PART 4

Mountain Farmers' Strategies and Sustainability Implications

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FARMERS' INNOVATIONS AND AGRICULTURAL TECHNOLOGIES

A.K. Gupta

Anil K. Gupta is a professor at the Centre for Management in Agriculture, the Indian Institute of Management, Ahmedabad, India

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INTRODUCTION

Mountain regions are characterized by low population densities, weak market infrastructures, high levels of emigration (particularly of males), the predominance of female-headed or female-managed households, money order economies,[1] poor linkages between the formal and informal sectors, and low levels of social and political articulation.

The value of traditional skills has gone down over time to such an extent that in many parts of the world these regions are seen as a reservoir of 'unskilled labour'. It is not without significance that the majority of emigrating labour occupies a low status employment 'niche' in urban or rural labour markets. Such a low rating of their skills by society leads to a decline in the pride of mountain peoples in their indigenous methods of resource management. Often, their low self-esteem is reinforced by public policies which fail to even recognize (much less to appreciate) the strength of indigenous institutions and traditional technological innovations. Jodha (Chapter 2) and Sanwal (1989) have rightly argued that despite a great deal of talk about integrated mountain development, the approaches are often segmented, sectoralised, and, in some cases, even dehumanizing. Official documents on the development of backward areas in India have, in fact, cautioned against an attempt to stem the migration of people from such regions elsewhere lest the supply of 'cheap' labour for infrastructural development projects be cut off!

It is in this context that we have to look at the strength of innovations developed by mountain people all over the world. Given the high ecological heterogeneity, it is not conceivable that technological transformation through diffusion of standardized technologies can take place. Organizational rewards for developing technologies that can diffuse only in small, localized 'niche' have been seen to be generally poor (Gupta 1985). Thus, eliminating the mismatch between design of R&D organizations and the expectations of the people is the central issue for recasting development strategies for sustainable mountain agriculture. We recognize that not all technological alternatives can be either anticipated or demanded by the farmers.[2] Therefore, we do not believe that future options will increase without simultaneously increasing the responsibility of the supply system to widen the decision-making horizon of the farmers. At the same time, we do recognize that the study of farmers' innovations, both technological and institutional, can broaden the vision of the scientists themselves (Gupta 1987b, 1987c).

This paper presents an analytical framework to look at the eco-institutional aspects of the choice of technology, and then briefly reviews some of the innovative technologies and institutions developed by the farmers and the issues involved in their search and scrutiny.

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[1] The implications of this for the nature of cash flows and attendant patterns of demand have to be carefully worked out. If surplus exists in even a few hands, without suitable opportunities for investment, it can establish wrong role models. The increasing influence of liquor consumption in many of the hill areas receiving inward remittances is a case in point.

[2] I strongly disagree with those who argue that farmers can always demand what they need. It has to be appreciated that our capacity to demand what we need depends upon our prior experience with the supply side, exposure to various alternatives, the skill to convert a need into a demandable output, and an understanding of the language in which the supply side understands our need as being distinct from a demand.

An Eco-institutional Framework for Analysing Choice of Technology

Human choices in a given eco-sociological configuration are circumscribed by the historical evolution of institutional structures. Institutions provide a framework of rules, sanctions, and meanings that is commonly understood by people grouped within a common boundary. In a way, institutional behaviour relies more and more upon internal commands rather than upon external demands. However, a combination of both moral and material sanctions provides legitimacy to an institution. In the present context, we are drawing upon another feature of institutions which, in the context of farming systems research in mountain regions, is extremely vital; that is the assurance provided by the institutions—formal and informal—to individuals and groups about various uncertainties faced over time and space.

We deal with mainly two types of assurances—horizontal and vertical. The former type includes the assurances that provide guarantees about others' behaviour vis-a-vis one's own. Thus, if I sow my crop early will others also? Or if I do not graze my animals on common land will others also not do so? Vertical assurances refer to the future returns from present investments. If I plant trees on common or private land will I be allowed to harvest them? Or if I apply organic fertilizer to a particular plot of land taken on lease will I be allowed access to it next year also (in view of the slower release of nutrients from the organic fertilizer)?

Assurances by themselves, however, are not sufficient. If I have assurances of better prices or better returns for certain kinds of collective behaviour but I do not have *access* to the given resource, or I do not have the skill or ability to convert a resource into an investment, or both, then assurances are of little use.

Assurances help in generating cooperative behaviour when we deal with common properties (Sen 1967, Runge 1986, Gupta 1985). In the case of private resources, assurances may stimulate demand for better access or technical skills or both. Likewise, if we have an institution in which people have access to resources and also have assurances, but do not have the skills or abilities, the investments will not follow.

All the three vectors of choice, that is, *access*, *assurances*, and *abilities*, must be synchronized to generate appropriate attitudes for change or maintenance of a resource use system. Thus, within a specific spatial, sectoral, and seasonal configuration, portfolios may vary within a given range because of changes in access, assurances, and abilities.

As we note in Fig. 16.1, the access to natural resources, to assurances from the institutions, to ability in terms of technology, and to attitudes in terms of culture, collectively influence the household portfolios. This framework also helps in designing interventions. Thus, if we want to introduce technologies that presuppose the existence of certain skills, access modes, or institutional structure, but some or all of these vectors are missing, we should not fault people for not using the given opportunity. It may be useful, therefore, to recognize that this framework can be used as a tool or as a filter to assess available information and generate further choices. If we know the given complexity of access and the abilities of the people in a given system, we should be able to anticipate what kind of assurances will generate or respond to the given attitudes. Attitudes here are both an outcome of historical experiences and inputs into future choices. The culture, I must add, does become modified over a period of time.

Ecology Traditional Modern

Space Season Sector Formal Informal Technology Culture

Public Private Communal

Access

Assurance

Ability

Attitude

Figure 16.1: Eco-institutional framework for analysing choice of technology
Source: Author's compilation

The same framework can be used to analyse the supply side that constitutes the response of scientists to various types of problems or social situations. For instance, if scientists do not have (1) assurance of peer approval (collective choice or horizontal assurances) or (2) career rewards (vertical assurances), but have (3) access to the facilities for on-farm research and also have (4) skills for performing experiments, we should not be surprised if they develop attitudes that are conservative or non-enterprising. In the same manner, changes in different parameters may help us to identify the corresponding changes required in other parameters.

The ecological dimension can be further looked at in terms of space, season, and sectoral interactions. Institutions could be traditional or modern, formal or informal, public, or communal. The technology could be based on local inputs or external inputs and culture may reinforce compliance (because of a feudal past), or trigger innovations, or both. For the sustainable development of mountain regions, we have to appraise every intervention through the matrices given in Figs. 16.1 and 16.2. We can, as a consequence, anticipate the likely changes that will come about in various subsystems if interventions are made to modify access, assurance, ability, or attitudes. An important point of departure in this framework is that sustainability is being defined primarily in its institutional context.

The socio-ecological paradigm (Gupta 1984, 1985, 1989, 1990a) provides the basis for understanding the choice of technology through the interaction of ecological, technological, and institutional variables. The eco-institutional framework provides additional linkages to the cultural core of the mountain society or other high-risk environments and the attitudinal basis for their current behaviour. It is accepted that inappropriate policies in the recent past have changed attitudes significantly in several parts of the world.

The 4-S Model

Several studies on farmers' adjustments to risk have shown a multi-market, multi-enterprise, and multi-institutional approach to survival (Jodha 1975, 1978, Jodha and Mascarenhas 1985, Gupta 1981, 1984, 1988, 1990a, Ostrom et al. 1989). The multi-market approach refers to the farmers' attempts to adjust to risks through simultaneous operations in different factor and product markets. The factor markets include land, labour, capital, and even information. The product markets include crops, livestock, and trees as well as various technologies of land and water use. The higher the risk in the environment, the greater the dependence between the decisions made in one resource market and those made in others. These links are important in well-developed regions also but, in these regions, many imperfections in respective markets can be offset through market mechanisms themselves over time and space. In high-risk environments, the cost at which these errors may be corrected will be far higher, and thus there is greater dependence on inter-market adjustments.

The multi-enterprise approach implies that farmers' adjustments to risks or the evolution of portfolios cannot be understood by concentrating on any one enterprise such as crops, livestock, labour, or trees. The 4-S model helps in understanding these linkages at the macro-level.

The multi-institutional perspective is helpful because various resources or enterprises, as mentioned earlier, may be governed by various kinds of property right regimes, in combination or separately. Livestock, for instance, may be managed by some households through biomass derived from private lands only. In other cases, it may be derived from private as well as common and/or open access lands. Thus, various institutional arrangements, whether or not regulated by the State, market, or both, further influence the choices at micro-level. Any framework that ignores the multi-market, multi-enterprise, and multi-institutional dimensions of household portfolios will generate only a partial understanding of the survival logic of the people. The innovative technologies or institutional arrangements are a part of dealing with these complexities. Innovations for survival sometimes may follow rules that are different from innovations for accumulation.

To use the 4-S model we use a three-dimensional matrix as shown in Fig. 16.2. Each dimension can be dichotomized for the purpose of creating ideal types. The basic principle of logic that we use here is 'compare and contrast'. If we want to understand a phenomenon it is useful to begin by comparing and contrasting the extreme values of its distribution. For instance, 'space' can be dichotomized in terms of high or low land, undulated or plain topography, higher slope or lower slope in the mountain regions. Likewise, 'sector' can be dichotomized as agriculture or industry, public or private, specialized or diversified, and single crop or diversified crop combinations, cash crop or food crop dominated. 'Season' can also be divided into uni- or bi-modal rainfall regimes, arid or humid, low or high rainfall, low or high diurnal temperature variations, or low or high seasonal fluctuations. (This is essentially the dimension or time with which the uncertainty is associated.)

Given any two parameters we can speculate about the third. For instance, in a region with low population density and high seasonality (low rainfall and high diurnal temperature variations in the arid plains and low diurnal temperature variations at high altitudes) the sectoral characteristics may be highly diversified. Instead of a single crop, farmers may prefer mixed or intercropping in several plots, if not all. Households may simultaneously pursue many activities such as crops, crafts, and livestock rather than being dependent on any one of these. The social exchange relations in such regions will be quite different from those in the regions with high population density, low seasonality, and specialized sectoral activities or diversification for accumulation rather than survival.

