture around the trees could be maintained. Many people of the villages suggested this was a preferred option.

Such upslope terraced agriculture is less productive and profitable than those in lower and flatter ground, and often belong to the poorer members of the village, either via land redistribution or recent arrival. Thus, the switch from mixed subsistence agriculture to the more profitable apple is an attractive one. Some of these terraces presently being planted with apple trees are not new, but are reclaimed from previously abandoned terraces. The young apple trees are surrounded by thick grass, a low to zero erosion risk, plus the future benefits of improved slope stability.

Actual encroachment on the forests by new orchards was rarely described in the forest inventory report, except in a few areas near Chachoga where the forest boundary was close to the village site. However, according to S.S. Madan (1995, pers.comm), "over 20 patches of forest have been clean-felled to make place for orchards right within reserved forest areas" in the Manali region. In the study area of the present project, most of the advance of apple orchards has been onto agricultural terraces and *Nautor* land in Chachoga's case, and onto agricultural terraces, upslope abandoned terraces, and steep haying areas in Goshal's case.

The amount of exposed soil within the forests near the village depends on the amount of animal traffic. Fencing between the orchards and the forests of Chachoga keeps animal traffic outside privately held orchards, so grazers travel up well worn rocky



(Left) An extreme example of gully erosion along pathway leading to the forest, Hamptah Valley, caused by animal traffic and some tree felling. Note clayey soil. (Right) Young orchards on terraced agriculture, legumes growing underneath, above Bahang.

paths to the forest. Concentration of cattle, as well as some sheep and goat traffic, along the fencing and just inside the forest, results in exposed soil paths. Aside from these limited traffic areas, little soil is exposed to rain-fall.

Upslope of Goshal, there remains some grazing and haying areas, as well as utilized and abandoned agricultural terraces, between orchard and forest. Grazing traffic paths leading up to the forests consist of exposed soil, rather than rocks. Rain running down these paths has led to serious gully erosion in many places. Along these paths, and further upslope, the practice of "wood throwing" while transporting timber downhill has exposed soil, and led to gully erosion (timber is transported down-slope by human power alone, thus the "sleepers" of wood were often thrown downhill rather than carried).

In the monsoons of 1993, some mud-slides occurred above Goshal. The cause of the slides was the particularly heavy rains that year. The site of the slide's origin was a steep grazing area, which was thinly treed. The site also lay upon a partially smooth rock face. Such slides are bound to occur when the monsoons are heavy, but would probably have been less likely had the area been thickly covered by trees and shrub.

Erosion was also apparent on a broad, steep, and grazed slope above Goshal. The slope, thinly forested in the recent past, is criss-crossed with animal paths. Some gully erosion has begun, and the Forest Department has made efforts to block gullies to halt erosion. Pine saplings are planted, but are often trodden upon, or browsed. The village is concerned about the snow avalanche risk of this slope.

Apart from the limited areas described above, the bulk of the forest area's soil is well covered by undergrowth, grasses and shrubs. However, some problems in forest regeneration and plantation success are attributed to trampling and browsing by grazing animals according to the forest inventories.

5 LOCAL PERCEPTIONS OF FOREST CHANGE, AND LOCALLY IDENTIFIED SUSTAINABILITY INDICATORS

This chapter consists of two sections. The first section describes and interprets data collected during the summer 1994 field season. The data consists of changes in the relative mix of tree species over 30 years. This local perception is according to Chachoga and Goshal villagers, and the forest range officer for the area. The preferred use for various tree species according to villagers was also noted to help interpret the changes. This sustainability monitoring approach was one of the indicators on the preliminary indicator list selected before the fieldwork. This indicator can show reverse succession. Implications for resources management and land-use policy based on the findings, are discussed in the final chapter. In the second section, locally identified sustainability indicators refers to those identified by the same villagers, and by nine local natural resources management professionals.

5.1 Trees: Species Change and Preferred Use

The idea behind researching "preferred use" is that there needs to be local input on what should be sustained. In other words, villagers should help shape the principles and desired conditions against which indicators will be compared. Determining what use is made of the forest, and the preferred species for that use, is key to deciding how to measure sustainability. Of course there are numerous objective criteria as well, but in the Himalayan context, people know well what aspects of their environments are important to their livelihoods, thus a subjective element needs to be considered. Changes in the relative species composition - trends in species change, or the availability and area of preferred species - can suggest whether levels of use of particular species are progressing at a sustainable level or not.

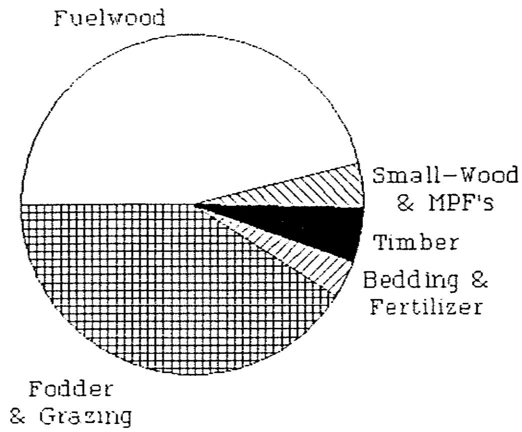


Figure 10. Relative importance of tree uses according to Goshal and Chachoga villagers (Based on response rate for tree use; MFP's are minor forest products, e.g. food, resin, seed-oil, and medicine).

5.1.1 Use of the Forest. Figure 10 suggests the relative importance, or frequency of end use made of trees and shrubs, by showing the number of times species were described as used and preferred by 20 Goshal and 16 Chachoga villagers. Fuelwood, and fodder & grazing species represented 46 and 41 percent of responses respectively, followed by timber at ten percent, bedding & fertilizer species at seven percent (all bedding ends up as fertilizer), and small-wood & MFP's at eight percent (small-wood refers to wood for tools, handles, furniture, and carving, while "MFP" means minor forest products such as food, oil, and medicines). Although fuelwood, and fodder & grazing uses dominate forest use, potential alternative sources for heating and cooking, and reductions in the amount of grazing activity, may change overall and relative importance of these uses.

5.1.2 Tree Species and Overall Trends in Change. Table 1 shows the English name, the local name (spelled phonetically), and the scientific name for the trees (including shrubs) used by village consultants. The species are grouped under what constitutes their most frequent use (see Table 3 on preferred use of tree species). Village perceived trends in availability and area covered by each species are shown on the right

Table 1. Tree species and trends in change[1] over 30 years and 2-3 years; aggregated perspective according to Chachoga and Goshal villagers.

	ENGLISH NAME[2]	LOCAL NAME	SCIENTIFIC NAME	30 YEAR	2-3 YEAR
FUEL[3]:					
	B.Kahti (shrub)	Kahti (black)	*Indigofera spp.*	↓	↔
	W.Kahti (shrub)	Kahti (white)	*Desmodium spp.*	↓	↔
	Sweet Chestnut	Kenorr	*Castanea sativa*	↔	↔
	Wild Chestnut	Jangli Kenorr	*Aesculus indica*	↓	↓
	Spruce	Roi/Rai	*Picea smithiana*	↓↓	↓
	Alder[4]	Kosh	*Alnus nitida*	↓↓	↔
	Silver Fir[5]	Tos	*Abies pindrow*	↓	↔
	Shyen (shrub)	Shyen	*Spirea spp.*	↓	↔
WINTER FODDER:					
	Oak[6]	Morr/Mohru	*Quercus himalayana*	↓	↔
	Black Mulberry	Chehwn/Tut	*Morus spp.*	↓	↔
GENERAL FODDER:					
	Willow	Behli/Manjanu	*Salix spp.*	N	↑
	Robinia	Kicker	*Robinia pseudoacacia*	N	↑
	Oak[6]	Ban/Bon	*Quercus leucotricophora*	↓	↔
	Elm	Mahan	*Ulmus wallenchia*	↓	↔
	Hazelnut[6]	Himli/Himri	*Corylus spp.*	↔	↔
	Oak[5]	Korsh/Kharsu	*Quercus semecarpifolia*	↔	↔
	Maple	Maundre	*Acer spp.*	↓	↔
CONSTRUCTION:					
	Deodar[7]	Deyar/Kaol	*Cedrus deodara*	↓↓	↓
	Pine[7]	Kail	*Pinus wallenchia*	↓↓	↔
OTHER UTILIZED SPECIES:					
	Poplar	Paoous	*Populus spp.*	↔	↑
	Ash	Ongu	*Fraxinus excelsia*	↔	↔
	Black Walnut	Awkrot/Korr	*Juglans nigra*	↑	↑
	Wild Walnut	Jangli Awkrot/Korr	*Juglans regia*	↓	↔
	Wild Apricot	Jangli Koobahni	*Prunus armeniaca*	↔	↔
	Beckeli (shrub)	Beckeli/Becki	*Principia utilis*	↓	↑
	Shambel (shrub)	Shambel	*Berberis spp.*	↓	↔
	Jarainth[8]	Shegaal	*Pyrus spp.*	↓	↑
	Birch[5]	Bhojh pater	*Betula alnoides*	↔	↔

[1] Changes are denoted by: (↑↑) large increase, (↑) increase, (↔) constant, (↓) decrease, (↓↓) large decrease, (N) introduced in the last 30 years, and (blank) species not found in area.

[2] The species are clumped under primary use, as indicated by number of responses (see "preferred tree species", Table 3).

[3] Preferred for clean burning and good heat.

[4] Preferred because of availability (beside river), especially in Goshal's past.

[5] High altitude (above 2800 M) species.

[6] Also a preferred fuel.

[7] These species have sticky smoke, however they are desirable fuel because of availability.

[8] Pears are grafted onto this species (also called bird cherry), recent increases because of use in grafting; has declined in the wild.

of Table 1. This aggregated perspective of Chachoga and Goshal shows 30-year, and 2-3 year trends. Where villagers indicate declining trends over 30-years and 2-3 years, the species is likely being used at unsustainable rates. Where the 30-year perceived trend shows decline, yet the 2-3 year trend shows constant or increasing trends, past unsustainable use is possibly being halted and a new lower stock is being maintained or increased. Downward perceived trends in the past 2-3 years are the most critical, as they suggest current unsustainable levels of use. As discussed in the following section, the accuracy of these village perspectives are supported by similar perspectives from the local forester.

In terms of forest management, sharp declines over 30 years need to be countered by definite increasing trends over recent years, so as to rehabilitate the benefits derived from the stock of those species in the past. Support for such a management goal comes from the fact that many of the species which show sharp 30-year declines (spruce, alder, deodar, and pine) are preferred for various uses (see Table 3). In some cases, such as Goshal's alder, as well as Goshal's spruce and fir, catastrophic flooding and fires respectively have been responsible for the declines.

A strong general decline perceived in fuelwood species over 30 years has halted in the recent 2-3 years in all but two species (wild chestnut and spruce). The village perspective of continued decline in these two species needs attention if stocks are not to decrease further (assuming accuracy of the village view). In general, these fuelwood species probably make up a lower proportion of the forest today than they did 30 years ago. The interview results of Table 1 thus suggest fuelwood species have been used at unsustainable rates until recently. There are some possible explanations for the general halt in the perceived decline of fuelwood species: In Chachoga, rules against the selling of fuelwood outside the village were recently created and enforced by the Mahila Mandal, a women's group (for more detail see K.Davidson-Hunt 1995). In Goshal, the greater distances people said they had to go for fuel, probably underlies the halt in Goshal's fuelwood decline. Decline in fuelwood availability has numerous livelihood implications: More time is required to gather, or guard fuelwood, thus reducing the time available for other tasks; choice of fuelwood becomes more indiscriminate, possibly depleting tree species for which there are other uses; dried dung may be substituted, thus reducing the manure available for use on the fields; kerosine may be purchased, requiring the use of cash, and possibly precipitating entrance into the economy as a wage earner. Such implications have numerous secondary and tertiary effects as well.

An increasing distance required to obtain fuelwood can effectively lead to sustainable levels of fuelwood harvest as follows: The amount which can be gathered near to the village becomes depleted, thus greater distances are travelled. The total stock of fuel species within a half day's return distance is greater than the stock within a quarter day's return distance. The perceived depletion of fuelwood over the past 30 years refers to the area within a quarter day's return travel (villagers described how two or more loads could be fetched in the past in the same time it takes to fetch one load today). Now that people travel further upslope into the forest use area, the available stock and sustainable fuelwood harvest is larger, so that depletion has halted. However, this self-regulating process faces the limit of distances that can be travelled in a day; much of the forest use area of the two villages cannot be reached in one day's travel.

The next cluster of tree species are under the heading of fodder (Table 1). The most critical time for fodder availability is during the winter months, either if stored fodder and grass run low, or as a supplement. The two species of winter fodder tree are important because they keep their leaves all year. According to the village consultants, these two species, have declined over the last 30 years either by over-use of fodder, or use as fuel in the case of the oak species. In recent years the perceived trends have stabilized at a lower level of availability.

The species used as general fodder (unavailable in winter) have not shown nearly the decline as either the fuelwood trees or winter fodder trees over 30 years. The reason is that livestock feed mostly upon grasses, thus general fodder species form only a small proportion of the diet. Further, livestock populations have declined over the last 30 years. Two introduced tree species are increasing in recent years while the other species have remained constant all along, or in yet other species, decline has halted.

The tree species most preferred for timber and construction is the highly valuable deodar. Deodar is one of the few local timber species that provides an opportunity for direct commercial use of the forest. The trends in construction species (which also includes spruce and silver fir) (see Table 3) have shown strong declines over 30 years according to village perspectives (Table 1). Over-harvesting by villagers, both legally and unsanctioned, and in Goshal's case, direct over-harvest by government clear cutting in the 1960's, and fires in 1970 and 1972, have been the evident causes of the decline. Such declines suggest highly unsustainable cutting of these species. The decline in pine and silver fir has halted in recent years, while the trends in deodar and spruce are perceived by the villagers to be continuing their decline.

Trends in high altitude species (silver fir, korsh oak, and birch) tend to be more stable. Trends in rare species (sweet chestnut, black mulberry, elm, ash, and wild walnut), where there may be only a handful of individual trees, are stable in the cases where the trees are considered holy by villagers (ash and walnut), but are declining in other cases (black mulberry and elm). This example demonstrates the livelihood implications of cultural factors.

The trends of other utilized species can be read from Table 1. In recent years, most of these species are perceived as constant or increasing. Referring back to the frequency and importance of different uses shown in Figure 10, the "other species" shown in Table 1 constitute only a small proportion of the pie graph, being neither fuel, nor fodder, nor commercially valuable. This fact alone probably explains why these species have suffered the least depletion over 30 years, and show the most positive trends in recent years.

5.1.3 Trends in Tree Species Change by Village, by Forester. Table 2 shows trends in perceptions of tree species change for each village, and contrasts these views with those of the forest range officer. In just over half of the cases, the villagers' and forester's views are the same. Agreement between forester and village tends to be lower concerning recent 2-3 year trends. In particular, the forester tends to be more optimistic regarding 2-3 year trends in commercially valuable species and trends in the more common species (deodar, spruce, and pine for Chachoga, and oak (korsh), silver fir, spruce, and deodar for Goshal - see Figures 8 and 9 for forest inventory). Whereas the forester is less optimistic on the 2-3 year trends of other less common species (many of which are preferred by villagers for various uses).

The villagers' perspectives directly oppose the forester's in only one case: The 2-3 year trend for deodar in Chachoga. In this case, the villagers perceive deodar as continuing to decline, whereas the forester suggests it is increasing. In discussion, villagers emphasize the continuation of unsanctioned felling of deodar, whereas the

Table 2. Goshal villagers', Chachoga villagers', and forester's perspectives on trends in tree species change[1].

SPECIES	CHACHOGA				GOSHAL			
	30 year		2-3 year		30 year		2-3 year	
	village	forester	village	forester	village	forester	village	forester
FUEL:								
B.Kahti (shrub)	↓	↓	↓[2]	↔	↔[2]	↓	↑	↔
W.Kahti (shrub)	↓	↓	↓[2]	↔	↔[2]	↓	↑	↔
Sweet Chestnut	↔	N	↔	↑	↔[2]	N	↑	↑
Wild Chestnut	↔	↓	↔	↔	↓	↓	↓	↔
Spruce	↓↓	↓	↓	↔	↓↓	↓	↔	↑
Alder	↓	↓	↔[2]	↓	↓↓	↓	↔[2]	↑
Silver Fir[3]	↔	↔	↔	↔	↓	↓	↔	↑
Shyen (shrub)	↓	↓	↓[2]	↔	↓	↓	↑	↔
WINTER FODDER:								
Oak (Morr)	↓	↓	↔	↓	↓	↓	↔	↓
Black Mulberry	↓	↓	↔	↓	↔	↓	↔	↓
GENERAL FODDER:								
Willow	N	N	↑	↑	N	N	↑	↑
Robinia	N	N	↑	↑	N	N	↑	↑
Oak (Bon)	↓	↓	↔	↔		↓		↔
Elm	↓	↔	↔	↓	↔	↔	↔	↔
Hazelnut	↔	↔	↔	↔	↔		↔	
Oak (Korsh)[3]	↔	↔	↔	↔	↔[2]	↔	↔	↔
Maple	↔	↔	↔	↔	↓	↔	↔	↔
CONSTRUCTION:								
Deodar	↓↓	↓	⇓[4]	⇑	↓↓	↓	↔[2]	↑
Pine	↓↓	↓	↓	↔	↓	↔	↑	↑
OTHER:								
Poplar	↑	↑	↑	↑	↔[2]	↑	↑[2]	↑
Ash	↔	↔	↔	↔	↔		↔	
Black Walnut	N	↑	↑	↑	↑	↑	↑	↑
Wild Walnut	↓	↔	↔[2]	↑	↓	↔	↔	↑
Wild Apricot	↔		↔		↔		↔	
Beckeli (shrub)	↔[2]	↓	↑	↔	↓	↓	↔[2]	↔
Shambel (shrub)	↔[2]	↓	↑[2]	↔	↓	↓	↔	↔
Jarainth[5]	↓	↓	↑	↑	↓[2]	↓	↑	↑
Birch[3]	↔	↔	↔	↔	↔	↔	↔	↔

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[1] Changes are denoted by: (↑↑) large increase, (↑) increase, (↔) constant, (↓) decrease, (↓↓) large decrease, (N) introduced in the last 30 years.

[2] Intra-village disagreement, where perspectives included both increase and decrease. Constant vs increase, and constant vs decrease disagreement is not noted in the table, but was at least as frequent as the intra-village polar opposite perspectives.

[3] High altitude (above 2800 M) species.

[4] The hollow arrows (⇓ and ⇑) indicate where villager and forester perspectives were opposite.

[5] Recent increases because of use in grafting; all agree that it has declined in the wild.

forester suggests Chachoga villagers are unaware of all the healthy deodar seedlings and saplings in many clearings, which are not visible from a distance. It is likely that the people of Chachoga are referring to the area and availability of a mature stock of deodar, from which they derive benefits of lopped wood, avalanche and slide control, stable hydrology, and the like - seedlings and saplings are not yet old enough to provide such products and services. Further, the difference in perspective may reflect a village view that saplings are not guaranteed to reach maturity.

As with Table 1, negative trends within the last 2-3 years should be given the greatest attention, and sharp perceived declines over 30 years should be countered with increases in recent years in order to rehabilitate the benefits of a larger stock, assuming accuracy of the village perspective. In all cases, the species suffering sharp decline (spruce, deodar, and pine in Chachoga, and spruce and alder in Goshal) are also preferred species for various uses (see Table 3).

In Chachoga, as shown in Table 2, villagers note 2-3 year downward trends in the fuelwood species of kahti and shyen (shrubs), and spruce, whereas the forester notes alder as the only fuelwood species in recent decline. Area of familiarity might account for the different views, for example shrub species are lost as agricultural lands are converted to apple orchards, and the shrubs which once grew along fencelines and between fields are cut. Table 2 also notes where there was some opposing perspectives within the village over kahti, shyen, spruce and alder (Table 2 shows the majority response). Such differences likely have to do with the type of interaction the person has with the forest.

Among Chachoga's winter fodder species (oak [morr] and black mulberry), the forester indicates that in recent years, both are continuing a downward trend seen over the past 30 years. Such recent declines in the important winter fodder species warrant concern, whether identified by villagers or forester. In contrast, the people perceive stable levels in recent years. Chachoga villagers, and the forester are in near perfect agreement over trends in general fodder tree species, although the forester states elm is in decline in recent years.

According to villagers, declines in Chachoga's valuable timber species of deodar and pine were sharp over the past 30 years, and both continue downward in the last 2-3 years - suggesting continued unsustainable use. The forester however states that the downward trend in pine has halted, and that deodar's trend has reversed. Only the forester's views on deodar suggest sharp declines in past years are being reversed today.

Other species in Chachoga show much more positive perceived trends overall. Some differing perspectives are noted on Table 2. A species called jarainth may also be called bird cherry, and is used as a base tree on which to graft pears. In recent years, this species is increasing because of increasing use in orchards, however in the forest, 30-year and 2-3 year trends are both downwards. Positive trends are seen with Chachoga's poplar and black walnut over both 30, and 2-3 year trends.

In sum, according to the villagers, recent years show a continuing decline in Chachoga's species of kahti, spruce, alder, shyen, oak (morr), black mulberry, elm, deodar, and pine. Unfortunately, deodar, spruce, and pine constitute Chachoga's most common forest cover, thus sustainability is in question.

In Goshal's forests, the situation is different. Referring to Table 2, sharp historical declines in the preferred fuelwood species of spruce and alder have at least halted according to village consultants, or are increasing in recent years according to the forester. Only one fuel species (wild chestnut) continues a downward trend. Some opposing views within the village are shown in the table for kahti and alder. A striking example of the dynamic environment of the area, is the village view of a 30-year decline in Goshal's preferred fuelwood species: alder. Much of the alder in the past was located in the historical bed of the Beas River close to the village. This alder provided a ready supply of fuelwood, preferred because of its proximity. The historical bed of the Beas River is a broad area of rock with some "islands" of agricultural fields, trees, and shrubs. The actual river only occupies a narrow channel. Over time the Beas has changed course. In 1948, and further in 1970, Goshal's alder was washed away by the Beas River as it made radical course changes during particularly heavy monsoons. Only a small patch of this stand of alder remains.

The two important winter fodder species of oak (morr) and black mulberry are said to be in decline over recent years in Goshal's forest as well as in Chachoga's. Goshal's general fodder tree species show stable or increasing trends. As was the case for Chachoga, there is near perfect agreement between village consultants and the forester concerning general fodder species.

Goshal's valuable timber species of deodar and pine are generally not as common as in Chachoga's lower altitude forests, yet a sharp decline in the 30-year trend of deodar is perceived. Villagers have some opposing views on recent deodar trends, but the majority response is that deodar decline has halted. The forester suggests deodar declines are now reversed. The forester is also more optimistic about the 30-year trend for pine, and all agree that pine is showing an upward trend in recent years. Perspectives on Goshal's other tree species show generally positive trends, especially in poplar and black walnut. Some differing intra-village views are noted in the table.

In sum, severe past declines of spruce, alder, and deodar have at least been halted according to villagers, and according to the forester, are increasing. Goshal's most common forest cover - korsh oak, a high altitude species - has remained stable over the years. However, wild chestnut, morr oak, and black mulberry are showing continued depletion in recent years. The overall importance of Tables 1 and 2 is the way they reflect the dynamism of the area from a village perspective. The villagers suggest that trends of depletion have occurred mostly among commercially valuable trees, or preferred fuel and winter fodder species.

5.1.4 Preferred Tree Species. Table 3 shows the preferred use for various tree and shrub species according to the villagers of Goshal and Chachoga. Under each heading (fuel, fodder, construction, and other), the tree species are shown in decreasing strength of preference. If trees were preferred for multiple uses, they were placed under the heading for which preference was strongest. The table also provides much detail in its numerous footnotes. Many species were preferred for multiple uses.

Preferred fuelwood species were described as wood which was clean burning, provided good heat, and was easy to fetch and carry, such as the shrub kahti. Spruce and deodar are also lopped for fuel as well as for the bedding material provided by the small branches and needles. Although these species are poorer fuel, they were preferred by virtue of their availability. According to the area's forester, the bottom quarter or third of evergreen branches can be lopped without harm to the tree. This can only be done once in the tree's life, as evergreens are poor coppicers. However, evergreen trees are often lopped so that only the top 15% of branches (the crown) remains. Such practice can lead to the thinning of forests as trees weaken and die and are then taken down for timber. Unfortunately, many of the preferred fuel species are uncommon

Table 3. Preferred tree species[1] for different uses, according to Goshal and Chachoga villagers.

SPECIES	USE					
English Name[2]	Fuel[3]	Fodder	Timber	Bedding/ Fertilizer	Small wood[4]	Food/ Oil
FUEL:						
B.Kahti (shrub)[5,6]	●	○			○	
W.Kahti (shrub)[5,6]	●	○			○	
Sweet Chestnut[6]	●	○				○
Wild Chestnut[6]	●	○				○
Spruce	●		○	○		
Alder[7]	●			○		
Silver Fir[8]	○		○			
Shyen (shrub)	○					
FODDER:						
Oak (Morr)[6,9]	○	●				
Black Mulberry[9]		●				
Willow[10]		●				
Robinia[10,11,12]		●				
Oak (Bon)[6]	○	●				
Elm		●				
Hazelnut[6]	○	○				
Oak (Korsh)[6,8]	○	○				
Maple[13]		○			○	
CONSTRUCTION:						
Deodar[14]	●		●	○		
Pine[14]	○		○	○		
OTHER:						
Poplar[11]				○		
Ash[11,15]						
Black Walnut[15]					○	○
Wild Walnut[15]					○	
Wild Apricot						○
Beckeli (shrub)[12]						○
Shambel (shrub)						○
Jarainth (pear graft)						
Birch[8]						

[1] Tree utilization denoted by: ("●") preferred by most (> half) of respondents, ("○") preferred by some (< half) of respondents. Villagers typically spoke about 5 - 20 preferred species.

[2] The species list is clumped according to greatest preferrence, based on the number of responses. Each clump begins with the strongest preferrence, and decends to the weakest.

[3] Two respondents indicated all species are used as fuel.

[4] Small wood refers to wood for tools, handles, furniture, and carving.

[5] Used in prayer and marriage ceremonies.

[6] Best fuel species because of clean burning and good heat (particularly Kahti - which is also easy to carry).

[7] Preferred as fuel because of availability by river, especially in Goshal's past.

[8] High altitude species, above 2800 M.

[9] Particularly important as winter fodder.

[10] Used by cattle in summer.

[11] A multi-purpose tree according to foresters. Villagers preferred poplar for many uses, but poplar still rare.

[12] Thorny, thus not preferred for fuel, Beckeli in particular is recognized as good fuel excepting its thorns.

[13] Eaten by water buffalo.

[14] These species have sticky smoke, however they are desirable fuel because of availability.

[15] Some individual trees considered sacred.

(alder), or not counted in forest inventories (kahti and shyen). Most of the "multiple purpose trees", robinia, poplar, and ash, were not preferred fuel. Probably the best coppicer, willow, could provide repeated harvests of fuelwood, but was also not a preferred species. These latter species, often found along the roads, were used as fuel by non-villagers living alongside the roads.

Table 3 also shows the preferred fodder species, the top two are winter fodder trees, with green leaves available year round. These are an important form of backup insurance if stores of hay are lost or insufficient for the winter season. Other species are preferred for certain types of livestock at certain times of year. Most summer fodder is actually provided by grass from pasture and haying areas with the tree fodder providing supplement. Willow and robinia are preferred summer fodder for cattle, while maple is eaten by water buffalo. Several of the fodder species are also preferred fuel. Unfortunately, as was the case with several preferred fuel species, many of the preferred fodder trees (black mulberry, willow, robinia, bon oak, elm, and maple) are not common.

On Table 3, the species preferred primarily for construction are really multiple purpose trees. In fact, two of the construction species are listed under preferred fuel species. The species listed under the heading "other species" are not so frequently used. As introduced species, poplar and ash, both multiple purpose trees according to the forester, were not often used as a result of their rarity, in the case of poplar, villagers stated they would use this species more, if it became more available. Some of these trees are also considered sacred, for example ash and walnut. Birch-bark is sometimes used to fashion dishes for special occasions, although birch is a high altitude species, and is hard to access. Jarainth, perhaps more commonly known as bird cherry, is important as root and trunk stock upon which to graft different types of pear.

Considering Figure 10, which shows the importance of fuel and fodder species over other uses, trees which are preferred for both of these uses would likely be highly desirable. Such species include the shrub species kahti, as well as all the chestnut and oak species, and hazelnut. From these species, only Goshal's stock of oak (korsh) forms a major portion of their forest cover, however, this oak species is only found at high altitudes, and is thus difficult to reach.

Figure 11 shows the results when village consultants were asked what species they

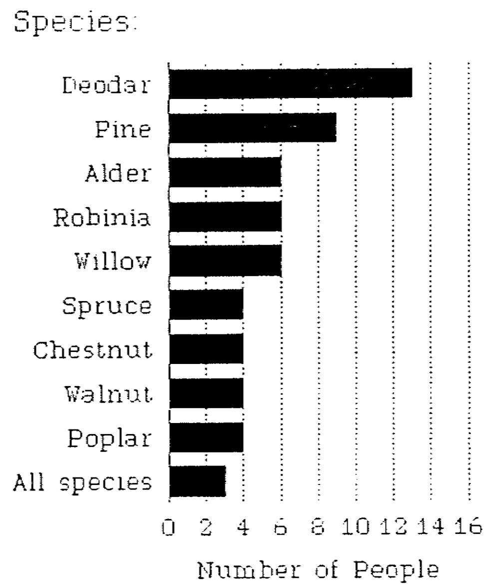


Figure 11. Tree species desired for planting according to Chachoga and Goshal villagers.

would most like to see planted, and thus increased. The results did not match what might have been expected. Preferred fuel and fodder trees (the most frequently used products of the forest) were not at the top of the list, rather, Figure 11 shows deodar and pine at the top. These are of course the most commercially valuable trees, and in Chachoga's case, deodar provides its majority of forest cover (note Figure 8). Alder, a convenient fuelwood species was the next most desired for planting. Alder typically grows alongside the Beas River and other nallas (side valleys), and would provide a nearby supply of fuel. Robinia and willow were next, followed by spruce, chestnut, walnut, and poplar. Spruce forms a significant proportion of the forest cover for both villages, and is a multiple use tree, thus desirable. Chestnut is preferred for both fuel and fodder, and is also a fairly common species. Three people responded that all species need to be increased.