Some of the characteristic ways of social exchange relations may include the following: the predominance of kinship and external family networks over the nuclear family system to hedge risks; the preponderance of non-monetary exchanges and the informal mechanisms of pooling bullocks, implements, and inputs;[3] dominance of generalized reciprocities over specific ones;[4] and choice of a much longer time frame to settle accounts.[5]

The communication systems in these regions are more metaphorical or *analogical* than digital. The strategies of technology transfer in on-farm research and extension systems would obviously have to be tailored to the typologies that can emanate from the simple matrix given above. One can make it more complex and generate richer insights but parsimony always has a price. I must acknowledge that the nature of institutions and market interventions can modify the initial conditions that may be predicted by the configuration of spatial, sectoral, and social variables. It might appear that some of the social relations are defined by the ecological variables in a deterministic manner. We have seen that the relationship between pastoral and cultivating communities in the Swiss Alps (Netting 1972), Northern Pakistan (Buzdar 1988), Bhutan, and some other Himalayan mountain regions (Gupta and Ura 1990) have striking similarities, although specific parameters may vary due to cultural and religious differences. Over time, however, formal

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[3] Anthropologists have provided rich insights into the pooling mechanisms in various societies living in hill areas, arid regions, or forests. The pooling of bullocks in Maharashtra, for instance, is called 'irjik'. As many as 10 to 12 pairs of bullocks can be seen ploughing the land in a particular catchment area across the fields on a specific gradient. Since the moisture recedes faster near the ridge line, the plots along the contour towards the ridge have to be ploughed first. It is possible that some people may contribute one bullock pair though they may have only half an acre or even no land in that areas, while others may have a much larger tract of land in this area and yet contribute the same pair of bullocks. The obligations for feeding the cattle and the ploughman are also worked out in many diverse ways. What is important to understand is that uncertainties over time and space may generate reciprocities that may be settled over a longer period of time and thus generate rationality of choice in the short term.

[4] The generalized reciprocities refer to exchange of labour for thatching huts with labour contributed for ploughing the land. It is very difficult to work out the equivalence between such related activities. How critical thatching is before the rains, only a poor family living in such a hut can realize. Likewise, the criticality of draft power in receding moisture conditions in light soil regions can be understood by someone who may miss the entire season in the event of failure to sow the crop at the right time. Traditional economic theories are of limited help because equivalence is not just the value of labour as assessed in the market place. Sometimes help provided in such a context may generate an IOU that can be redeemed much later. The specific reciprocities on the other hand refer to exchange of the same goods or services. I have paid for your tea today, you should pay for me tomorrow or I have given you five kilogramme of wheat seeds and you return the same amount of the same crop later. Commercialized societies often would have a dominance of specific reciprocities. Decision-making with constrained resources cannot be analysed without looking at these reciprocities.

[5] Studies have shown that IOUs are settled in the regions described here over far longer time periods extending sometimes to several generations. A good or bad turn may invoke a return gesture not necessarily on the same day or in the same month or even the same year. Even the nature of factional leadership remains divided at village level for longer periods than at the State or national level where loyalties can shift quickly without generating problems of legitimacy or social acceptance.

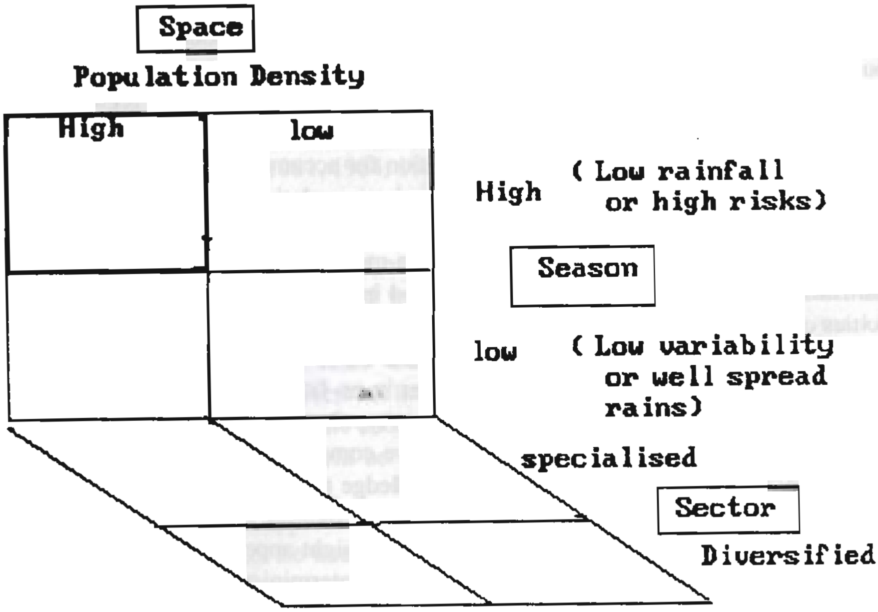

Figure 16.2: Three-dimensional matrix

institutional inroads and market developments do modify these strategies. The availability of walkie talkies means that Swiss pastoralists do not have to develop specific whistling styles as observed in the Andean mountains or in the Himalayan Mountain regions. However, the need for surviving collectively is felt in almost all such socio-ecological conditions.

Socio-ecological Framework

I make two assumptions: (1) ecological conditions define the range of economic choices that can be sustained in a given region and (2) the scale on which different enterprises are selected, however, is a function of the access to factor and product markets; kinship networks, public, private, and common institutions; and historical resource reserves. Instead of calling the framework socio-ecological, as I have so far, I shall now call it eco-sociological because of the dominance of the ecological dimensions of the socio-economic processes.

Earlier it was assumed that in any given ecological 'niche' only certain economic enterprises were feasible at the given level of technological and institutional infrastructure. However, I modify this condition to suggest that the ecological endowments of the proximal environment of a particular social community need not be the major determinant of portfolio. Distant environments where the community has customary or traditional rights through migration, or other mechanisms, have also to be taken into account.

Thus, once a mix of enterprises or a portfolio is selected, drawing upon resources from private, public, and common properties, the nature of risk inherent in this portfolio can be analysed through a matrix of mean or average return and variance in returns. The high mean, low variance portfolios would obviously have different implications for individual and collective behaviour than portfolios with low mean and high variance.

Given an initial portfolio and its mean variance or risk return characteristics, households may respond to a given risk in the environment and any of the following alternative means: household-level risk adjustments; public and market risk-reducing mechanisms; and communal and common property risk adjustments.

Household risk adjustments can be further analysed at intra-household levels and inter-household levels. The intra-household risk adjustments include measures that the household employs by negotiations within the household. For instance, asset disposal, migration, and reduction or modification of family consumption. The inter-household risk adjustment strategies include tenancy, borrowing, labour contracts, and group ploughing.

Public risk-adjustment mechanisms imply the availability of drought and flood relief insurance mechanisms, public employment programmes, etc. The market-based risk adjustment option includes forward trading, the interlocking of factor and product markets, insurance cover, and so on.

Communal risk-adjustment strategies refer to the group-based measures that require collective decision-making either to use or to preserve private or common property resources. The pooling of resources, such as bullocks or implements, is also a part of communal risk-adjustment strategies.

Once the range of risk-adjustment options is known the households may modify either their perceptions or their response or both by changing the discount rate or time frame used for appraising returns from each investment. Thus, while discount rates capture the control the household has in a given resource market, the time frame may capture the certainty with which the household views a particular resource stream. In fact, either of the two can be used to derive risk preference. The shorter the time factor in which households (or scientists) appraise their choices, the less likely it is for technology to be sustainable. Development, I have argued, is nothing but widening the decision-making horizon and extending the time frame of disadvantaged households (Gupta 1981). It is obvious that not everybody's choices can be widened at the same time and in the same proportion given the limitations of resources in a developing society. It is at this stage that an eco-sociological framework has to become an eco-political framework. Constraining the choices of some while widening those of others is an institutional issue which is discussed elsewhere (Gupta 1990b).

The uncertainty of an outcome may vary differently for different households depending upon previous experience with a particular enterprise or crop; immediate past experience; successive losses or gains; accumulated defects or surpluses in the household cashflow; future expectations of returns; and complementarity between other assets or enterprises and the proposed investment.

The cashflows of the households resulting from a given portfolio, modified by various risk-adjustment options, may be in surplus, deficit, or subsistence. In addition, the variability in these cashflows may be evened out over space, season, sector, and social networks. The stakes of different social groups in the management of ecological systems will vary in each resource market.

The trick is to develop a calculus in which unequal stakes of different groups in various resource systems or regimes generate a set of expectations that are equitable or appear equitable (given differences in cultural and social ways of perceiving returns) at the portfolio level of the households. The group-level estimation of the aggregated effects of individual portfolios may generate rules that modify the conditions for use of resources, technology, and institutions. Under extraordinary circumstances, the cultural norms are also modified to accommodate ecological and sociological imperatives.[6]

The household budget influences the choices differently than would be the case if the budget was even, that is, sufficient for subsistence, or if it was in surplus, that is, more than subsistence. A number of researchers have mistakenly grouped deficit budget groups with surplus ones. A sustained deficit may shift the portfolio in favour of low mean, low risk assets and in some cases low mean, high risk assets, provided the risk is not co-variant. In some cases, low mean, high risk assets can be accommodated in the portfolio also, because much of the cost is transferred on to the open access or common property resources. Sheep herding is one such example. Stall-feeding is rarely practized and sheep herds are characteristically maintained by some of the poorest households.

At aggregate level, shifts in the portfolio can be seen by differential growth rates of various species and varieties of crops, trees, and livestock. Public policy at the macro- and micro-level influences the portfolios through changes in the access modes, assurances (through various risk-adjustment strategies), and abilities. The attitudes are also modified by the expectation of future changes in the various sources of subsistence in future.

Changes in the individual stakes in various resource systems feed back into ecological conditions. Once the ecological conditions are modified, the changes in the enterprise mix become inevitable. It may be necessary to note here that I am not underplaying the importance of changes in the institutional conditions or the technological choices as already mentioned earlier. However, a multi-stage or a multi-plane analysis requires that we do not mix the assumptions necessary for analysis on one plane with the assumptions relevant on another plane. These frameworks can be used to understand the context in which people survive at altitude.

The innovations in hill areas were necessary because the complexity of the environment would not permit any one set of strategies to sustain livelihood indefinitely into the future. Since technology cannot be understood without looking at its ecological, cultural, and institutional context, we will try to isolate the patterns in the innovations that hill people have tried to develop. It is obvious that the systematic taxonomy of innovative strategies in different parts of the world will require a much wiser collaborative effort. This paper only illustrates the legitimacy and the feasibility of such an intellectual adventure. Various dimensions identified by Jodha (Chapter 2), as a part of the mountain perspective, provide a very rich basis to begin the synthesis of the analytical framework, which should be responsive to the strengths of people's own technologies, institutions,

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6 Aggarwal (personal communication) provides an interesting example of a village in which the punishment for poaching on a common property was to offer grains to the birds while standing barefoot under the sun. Such logic cannot be analysed in the classical tradition of institutional analysis. Such sanctions cannot be justified on economic grounds at all. The reciprocities here extend to claimants of resources that do not have a vote, that is, the birds. But in the process, suffering in public by standing barefoot in the sun generates a collective responsibility. It is recognized that the moral appeal may have a longer-lasting effect than an economic tax or fine. The public display of the punishment may also generate guilt.

The cultural norms for individual and group behaviour thus do modify the perception and response to the risks and resources. While the fuelwood crisis may generate a tendency to poach, the sanctions generated by institutions may safeguard, to some extent, the scarce and depletable common property resource. In Southern Bhutan we came across a case in which a group of villagers had restricted the introduction of a male bull of exotic breed lest the local breed become adversely affected (Gupta and Ura 1990). Even today, many villages in South Asia follow a similar practice.

and culture. Such a framework will have to explicitly reject the possibility of any person in a high risk environment being thought of as totally 'unskilled'.

FARMERS' INNOVATIONS: SEARCH AND SCRUTINY

Several researchers have identified the barriers to scientific perception (Chambers 1983, Chambers et al. 1989) and. curiosity (Gupta 1985, 1987a, 1987b, 1988a, 1988b, and Richards 1989). The assumption that the low level of literacy is responsible for the backwardness of such regions is criticized by Richards (1989). He argues that such an approach discounts heavily the *oral* and *practical* skills that have been developed over hundreds of years. The success of technological change in high-growth regions should not blind us to the richness of the ethnic basis of local knowledge systems. Studies have shown that the more diverse the environment and the lower the population density, the greater the need for social networking. Box (1988) argues that knowledge networks provide a platform for farmers to satisfy their curiosity about the different innovations being tried by different people, not always successfully. It is important to note that communications among people about innovations very often are not purposive. Often, the search for innovations is a set of continuous events rather than discrete events, accidents, or milestones.

The process of innovation involves constant experimentation, improvisation, adaptation, and simultaneous rejection of certain results either partly or completely depending upon individual or collective feedback. Many times, while searching for innovations, people have drawn negative inferences about the innovative potential of peasants. They were either looking for the wrong things, or looking through inappropriate prisms, or asking the wrong questions in the wrong places.

The interest in indigenous innovations in the Indian subcontinent and China has been there for several centuries, although the intensity of the interests has varied (ICAR 1964). Munshi (1952), in his lecture 'The Gospel of Dirty Hand' to agricultural scientists, highlighted the relationship between soil and soul. He emphasized the need for close cooperation between farmers and scientists. More recently, Verma and Singh (1969) and Verma (1967) provided a rich account of the indigenous innovations that animal husbandry farmers had developed in the hill areas of Himachal Pradesh as well as the then Punjab. Verma (1967), Dharampal (1983), and several others have done considerable work in India on local innovations. It is a pity that scholars in the third world have often ignored the paths opened by local studies and have tried to follow a trail only when it emerged from the West. Even so, nothing much would be lost if that were to happen in a proper manner. The damage is really done when, in place of culturally rooted concepts and terms, we try to analyse or catalogue the innovative genius of local peasants in alien concepts or categories. Such an approach often results in the indigenous knowledge of the people becoming inaccessible to us.

The lack of interest among scientists (biological or social) concerning innovations could be a function of the evaluative criteria. The scales by which they evaluate local innovations may be calibrated by the cultural biases inherent in western philosophy. Tillman (1988), Warren (1986), and Dharampal (1983) highlighted the scientific and technological strengths in the Indian subcontinent which were acknowledged to be superior to some of the western technologies available in the 18th century. Part of the reason for the decline of some of the traditional, more sustainable technologies could be that innovations of a collective nature (Osti 1988), concerned with survival through collective action or sharing (Gupta 1988), were generally less well integrated into the formal networks of institutions. We know much less about what worked and much more about what did not.

Prain (Rhoades and Bebbington 1988) described the case of a farmer in Chicche village in Montoro Valley who developed the hypothesis that varieties expressing apical dominance would yield fewer but larger potato tubers. The market price for such tubers was also higher. There are several other examples which Rhoades gives about the curiosity experiments pursued by farmers, sometimes alone but sometimes collectively. He also illustrates the problem-solving and adaptation experiments pursued by farmers. The former included an attempt by farmers to drive away the Andean weevil by sunning the potatoes (as noted by Prain). The fact that aphids were attracted to green sprouts and not to red sprouts was another observation. The diffused light method of storing potatoes is too well known to warrant a repetition as an illustration of adaptive experiments.

An important conceptual contribution made by Rhoades and Bebbington (1988) is that wherever a transition between two major vegetative communities or biomes exists, the probability of experimentation by farmers is much greater. This has an operational implication for studies on innovation. (Fig. 16.3) Innovations could possibly come about through 'comparing and contrasting' the opposites, i.e., farmers with extremely divergent practices (possibly using ecological maps).

What Rhoades suggests can be linked to the 'compare and contrast' idea. It would thus be useful to pursue such explorations from the transitional boundaries towards the centre of the niche. This has a sociological implication also. The social communities that inhabit the transitional zones are also often new settlers or people from outside. Therefore, experimentation is a necessity for survival. Scientists desirous of looking for innovative practices may be disappointed if they try to concentrate only on the clustered settlements or densely cultivated 'niche'. Verma (1967) described several practices with regard to navel cutting, disposal of the placenta, and therapeutic measures against ingestion of the placenta.

Recognizing that even the availability of human health services is scarce in various developing countries, the possibility of providing animal husbandry services in mountain regions would definitely be an even more distant goal. In a way there may be a virtue in this vice. Indigenous innovations that evolved to manage pasturelands over large stretches are equally fascinating. Our accompanying paper (Chapter 23) provides an example about the way yak and cattle herds coordinate their movements so that the two herds do not meet (because some disease may be transferred from the cattle to the yak). The paper also discusses imaginative institutional rules that nomadic peoples or communities have evolved in consultation with settled communities to manage the access to pastures and the exchange of livestock goods. Equally rich illustrations are available regarding cropping systems, forestry systems, and the interactions among crops, livestock, trees, and tools.

Disadvantaged households should never be called resource-poor, as long as we believe that knowledge is a resource. Formal institutions may not price this knowledge properly or build upon it adequately.

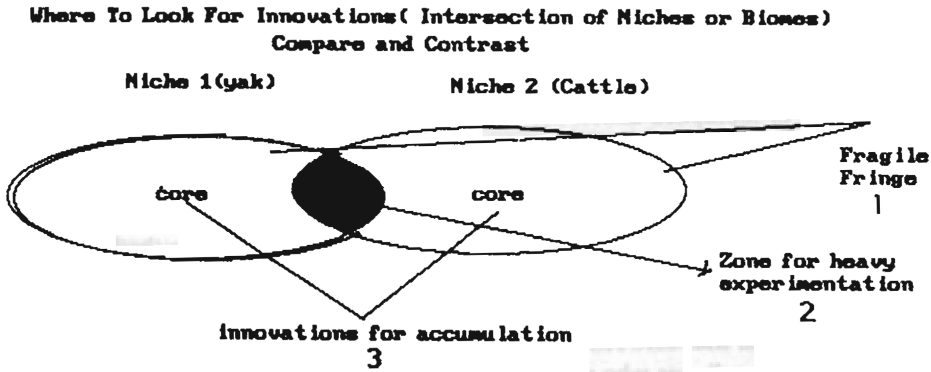

Figure 16.3: Where does one look for innovations?

Interaction between Scientists and Innovating Farmers

Recently we analysed the linkages between demand and supply through the following interfaces (Gupta et al. 1988, Gupta 1987a, 1987b, 1987d, 1989).

(1) The needs of the well-endowed areas and sections of society often merged with the objectives of the research system because market forces were there to steer. Input selling agencies cannot sell many inputs in hill areas, or in flood or drought-prone regions. With all the uncertainties of transportion and insurance costs, why should these institutions locate distribution points in the mountains? In the absence of distribution points for various inputs, located nearby, the real price of using many technologies becomes very high and farmers rationally avoid trying otherwise useful technologies. There is an essential need to modify the policies of public finance for this purpose, for example, with freight equalization policies aimed at reducing the transportation costs or incentives for smaller packages (of fertilizers, for example) through rebate in excise and sales tax.
The markets acted as monitors for only certain types of links. For example, suggestions from the association of industries or the chambers of commerce are often heard by finance ministers before they finalize their budget proposals. Such a consultation is unlikely to take place with disadvantaged households inhabiting mountain regions. As if to compensate for the isolation from the market and the public institutions, people evolve knowledge networks embedded in very strong kinship networks. Policy makers will have to appreciate the dynamics of these knowledge networks if strategies for sustainable technological change in mountain areas are to evolve.

(2) Given the poor articulation of their needs, farmers do not even demand a different type of technology when the opportunity for such dialogues emerges. Scientists can then 'safely' believe that since there was no demand or complaint nothing much needed to be done. However, with the increasing concern for the environment, migration, and sustainability of even the valley production systems, the attitude of the supply-side agencies is slowly changing.

(3) The link between the skills of disadvantaged households and their resources is sometimes weak because of the time frame in which they want to use the skills available for managing the resources efficiently. Their time frame does not match with the time frame of public institutions. The government expects that an innovation that evolved in a particular period of time, with the support of institutional systems, could be scaled up or multiplied almost mechanically even without such institutional support. The time frame used by any decision maker is the function of the control he or she has on the respective resource market. The choice of species, the combination of tree, livestock, or other components, and the available market stimuli are all influenced by the time frame. If scientists ignore this dimension they may miss the fundamental basis of some of the survival technologies.

(4) To deal with the State even the more articulate, well-endowed urban people need advocates. The link between the farmers and scientists may be quite strong or only through intermediaries who may play the role of a bridge, broker, advocate, or even *bania* (moneylender). If new links have to be forged, some of the debilitating links will have to be broken or weakened. The role of extension machinery is quite different in mountain regions. In the early years, they will have less to transfer from the lab to the land and more from the land to the lab or from the tiller to the technologist. The training of disadvantaged people needs careful conceptualisation. The training and visit system is singularly unsuitable for mountain regions, notwithstanding the millions of dollars that the World Bank invests in it.

(5) The link between the individual and collective rationality of the scientists and the farmers often poses the biggest challenge. The ability of scientists to deal with the farmers in groups rather than individually has not been built up over the years because of the individual-oriented approach of technology transfer. Given the fact that the common property resources and even open access resources, managed through collectives, play a pivotal role in the survival mix of the poor people, we have to learn to deal with collective choice problems (Gupta 1989).