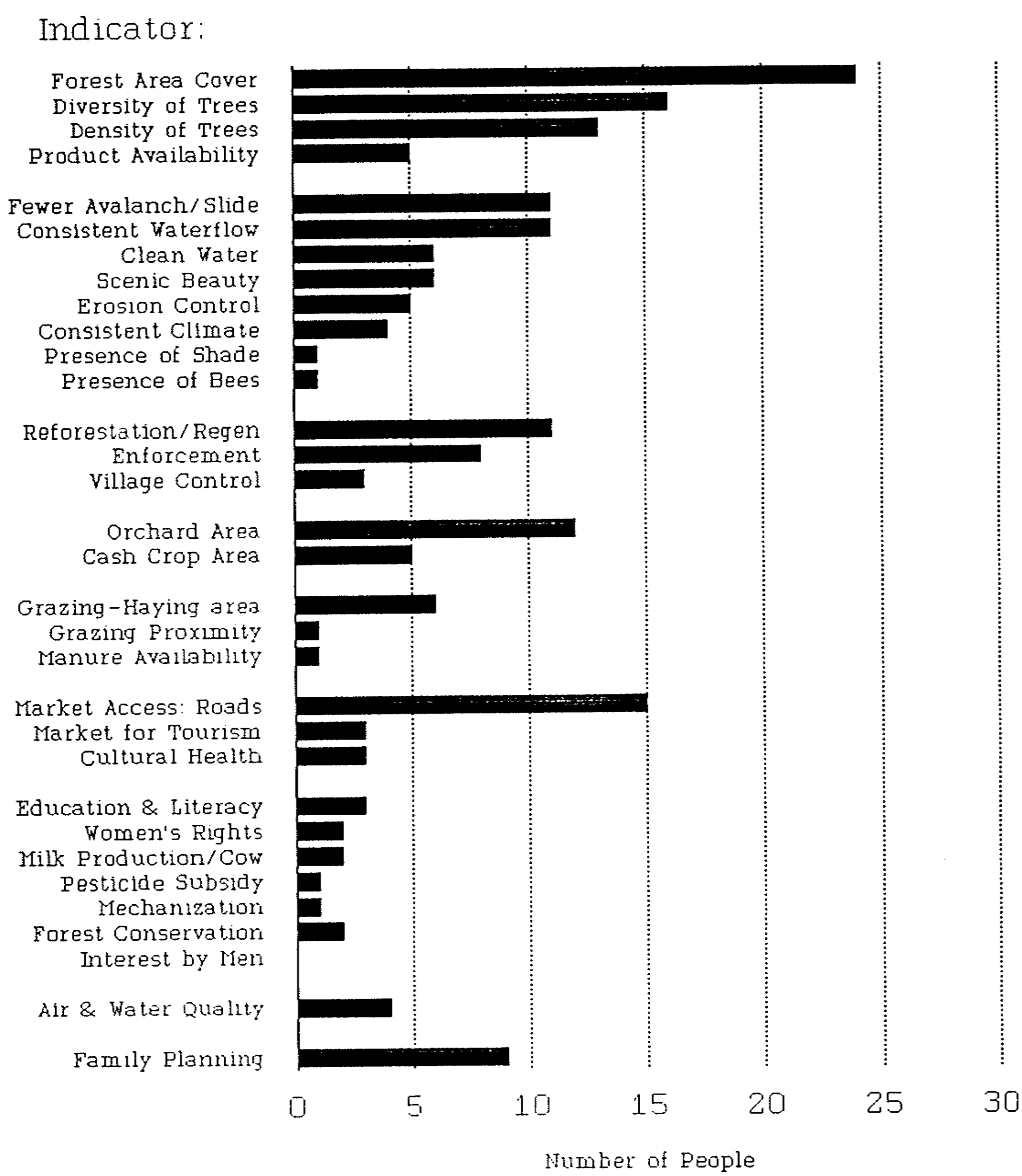
5.2 Locally Identified Indicators of Sustainability

The results of 36 interviews with Goshal and Chachoga villagers on what "signs and/or signals should be monitored in order to predict a good future" are shown in

Figure 12. This figure shows compiled raw data. The numbers on Figure 12 are the number of responses given for each of the various indicators. There was little in the way of prompting, villagers independently suggested the indicators in each interview. The indicators have been grouped in nine clusters discussed below. Appendix 5 shows the field data used to create Figure 12. The main results in Figure 12 (those indicators identified by more than eight or ten people) would likely have withstood a larger sample size. However, one can speculate that in a group process, villagers together might give greater weighting to indicators identified by only one, or a few people, for example, the presence of bees (discussed below).

5.2.1 Forest Indicators. The first grouping of indicators in Figure 12 relates directly to the quantity and quality of the forest. These indicators include forest area cover, tree species diversity, forest density, and the availability (time required to gather) of forest products (fuel, fodder, bedding, MFP's, and timber). The first three are considered positive indicators of a good future, while the forth is a positive result of high levels among the first three. The first three were the most frequently identified measures (excepting one) by the villagers of Goshal and Chachoga. The measures may seem obvious and simplistic, yet these indicators relate to a multitude of present and future human-environment interactions, and to the ability of people in the villages to cope with and adapt to events and changes in livelihood. Forest indicators would measure the stock of natural capital (cover, diversity, and density), and help us recognize whether the interest being drawn (in the form of forest products) is appropriate. Monitoring may also reveal aspects of the "pressure-state-response" dynamics of this system, and help determine the appropriateness of management, and whether system resiliency is being maintained.

5.2.2 Forest-Linked Indicators. The forest measures described above impact other components of the environment. The second cluster of indicators identified by the villagers in Figure 12 captures the secondary effects of the state of forest cover, diversity, and density. The number of snow avalanches and landslides (understood and distinguished by the people), and consistent hydrology (of streams, springs, and rivers) were the two most frequent response in this grouping. Clean water, and scenic beauty



Sample of 36 (20 Goshal, 16 Chachoga)
Median # of suggested indicators 4 - 7

Figure 12. Signs and Signals which should be monitored in order to predict a good future, according to Goshal and Chachoga villagers - a proxy for locally identified sustainability indicators.

of the area were the next most identified as signs or signals to be monitored, followed by control of erosion, and consistency of climate - all of which relate to forest cover. The amount of shade (an indirect measure of crown closure), and the presence of bees (as pollinators for apple orchards and crops) were also identified as signs or signals to observe, which relate to forest quantity and quality.

(Left) A scenic waterfall above Bahang, looking east. (Right) The shifting Beas River, in front of Goshal, looking southeast.

5.2.3 Forest Management Indicators. The third cluster of village indicators in Figure 12 relate to forest management. Like the first set, these are forward-looking measures. The presence of reforestation efforts and natural forest regeneration, together constitute the most important sign or signal of a good future forest. This indicator supports the present project's analysis of tree age-class structure, and demonstrates the obvious importance of healthy new growth which will eventually be needed to replace the older forest.

Enforcement effectiveness over the annual timber harvest allowed by households (called "right holders") is the next most important thing to monitor according to villagers. The number of individual trees marked for harvest by right holders is set by the Range Forest Office. This process, called "timber distribution", is referred to as "TD" rights. In the recent past, each household was allowed five trees per year, this has been reduced incrementally to one tree every five years, and just in 1994, was changed to a system where the household has to justify its need for a tree. It remains to be seen how this system can be maintained in the face of the rapid growth in tourism - tourism which leads to increased wood demand for hotel construction and cooking in Manali. There is already some evidence of unsanctioned felling of green trees, which are sold on an illegal market for one quarter the legal price.

A recent enforcement challenge in Chachoga's forests was the selling of "headloads" of fuelwood in Manali. This sale of fuelwood made it more difficult to acquire fuelwood for local use, as nearby sources were used unsustainably. In response to this, and to the illegal fellings, a women's group called the Mahila Mandal took up the role of enforcement. They made selling of fuelwood outside the village illegal, and patrolled the forests in groups to prevent illegal harvest. A third positive indicator, suggested by a few people, would be increased village control of timber distribution, and increased village enforcement of rules.

5.2.4 Orchard, Crop, and Grazing Indicators. The fourth and fifth indicator groups, counting from the top of Figure 12, relate to agriculture. Increased area under apple orchard and increased area of any other cash crop are both considered signs of a good future. The term "cash crop" likely refers in the most part to apples, and less to other crops such as peas and red rice. The switch to more orchard and cash crop area would come at the loss of former mixed-crop agricultural area. The emphasis on apples reflects the growth of the agricultural cash economy over the last 30 years. As a result of the increase in orchard cover in a limited agricultural area, mixed-crop agriculture,

Goshal at upper right-hand side, showing lopped trees in foreground, mixed agriculture and young orchards below, and the Beas River (Looking east).

and thus food self-reliance (especially grains) is in decline. Observation of young apple trees interplanted with mixed-crops suggests that 90 percent of the agricultural area will eventually be covered by thick orchard, with insufficient light for understorey crops. This assumes normal size apple trees; dwarf apple trees have not been introduced to the area at this time, although such introduction would allow the maintenance of mixed crops.

The village perception that increased orchard and cash crop area are signs of a good future is an indication of the importance of the economic dimensions of sustainability in the minds of those respondents. Many factors relate to the long-term success of such agriculture, yet such factors were rarely mentioned by villagers as important to future sustainability. Some factors which must be considered in sustainable apple cropping include: selection of appropriate apple tree species for the climatic conditions (given the risk of late snows during blossoming); maintaining an apple tree ratio of at least one pollinizing species (e.g. golden delicious) for every five to six non-pollinizing species (e.g. red and royal delicious) - the ratio was said to be approaching

20 to one, as orchardists concentrated on the valuable red and royal delicious; maintenance of pollinator species (approximately 80% of pollination is done by bees, and some by butterflies); select use of broad spectrum insecticides which might affect pollinators - apples are generally a very chemical intensive crop; use of manure fertilizer, and control of soil erosion to maintain crop productivity, to name but a few (Dr. J.C. Gupta and Dr. Kapoor 1994, pers.comm). Unfortunately it was not possible to sample for these factors during the field season.

Two assumptions were likely being reflected in the respondents choice of apple and cash crop area as indicators, first, villagers may be assuming that orchard management is sustainable with respect to soil, and with respect to apple species diversity (important for long-term crop resiliency); these are both dubious assumptions. Secondly, and less dubious, is that a market for the product is maintained. An area of further concern is the use of pesticides on orchards. Recent perceived declines in bird, insect, and bee populations and diversity may be a result of excessive pesticide use, and bodes poorly for ecosystem function.

Weaving on a hand loom, making shawls for household use and for sale in Manali, sister of senior translator, Goshal.

Area of quality grazing, and area for hay growth are first in the next cluster. These two are together considered a good sign, and would be telling of good grazing management. Proximity of good grazing was also mentioned as a positive sign. Finally, the availability of manure for fertilizer is something which respondents thought should be monitored. Manure is mixed with bedding material and distributed on the fields and around apple trees, it is the fertilizer of choice in every case. It is also free, unlike costly manufactured fertilizers. Manure is sometimes used as cooking fuel, desirable for its slow consistent heat, but is used principally as fertilizer.

5.2.5 Economic and Social Indicators. The sixth group of signs or signals identified for future monitoring in Figure 12 starts with market access, in particular, the existence of good roads down to the plains. This single indicator is the third most

Hotel development in Manali, looking northeast.

frequent response after forest area cover and tree species diversity. Access, important for apple crop export, and for the import of tourists, is of obvious importance to emerging cash economy-based livelihoods.

Discussion of livelihoods based on apples, and those which rely more on tourism is needed at this point. Many of the people interviewed in the villages belonged to households which owned at least some orchards, and such people would obviously have an interest in market access. However, villagers usually base their livelihoods on several sources; orchard owning households are often involved with tourism via weaving (for sale Manali), or by having some members of the household involved in trekking, or running a business in Manali. The market for tourism is thus also important. There are however, village households which rely more heavily on a business located in Manali (or located along the roads below Chachoga, or in Bahang, which lies across the Beas River from Goshal). The market for tourism would obviously have greater bearing on the livelihoods of these people (the actual number of tourists visiting the area includes 250,000 Hindu pilgrims, 25,000 trekkers, and 75 expeditions to the Gangotri glacier, source of the Ganges (Denniston 1995)).

Those with the greatest reliance on tourism are the people of Manali, although many of the larger tourist oriented businesses in Manali are owned by people from the plains, Kangra district, Lahaul to the north, by Tibetans, and increasingly by foreigners. Some antagonism towards this concentration of non-local ownership was felt by villagers.

The next sign or signal to be watched is the flow of tourism into the area. Consultants from the villages were aware that if violence in Jammu and Kashmir ceased, tourists would be drawn away to Jammu and Kashmir - historically a much more important tourist destination. The third indicator in this cluster is closely linked to markets and access to the plains: cultural health. Undesirable aspects of opening a culture up to a larger market include challenges to cultural identity, assimilation into mainstream plains culture, crime, and examples of undesired lifestyles. An example of undesired lifestyles, according to people of the villages, are Manali's and Old Manali's fluctuating "hippie" population, a heterogeneous non-Indian group, some there since the 1960's and presently raising children. Other "new" hippies, more recently from Israel, Britain, France, and other countries, stay for several years, or return for half of each year, attracted by the location, by the availability of *Cannabis sativa* (known as bhang, marijuana, or hashish - grown legally for hemp-rope fibre), by the availability of other illegal substances, and by the low cost of living.

5.2.6 Mixed Category Indicators. As indicated on Figure 12, the seventh cluster of signs and signals to monitor includes education and literacy for children, and women's rights, particularly for the coming generations. Respondents suggested that the forest conservation interests of young men would be a good sign, although currently young men tend to favour the profitability of working in Manali. Their lack of interest in forest use and conservation, and perhaps even their active participation in unsanctioned harvesting of green timber, leaves the job of forest conservation to women. Denniston (1995) supports this when he suggests that 70-80% of the agrosilvipastoral work is done by women (yet states that women still have little access to land, credit, and technical support).

Increased milk production per cow is considered a good sign. Introduction of Jersey cattle crossed with small Himalayan breeds has resulted in milk production rising from half a litre per day, to between five and ten litres per day (and possibly much more). One cow, rather than five, can now meet the needs of a household. Less grazing area is needed per litre of milk, although how much less is not clear. However, one cow means the availability of manure per household is reduced, and people are more vulnerable if one cow dies.

Mechanization of agricultural labour, and subsidization of pesticides, were also considered signs to monitor. Mechanization is nearly non-existent today, probably a result of very small terraced fields, as well as cost. Ploughing is done by bullock, and planting, weeding, harvesting, and fertilization (using manure and bedding material), is all done by hand, mostly by women, except for ploughing. Various pesticides are 50 percent subsidized as a government policy, and manufactured fertilizers were also subsidized until recently (Gupta and Kapoor 1994, pers.comm).