The household's portfolio of resources, skills, and opportunities has to be carefully understood and analysed before embarking upon technological interventions. The more diverse the environment, the greater the linkage between different subsystems and the need for scientists to talk across disciplines.

IMPLICATIONS FOR THE FORMAL R&D ORGANIZATIONS

The learning at individual and organizational level can be strengthened if the emphasis is on monitoring the *context* in which the scientists work rather than the *content*. The barriers to learning in any developmental organisation (whether in a mountain region or otherwise) could include the following propositions (Gupta 1984, 1987c, and 1987d).

(1) My learning is not enough, others must also learn,
(2) The benefits assumed from learning are not sure and sufficient,
(3) The cost of my not learning is borne by others, why does it matter if I do not learn?
(4) Learning takes time, one is always in a hurry while planning, who has the time to review past experiences and learn from previous mistakes?
(5) Learning from below and outside (i.e., from juniors, farmers, and extension workers

for researchers and vice versa) requires the capacity to acknowledge the lack of correlation between status and skills,

(6) Replicating success rather than the process of discovering the rules or the grammar of success is most admired in bureaucracies. Allowance for learning the process may mean providing room for decentralized designing. Who will take the risk of having diversity in programme content? Will it not increase the burden of monitoring?

Learning implies being accountable both horizontally (towards the clients) and vertically as well as taking care to monitor client satisfaction or creativity at lower levels. In the mountain regions, the excessive emphasis on budget exhaustion as an indicator of project success will invariably lead the researchers, administrators, and extension workers to concentrate their efforts on the valley regions. Thus, as I have argued earlier (Gupta 1987c), a change not monitored is a change not desired.

To overcome various barriers, several strategies have to be tried depending upon the institutional and political economic context.

(1) Creation of *demand groups* of the 'farmers on the fringe' by the scientists may help to counteract the demands made by already well-endowed and articulate farmer groups. Let us recognize that such dispersed, disadvantaged, and inarticulate farmers cannot be expected to demand different types of technologies from scientists in the short run.

(2) There are several other pressures that scientists have to face, including pressure from parliament, media, donors, and public administrators. The strengthening of a research management system cannot take place unless we study these pressures and ways of coping with them. Too much emphasis on the technical aspect, disregarding management and organization, might meet the same fate as many five year plans have met in India in terms of the goal of poverty alleviation or balanced regional development.

(3) When resources are scarce, the need for networking is higher. However, which scientists' group will network with whom will often depend upon the way the top leaders of the R&D system monitor performance. If the purpose is to reorient forestry or watershed development, appropriate arrangements for networking and inter-organizational coordination will have to accompany the technology development and transfer. For far too long, the institutional issues have been taken as constraints for which adaptations have to be made. If technologies and institutional arrangements for managing the natural streams or '*kools*' have to be modified then the strategic linkages will be of a qualitatively different type than would be the case if scientists were responsible for most of the functions over a given spatial unit (as is the case in on-station research). The need for on-farm research is higher when ecological diversity is higher and technologies developed at one location cannot be replicated at another location even a short distance away.

(4) The links among farmers and scientists have to be placed in the ecological context by use of a mean-variance matrix (Fig. 16.4). The eco-institutional perspective requires scientists to take care of the vertical assurances and the horizontal assurances while providing either new resources or new skills or both. In other words, even if scientists are trying to strengthen an already existing indigenous innovation they should make the boundaries of their role very clear. Undue expectations can lead to mutual distrust and disrespect.

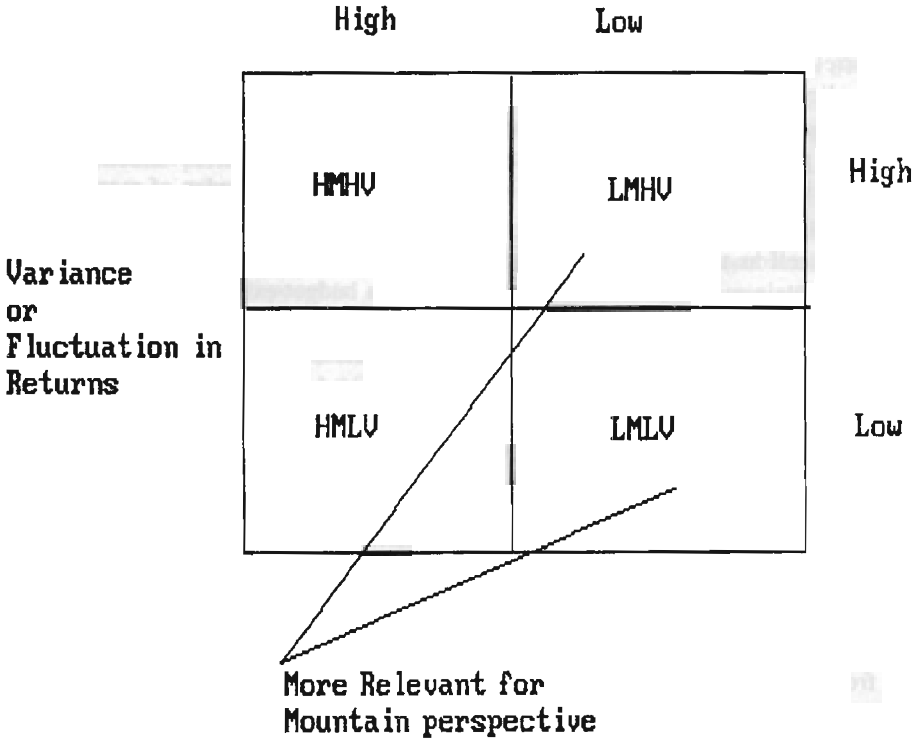

Figure 16.4: Average or mean return
Source: Author's compilation

We can understand how different types of linkages will need to be forged in different types of regions having a varying combination or portfolio of endowments. For example, if the household portfolios of various enterprises comprising their farming system generate a *high average or mean income with high variance*, one can anticipate the availability of market channels. Public interventions can be restricted to regulation. The extension system could be commodity-based rather than household or region-based. In such a context there may not be any need for village-based extension workers but there would be a need for focussing on the issues of sustainability. Farmers may try in the short run to reduce their risks by excessive use of chemical inputs. The households with such portfolios may perhaps be served through contractual services rather than through a mandatory public supply system.

Farmers having *high mean and low variance* portfolios would really be the best-endowed farmers whose goals would be to move towards value-adding technologies. In such cases, farmers' groups can even hire the scientists rather than relying on public or private channels. The government should provide tax concessions to promote such organizations and reduce the size of the public bureaucracy. In the case of households with *low mean and low variance* or *low mean and high variance* portfolios the role of scientists has to be much more evident. Given the high vulnerability in the case of high variance portfolios around low mean returns, the risk-bearing systems are necessary for technological trials on farmers' fields. We have argued that there will be limited use of the transferral of ready-made technologies in such a context. One has to transfer scientific principles so that farmers can develop their own technology. However, there would be areas such as biological pest control or the management of synchronized sowing or other farm operations which need institution building support.

(5) Horizontal links among farmers and scientists cannot be built without weakening the vertical links among junior and senior scientists. The accountability to peers, including farmers, at local level can be strengthened only if top-level scientists recognize the need to be accountable towards the lower levels in the organisations. This principle is valid even in other cases, but in mountain and other risk regions it is critically important. Decentralized experimentation in collaboration with farmers will not take place if there is tolerance of such a process at a higher level. Given the communication system, there is no way innovations can be general in a tightly coupled or linked system.

(6) Reinforcing the pride of mountain people is important. If the pride of the people is a major casualty of wrongly designed policies in the recent past, then restoration of that pride should be the first priority now. Awards for innovative systems and technologies developed by farmers and pastoralists must be given. Scientists should give due acknowledgement to farmers in their publications when their ideas provide the precursor for research insights or experimental design.

(7) Recognition for developing technologies for limited diffusion is essential. If sustainability of technology in fragile regions depends upon compatibility with diverse ecological systems, then the possibility of developing technologies that diffuse widely is limited. Organizational rewards for work that cannot be measured in terms of numbers of farmers, or acreages under cultivation of a new technology, may be necessary.

(8) There is a need for a larger number of experimental sites and higher budgets. The higher the risks and the greater the variability in the production environment the greater will be the number of observations required to verify any experimental research. The challenge before scientists is to develop a network of experiments that are sufficiently broad-based to produce good results.

Ethical and Moral Issues in Knowledge Transfer

It is unfortunate that, while looking for alternatives for the sustainable development of high-risk environments, we often ignore the ethical and moral issues involved. For instance, if the major resources of hill regions are herbal medicines, honey, and other such products, how do we ensure that the interest of the corporate world (national and international) will not lead to reduction of biodiversity and the extinction of certain species?

How do we apportion responsibility for taking undue risks at the farmer's cost? Do we educate the farmer about the various implications of a particular experiment? Do we do it individually or in groups? How do we bear the cost of our mistake, e.g., recommending a variety that has not been tested adequately or bringing seeds without proper processing so that new weeds or diseases come into the region with disastrous long-term consequences.

When we do learn from farmers' innovations we expect rent, royalty, or profit for documenting or sharing their knowledge. How do we share part of the rent with the provider of the knowledge? What are the institutional mechanisms to monitor their sharing? Should judgments on the above issues be left to individual choices? And if so how do we evaluate the morality of such freedom? How do we judge the ethics of the assumption that farmers can always guide the direction of the research that scientists should take? Can farmers demand when they do not even know what scientists can deliver? How do we incorporate the innovating farmers as a part of the educational system in which they also teach and we also learn? How can post-graduate curricula be modified so that future resource managers in high-risk environments develop sensitivity to the above concerns?

In this paper we have discussed the dilemma that we face when we try to develop a system of *lateral learning* and *mutual monitoring* among farmers and scientists. There is no doubt that there is a tremendously rich reserve of innovations available with the farmers which can guide or influence the direction of research. There may be an equally rich reserve of ideas available with the scientists who crave different sets of rewards than the ones available within the organizations.

The challenge is to generate institutional innovations which can link such scientists with innovative farmers in marginal regions. We have no doubt that these links cannot be forged unless the legitimacy of such linkages is established. There is no escape from recognizing that the sustainable development of mountain regions requires that we rethink the very basis of the ethics and politics of resource management. The experimental ethics of mountain peoples need to be nurtured and their skills need to be properly priced. A viable strategy will require that we not only improve their access to resources and upgrade their skills but also provide assurances to them that their restraint in resource use will be valued. Why should they conserve genetic diversity, technological skills, and ecological balance if the benefits accrue only to the people in the plains?