5.2.7 Air and Water Quality as Indicators. The next to last indicator type on Figure 12 identified by villagers was air and water quality. Respondents expressed concern over air pollution in and near Manali, as well as along roads. Negative effects of air pollution on human health, crops, forests, and climate, were discussed by respondents. Concern over water pollution included sewage and garbage entering the Beas River, however the importance of village water potability was given greater emphasis. The driving force behind air and water quality concern is the increased number of people (both tourists and immigrants seeking work in the tourist industry) in the regional centre of Manali. Steps to improve air and water quality would likely be considered a positive sign, although none were described.

5.2.8 Family Planning as Indicator. The last sign or signal to monitor for a good future identified by some people of Chachoga and Goshal, was population control (Figure 12). The villager consultants placed emphasis on local family growth in villages, rather than on people arriving via immigration. It seemed immigration was mostly into Manali, not into the villages. Population statistics were inadequate, more research is thus needed in this area, although the general population growth rate in the Himalaya is 2.5%, with a doubling time of 28 years (Denniston 1995). The topic of population is controversial among many people of the villages, and the people who identified it as a sign or signal were often older men in positions of political or commercial significance (usually the two coincided). There are many theories relating social, economic, cultural, political, and environmental conditions to population growth. Yet in the village context, with its direct interaction with, and reliance on, a limited area of forest (Figure 3), increases in population, without reduction in per capita use of forest products, could deplete or change the forests undesirably, and reduce resilience in the human/environment system.

5.2.9 Village Perspectives on Sustainability: Summary. Figure 12 gives an initial idea of the signs or signals villagers think should be monitored in order to predict a good future. Used as a proxy for sustainability indicators, these signs and signals are most relevant to the people of Goshal and Chachoga. The spontaneous responses shown totalled in the figure make it possible to weight the different indicators once monitoring is undertaken. Some village indicators would probably show positive trends, other negative, thus weighting is required to obtain an overall picture of whether the livelihood system is becoming more or less sustainable.

The most frequently identified indicators (identified by 15 or more village consultants), and which should be more heavily weighted once ascertained are:

- forest area cover;

- tree species diversity; and
- market access.

Those identified by ten or more village consultants also include:

- forest density;
- orchard area;
- avalanche and landslide frequency;
- waterflow consistency; and
- reforestation and regeneration area and success.

Those identified by five or more village consultants also include:

- family planning - population growth;
- forest protection enforcement success;
- clean water availability from the forest;
- scenic beauty;
- grazing and haying area;
- availability of forest products - time to harvest;
- amount of erosion; and
- cash crop area.

Indicators identified by less than five villagers include:

- consistent climate;
- air and water quality;
- village control of forest management;
- strength of tourism market;
- cultural health;
- education and literacy;
- women's rights;
- forest conservation interest by young men; and
- milk production per animal.

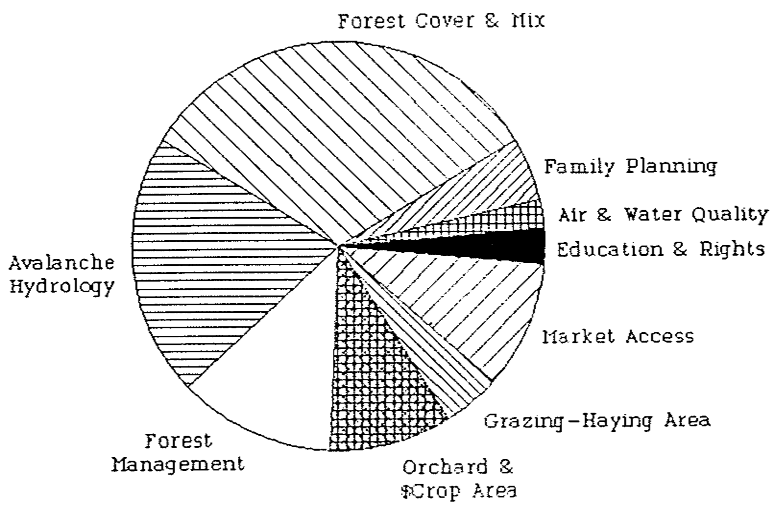
Indicators identified by one person include: presence of shade; presence of bees; proximity of grazing areas; availability of manure; pesticide subsidy; and mechanization. These last two are not recommended.

5.2.10 The Perspectives of Local Natural Resources Professionals in Contrast. In addition to the 36 interviews with village consultants, nine other interviews were made with various local professionals in the field of natural resources as a comparison to the village perspectives. Agricultural, horticultural, and entomological researchers, foresters, an environmental non-government organization representative, and a representative from the Mountain Research Institute of Manali were interviewed with a non-scheduled structured questioning technique. The questions generally focused on environmental issues of sustainability, and helped identify indicators. All interviewees spoke English. Appendix 6 shows the field notes from these interviews.

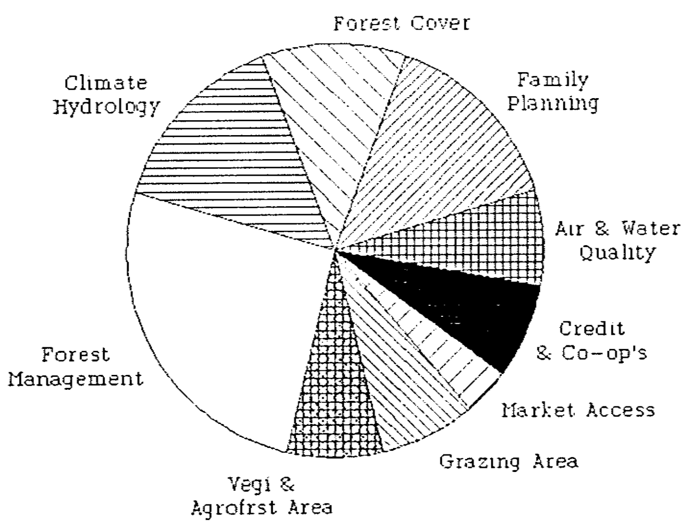
In the same way that the village consultants' responses are clustered into nine themes, so too are the responses of the local natural resources professionals. The nine indicator themes are roughly parallel, and the weighting given to each are compared in two pie charts in Figure 13. The two pie charts should be read counter-clockwise from the top.

In the village perspective, two-thirds of the weighting is on forests, measures directly linked to forests, and forest management, whereas the local professionals give a one half weighting to these same measures. Among the factors related to forests, villagers emphasized avalanche and landslide frequency, and stable hydrology, while the local professionals emphasized the relation of Kullu Valley climate to forest cover, and again stable hydrology. Although both groups mentioned the presence of bees, professionals added birds, which are said to be in decline, and attributed the current absence of bees (and birds) to excessive use of pesticides on orchard. This last point was emphasized strongly as an issue of concern (the use of birds as an indicator is also recommended in the literature by Denniston 1995). The natural resource professionals gave relatively much greater weighting to good forest management than did the village consultants.

The weighting given to the measure of agricultural area was equal, although villagers focused on apples and cash crops more generally, while professionals emphasized vegetables as being the cash crop of the future, and recommended agroforestry in general. The suggested vegetable crops were summer squash, cabbage, summer cauliflower, potato, baby corn, and onion. The recommended practice of agroforestry includes diversifying apple species, including more pears, apricots, cherries,



Chachoga and Goshal Villagers



Local Natural Resources Professionals

Figure 13. Comparing the relative importance of nine types of sustainabiltiy indicator - according to the two villages, and according to local natural resources management professionals.

and including more multi-purpose trees such as robinia, ash, poplar, beech, and willow. The professionals gave greater weighting to the importance of grazing area, which includes manure availability, but did not note the importance of haying area for fodder as an indicator. The positive benefits of agroforestry are supported in the literature. For example, nine inches of leaf mulch on the soil, from intercropped trees, allows soil to hold its moisture through a month of drought, thereby reducing stress on agriculture and horticulture crops (Azad and Verma 1993).

Villagers gave greater bearing to market access, and existence of a tourism market, whereas the local professionals considered the existence of village business co-operatives and availability of credit to be of greater import for monitoring. If the two indicator themes of market access and credit and co-operatives in the lower pie chart are clumped together as "economic sustainability", and market access in the upper pie is also renamed, then both groups gave them similar relative weighting.

The local professionals did not mention education, literacy, and women's rights as signs or signals to monitor, although village "environmental awareness" was mentioned once. The exodus of young men and women as an indicator was described by both groups. Professionals gave greater weighting to air and water quality as indicators, citing unplanned tourism development as the primary problem. Professionals also considered family planning, or its opposite, population growth as a relatively more important indicator than did the consultants from the villages.

After the fieldwork, and in response to technical reports sent to India, facsimile communication with a representative from a local NGO (non-government organization) contained a perspective on the actual data which might be found, if the locally identified indicators were monitored. Appendix 7 shows this perspective.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 THE VALUE AND ROLE OF INDICATORS

> If we cannot reliably measure whether a given current management practice is sustainable, or predict whether an alternative would be more or less sustainable, how can we move toward sustainability? (Carpenter 1994, quoted in Rees 1995:351).

The question posed above captures the value of sustainability indicators, whose role is to assist resources management practice and land-use policy decisions. Resources management practice and land-use policy are effectively blind without indicators. However, indicators are no surrogate for data; actual data for the variables are required for indicators to be of any use. There are hundreds of possible sustainability indicators, and their data can be difficult and costly to collect. It thus becomes necessary to identify key indicators which are workable, through using local input, conceptual biophysical flow models, and background literature. In this way, the indicators selected are ultimately more relevant for sustaining people's livelihoods in the Himalayan front ranges, Upper Kullu Valley, headwaters of the Beas River, Himachal Pradesh, India. When data from such indicators are used to help direct resources management practice and land-use policy, the ultimate goal of sustaining livelihoods becomes possible. To do so requires the development of socially desirable goals or targets against which measures can be compared. Understanding which are the most important indicators further helps decision-making when practice or policy has a positive effect on one indicator, and a negative effect on another.

In light of the value and role of indicators, the purpose of this research is to identify, evaluate, and select indicators to monitor the sustainability of human activity in forested mountain watersheds. The indicators should facilitate management for the sustainability of local livelihoods by being feasible to monitor. Such indicators would be applicable, among other places, to an upper watershed of the Beas River, and in particular, to the villagers of Chachoga and Goshal.

To fulfil the purpose, the main objectives of this research, in summary, were: 1) To identify preliminary (pre-fieldwork) indicators, based on a conceptual model and background literature; 2) To test the feasibility of the use of these preliminary indicators in the study area; 3) To use input from interviews conducted in the study site to identify indicators which are most relevant to local livelihoods; 4) To recommend to policy-makers and other researchers those indicators which could be monitored to help improve natural resources management and land-use policy decisions, and to communicate the results.

6.2 Preliminary Indicators, the External Perspective

In relation to objective one, a list of preliminary indicators was assembled prior to the fieldwork for this research. The choice of these indicators was based on a synthesis of the background literature on indicators and the study site; a conceptual model of biophysical flows in the human/environment system; logical deduction; and, discussion with thesis committee advisors. These indicators constitute an external perspective of the key variables to monitor. They are called preliminary indicators because they had not yet been exposed to the practicalities of the field. The preliminary (externally identified) indicator list, developed from the above work included:

1) forest indicators of cover extent, cover density, diversity, and tree age-class structure (drawn from the conceptual model, and from Costanza's (1991) and Costanza and Daly's (1992) ideas on natural capital);

2) changes in the mix of forest tree species and species preferred for use, as determined by village interviews, to watch for reverse succession caused by over-use (drawn from Holling's (1994; 1986) ideas on pressure and ecosystem change);

3) frequency and magnitude of hazards and disasters such as landslides and floods (drawn from the literature on risks in mountain areas, in particular Ives (1992) and Ahmad (1993));

4) soil measures of quality and erosion - although a walking survey of soil erosion characteristics alone, mapped using a GPS (global positioning system), was thought to be more feasible - (drawn from the conceptual model and natural capital theory);

5) measurement of the use of biomass resources by people of the area. This indicator was refined to an estimation of the hypothetical primary productivity of an area (from remotely sensed images) as compared with the extraction of products of photosynthesis (drawn from discussion and ideas on the appropriation of natural capital);

6) organization of indicators on the diverse spatial patterns of vegetation cover, soil, slope aspect, and altitude found in mountain areas, and a focus on the watershed as a unit of study;

7) emphasis on the importance of verticality and biophysical flows between vertical zones in mountain areas; and

8) interviews with local villagers and natural resources experts to identify further indicators which are considered most important from a local perspective.

Preliminary indicators 6) and 7) are organizational approaches which could be stored in a GIS (geographical information system) for easy retrieval and analysis. The last, preliminary indicator 8), is also an approach to indicator identification.

6.3 Indicator Data Collected, Implications, and Natural Resources Management Recommendations

In relation to objective two, baseline and trend data were collected for several of the preliminary indicators during the 1994 field season for the villages of Goshal and Chachoga. The collected data included: forest cover maps; forest density and quality descriptions; tree age-class structure; soil erosion potential descriptions for orchards, forests, fields, and the forest-agriculture interface; village and forester perceptions of changes in the relative mix of tree species; tree species preferred for various uses according to villagers; and, an estimation of forest and agricultural area available per household, and the ratio of forest to agricultural area for the two villages of Chachoga and Goshal. The data relating to each was presented in Chapter 4, and in first part of Chapter 5 (section 5.1) - a summary follows:

Relating to preliminary indicator 1, government map information of forest cover for the two villages' forest use areas show a general decline in forest cover since 1918. Records describe low success rates in reforestation and regeneration in many instances. Fire and grazing are both described as major players in forest clearing and reduced regeneration respectively in the Forest Department records for Goshal and Chachoga. As enforcement of forest management rules are beyond the resources of the Forest Department, management cooperation (co-management) with villagers, especially those who graze animals, is required to sustainably manage the forest in a manner which is fair and adequate for the users.

The allowance of timber per village household has been lowered in recent years, from five trees per year, to three, to one, to one tree every five years. As well, the one tree is allocated on the basis of demonstrated need. The results of this change in policy remain to be seen, and depend upon the effectiveness of enforcement. If enforcement is adequate, there could be an increase in forest cover assuming successful regeneration. If inadequate, unsanctioned felling will continue to feed hotel growth in Manali, and forest cover increase will become less likely.

Records of tree age-class structure described and discussed in Chapter 4, suggest a future shortfall for important species in the village forest use areas, but not necessarily in the forest region as a whole. As an example, insufficient numbers of young (10-30 cm) trees today, will mean a shortage of mature (e.g. 50-70 cm) trees in the future. Thus needs met by the products and services of those mature trees will not be met, or will be met from other, as yet unknown sources. The age-class structure of Goshal's silver fir, spruce, deodar, pine, and chestnut, and Chachoga's spruce, pine, chestnut, and silver fir, all show a lack of young trees (10-30 cm). This lack does not bode well for future use of those trees. Management implications include planting, and ensuring the survival of, an "over-abundance" of seedling and sapling trees to partially compensate for the lack of the 10-30 cm age-classes. A second approach, is to search for alternatives to meet local needs in the face of a future lack of mature tree, and plan for them now.

Relating to preliminary indicator 4, erosion was found to occur where animal traffic was high, and where there was a history of transporting timber down-slope. However, the predominance of clay and clayey loam soils, plus layers of undecomposed humus, although patchy, results in a naturally low erodability of soils; as opposed to sandy soils. Management implications include increased enforcement of timber transport practices, managing for animal traffic to take rotating paths, or take paths which are covered in stones.

Encroachment of orchards into the forests did not seem to be occurring in the two village areas; rather, new orchards were usually located in agricultural terraces, abandoned terraces, steep haying areas, and *Nautor* lands. Food self-reliance is declining as a result of orcharding. The major implication of these changes is that the people of the Kullu Valley are moving increasingly toward a cash economy, and away from the agrosilvipastoral system which has formed the basis of local livelihoods. On-going development of sustainability indicators will therefore be required to maintain their appropriateness in future years, given this scenario.

Relating to preliminary indicators 2 and 5, a local village perspective suggests there has been a 30-year decline, or downward trend, in the availability and area cover of preferred fuelwood, fodder, and timber tree species. These 30-year downward trends in preferred species are likely a result of overuse. Such declines, however, have apparently stopped in recent years, thus stabilizing availability and area cover at reduced levels. In other cases, the declines have reversed in recent years, and the trend has turned upwards. Most of these observations were confirmed by the local government forester during the 1994 fieldwork.

The stopped or reversed declines are likely a result of increased enforcement by a local women's group in Chachoga, and by the larger available stock accessible when increasing distances are travelled in the case of Goshal, although other causes are possible. As increasing distances to obtain forest products leads to more time and drudgery to meet basic needs, greater local control over enforcement and forest management is suggested. Although caution must be exercised over which villagers end up with enforcement control (see K. Davidson-Hunt 1995 for discussion of the situation in Chachoga).

In the forests, species change interviews suggest fewer large trees, and more shrubs. Possible successional (seral) change to a forest type called temperate secondary scrub may be occurring. If so, this follows Holling's (1986) ideas on ecosystem change under pressure, and indicates those pressures are unsustainable if ecosystem change is to be avoided. The resulting management implications include: reducing use rates and improving enforcement; ensuring villager participation in forest management decisions such that villagers have more vested interest in the forest resource (for example by planting village preferred species as identified in Figure 11); improving reforestation and regeneration (i.e. planting, and improving seedling and sapling survival rates) through cooperation with villagers.

Relating to preliminary indicator 3, interviews also identified horticulture, particularly apple growing, as a topic of concern. Local professionals suggested that the current emphasis on only a few apple varieties will increase the risk of crop failure, and that excessive use of pesticides may be reducing the population and diversity of bees, insects, and birds. The 80 percent crop reduction which resulted from late snows in the spring of 1994, and perhaps from a lack of pollinating insects, supports this concern. The resulting implications include managing for increased variety of apple and other cash crops, managing for appropriate use of pesticides, managing for increased number of bee hives (fewer people keep bees in recent years), and managing for the maintenance of important bird habitat. Management could take numerous forms, including incentives and disincentives.

Population density and population growth are clearly important factors in sustainability assessment; they affect present and future pressure on village natural resources. However, the official population figures available for the two study villages were found to be not reliable. Thus, the populations of Goshal and Chachoga were calculated by multiplying the number of households (130 and 80) by an estimated ten people per household. Using this method, Goshal's population is 1300, and Chachoga's is 800.

Using village land-use area maps based on Forestry Department and local village information, the forest available per household in Goshal and Chachoga was estimated at 5 ha and 2 ha respectively (or 0.5 and 0.2 ha per capita). These figures do not include the summer grazing range of herds, which extend beyond the mapped area. Although these figures exceed the state average per capita figure of 0.18 ha (Azad and Verma 1993), the numbers do not account for differences in forest productivity.

Agricultural land area estimates averaged 0.8 ha per household in Goshal, and 1 ha in Chachoga. These figures are close to the Kullu Valley average of 1 ha per household (ODA 1994).

Relating to preliminary indicator 5, the ratio of forest land to agricultural land in Goshal is approximately 4.8 ha of forest per hectare of agricultural land, and 2 ha in Chachoga. Robinson (1987) estimates that inputs of fodder, bedding, and other inputs from 2.8 to 18 ha of forest are required to maintain one hectare of agricultural land. The figures for Chachoga and Goshal are at the low end of Robinson's estimate.

The above findings have several implications for sustainable resources management in the study area. Drawing from the collected indicator data summarized above, the following recommendations for natural resources management are made:

- Plant and manage for desired forest species to meet requirements by village area;
- Ensure village participation in forest management through local input and co-management between the Forest Department and villages;
- Over-plant to compensate for age-class gaps by tree species within village areas;
- Institute an outreach program for use of appropriate species, varieties, and pesticide use in orchards and other cash crops;
- Encourage use of community economic development tools such as credit availability and producers' co-operatives to diversify field crops and agroforestry crops; and
- Encourage community economic development that takes advantage of the growing tourism industry, by offering more tourist services to take advantage of local scenic and heritage resources (e.g. trekking, religious sites, and snow).

6.4 Locally Identified Sustainability Indicators

In relation to objective three, interviews with villagers and local natural resources professionals were conducted to gather locally identified indicators. These indicators were used to augment the externally identified preliminary indicator set, to screen the hundreds of possible indicators, and to show which indicators were most important to livelihood sustainability.

Figure 12 in Chapter 5, section 5.2, showed the 32 indicators identified as important by the people of Chachoga and Goshal. In decreasing order of response frequency, the top ten indicators were: the extent and quality of forest cover; tree species diversity; adequate market access; forest density; orchard area; number of landslides and avalanches; consistent waterflow; amount of reforestation and regeneration; family planning; and enforcement of tree-felling rules. Interviews with nine local resource management professionals identified many of the same indicators, as well as two additional indicators: access to credit and training; and ability to set up cooperative businesses. These latter two indicators bring the total number of locally identified indicators to 34. All the local professionals emphasized enforcement success of tree-felling rules, and reforestation and regeneration success as indicators. The existence of locally identified indicators not found on the preliminary list demonstrates the importance of adding local input to the indicator development process.

When the indicators identified by villagers and local professionals are compared with the preliminary list described in the previous section, it is clear that the locally identified indicators cover a much broader range of categories than did the external perspective. Evidently, the focus of the preliminary set of indicators was too narrow from the local perspective. The locally identified indicator set went beyond the preliminary list by including forest management practice and success itself as an indicator; more forest-linked indicators such as clean water, scenic beauty and consistent climate; agricultural indicators of orchard and crop area, and grazing area; market indicators of road access, credit access, number of tourists, and impact on cultural health; social indicators of education, rights, and interest in forest conservation; air and water quality; and family planning.

The biophysical indicators identified by villagers and local resource management professionals all fit within the conceptual biophysical flow model (Figure 3) developed in section 2.2.1. The model shows the fundamental importance of forests to sustainable livelihoods in the study area, thus implying the importance of good forest management. The model also accommodates the locally identified indicators of grazing, agriculture, and horticulture area; market access for income based flows; air and water quality as a service from natural surroundings; and the impact of population on use rates of natural capital.

Costanza's (1991) and Costanza and Daly's (1992) theories of natural capital support most of the locally identified indicators. The locally identified social and market indicators are supported by Chambers (1994) and Singh and Titi (1993). Most of the locally identified indicators can be found among the hundreds shown in the background literature (see Appendices 2, 3, and 4); fortunately the local indicators help pare down those hundreds. As well, several locally identified indicators were original in the way they were described, for example, the local indicators of: presence of shade, presence of bees, and interest in forest conservation by young men. Two further local indicators, pesticide subsidy, and mechanization (each identified by one respondent), are logical responses to the question of "what good changes have occurred," although they seem misplaced as indicators.

The locally identified indicators, and the weighting of them by response rate, are only relevant to the social, cultural, economic, and ecologic interactions of the upper Kullu Valley in 1994. These interactions differ from place to place, and may also change over time. Periodic updating of the local perspectives would help adjust management goals. Comparative results from the Canadian Cordillera will help identify indicators which are cross-culturally applicable and robust, and have a high relative importance.

6.4.1 Overlap of Externally and Locally Identified Indicators. In relation to objective three, the external perspective (preliminary) indicators were found to overlap with several of the indicators most often identified by villagers. For example, the locally identified indicators of forest area cover, forest density, and tree species diversity all overlap with preliminary indicators 1) and 2) in section 6.2 (forest and tree species change). Avalanches and slides, and consistent waterflow overlap with preliminary indicator 3) (hazards and disasters). Erosion control overlaps with preliminary indicator 4) (soils). Forest product availability overlaps with preliminary indicator 5) (biomass use). Finally, the local input approach to indicators shown in preliminary indicator approach 8) is in fact used in this research.

All the overlapping indicators fit the background theory of natural capital, in that the indicators concern stock of natural capital, and flow of products and services. In addition, the overlap indicators of consistent waterflow, number of avalanches and landslides, and changes in tree species mix are conceptually supported by Holling's

(1986) "science of surprise" (see Chapter 3, section 3.2.5).

Locally identified indicators, which were not among the preliminary external indicators, include the following, in descending order of response frequency: market access by roads; orchard area; reforestation and forest regeneration; family planning; enforcement of forest use rules; clean water; scenic beauty; grazing and haying area; cash crop area; consistent climate; and air & water quality. These only include the local indicators which were identified by more than three people.

6.4.2 Sustainability Principles Inherent in External and Local Indicators. In relation to objective three, the externally and locally identified indicators were compared with sustainability principles, criteria, and standard measures described in the literature (Chapter 3, section 3.4).

The development of indicators needs to be based on overriding principles (ideals or goals) which are then refined following fieldwork. Drawing on principles selected from the background literature (Chapter 3, section 3.4), and refined following the summer 1994 fieldwork, the principles most applicable to the study area and mountain environments include: maintenance and enhancement of long-term multiple socio-economic benefits to meet social needs; maintenance of ecosystem health, vitality, and productive capacity; conservation of biodiversity; maintenance of soil and water resources, air, water, and land quality; maintenance of healthy living environment in communities, including education; and empowerment of local people as stewards of environment and economy.

The indicators identified in this research from local and external perspectives, if monitored, could together assess progress towards most of the above goals. For example, maintaining the flow of forest products upon which people base much of their livelihoods, a component of the principle of maintenance and enhancement of long-term multiple socio-economic benefits to meet social needs, can be monitored by measures of forest cover, density, age-class structure, species mix, and product availability. The principle of maintenance of diversity of all ecosystem components and species is partially addressed by monitoring the mix and change of tree species. Unfortunately, surveys for all forms of diversity is a very difficult task, and would not pass the indicator selection criteria of feasibility.

Clearly, certain criteria are necessary to select indicators. The selection criteria established during the literature review for the study site (Chapter 3, section 3.4) include: workability of the indicator (i.e. is the indicator measurable and is data available in a cost effective manner); responsiveness to change (does the indicator show results of actions taken); reflective of local concerns via local input; cover biophysical, social and economic realms; understandable to decision makers; relate to more than one principle; and have predictive ability. All of these criteria are met in the list of external and locally identified indicators. Forest indicators can be used as an example of indicators which meet each of the above criteria, as follows: data is available and can be updated using remote sensing; forest indicators respond to many types of impacts including changes in human activities; forests are important to local livelihoods; forest indicators are biophysical, but relate indirectly to social and economic realms; forest indicators are understandable; and forest indicators have predictive ability (for example age-class structure).

The literature on sustainability indicators also suggests that several "standard measures" should be monitored in all sustainability assessments (Carpenter 1994). These measures include yield characteristics, hydraulic cycle, water quality, soil condition, atmosphere, and keystone and pest species. The indicators locally identified cover all these standard measures - attesting to the local understanding of the dynamics of mountain ecosystems in which these people live.

6.4.3 Indicators Selected After the Fieldwork. In relation to objective three, a third set of indicators and indicator approaches were selected after the fieldwork was completed. New perspectives and insights gained during the fieldwork, together with a rethinking and revisiting of the background literature, resulted in this third set. Keeping in mind that the following list may be more or less applicable to developed, or to developing countries, the third set includes:

- time required to gather biomass for basic needs;
- additional work on the ratio of forest and scrub land to agricultural land;
- diversity of livelihoods reflecting the diversity of micro-climates and biodiversity found in mountain areas;

- village self-reliance for basic needs;
- access equality by households to the village forest use area;
- political and social service availability;
- degree of control over decision making affecting natural resources management;
- space for cultural assertion (ability to maintain a distinct culture);
- ecosystem integrity assessment through the quantitative analysis of material and energy flow, together with population and biodiversity analysis; and
- quantitative comparison of the area's production and assimilative capacities, with the appropriation and waste generation flows of human activities.

Most of the indicators and approaches in the third set take a more human perspective than do the preliminary indicators with their biophysical focus. In hindsight, selection of such socially oriented indicators is more logically done after spending time with people in the study site.

6.4.4 Indicator Workability. In relation to the last part of objective three, the feasibility of indicators and indicator approaches in the three sets was evaluated. The three indicator sets included the preliminary indicators listed in section 6.2 of this Chapter, the locally identified indicators described in Chapter 5, section 5.2, and the third indicator set that was selected after the fieldwork was completed, described in the previous section. Feasibility, or workability evaluation incorporates data availability and accessibility, time, resources, and cost to collect data. Feasibility evaluation is partially a subjective process where knowledge of Indian government records and Indian culture derived from fieldwork, indicator feasibility discussion in the literature, and logic and common sense are pulled together to chose workable indicators.

All of the preliminary indicators and indicator approaches are deduced to be feasible. In particular, the indicators for which data was collected (section 6.3 in this Chapter), demonstrate that in several cases data are available and accessible. Among forest indicators (preliminary indicators 1 and 2), limited surveys of some types of diversity are feasible, although an exhaustive biodiversity survey is not, given costs and amount of research required. Qualitative soil analysis (preliminary indicator 4), although beyond this researcher's resources, is certainly workable. As well, comparison of primary productivity with appropriation of photosynthetic products (preliminary indicator 5) is workable using remotely sensed data, village surveys, and observation. The use of remotely sensed images to quantify and monitor land cover changes over time, and the use of GIS (geographic information systems) to store, access, manipulate, and analyze indicator data in a spatially referenced manner (in relation to preliminary indicators 5, 6, and 7) are both workable, given access to the images and the technology.

All the locally identified indicators are workable to monitor as well. The locally identified indicator groups discussed in Chapter 5, section 5.2 (forest cover and mix; forest-linked indicators; forest management; orchard, cash crop, and agroforestry; grazing and haying; market access and credit; education and basic human rights; air and water quality; and family planning) are all plausibly workable. For the most part, data are also available for the local indicators (a representative from a Manali NGO provided some of these data during communication after the fieldwork was complete, see Appendix 7).

The third set of indicators were all selected with workability in mind, thus all but the last two are deduced to be workable. The last two indicator approaches in the third set, i.e. ecosystem integrity assessment, and comparison of ecosystem capacities with appropriation and waste flows, were included as ideal approaches, that would enable fuller understanding and predictive ability over the biophysical sources of local livelihood sustainability. Unfortunately, predicting an ecosystem's integrity and capacity would not only be costly, but may not even be possible without large scale experiments on similar ecosystems.

6.5 Recommended Indicators

The results of this study have implications for the assessment of village sustainability in forested mountain watersheds. In relation to objective four, the recommended indicators and monitoring approaches which can best be used to monitor livelihood sustainability in the study area are: <u>all three sets of sustainability indicators taken together.</u> The recommended indicators thus include the preliminary indicators, the locally identified indicators, and the third set of indicators selected after fieldwork. Two exceptions in the latter two lists are not recommended: pesticide subsidy and mechanization - identified locally; and, ecosystem integrity assessment, and comparison of ecosystem capacities with appropriation and waste flows - described in the third set.