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17

LAND-USE MODIFICATION AND LABOUR SHORTAGE IMPACTS ON THE LOSS OF NATIVE CROP DIVERSITY IN THE ANDEAN HIGHLANDS

K. Zimmerer

Karl Zimmerer is an Assistant Professor, Department of Geography, University of Wisconsin-Madison, USA

CONTENTS

INTRODUCTION

Biological Diversity in Mountain Agriculture

The agriculture of peasants and indigenous people in the mountainous regions of the tropics and sub-tropics has long been recognized as containing an extraordinary diversity of crops (Vavilov 1951, Sauer 1952). It also supports concentrated numbers of the intra-specific variants (cultivars or landraces) of these species. Most major crops as well as dozens of secondary ones underwent the majority of their evolutionary divergence in mountain environments. Three characteristics of mountain agriculture especially promoted the diversification of crops: (1) its relative antiquity, having comprised many of the earliest sites of plant and animal domestication in South and Middle America, Africa, China, and the Southwest, South, and Southeast portions of Asia; (2) biophysical diversity of the environment; and (3) the ethnic diversity of cultivators.

The maintenance and expanded use of biologically diverse native crops have been identified as the major focusses necessary for sustainable agricultural development in mountain regions (Camino, Chapter 22, Partap, Chapter 15, Tapia, Chapter 4). Successful development along this path, however, cannot be guided solely by the presumed persistence of mountain traditions but rather must examine the contingent conditions that will allow the continued integration of native crops into peasant production strategies.

The present paper focusses on one especially important set of contingent conditions necessary for maintaining the diversity of native mountain crops, namely the recruitment of labour by peasant and indigenous farmers (Zimmerer n.d.a). It argues that in many mountain regions the cultivators of diverse crops are increasingly beset by an acute seasonal shortage of labour that leads to the modification and transformation of their agriculture. Such change can lead to the loss of native crop cultivars, a process referred to as 'cultivar loss'.

Crop Diversity and the Strategies of Peasant Farmers

The intra-specific diversity of native crops has been found to play various roles in the farming strategies of mountain peasants. Production purposes, consumption rationales, and cultural reasons indirectly related to subsistence constitute three primary areas of usefulness. Diverse cultivars of native crops are often maintained by mountain peasants for production purposes, especially as a means of maximizing the certainty of yield. Falling under the general category of risk aversion strategies, the practice of planting multiple cultivars tends to assure a modicum of yield under the highly variable biophysical conditions characteristic of mountain environments. Within native crops, certain cultivars are most tolerant of drought while others best resist frost and yet others yield well despite waterlogged soils (Clawson 1985).

The marginality of mountain environments, especially their climatic and edaphic variations, favours the planting of multiple native cultivars. Mountain peasants continue to plant cultivar mixes also because of the uncertain availability of agrochemical inputs. Here the economic marginality of mountain people (Jodha, Chapter 2) is seen to encourage the planting of diverse cultivars for production purposes rather than the adoption of 'improved' varieties.

Consumption rationales are often a primary consideration in the maintenance of diverse native cultivars by mountain peasants. In both major and secondary crops, distinct sets of cultivars are used for separate culinary purposes. The maintenance of the diversity of maize cultivars in the Peruvian Andes, for instance, depends in part on the variety of preparations used by peasant farmers (Grobman et al. 1961). Maize preparations involving parching, boiling, and the making of beer each draw on a divergent, albeit overlapping, group of cultivars. The variety of culinary preparations enabled by the continued planting of native cultivars provides nutritional benefits as well as much-needed diversity in the diets of mountain peasants.

The importance of diverse native crops extends beyond production and consumption rationales to include symbolic usefulness. Mountain peasants often view native cultivars as symbols that are central to cultural and ethnic identity. Again, taking an example from Quechua peasant farmers in the Peruvian Andes, it has been shown that the maintenance of diverse native potato and maize cultivars forms an important part of 'being Quechua' (Zimmerer n.d.b). The symbolic importance of native cultivars highlights an often overlooked way in which biological diversity serves as a cultural resource for mountain peoples.

CULTIVAR LOSS AND AGRICULTURAL CHANGE: THE ROLE OF LABOUR

Cultivar Loss and Genetic Erosion

'Genetic Erosion' is a broad term that refers to the decline of biological diversity in crop species and their wild relatives resulting from various human-induced processes, including habitat destruction, plant breeding practices, germplasm storage techniques, and the disappearance of native crop cultivars from peasant and indigenous agriculture (Frankel and Bennett 1970, Frankel and Hawkes 1975). The last of these, in particular (cultivar loss), threatens the maintenance of diverse cultivars in mountain agricultural systems and hence undermines the feasibility of sustainable agricultural development based on biologically diverse crops.

Existing explanations of cultivar loss, which agree that the problem is due to agricultural change in peasant and indigenous societies, focus on a shortage of land as the primary cause. In the scenario posited by the land deficiency explanation, introduced 'improved' varieties directly displace native cultivars. The present paper contends that, in the marginal environments characteristic of mountain agriculture, a seasonally accentuated deficit of labour is as important as or more important than the shortage of land as a cause of cultivar loss.

The Shortage of Labour in Peasant Societies

The shortage of labour in mountain agricultural system needs to be viewed as part of a 'double reproduction squeeze' (Bernstein 1982). In essence, the 'double reproduction squeeze' refers to the condition whereby agricultural households have increased consumption requirements while, at the same time, they receive a decreased return per unit of their fixed inputs, especially land. Mountain societies, like other groups of peasants, are pressured due to combination of demographic, social, and political-economic changes characteristic of their marginal context (Jodha, Chapter 2).

Increased consumption needs, for instance, often arise from a combination of population growth and expectations concerning access to basic durable consumer goods such as cooking ware and bicycles. A decreased return to agriculture per unit of land frequently comes about as the result of unfavourable terms of trade (a political-economic condition reflecting the weakness of the agricultural sector and the general urban bias of development policies) and the diminished capacity for production that results from environmental degradation.

Peasant households in many mountain regions confront a growing deficit of labour as they must expand their work efforts to survive under the unfavourable conditions surveyed above. A major economic practice manifesting the household labour shortage is temporary labour migration (a commercialization strategy indicating the weakness of agricultural product markets, a condition due in part to the 'inaccessibility' referred to by Jodha in Chapter 2). Undertaken by a member of one-half or more of all households in regions of the Andes as well as the Nepal Himalaya, the decision to migrate leaves agricultural households with significantly less labour available for farming tasks.

In many regions again, including much of the Andes and Nepal, the increased prevalence of temporary labour migration has contributed to the 'feminization of agriculture'. Women, young children, and elders are left to carry out agricultural chores while young men typically migrate for short or medium periods to work in activities such as construction, commercial agriculture (usually in the lowlands), and extractive industries such as logging.

The contracting supply of labour available to the peasant household for land use activities and agriculture threaten the maintenance of native crops due to several features of diverse cultivar production (Zimmerer n.d.a). In particular, the staggered production calendar that underlies diverse-cultivar agriculture often conflicts with the highly seasonal bottlenecks in the household's capacity to recruit workers. Although peasant farmers are sometimes able to rearrange the production calendar without abandoning native crops, biological constraints ultimately limit the flexibility available for temporal changes.

Native crops in mountain environments, especially, contain cultivars possessing a wide range of growing seasons, a genetically controlled trait assumed to have been selected over millennia in order to stagger the supply of foodstuffs as well as the demand for labour. Yet today the same array of growing seasons, while still highly adapted to the diversity and marginality of mountain environments, is increasingly found to conflict with the need of peasant households to allocate labour to other economic activities, not only off-farm, such as temporary labour migration, but also intensified production on the farm.

Environmental resources, other than diverse native crops, can also be seen to be threatened by the diminishing capacity of peasant households to allocate labour for time-demanding sustainable practices. In mountainous regions, peasant and indigenous farmers have mastered a staggering repertoire of techniques and local knowledge used in the management of soil resources (Denevan 1980). Terracing, tillage techniques, and field boundaries are commonly managed to maintain high productivity on sloping land. Yet the capacity of contemporary cultivators to continue such practices is jeopardized by the shortage of household labour brought by the double reproduction squeeze. During certain periods of the year (which usually are defined by seasonality), environmentally sound practices must be modified, frequently in the form of 'short-cutting', or even abandoned.

CASE STUDY OF CULTIVAR LOSS IN ANDEAN MAIZE

The Region

A case study of cultivar loss in the Peruvian Andes can be used to illustrate the impact of labour shortages, within the peasant household economy, on the cultivation of diverse native crops and, by extension, on the possible maintenance of biologically diverse crops in sustainable development. The study area chosen is the highland Paucartambo region of Southern Peru (Fig. 17.1). Located in the eastern Andes between the urban centre of Cusco and the lowlands of the Amazon Basin, Paucartambo is characterized by high transportation costs '(inaccessibility') that limit the movement of goods from the economically more developed regions of the coast.

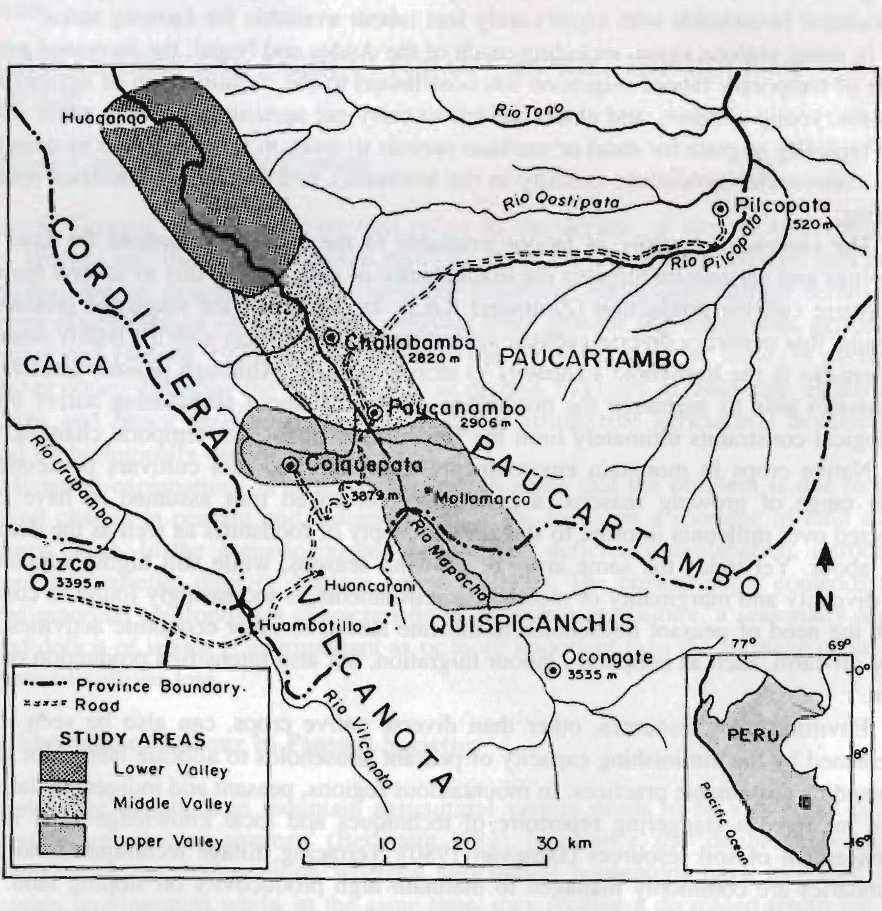

Figure 17.1: The Paucartambo region of Southern Peru

It also is marked by a diverse array of biophysical environments (marginal environments) poorly suited to mechanized agriculture and the reproduction of improved varieties. Moreover, the vast majority of the inhabitants of Paucartambo are Quechua-speaking agriculturalists and herders who make up an economically impoverished peasantry (economic marginality) that at the same time possesses little political power (political marginality).