There are several further recommendations relating specifically to approaches for future indicator development - these include:

- Local input and conceptual modelling during indicator identification and development;
- Focus on operationalization of indicators using available data;
- Use of GIS and remotely sensed images to quantify, store, and monitor changes over time;
- Local input to identify desired condition against which to compare indicator data; and
- On-going local input to update choice of indicators.

6.6 MONITORING SUSTAINABILITY: CONCLUDING REMARKS

Indicators are not in themselves an end, they are a beginning; to be of any ultimate use, they must be monitored. The aim of indicators, once monitored, is to improve decisions that pertain to natural resources management practice and land-use policy. Improved decisions are those which improve and sustain the livelihoods of local people for the long-term. Only then can the value of monitoring sustainability be realized. Although this research is part of a scholarly project through the CIDA-Shastri Partnership Program, and is funded by SSHRC, the villagers of Goshal and Chachoga should be considered the real clients.

This type of research (i.e. research that identifies indicators using local input and collects indicator data on the resources available to each village), can help local people in a second way. The reports generated help to legitimize village perspectives in the eyes of many decision makers. Such legitimization helps empower villagers. For example, this report points out gaps in the age-class structure of several of the villages' important tree species. At a regional scale (the typical perspective taken by the Forest Department) such gaps are not seen. Yet, it is from the village view and village-scale analysis, that the gaps become apparent. For the users of the forest, the resources actually available to them are what counts. Such findings suggest that management and policy decisions are best made - and are more conducive to sustaining local livelihoods -

when they are made while looking through the eyes of local people themselves. The easiest way to ensure that local perspectives are carried into decision making, is for those decisions to be made, or directly impacted upon by a representative village institution; in effect local management or co-management.

There are several avenues open for future research in the field of sustainability monitoring. Targets (or desired conditions) for indicator variables need to be identified and developed using local input. Collected data can then be compared against such targets to provide instant feedback. Weighting the importance of the various indicators will be necessary to assist decision making where changes in resources management practice or land-use policy improve some indicators and worsen others. Finally, integration of sustainability monitoring research with analysis of market forces and the role of commercialization, would help flesh out a fuller understanding of how livelihoods are, and could best be sustained within the evolving human/environment interactions of the Kullu Valley.

REFERENCES

Agarwal A. 1987. *Gandhi, Ecology and the Last Person*. 13th Gandhi Peace Foundation Lecture. Centre for Science & Environment (807 Vishal Bhawan, 95 Nehru Place, 110019), New Delhi.

Agriculture Canada. 1994. "Developing indicators for Canada, general proposal." Environmental Indicators Working Group, Agriculture, and Agriculture and Food Canada. Ottawa.

Ahmad A. 1993. Environmental impact assessment in the Himalayas: An ecosystem approach. *Ambio* 22: 4-9.

ARTEE. 1994. *Creating Alberta's Sustainable Development Indicators*. Alberta Round Table on Environment and Economy Secretariat, Environment Council of Alberta, Edmonton.

Azad K.C., and R.L. Verma. 1993. *Horticultural Forestry, Solution to many ills of the hills*. Minerva Book House, Shimla, India.

Balaton Bulletin. 1993. The newsletter of the Balaton Group. Fall.

Bandyopadhyay J. 1992. From environmental conflicts to sustainable mountain transformation: Ecological action in the Gharwal Himalayas. In *Grassroots Environmental Action, People's Participation in Sustainable Development*. D. Ghai, and J.M. Vivian, eds. Routledge, London and NY.

Bergstrom S. 1993. Value standards in sub-sustainable development. On limits of ecological economics. *Ecological Economics* 7: 1-18.

Berkes F., and C. Folke. 1994. "Linking social and ecological systems for resilience and sustainability." Background paper and framework prepared for a workshop on August 29, 1994 for Subproject 9 of the Research Program on Property Rights and the Performance of Natural Resources Systems. Beijer International Institute of Ecological Economics, Stockholm, Sweden.

Berkes, Fikret. ed. 1989. *Common Property Resources, Ecology and Community-Based Sustainable Development*. Belhaven Press, London UK.

Bickerstaff A., W.L. Wallace, and F. Evert. 1981. *Growth of Forests in Canada, Part 2: A quantitative Description of the Land Base and the MAI*. Forestry Services Canada, Environment Canada, Ottawa/Hull.

Billings, W. Dwight. 1979. High mountain ecosystems: Evolution, structure, operation and maintenance. In *High Mountain Geoecology.* Patrick J. Webber, ed. Westview Press, Boulder, Colerado.

Boulding, Kenneth. 1966. The economics of the coming spaceship earth. In *Economics, Ecology, Ethics: Essays Toward a Steady-State Economy.* 1980. Herman Daly, ed. W.H. Freeman Press, San Francisco.

Carpenter, Richard A. 1994. Can sustainability be measured? *Ecology International Bulletin* 21: 27-36.

Carpenter R.A., and D.E. Harper. 1989. Towards a science of sustainable upland management in developing countries. *Environmental Management* 13: 43-54.

Chambers, Robert, and Gordon Conway. 1992. "Sustainable rural livelihoods: practical concepts for the 21st century." IDS Discussion Paper 296. Institute for Development Studies, University of Sussex, UK.

Chambers, Robert. 1994. *Poverty and Livelihoods: Whose Reality Counts?* A Policy Paper commissioned by UNDP for the World Summit for Social Development. New York, NY.

Chib S.S. 1977. *This Beautiful India: Himachal Pradesh.* Light & Life Publishers, New Delhi.

Clutter J.L., J.C. Fortson, L.V. Pienaar, G.H. Brister, and R.L. Bailey. 1983. *Timber Management, a Quantitative Approach.* John Wiley & Sons, Toronto.

Cocklin C., S. Parker, and J. Hay. 1992. Notes on cumulative environmental change II: A contribution to methodology. *Journal of Environmental Management* 35: 51-67.

Costanza, Robert, and Herman E. Daly. 1992. Natural capital and sustainable development. *Conservation Biology* 6: 37-45.

Costanza R. ed. 1991. *Ecological Economics: The Science and Management of Sustainability.* Columbia University Press, New York.

Dalbir S. 1989. Common property resources and livestock farming in Chila village of Himachal Pradesh. In *Livestock Economy of India.* Oxford & IRH Publishing, New Delhi.

Dale V.H., R.V. O'Neill, M. Pedlowski, and F. Southworth. 1993. Causes and effects of land-use change in central Rondonia, Brazil. *Photogrammetric Engineering & Remote Sensing* 59: 997-1005, June.

Daly, Herman. 1980. *Economics, Ecology, Ethics: Essays Toward a Steady-State*

Economy. W.H. Freeman Press, San Francisco.

Daly H., and J.B. Cobb. 1989. *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future*. Beacon Press, Boston.

Damodaran A. 1990. "The people, the state and participatory management of common and public natural resources." Tech. Rep. No. 62. Centre for Ecological Sciences, Bangalore, India, August, 54pp (double space).

Davidson-Hunt, Iain J. 1995. "The state, village and the commoner: Interactions in the management of a western Himalayan commons." Tech. Rep. No. 4 (June).

Davidson-Hunt, Kerril. 1995. "Gender, class and the commons: A case study from the Indian Himalayas in Natural Resources Management." Tech. Rep. No. 3 (May).

Denniston, Derek. 1995. "High priorities: Conserving mountain ecosystems and cultures." World Watch Paper No. 123 (February).

Friend T. 1992. Environmental and resource accounting in developing countries. In *Ecological Economics: Emergence of a New Development Paradigm*. IREE/CIDA Workshop (7-10 November 1992, Rockland, Ontario). Institute for Research on Environment and Economy, University of Ottawa, Canada.

Gadgil M., and R. Guha. 1992. *This Fissured Land. An Ecological History of India*. Oxford University Press, Delhi.

Georgescu-Roegen, Nicholas. 1971. *The Entropy Law and the Economic Process*. Harvard University Press, Cambridge, Massachusetts.

Ghildyal B.P. 1990. Soils of the Himalaya. In *Himalaya: Environment, Resources, and Development*. N.K. Sah, S.D. Bhatt, and R.K. Pande, eds. Shree Almora Book Depot, Almora, India.

Girardet H. 1993. "Balaton Bulletin." The newsletter of the Balaton Group. Summer.

Gupta P.K., and B.C. Joshi. 1987. Fragile ecology of Himalaya. In *Environment Management in India v.1*. R.K. Sapru, ed. Ashish Publishing House, New Delhi.

Haigh M.J. 1988. Understanding Chipko: The Himalayan people's movement for forest conservation. *International Journal of Environmental Studies* 31: 99-110.

Ham, Laurie. 1995. "Livelihood security in mountain ecosystems: Coping and adapting in two Himalayan villages." Tech. Rep. No. 5 (June).

Hardi, Peter, and Laszlo Pinter. 1995. "Models and methods of measuring sustainable development performance." A revised draft discussion paper prepared for the sustainable development coordination unit of Manitoba. International Institute for

Sustainable Development, Winnipeg.

Holling C.S., D.W. Schindler, B.W. Walker, and J. Roughgarden. 1994. Biodiversity in the functioning of ecosystems: An ecological primer and synthesis. In *Biodiversity Loss: Ecological and Economic Issues.* C. Perrings, K.G. Maler, C. Folke, C.S. Holling, and B.O. Jansson, eds. Cambridge University Press, Cambridge, UK.

Holling C.S. 1986. Resilience of ecosystem: Local surprise and global change. In *Sustainable Development of the Biosphere 292-317.* E.C. Clark and R.E. Munn, eds. Cambridge University Press, Cambridge, UK.

Holling C.S. 1973. Resilience and stability of ecosystems. *Ann. Rev. Ecol. Systems* 4: 1-23.

Holmberg, John, and Sten Karlsson. 1992. On designing socio-ecological indicators. In *Society and the environment,* U. Svedin and B. Aniansson, eds. Kluwer Academic Press, Dedrecht, Netherlands.

IDRC. 1994. *Report of the Workshop on Grassroots Indicators for Sustainable and Equitable Development.* International Development Research Centre, October 18-19, Ottawa.

Ives J.D. 1992. The theory of Himalayan environmental degradation: Its validity and application challenged by recent research. In *Dynamics of Mountain Geo-Systems.* R.B. Singh, ed. Ashish Publishing House, New Delhi.

Jodha N.S. 1993. "Property rights and development, privatisation process of rural common property resources in dry regions of India." Paper for the meeting on Property Rights and the Performance of Natural Resource Systems, Beijer Institute, Stockholm, Sweden, September 2-4.

Kay J.J. 1991. The Concept of ecological integrity, alternative theories of ecology, and implication for decision-support indicators. In *Economic, Ecologic, and Decision Theories: Indicators of Ecologically Sustainable Development.* The Canadian Environmental Advisory Council, Ottawa.

Kayastha S.L. 1992. Forests and ecology in the Himalaya. In *Dynamics of Mountain Geo-Systems*, R.B. Singh, ed. Ashish Publishing House, New Delhi.

Kimmins, Hamish. 1992. *Balancing Act, Environmental Issues in Forestry.* University of British Columbia, Vancouver.

La Mendola, Walter, J.A. Martin, V. Snowberger, M. Zimmermann, and D. Easterling. 1993. *Choices for Colarado's Future: Environmental Scan*, The Colorado Trust.

Life in Jacksonville. 1993. *Life in Jacksonville: Quality Indicators for Progress,* Jacksonville Community Council, Inc., Jacksonville, Florida.

Moench M. 1986. "Turf and forest management in a Garhwal hill village." A working paper for The Environment and Policy Institute, Honolulu, Hawaii.

Montreal Process. 1995. "Criteria and indicators for the conservation and sustainable management of temperate and boreal forests." Proceeding of a working group ("Montreal Process"), Santiago, Chile. Canadian Forest Service, Natural Resources Canada, Ottawa/Hull.

Negi S.S. 1990. *A Handbook of the Himalaya.* Indus Publishing, New Delhi.

Negi Y.S., L.R. Sharma, and S. Jagtar. 1986. Factors affecting fuel-wood consumption - a micro level study. *Indian Forester* 112: 737-741, March/April.

Nelson J.G., and R. Serafin. 1992. Assessing biodiversity: A human ecological approach. *Ambio* 21: 212-218.

Noble, Christina. 1991. *At home in the Himalayas.* Harper Collins, Glasgow, UK.

Norton B.G., and R.E. Ulanowicz. 1992. Scale and biodiversity policy: A hierarchical approach. *Ambio* 21: 244-249.

NRTEE. 1993. *Toward Reporting Progress on Sustainable Development in Canada.* National Round Table on the Environment and the Economy. Report to the Prime Minister, December.

ODA. 1994. *Himachal Pradesh Forestry Project: Socio-Economic Setting, Kullu and Manali Districts.* Vol. 2, Annex 1. Overseas Development Administration Report.

Opschoor, Hans, and Lucas Reijnders. 1991. Toward sustainable development indicators. In *In Search of Indicators of Sustainable Development,* O. Kuik and H. Verbruggen, eds. Kluwer Academic Press, London.

Ostrom, Elenor. 1990. *Governing the Commons, The Evolution of Institutions for Collective Action.* Cambridge University Press, Cambridge UK.

Pearce D.W., and G.D. Atkinson. 1993. Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability. *Ecological Economics* 8: 103-108.

Pearce D.W., and R.K. Turner. 1990. *Economics of Natural Resources and the Environment.* John Hopkins University Press, Baltimore.

Pelt M.J.F. Van. 1993. Ecologically sustainable development and project appraisal in developing countries. *Ecological Economics* 7: 19-42.

Perrings, Charles. 1987. *Economy and Environment.* Cambridge University Press, Cambridge, U.K.

Perrings C., C. Folkes, and K-G. Maler. 1992. The ecology and economics of biodiversity loss: The Research Agenda. *Ambio* 21: 201-211.

Pirazizy A.A. and R.B. Singh. 1992. Forest energetics and environmental a nomaly in temperate Himalaya. In *Dynamics of Mountain Geo-Systems*, R.B. Singh, ed. Ashish Publishing House, New Delhi.

Price, Larry B. 1981. *Mountains and Man, A Study of Process and Environment.* University of California Press, Berkeley.

Ralhan P.K., G.C.S. Negi, and S.P. Singh. 1991. Structure and function of the agroforestry system in the Pithoragarh district of central Himalaya: An ecological viewpoint. *Agriculture, Ecosystems and Environment* 35: 283-296.

Rees, William E. 1995. Achieving sustainability: reform or transformation? *Journal of Planning Literature* 9: 343-361.

Rees, William E. 1992. Understanding sustainable development: natural capital and the new world order. Draft May 1992, forthcoming in the *Journal of the American Planning Association.*

Robinson, John B. 1993. "Brazilian/Canadian case studies on indicators of sustainable development." Project Proposal submitted to the IDRC Sept 3, 1993. Sustainable Development Research Institute, University of BC.

Robinson, Patrick J. 1987. The dependence of crop production on trees and forest land. In *Amelioration of Soil by Trees. A Review of Current Concepts and Practices*, R.T. Prinsly and M.J. Swift, eds. Commonwealth Secretariat, Commonwealth Science Council, London UK.