Maize Diversity in the Region

The peasant farmers of highland Paucartambo produce an extremely diverse array of crops, as well as cultivars within these species. Among the native crops, the major ones are maize (domesticated in Middle America but introduced into South America at least 3,000 years ago) and potatoes, while secondary species include *quinoa* (*Chenopodium quinoa*), lisas (*Ullucus tuberosus*), anu (*Tropaelum tuberosum*), and oca (*Oxalis tuberosa*). Together, the native crops of highland Paucartambo contain hundreds of distinct cultivator types. The study region, like several others located in the easterly range of the Peruvian Andes, is distinguished by exceptionally high levels of biological diversity in its native crops due to the extreme variation of biophysical environments, the presence of the wild relatives (and presumed ancestors) of the major crop species, and the likelihood of early agricultural development.

The native maize crop of Paucartambo was found to represent at least 11 of the 33 major maize races found in Peru. (In maize taxonomy, 'race' is a supra-cultivator designation that is the most useful—and presently the only practical—systematic rank for comparing regional diversity.) Given the extraordinarily high morphological diversity of Peruvian maize, which has been estimated to be the most diverse in the world (Brandolini 1970, Grobman et al. 1961), the agricultural systems of highland Paucartambo are seen to encompass an impressive array of intra-specific variants within the crop.

Peasant farmers in the northern portion of Paucartambo produce the greatest diversity of native maize types. Individual households maintain extremely diverse sets of cultivars by organizing native maize production into a complex calendar made up of three staggered plantings referred to as 'big seed' (*hatun muhu*, planted in September and harvested in June), 'middle seed' (*chaupi muhu*, planted in October and harvested in either May or June), and 'small seed' (*uch'uy muhu*, planted in November and harvested in May). Each of the planting categories consists of a distinct set of native cultivars.

The length of the cultivar's growing season corresponds to its belonging to a certain planting. Slow-maturing cultivars, for instance, constitute the big-seed planting, i.e., the calendric 'niche' with the longest growing season. The ecological 'niche' concept is useful here in highlighting the close match between the diversity of planting schedules (temporal niche) and cultivar types. The maintenance of calendrically staggered maize plantings, along with the provisioning of a variety of maize cultivars useful for several culinary purposes, however, is not assured a permanent place in the mountain landscape of Paucartambo.

Temporary Labour Migration and Cultivar Loss

The peasant farmers of highland Paucartambo, especially in the region's northern portion, have become increasingly involved in temporary labour migration. Pressured (or squeezed) by the unfavourable terms of trade in highland agriculture, whereby the price of agricultural inputs has risen much more rapidly than the selling price of agricultural production (Alvarez 1983), many households periodically send one or more of their members to regions of expanding economies.

The lowlands adjacent to Paucartambo (the Pilcopata region) in particular have served as the destination for most temporary migrants from the study region. The production of rice, pineapples, and cassava on large commercial farms in Pilcopata draws labour from Paucartambo during the periods when lowland producers need workers in planting and harvesting (the months of August and September and those of June and early July, respectively).

Increased temporary labour migration in the northern portion of highland Paucartambo has reduced notably the calendric complexity of the native maize crop and threatens to eliminate completely the production of certain cultivars. Incipient cultivar loss is occurring as a consequence of local households being unable to marshall sufficient agricultural labour during certain periods, especially August-September and June-July. The seasonally specific bottleneck in the supply of labour is leading many peasant farmers to forego production of the big-seed planting of slow-maturing cultivars.

Maize cultivars belonging to the big-seed planting, which belong to the racial categories *Huancavelicano*, *Paro*, and *Ancashino*, are thus in jeopardy due to the impending disappearance of their temporal 'niche'. It is worth noting that, due to the close match between cultivar type and planting (the so-called temporal 'niche'), big-seed maize types cannot be transferred to either the middle-seed or the small-seed grouping.

A notable social cleavage has accompanied the growing disappearance of slow-maturing maize cultivars belonging to the big-seed planting. Unexpectedly, perhaps, the households that continue production rank among the wealthiest in the northern portion of highland Paucartambo. The majority of agriculturalists still producing big-seed maize are considered 'rich peasants', one of the designations used by local inhabitants in ranking the wealth of their fellow peasants. As a result of opportunities for earning income from large and relatively productive field areas as well as cattle herds, wealthier peasant households in the region rarely send migrants to the lowlands. Moreover, if short of labour for field production, the wealthy households can contract help for the production of slow-maturing big-seed cultivars from their neighbours in the region.

Socially and economically powerful, the relatively rich peasants in Paucartambo (like their counterparts in other mountain peasant societies) recruit labour through the use of a wide array of social relationships including wage labour, reciprocal labour, exchange, and payment in kind. Those peasant households possessing less social and economic power have less capacity to allocate labour and must therefore forego certain tasks, as in the case of the extended production calendar supporting biologically diverse native maize.

CONCLUSIONS AND IMPLICATIONS FOR PUBLIC INTERVENTION

The loss of native maize cultivars in the highland Paucartambo region of Southern Peru is seen to be arising from a seasonal shortage of labour in agricultural households. Slow-maturing maize types, occupying a distinct temporal 'niche', (the big-seed planting) are in jeopardy due to the conflict that peasant farmers face in continuing to allocate labour for maize production or instead channelling it to temporary off-farm migration, especially to the nearby lowlands. A so-called double reproduction squeeze characteristic of socially and sectorally disarticulated peasant economies such as those that mark mountain regions in the Third World is found to be forcing agricultural households to expend ever-larger amounts of labour in order to survive.

In the Peruvian Andes, the double reproduction squeeze results primarily from declining terms of trade and the chronic over-production of traditional crops as well as a stagnant or shrinking land base. The increased frequency of temporary labour migration, not only in the Andes but also in other economically marginal mountain regions (Jodha, Chapter 2), is a prominent manifestation of the growing shortage of household labour.

Results of the present study controvert the view that the loss of biologically diverse native crops is brought about solely by the displacement of native cultivars and subsistence production by commercial agriculture and improved varieties. The disappearance of slow-maturing maize cultivars is not associated with the adoption of improved varieties. It also is found not to signal the conversion of the peasant farmer into a completely commercial (capitalist) agriculturist.

In light of the present findings, public intervention promoting sustainable agricultural development needs to recognize that agricultural change is taking place in the context of a persistent peasantry. In mountain regions, the notable persistence of the peasant economy is linked to a growing shortage of labour within local farming households, a key condition demanding consideration by intervention efforts aimed at sustainable development.

The *in situ* conservation of native crops, which has been recognized as a key component of sustainable development in mountain regions (Camino, Chapter 22, Partap, Chapter 15, Tapia, Chapter 4), must be viewed as depending upon the peasant household's capacity to allocate land, capital, and labour. The latter, in particular, increasingly poses a constraint due to the increased frequency of temporary labour migration and the ensuing exacerbation of competition for labour that previously was devoted to the cultivation of diverse crops.

Public intervention in sustainable agricultural development therefore needs to address the causes and consequences of labour shortages in mountain regions. At perhaps the most immediate level, those designing intervention efforts should identify and address pronounced seasonality of labour bottlenecks that result in environmental degradation, including the loss of native crop diversity. If environmentally costly, acute labour shortages and their alleviation are compelling targets for intervention on behalf of sustainable agriculture.

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FARMERS' STRATEGIES IN THE MOUNTAIN AREAS OF WEST SICHUAN: CHINA

Liu Yanhua, Wang Fei and Yu Dafu

Liu Yanhua is a geographer with the Chinese Academy of Sciences and Wang Fei and Yu Dafu are from the Institute of Mountain Disasters and Environment of the Chinese Academy of Sciences

CONTENTS

INTRODUCTION

Experience generally suggests that the regional economy of mountain areas, as well as people's livelihood, were founded upon agriculture. This indicates that agriculture is the principal form of production. A review of agricultural development in mountain areas further shows that its patterns and levels differ from place to place. These differences can be partly attributed to the diversity of farming systems characterizing mountain areas.

The development of mountain agriculture depends largely upon the scope and intensity of resource use and management, in relation to the physical and socioeconomic environment, for ensuring both people's basic needs and increased demands. By examining agricultural development approaches vis-à-vis mountain-specific conditions, Banskota and Jodha (Chapter 3) report the uneven progress of agriculture in different mountain areas. Rapid population growth, market forces, and the side-effects of public interventions have accentuated resource extraction in the mountains giving rise to indicators of unsustainability (Jodha, Chapter 2). For understanding a farming system and the role of farmers' responses to the constraints and potentialities of the production environment, in the following discussion we focus on the constraints in the production environment and people's adaptations to those constraints.

However, whatever the number and nature of forces indirectly influencing agricultural resource use and its sustainability, the farmer should be considered to be the central actor whose decisions and actions directly influence the pattern and intensity of resource use. These decisions and actions are also the manifestations of farmers' strategies to bring about adjustments to the biophysical environment. Farmers' strategies in the selected areas of West Sichuan were examined (Dafu et al. 1990) as a part of the studies on farming systems in different countries of the Hindu Kush-Himalayan region.

Although, owing to institutional changes in China following the Revolution, the sphere of individual farmers' decision-making and the choice of specific practices were reduced, in mountain areas some traditional practices survived. Following the reforms of 1978, in spite of some collective obligations, the farmer is able to make his own individual decisions. Our ensuing discussions are preceded by a brief introduction to West Sichuan and to agro-development in the area. Figure 18.1 sketches the overall framework in which the farmer operates.