Sangeeta P. 1987. Role of forestry in eco-development of rural areas. In *Ecology of Rural India, v.1*, Pramod Singh, ed. Ashish Publishing House, New Delhi.

Sanwal M. 1989. What we know about mountain development: Common property, investment priorities, and institutional arrangements. *Mountain Research and Development* 9: 3-14.

Sen Sarma P.K. 1987. Forest, environment and development. In *Environment Management in India v.1*, R.K. Sapru, ed. Ashish Publishing House, New Delhi.

Shah M.H. 1988. Role of nomads in the destruction of alpine and subalpine pastures and future strategies. In *Rangelands, Resources, and Management*, P. Singh and P.S. Pathak, eds. Proceedings from the National Rangelands Symposium, IGFRI, Jhansi, November 9-12, 1987.

Sharma P.K., and R.S. Minhas. 1990. Wastelands of Himalayan region of north-west India and the proposed techniques for restoring their productivity. In *Environmental Education and Sustainable Development*, D. Bandhu, H. Singh, and A.K. Maitra, eds. Indian Environmental Society, India.

Sheehy, Greg. 1989. "The use of forestry indicators to show the state and recent trends in sustainable development: A forestry pilot study." Paper prepared for State of the Environment Reporting Office, Ottawa/Hull.

Shoumatoff A. 1991. The mountain is rising (Nepal). *Conde Nast Traveller* 26: 96-99, August.

Singh J.S., U. Pandey, and A.K. Tiwari. 1984. Man and the forest, a Himalayan case study. *Ambio* 13: 80-87.

Singh S.P., and J.S. Singh. 1991. Analytical conceptual plan to reforest central Himalayas for sustainable development. *Environmental Management* 15: 369-379.

Singh N., and V. Titi. 1993. *Empowerment for Sustainable Development, a Working Paper*. International Institute for Sustainable Development (IISD), Winnipeg, Manitoba.

Sustainable Seattle. 1993. *The Sustainable Seattle 1993: Indicators of Sustainable Community*, Sustainable Seattle, Washington.

Tejwani K.G. 1994. *Agroforestry in India*. Oxford & IBH, New Delhi.

Tyler, Mary-Ellen. 1988. *Adaptation and Transfer of Remote Sensing Technology to a Native Tribal Group for Resource Management*. PhD Document, University of Calgary, Alberta.

Victor P.A. 1991a. Indicators of sustainable development: Some lessons from capital theory. In *Economic, Ecologic, and Decision Theories: Indicators of Ecologically Sustainable Development*, The Canadian Environmental Advisory Council, Ottawa, Canada.

Victor P.A. 1991b. Indicators of sustainable development: some lessons from capital theory. *Ecological Economics* 4: 191-213.

Vitousek, Peter M., Paul R. Ehrlich, Ann H. Ehrlich, and Pamela A. Matson. 1986. Human Appropriation of the Products of Photosynthesis. *Bioscience* 34: 368-373.

Vollers M. 1990. Mountains: Regal highlands erode downhill. *International Wildlife* 20: 16-17, March/April.

Wackernagel M., J. McIntosh, W. Rees, and R. Woollard. 1993. "How big is our ecological footprint? A handbook for estimating a community's appropriated carrying capacity, discussion draft." Task Force on Planning Healthy and Sustainable Communities, University of British Colombia, Vancouver BC, July 1993.

Zurick D. 1987. A question of balance, life in Phalabang. *Sierra* 72: 46-50, July/August.

PERSONAL COMMUNICATION

Gardner, James. March 1994. Professor, Department of Geography, University of Manitoba.

Gupta J.C. July 1994. Agricultural Researcher, University of Palampour, Patlikuhl, HP.

Kapoor. July 1994. Entomologist, Indian Agricultural Research Institute (IARI), Kullu, HP.

Madan S.S. April 1995. Chairperson, Society for Holistic Action in Rehabilitation & Ecology (SHARE), Manali, HP.

Tyler, Mary-Ellen. May 1994. Professor, Department of City Planning, University of Manitoba.

Walia J.S. July 1995. Divisional Forest Officer, Kullu Forest Division, Kullu, HP.

APPENDIX 1

CHARACTERISTICS OF HIGH MOUNTAIN ECOSYSTEMS
(Billings 1979:119)

PHYSICAL COMPONENTS:
- relatively low daytime temperatures
- other than tropics, all have relatively high precipitation, much as snow
- lower atmospheric pressure with increased elevation
- partial pressures of the metabolic gases O_2 and CO_2 are lower with increased elevation
- relatively high solar and terrestrial radiation flux rates relative to regional lowlands
- wind speeds are higher than in adjacent lowlands
- long-lasting snow and ice
- number of degree days above 0°C is low compared with adjacent lowlands
- steep, unstable slopes are the rule
- soils mostly shallow and susceptible to erosion
- solifluction and soil frost activity are common
- high habitat diversity or environmental patchiness, because of the interaction of elevational, mesotopographical, and microtopographic gradients

BIOLOGICAL AND EVOLUTIONARY COMPONENTS:
- limited number of options for plant life forms, and plant metabolic processes
- endemism is high in plant species and certain animal taxa
- there can be relatively rapid rates of adaptive radiative evolution in genetically pre-adapted taxa
- all high mountains have biological communities which are unique to relatively small and specific areas
- all natural high mountain ecosystems evolved in the absence of humans, and many in the absence of hoofed mammals

AESTHETIC COMPONENTS:
- high mountains have certain artistic values
- these values in themselves lead to use by tourism and recreation which in themselves are economic components

ECONOMIC COMPONENTS:
- all mountains yield water as runoff
- most mountains yield some forage and/or timber
- most mountains contain useable minerals

APPENDIX 2

COMPARISONS OF VARIOUS INDICATORS OF STRESS IN ECOSYSTEMS

(after Slocombe and Woodley, quoted in Kay 1991:35)

ODUM 1985:

Energetics

1. Community respiration increases
2. Production:respiration ratio becomes unbalanced
3. Production:biomass ratio and respiration:biomass ratio increase
4. Use of imported energy increases
5. Unused primary production increases

Nutrient Cycling

6. Increases nutrient turnover
7. Horizontal transport increases, vertical cycling decreases
8. Nutrient loss increases

Community Structure

9. r-strategists increase
10. Size of organism decreases
11. Lifespan decreases
12. Food chains shorten
13. Species diversity decreases

General System Level Trends

14. Ecosystems become more open
15. Autogenic successional trends reverse
16. Efficiency of resource use decreases
17. Parasitism, etc., increases; mutualism, etc., decreases
18. Functional properties are more robust than structural properties

RAPPORT ET AL. 1985:

1. Changes in nutrient cycling
2. Changes in primary productivity
3. Changes in species diversity
4. System retrogression
5. Changes in size distribution of species
6. Increase in disease incidence
7. Changes in the amplitude of fluctuations in component populations

SCHAEFFER ET AL. 1988:

1. Falling numbers of native species
2. Overall regressive succession
3. Changing standing crop biomass
4. Changing relative amounts of energy flow to grazing and decomposer food chains
5. Changes in mineral micronutrient stocks
6. Changes in both the mechanisms of and capacity for damping undesirable oscillations

SCHEEHAN 1984:

(for polluted ecosystems)

Ecosystem Structure and Dynamics

1. Reduction in population size, and species extinction
2. Loss of species with unique functions
3. Decrease in species richness
4. Changes in community composition and dominance patterns
5. Decreased species diversity
6. Changes in the ecosystem spatial structure
7. Reversal of some aspects of succession with stress

Ecosystem Functional Changes

8. Reduced decomposition, nutrient conservation, and primary productivity
9. Increased energetic costs
10. Alteration of cycles of essential nutrients, food web and functional regulation of ecosystem processes

APPENDIX 3

SUSTAINABILITY AND SUSTAINABILITY RELATED INDICATORS FROM THE LITERATURE

SELECTED GRASSROOTS INDICATORS FOR SUSTAINABLE AND EQUITABLE DEVELOPMENT (after IDRC 1994)

- Spontaneous plant growth (indicates soil condition)
- "Life under rocks"
- Grazing movement (area left fallow; regeneration)
- Change in speciation (eg. cattle to goat) (at household level)
- Percentage of people in face to face group work (can lead to cooperative maintenance of ecosystem)
- Change in decision making authority (local, elders?)
- Violence (breakdown of cultural capital?)
- Conflicts over grazing rights (shows scarcity of shared resources;unsustainable)
- Local observation of change in soil colour and structure

BRAZILIAN/CANADIAN CASE STUDIES ON INDICATORS OF SUSTAINABLE DEVELOPMENT - SELECTED INDICATORS (after Robinson 1993)

- Existing or change in decision making process and land use planning.
- Change in yield or primary productivity (adjusted for subsidies).
- Change in biotic composition to favour opportunistic species.
- Decreasing size distribution of biota.
- Increasing nutrient load in water run-off.
- Increasing circulation of contaminants in air and water.
- Decreasing biodiversity.

All of which can lead to increased risks to human health

SELECTED AGRICULTURAL-ENVIRONMENTAL INDICATORS (after Agriculture Canada 1994, "developing indicators")

- Agricultural yield and variability (decreasing yield and increasing variability may indicate inappropriate land management, soil degradation, or climate change).
- Input use efficiency (lower efficiency could indicate increased environmental impact).
- Agricultural soil management:
  - percentage area fallow
  - percentage area under winter cover
  - percentage area monocrop
  - percentage area zero till
  - percentage area as rotating forage crop
  - total area of marginal land returned to permanent cover

A Partial List of Rudimentary Indicators by the National Round Table on the Environment and the Economy (NRTEE 1993:28)

Ecosystem:

- temperature (daily trends over time)
- concentrations of contaminants in indoor and outdoor air that are: common (CO_2, NO_2, ground-level ozone, carbon monoxide); and toxic (dioxins, lead, etc.)
- concentrations of contaminants in water (mercury, DDT, PCBs etc.)
- concentrations of contaminants in the tissue of fish, birds, wildlife, and humans (lead, PCBs, DDT, etc.)
- rates of soil erosion
- acid deposition
- loss of wildlife habitat
- the state of biodiversity:
  - -genetic (diversity within species)
  - -species (diversity in the number of distinct species)
- species health (birds, survival rates, deformities, leaf or needle loss, etc.)
- population shifts of wildlife (eagles, caribou, counts of migrating salmon in the Fraser river, etc.)

Interaction:

- contribution to well-being by activity (value-added by: agriculture, manufacturing, financial services, housework, etc.)
- resource use (per unit of time, or per unit of output)
- generation of contaminant emissions:
  - -heat and waste products per capita, or per unit of production
  - -loadings to air, surface water, groundwater, or land by activity (by automobiles, pulp and paper, manufacturing, energy production, etc.)
  - -the totals for regions and the nation
- proportion of materials recycled
- renewable resource harvest rates
- non-renewable resource extraction rates
- degree of compliance with laws and regulations

People:

- infant mortality rate
- literacy rates
- life expectancy at birth
- incidence of disease
- employment and unemployment rates
- income levels
- degree of pride in community and culture
- corporate bankruptcies
- level of indebtedness (individual, community, and nation)
- obesity (adults)
- malnutrition (children)
- caloric intake, and the proportion of it acquired from local, Canadian, and foreign foods

APPENDIX 4

SUSTAINABILITY INDICATOR PROJECTS - RECENT RESULTS

ALBERTA'S SUSTAINABLE DEVELOPMENT INDICATORS (ARTEES 1994):

1. Air quality index
2. Exposure to substandard ambient air quality
3. Production of acid forming emissions
4. Purchase of ozone-depleting substances
5. Emission of carbon dioxide and other greenhouse gases
6. Area of land affected by soil erosion
7. Total area of contaminated sites
8. Area of lands under formal agreement for wildlife habitat
9. Number of commercial crop varieties
10. Number of biogeographical regions with adequate protected areas
11. Number and size of recreational, cultural and spiritual sites
12. Percent of urban areas in parks and playgrounds
13. Total area in significant land-use categories
14. Percent of harvested forest that is successfully restocked
15. Waste per capita going to landfills
16. Size and distribution of significant wetlands
17. Groundwater quality index
18. Lake water quality index
19. Condition of major rivers
20. Length of heritage rivers
21. Percent of runoff treated at primary, secondary and tertiary levels
22. Per capita water consumption
23. Water resource depletion rates
24. Number of species at risk
25. Proportion of species approaching target population size
26. Population of species for which Alberta has a key custodian role
27. Efficiency of non-renewable resource recovery and use
28. Proportion of energy from fossil and non-fossil fuel sources
29. Per capita energy consumption
30. Employment index
31. Average education level attained
32. Percent of post-secondary graduates finding employment in there field
33. Job satisfaction index
34. Percent of Albertans on welfare
35. Volunteer rate
36. Percent of population taking each mode of transportation to work
37. Average commuting distance to work
38. Population growth
39. Urban and rural crime rates
40. Percent of GDP spent on research and development
41. GDP per capita
42. GDP per capita adjusted for natural resource depreciation
43. Percent of GDP from secondary production and business services
44. Number of environmental services, products and technologies exported
45. Per capita debt
46. Accumulated depreciation of natural resources
47. Degree of non-compliance with environmental regulations

48. Percent of performance based regulations
49. Percent of sustainable development compatible legislation
50. Public perception of information accessibility
51. Percent of organizations that have adopted sustainable development
52. Percent of management job descriptions including sustainable development
53. Sustainable development literacy of the public
54. Amount of foreign aid contributed
55. Frequency of sustainable development in K-12 countries
56. Market value of permits traded or sold
57. Percent of products and services where price reflects life-cycle cost
58. Percent of recyclable products actually recycled
59. Number of people involved in recycling initiatives

OREGON'S BENCHMARK INDICATORS (La Medola et al. 1993):

Classification of Indicators	Sub-Classes of Indicators	Indicators
Children and Families	Early Childhood Development	•percentage of children that kindergarten teachers feel are ready to succeed in school
	Teen Pregnancy	•pregnancy rate per 1,000 females ages 10-17
	Drug-Free Babies	•mothers not using alcohol during pregnancy •mothers not using tobacco during pregnancy •mothers not using illicit drugs during pregnancy
	Drug-Free Teens	•free from involvement with alcohol in the previous month •free from involvement with illicit drugs in the previous month •free from involvement with tobacco in the previous month
	Safe Child Care	•child care facilities which meet established basic standards
Education and Work Force Preparation Reforms	Education Skill Levels	•composite reading and math skills (students achieving established skill levels) •composite writing skills (students achieving established skill levels)
Work Force Training	Job Skill Preparation	•high school students with significant involvement in professional-technical education and entrepreneurial programs
	Disabled Students	•disabled high school graduates moving to competitive or supported programs
	Workforce Adaptability	•displaced workers re-employed within 24 months and earning at least 90% of previous income
Value-Added Products, Global Business	Value Added Natural Resource Products	•value added manufacturing as a percentage of total industry employment
	International Trade	•manufactured goods sold outside of the U.S.
Health and Health Care	Health Care Access	•percentage of Oregonians with economic access to basic health care
	Rural Health Care	•Oregonians with geographic access to basic health care
	Health Care Costs	•costs relative to 1980 costs
	Human Immuno-deficiency Virus	•annual percentage of HIV cases with an early diagnosis •total number of HIV cases with an early diagnosis
Physically Livable Communities	Air Quality	•Oregonians living where the air meets government air quality standards
	Affordable Housing	•Oregon households below median income spending less than 30 percent of their household income on housing

	Mobility	•vehicle miles travelled per capita in Oregon metropolitan areas
	Public Safety	•number of communities involved in a community-based strategic plan for law enforcement •average rate of reincarnation of paroled offenders within three years of initial release
Socially Livable Communities	Arts and Culture Funding	•rank in per capita funding
	Hate Crimes	•reported crimes against people or property motivated by prejudice per 100,000 Oregonians
Clean Natural Environment	Stream Flow	•key rivers and streams with in-stream water rights meeting in-stream flow needs 9 or more months out of the year
	Stream Quality	•miles of assessed Oregon rivers and streams not meeting state and federal government in-stream water quality standards
	Salmon	•key sub-basins in which wild salmon and steelhead populations are increasing or at target levels
Government Efficiency: Revenue Reform	Taxes	•Oregon ranking in state and local taxes per capita
	Public Infrastructure Investment	•real per capita outlays for facilities
	Public Agency Performance	•agencies that employ results oriented performance measures •Oregonians who think the government is doing a good job providing government services
Education	Student Skills	•11th grade students who achieve skill proficiency: composite reading and math skill •11th grade students who achieve skill proficiency: composite writing skills
	Comparative Math Skills	•ranking of 12th grade students on international math assessments
	Adult Education Attainment	•adults who have completed high school or equivalent program •adults who have completed baccalaureate degree
	Adult Literacy	•adults with intermediate proficiency at prose literacy •adults with intermediate proficiency at document literacy •adults with intermediate proficiency at qualitative literacy
Individual and Family Health	Adult Heath	•adults with good health practices
	Family Stability	•children ages 0-17 living 100% above the poverty level •number of children abused or neglected per 1,000 persons under 18
Clean Environment	Air Quality	•Oregonians living where the air meets government air quality standards
	Natural Resource Lands	•1970 agricultural land still preserved for agricultural use •1970 forest land still preserved for forest use •1990 wetlands still preserved for wetlands
	Groundwater	•quality of Oregon groundwater
Livable Communities	Affordable and Available Housing	•Oregon households that can afford the median-priced Oregon home for sale
	Transportation	•Oregonians who commute (one-way) within 30 minutes where they live and where they work •Oregonians living in communities with daily scheduled inter-city passenger bus, van, or rail services

	Sense of Community	•index crimes per 1,000 Oregonians •Oregonians who volunteer at least 50 hours of their time per year to civic, community, or non-profit activities •eligible Oregonians who vote •Oregonians with positive view of the state
Personal Income, Economic Diversity and International Trade	Personal Income	•Oregon's real per capita income as a percentage of the U.S. real per capita income •level of real per capita income •income per capita as a percentage of the Oregon overall per capita income •Oregonians in the middle income range •average annual payroll per covered worker (all industries, 1990 dollars)
	Economic Diversity	•manufacturing employees outside of state's five largest manufacturing industries •percentage of Oregonians employed outside the Portland tri-county area
	Manufacturing Exports	•manufactured goods sold outside of the U.S.

SUSTAINABLE SEATTLE INDICATOR SETS (Sustainable Seattle 1993):

Classification of Indicators	Indicators
Environment	•wild salmon runs through local streams •biodiversity in the region •number of good air quality days per year, as reported by the pollution standards index •amount of topsoil lost in King County •acres of wetlands remaining in King County •percentage of Seattle streets meeting "Pedestrian-Friendly" criteria
Population and Resources	•total population of King County (with annual growth rate) •gallons of water consumed per capita •tons of solid waste generated and recycled per capita per year •vehicle miles travelled per capita and gasoline consumption per capita •renewable and non-renewable energy consumed per capita •acres of land per capita for a range of land uses (residential, commercial, open space, transportation, wilderness) •amount of food grown in Washington, food exports and food imports •emergency room use for non-emergency purposes
Economy	•percentage of employment concentrated in the top ten employers •hours of paid employment at the average wage required to support basic needs •real unemployment, including discouraged workers, with differentiation by ethnicity and gender •average savings rate per household •reliance on renewable and local resources in the economy •percentage of children living in poverty •housing affordability gap •health care expenditures per capita
Culture and	•percentage of infants born with low birthweight

Society

- ethnic diversity of teaching staff in elementary and secondary schools
- number of hours per week devoted to instruction in the arts for elementary and secondary schools
- percent of parent/guardian population involved in some form of community service
- juvenile crime rate
- percent of youth participating in some form of community service
- percent of enroled 9th graders who graduate from high school
- percent of population voting in odd-year (local) primary elections
- adult literacy rate
- average number of neighbours the average citizen reports knowing by name
- equitable treatment in the justice system
- ratio of money spent on drug and alcohol prevention and treatment to money spent on incarceration for drug and alcohol related crimes
- percentage of population that gardens
- usage rates for libraries and community centres
- public participation in the arts
- percent of adult population donating time to community service
- individual sense of well-being

LIFE IN JACKSONVILLE INDICATORS (Life in Jacksonville 1993):

Classification of Indicators — **Indicators**

Education

- public high school graduation rate
- average achievement-test percentile scores
- public school expenditure per student
- average public school teacher salary
- teachers holding advanced degrees
- students attending desegregated schools
- faculty holding terminal degrees
- higher education degrees awarded
- student participation in higher education programs

The Economy

- net job growth
- total/black unemployment gap
- effective buying income per capita
- retail sales per capita
- taxable real estate value
- new housing starts
- affordability of single family house
- students in free/reduced lunch program
- tourism/bed tax revenues
- cost of 1,000 kwh of electricity

Public Safety

- people feeling safe walking alone at night
- violent index crimes per 100,000 population
- non-violent index crimes per 100,000 population
- people reporting being victims of crime
- average rescue call response time
- average fire call response time
- average priority one police call response time
- motor vehicle accident deaths per 100,000 population
- other accidental deaths per 100,000 population

- motor vehicle accidents per 100,000 population

Natural Environment

- days with air quality index in good range
- river compliance with metal standards
- stream compliance with dissolved oxygen standards
- water level in Floridan-aquifer wells
- new septic-tank permits issued
- sign permits issued
- tons per capita of solid waste

Health

- infant deaths per 1,000 live births
- age adjusted death rate per 100,000 population
- deaths from heart disease per 100,000 population
- deaths from lung cancer per 100,000 population
- packs of cigarettes sold per capita
- new AIDs cases per 100,000 population
- student fitness test scores, 50^{th} percentile
- alcohol use reported by youth
- people rating heath-care system good/excellent
- people reporting having no health insurance

Social Environment

- people believing racism is a local problem
- substance-exposed new-borns per 1,000 live births
- substantiated child abuse/neglect reports per 1,000 children under 18
- births to females under 18 per 1,000 live births
- employment-discrimination complaints fielded by JEOC
- people reporting having volunteered in the past year
- city human-services expenditures per capita
- contributions per capita to United Way and agencies

Government/ Politics

- people who rate local government leadership good/excellent
- percent 18 and older registered to vote
- percent registered to vote
- percent of city council members non-white
- percent of city council members female
- people accurately naming two city council members
- people keeping up with local government news frequently
- people feeling local government services are frequently effective

Culture/ Recreation

- city financial support per capita of arts organizations
- city parks and recreation expenditures per capita
- public park acreage per 1,000 population
- public library materials per capita
- public library book circulation per capita
- event/days of bookings at major city facilities
- museum of science & history attendance per 1,000 population
- symphony attendance per 1,000 population
- zoo attendance per 1,000 population

Mobility

- people reporting commuting time 25 minutes or less
- weekday commercial flights in and out of JIA
- destinations with direct flights in and out of JIA
- average weekday JTA bus ridership per 1,000 population
- average weekday miles of JTA bus service
- JTA bus headways within 30 minutes/60 minutes non-peak

APPENDIX 5

TWO VILLAGE PERSPECTIVES ON "SIGNS AND/OR SIGNALS" OF A GOOD OR BAD FUTURE: CHACHOGA AND GOSHAL

THE OPEN ENDED QUESTION:

"What "signs and/or signals" should be watched to predict a good or bad future for you, your children, and your grand children? In general? Specifically in the natural environment around you?"

However, the first several interviews posed the question as:

"What good and bad changes have occurred and are occurring in this area?" (posed this way, there was a broader range of responses, especially those pertaining to economic matters)

THE RESPONSES, and number of people giving each response:

CHACHOGA:

Forest:	
Cover extent	11111111111
Emphasis on diversity of trees (all species)	11111
Emphasis on *thick* forest (tree stem density)	11
Emphasis on preferred species availability	1
Availability of fuel wood	1
Linkages to forest:	
Avalanche protection	1111111
Pure/clean water	111111
Beauty	11111
Erosion control	11
Consistent rain	11
Existence of glaciers	1
Deforested pasture is bad (Grazing not seen as the problem)	11
Forest management:	
Reforestation (plantations - 2 emphasized Deodar)	111111111
Enforcement of cutting rules (particularly effective when carried out by the women's group - the Mahila Mandal	11111
Rule enforcement & protection (from illegal felling and *wood throwing*)	11111
Existence of Timber Distribution (*TD*) rules	1
Local control (local rule making or local enforcement)	1
Existence of the Mahila Mandal	1
Orchard area (implied market access)	1111

Cash crop area (implied market access)	11111
Grazing and Haying area for sheep (for shawls, for use and sale)	11111
Tourism (implies market access)	11
Western culturalization (threatens cultural health)	1
Literacy	11
Women's rights	11
Conservation interest in the forest by young men	11
Availability of *improved agriculture*	11
Clean water (as local shortages occur)	11
Threat of population pressure	11111

GOSHAL:

Forest:	
Cover extent	1111111111
Forest edge change	1
("Little edge change in 15 years")	1
("Forest edge pushed back by Nautor, land redistribution, in grandma's life")	1
Emphasis on "darkness" of forest (tree stem density) means more fuelwood, fodder, and bedding	1111
("Forest density has decreased a lot above Maju Khut, a flat grassy area above and west of town")	1111
("Forest density has decreased a lot in grandma's life south of town")	11
Fuelwood species availability change (from Alder to evergreen)	111111
("Fuel wood availability was 3-4 bundles/day, now 1")	
Availability and proximity of forest and its products	1111
Emphasis on diversity of trees (all species)	111
Species change (especially preferred tree species)	1
Introduction of new species	1
Linkages to forest:	
Consistent rain	1111111
Erosion control	111
Avalanche protection	11
Landslide protection	11
Stable hydrology (& flood control)	11
Consistent climate	11
Beauty	1
Existence of glaciers (important for tourism)	1
Shade availability	1
Existence of pollinators (Bees)	1
Forest management:	
Reforestation (Planting of forests - one emphasized Deodar)	1111
Government control of resources, as local control seen as problematic	11
Enforcement of cutting rules (particularly effective when carried	

out by the women's group - the Mahila Mandal	1
Local usage of forest products, not exported	1
Orchard area	11111111
Grazing & Haying:	
Availability of nearby grazing area ("going down")	1
Availability of open thinner forest for grazing	1
Availability of manure ("lower today, thus nitrogen fertilizer is required")	1
Amount of good haying grass ("amount of the available good grass has increased")	1
Proximity and availability of haying grass ("has become harder to get: was 3-4 bundles/day, now 1")	1
Market access (Roads in particular)	1111
Allows tourism	1
Allows orchards	1
Allows other cash crops	1
But also leads to:	
Traffic congestion	111
Crime	11
Negative impact of tourism on cultural health	1
External control and ownership of large businesses (seen as a negative)	1
Education of women	1
Education	1
Milk production per cow ("change from 0.5 to 10 litres per cow")	11
Mechanization	1
Subsidization of wheat and corn seed and various sprays for apple growing ("fertilizer subsidization recently stopped")	1
Unplanned construction	1
Water pollution	11
Air pollution	11
Threat of population pressure	111
("linked to less income")	1

APPENDIX 6

PERSPECTIVES ON "SIGNS AND SIGNALS" PREDICTIVE OF A GOOD OR BAD FUTURE ACCORDING TO LOCAL NATURAL RESOURCES PROFESSIONALS

Forest:	
Cover	111
Gas availability	1
Fuelwood depot	1
Linkages to forest:	
Local temperature/climate	1111
("linked to population $\uparrow$ and deforestation, prime apple belt moving up valley, Katrain not as good for apples now")	
("as result of deforestation, more fans in Kullu, Deodar success dropping in Kullu, range going higher")	
("result of population growth")	
("result of deforestation, population, & pollution")	
Water quality	1
Forest management:	
Strong women's enforcement	11
Enforcement	11
("hotels and mafia")	
Overall management system	1
Paying full value for tree	1
Inventory problems (if low access)	1
Agroforestry area	1
Vegetable cash crop area	1
(recommends: "summer squash, cabbage, summer cauliflower, potato, baby corn, and onion")	
Herding area	1
Manure availability	1
("need more dairy and poultry for manure")	
Market access for winter shawl weaving	1
Business co-operatives in villages	1
Availability of loans, credit	1
Tourism - unplanned	1
Recycling packing crates	1
Insecticide use	1
("Affects bees and birds")	1
Village "awareness"	1
Exodus of young men and women	1
Pollution	1
Population	1111

APPENDIX 7

POST HOC DESCRIPTIONS OF INDICATOR FINDINGS - AN ADDENDUM BY A LOCAL NGO

THE FOLLOWING IS A DESCRIPTION OF WHAT THE VILLAGE IDENTIFIED INDICATORS SHOW, ACCORDING TO S.S. MADAN (1995, pers.comm):

Forest area cover indicators:
- Excessive lopping damage to deodar and pine to obtain bedding
- Large clear felling of Golaba slopes 6 km north of Goshal in 1960's with very poor restocking
- Unnecessary clearing of forests by the Border Roads organization

Forest management indicators:
- Lack of forestry department control seen in excessive illegal green felling by slowly killing the trees by girdling, or excessive resin extraction, to feed explosive growth in the number of hotels
- Use of higher altitude spruce and fir for apple crates apparently continues, cardboard and eucalyptus account for only 20-30 percent of crates (1 tonne of apples requires half a tonne of wood
- Presently there is absolutely no local control of forests

Recommendations:
- Recommends letting villagers keep 50-75% of harvest from undemarcated protected forests (UPF areas), and 25-40% from demarcated protected forests (DPF areas)
- Recommends handing control of forests close to villages to village panchayats (councils)
- Recommends setting up a depots of imported Indian Teak and conifer wood at prices marginally higher than that for illegal timber

Orchard and crop area indicators:
- Severe loss of biodiversity, seen in loss of birds, bees, and insects as a result of pesticide use in orchards
- Food self-reliance is in decline as millets, amaranthus and other hill crops are replaced by hybrid wheat, corn, and poor yield pulses
- Increasing orchard area benefits only major landholders, thus leading to inequity

Grazing and haying area indicators:
- Shortage of fodder available for animals
- No more rotation grazing leading to pasture depletion

Market and access indicators:
- Poor planning of roads, and inadequate consideration for slope stability
- 75% of youth is unemployed or underemployed
- 80% of tourist driven benefits go to non-locals
- over 70% of school teachers, bank employees, and electricity board employees are non-local
- majority of large and medium hotels are non-locally owned

Education and rights indicators:
- 40% of women remain illiterate