BACKGROUND AND AGRO-DEVELOPMENT IN WEST SICHUAN

The Mountain Areas of West Sichuan

Located in the western part of Sichuan Province, the mountain region of West Sichuan (Fig. 18.2) embraces an area of 0.315 million sq km. It had a population of 6.18 million in 1986, accounting for 55.3 per cent and 6 per cent of the population of Sichuan Province. Administratively, West Sichuan includes three autonomous prefectures (Ganzi, Aba, and Liangshan), one municipality (Dukou), and a part of Ya-an District (Hanyuan County and Shimian County).

The West Sichuan region is mainly characterized by a complex topography with a high plateau and mountains. It forms a major section of the Hengduan Mountains in the eastern part of the Tibetan Plateau and belongs to the highest topographical realm

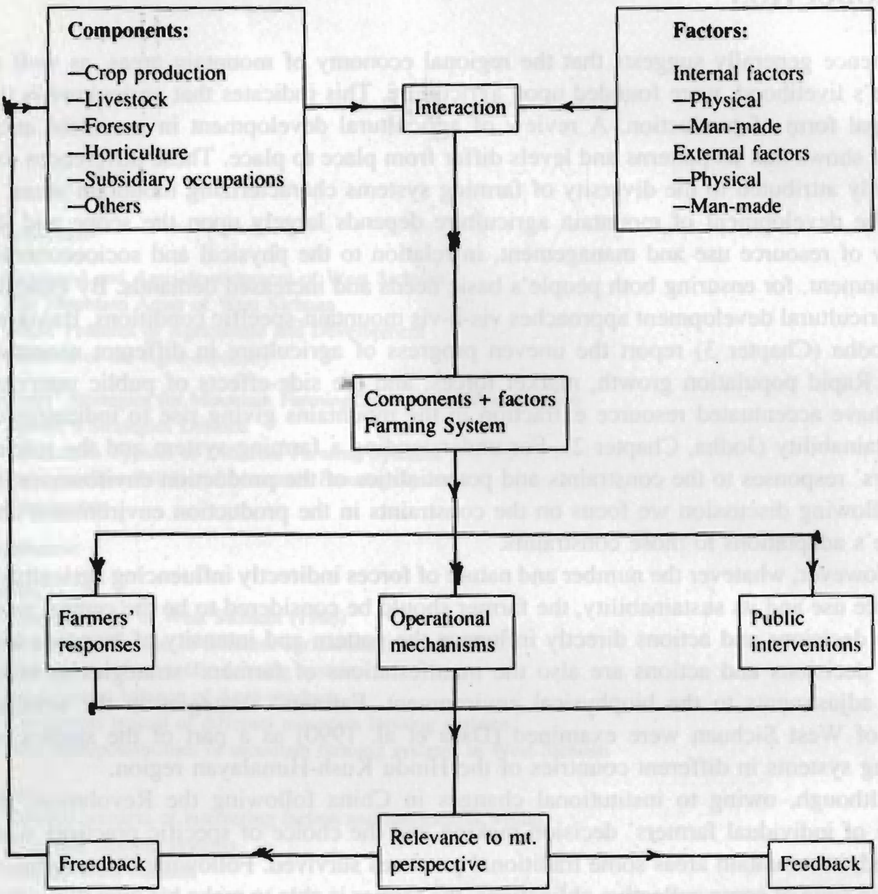

Figure 18.1: General scenario of interacting factors and mechanism within mountain farming systems

of the three realms or zones of China (plains, hills, and high plateaux/mountains). The elevation of West Sichuan, on average, is about 3,000 masl and declines from northwest to southeast. Three large rivers, namely the Jinsha, the Yalong, and the Dadou, and their tributaries dissect the plateau surface and form deep gorges and river valleys. A distinctive, vertical variation in relief dominates the general features of the region. In the northern part, the elevation is higher than 3,400 masl with comparatively level and wider landscapes. Southwards, lands are deeply dissected with height differences of 1,000–3,000 m between the valleys and the mountains. In contrast, the southern part of West Sichuan is relatively lower, averaging 2,000 masl with gently sloped mountains, broad intermontane plains, and wide river valleys. Out of the total land area, the plateau accounts for 50 per cent, the mountains 45.8 per cent, and the intermontane basin and broad river valleys only 2.2 per cent. The latter area is quite populous and is the most intensively cultivated.

Climatically, West Sichuan is a transitional zone between the sub-tropical climates

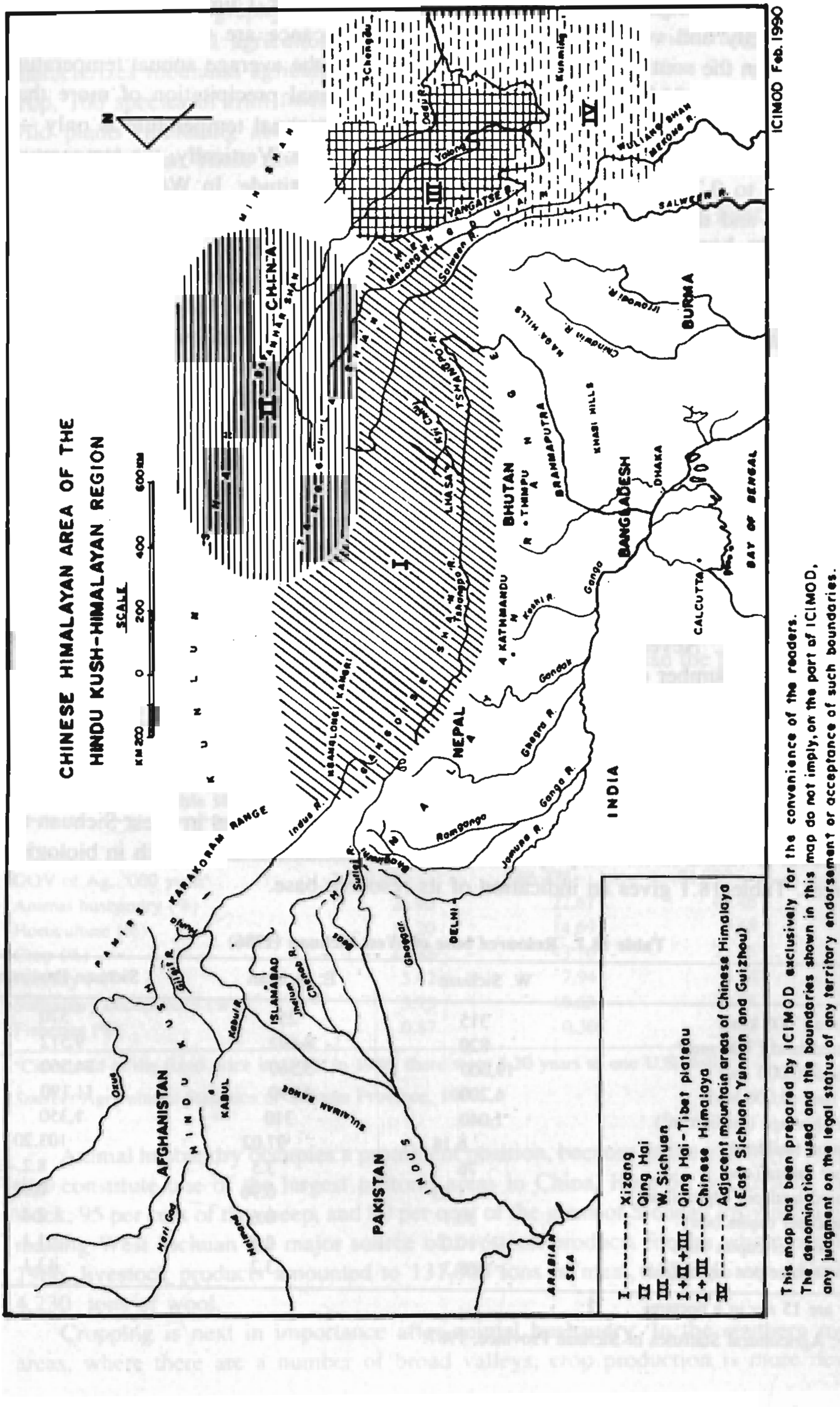

Figure 18.2: Chinese Himalayan area of the Hindu Kush-Himalayan region

in the south and the highland, frigid climates in the northwest. Climatic conditions vary both horizontally and vertically. Of agricultural significance are the temperature and precipitation. In the southernmost part of West Sichuan, the average annual temperature can reach as high as 10 to 20°C, with an average annual precipitation of more than 1,000 mm, while, in the northwestern part, the average annual temperature is only −1 to 4°C with an average annual precipitation below 500 mm. Vertically, the temperature decreases 0.5 to 0.7°C with each increase of 100 m in altitude. In West Sichuan, the warm season and the rainy season coincide between June and September, making the area favourable for farming and agro-production.

The mountain areas of West Sichuan are the homeland of several minority groups (mainly Tibetan, *Yi, Qiang, Hui, Susu, Buyi,* and *Naxi*). Although *Han* people are mixed in among the minority groups, the basic features of mountain traditions, such as living customs, culture, and social psychology, predominate. However, the transitional characteristics are also obvious. In the southern and eastern part of West Sichuan, influences from the plains or the basin areas, in terms of culture and technology, appear to be much more evident than in the northwestern areas.

From the socioeconomic aspect, among the three zones of China, West Sichuan belongs to the underdeveloped economic zone (the east-coast zone is developed, the mid-zone is moderately developed, and the west zone is underdeveloped). With a primitive industrial base and no market economy, and being in the primary stages of agro-development, West Sichuan is one of the poorer mountain areas and suffers from slow economic growth. Nevertheless, the vast territory and rich natural resources in West Sichuan offer a number of potentials to the regional economy.

Major Features of Agriculture and Development

Agricultural Resources

Compared to other parts of the province, agricultural resources in West Sichuan are spread over a vast area that displays varied physical conditions and is rich in biological resources. Table 18.1 gives an indication of its resource base.

Table 18.1. Resource base of West Sichuan (1986)

Item	W. Sichuan	E. Sichuan	Sichuan Province
Land area ('000 km^2)	315	255	570
Cultivated land ('000 *mu*)[a]	820	8,692	9,512
Grassland (0,000 *mu*)	19,000	5,560	24,560
Forest land (0,000 *mu*)	6,200	4,990	11,190
Timber shortage (million m^3)	1,040	310	1,350
Population (million)	6.18	97.02	103.20
Land per capita (*mu*)	76	3.5	8.2
Cultivated land per capita (*mu*)	1.33	0.90	0.92
Grassland per capita (*mu*)	30.7	0.6	2.4
Forest land per capita (*mu*)	10.0	0.5	1.1
Timber storage per capita (*mu*)	168.3	3.2	13.1

[a]There are 15 *mu* in a hectare.

Source: Agricultural Statistics of Sichuan Province, 1987.

The varied topography and a number of micro-climates has led to the development of three-dimensional agriculture in these mountain areas. A wide range of resources characterizes mountain agriculture. For example, so far, more than 20 species of grain crop, 100 species of fruit trees, 600 species of animals, and 6,000 species of valuable wild plants (including about 2,000 species of medicinal plants) have been identified in West Sichuan. These diversified resources make it a promising area for agricultural development.

However, there are some weaknesses in resource conditions also. First, the mountain topography, which is dominated by slopy lands, makes the use and management of resources difficult; consequently, agricultural inputs such as irrigation and transportation are relatively high. Second, the sparse distribution of resources does not favour scaled production and mountain agriculture is restricted by small-scale operations and dispersed distribution. Third, the mountain environment is relatively fragile; soil erosion and natural hazards frequently occur. In West Sichuan, the main causes of unsustainable agriculture are landslides, drought, floods, and frost.

Features of the Agro-economy

Agriculture is the predominant sector in the regional economy. It is dependent largely upon natural resources and extensive management. In 1986, the gross output value of agriculture and industry (GOVAI) in the area was 2,550 million RMB yuan (according to the statistics for Ganzi, Aba and Liangshan, the gross output value from agriculture accounts for 57.63% of the GOVAI, and this is much higher than the provincial average, 34.11%).

The agricultural system is dominated by crop farming and animal husbandry. The allocation of agro-production in terms of output value is shown in Table 18.2.

Table 18.2. Gross output value of different agricultural sectors (1986)

	Sichuan	Liangshan	Aba	Ganzi
GOV of Ag. '000 yuan[a]	2,809,400	86,278	31,899	28,784
Animal husbandry (%)	26.90	22.67	46.46	59.06
Horticulture (%)	18.20	14.69	9.68	2.16
Crop (%)	42.88	43.76	23.76	19.09
Forestry (%)	5.42	7.94	8.14	4.01
Subsidiary occupations (%)	5.73	10.63	10.78	15.63
Fisheries (%)	0.87	0.30	0.03	0.05

[a]Calculated at the fixed price in 1980. In 1986, there were 3.20 years to one U.S. dollar.

Source: Agricultural Statistics of Sichuan Province, 1987.

Animal husbandry occupies a prominent position, because of the extensive rangelands that constitute one of the largest pastoral areas in China. Here 50 per cent of the large stock, 95 per cent of the sheep, and 80 per cent of the goats of Sichuan Province are raised, making West Sichuan the major source of livestock products for the whole province. In 1986, livestock products amounted to 131,000 tons of meat, 172,000 tons of milk, and 4,230 tons of wool.

Cropping is next in importance after animal husbandry. In the southern mountain areas, where there are a number of broad valleys, crop production is more developed than in the northern areas. Although the output from cropping in West Sichuan was only 24.4 per cent of the total for the whole province in 1986, it is an essential component of the mountain farmer's livelihood. In 1986, 1.75 million tons of crops (Liangshan, Aba, Ganzi, and Dukou) averaging 304 kg per capita for the rural population (less than 80% of the provincial average) were produced.

Although the agro-productivity is quite low—e.g., the grain yield was 219 kg/*mu* in 1986 (53% of the provincial average), the GOV of agriculture per unit of land was 4,886 yuan RMB/km^2 (9.9% of the provincial average). Thus, agriculture does have a meaningful contribution to make to the regional economy. Out of the total population in West Sichuan, 85 per cent are living in the rural areas and are engaged in agriculture.

Process of Agricultural Development

Based on recorded history, agriculture has been carried out for more than 2,000 years in West Sichuan. But, owing to the complicated physical and cultural conditions, the situation has not changed essentially throughout that period.

Up to 1950, the region remained feudal with numerous small tribes or even some primitive communes. Because of the mountains, West Sichuan was isolated from the mainstream of development and the local economy was characterized by very primitive practices. In the northern part of the region, nomadic pastoralism predominated, whereas, in the southern areas, two kinds of farming system, valley farming and hill farming, were practised.

By the end of 1949, a political change took place and West Sichuan entered a completely new development stage. The minority peoples from different social systems, no matter how uneven their development, all took part in the socialist transformation process. Through several stages of land reform, i.e. land redistribution, multi-aid teams, agricultural cooperatives, and people's communes, agriculture developed rapidly. By 1978, the gross agricultural output value (calculated at fixed prices) increased three times compared to that of 1950, a network of highways, linking each county of the region, had been constructed, and a research and extension system for agriculture had been established and consolidated. Most importantly, the agricultural production in West Sichuan broke through its isolation and began to develop in line with national standards.

Since 1978, a wave of economic reforms has swept the countryside in West Sichuan, particularly in the context of the implementation of the 'household responsibility system', which has opened up new prospects in agricultural production. The responsibility system allows farmers to run their farmlands on a contract basis and gives the right of decision-making in agro-production to the farmers. This new policy and its implementation has given the incentive to peasant farmers to adapt diversified agro-practices to their needs. To a great extent, this system suits the conditions of mountain areas where there are specific 'niche'. Accordingly, agriculture has progressed a great deal.

Agro-zones in West Sichuan

On the basis of broad similarities among physical conditions, socioeconomic situation, background of agricultural production, and prospects of area development, West Sichuan can be classified into three basic agro-zones (Fig. 18.2). The major features of the three agro-zones are described below.

The cropping-forestry-animal husbandry zone comprises the mid-mountain, wide valley areas of the Southwest. Situated in the transitional area of the Tibetan Plateau, Yun-Gui Plateau, and Sichuan Basin, this zone is characterized by mountains and wide valleys/basins, with altitudes ranging from 1,000 to 3,000 masl. The climatic conditions are sub-tropical and semi-humid. The valley areas, which have an average annual temperature of 17–20°C and an average annual precipitation of 800–1,000 mm, are extremely suitable for agriculture.

So far, cropping has been the predominant sector. Cultivated lands account for less than 6 per cent of the total area and are mostly concentrated in broad valleys. Crop production accounts for 60 per cent of the total output value of agriculture. The staple grain crops are paddy, maize, wheat, and potatoes. In terms of cash crops, sugarcane and tobacco are significant.

The area has 28 per cent forest coverage, out of which air-seeding forests account for a large proportion. Since the 1950s, the air seeding of Yunnan pine has been very successful, especially in the mid-mountain areas. Forestry development has a lot of potential, since it is estimated that 48 per cent of the total area of the zone, mainly on mountain wasteland, can be reforested.

The forestry-cropping-animal husbandry zone is situated in a very rugged area of high mountains and deep valleys. The relative difference in elevation is normally 1,000–3,000 m, while the highest altitude is 6,000 m. The steep slopes and narrow valleys constrain, to a great extent, the exploitation of resource and agricultural development. Influenced by the relief, climatic conditions are subject to significant variations vertically. In moving from the low land to the high mountain ridges, the average annual temperature ranges from 15°C to below 0°C and the accumulated temperature (> 10°C) from over 3,000°C to below 300°C. Deep valley areas are mostly dry and mid-mountain areas are relatively humid.

Forests, the most important resource in the zone, are mostly distributed throughout the mid-mountain areas where they are comparatively inaccessible. The area covered by forests and the reserves of standing timber account for 28.5 per cent and 44.4 per cent of the total of Sichuan Province. The major tree species are fir, spruce, birch, and alpine oak. Among the cash trees, apples and pears are the best known.

Although cultivated land is quite limited, crop cultivation is the activity on which people depend for their livelihood. Crop cultivation in the zone is characterized by small-sized and sparsely distributed farmland, rainfed agriculture, and low productivity. The predominant crops are maize, wheat, barley, and potatoes.

The animal husbandry zone, in the high plateau in the northwest, is the highest zone in Sichuan Province, with an average altitude of more than 3,500 masl. Its topography features a vast flat plateau surface, open valleys, and mountains with gentle slopes. Its climatic condition ranges from frigid to subhumid. The average annual temperatures (> 10°C) are from 400 to 1,500°C, and the area is free of frost for less than 100 days. The low temperature condition is the major constraint to agriculture. There are vast areas of pastoral land, accounting for 68 per cent of the total area. The vegetation is mainly alpine and sub-alpine meadow, belonging to the herbaceous, nutgrass, and leguminous species.

This zone has the largest pastoral area, and caters for 76 per cent of the yaks, 57 per cent of the horses, and 53 per cent of the sheep in Sichuan Province. Beef and wool production account for 33 per cent and 50 per cent of the provincial total. Because of poor physical conditions, poor management, a low level of commercialism, and poor manufacturing capabilities, animal husbandry is developed.

Forests, covering 7 per cent of the area, are distributed along the upper reaches of the Jinsha, Yalong, and Dadu rivers. These forests play a significant role in water resource conservation. Crop cultivation is limited in this zone, with highland barley and spring wheat as the main food crops and rapeseed as the major cash crop. The crop productivity is low (about 120 kg/*mu*), and grain crop production is far from sufficient for local consumption.

FARMERS' STRATEGIES FOR MOUNTAIN FARMING SYSTEMS IN WEST SICHUAN

Farmers' Strategies Defined

Historically, farming systems in mountain areas have evolved in response to the ecological and agro-climatic attributes of the mountain regions. These systems contained a lot of features in terms of choice of land-based activities and their management practices which helped to both protect the resource base and maintain the level of productivity.

Farmers' strategies include the response of farmers towards mountain environmental conditions in the context of the use of natural resources and management of socioeconomic circumstances. The adaptation of farmers' strategies is affected by both individual behaviour, in relation to changing economic variables, and the nature of policies pursued by the public sector. Farmers' strategies, to a great extent, reflect the scope for harnessing land use in a diversified or integrated manner to ensure the basic needs of the people and a degree of sustainable development for mountain farming systems. The study of farmers' strategies was involved in identification of elements (such as linkages between different land-based activities, indigenous methods of resource management, and an inventory of traditional technologies) that helped in the sustainability of mountain agriculture and was involved in the examination of the feasibility and viability of these elements in the context of recent changes.

Based on the case study (Dafu et al. 1990), several constraints and potentials of mountain farming systems in West Sichuan can be identified. Constraints refer to the restrictions or negative processes that deteriorate the production environment of farming systems in the long run and also adversely affect its current performance. Potentials imply the possibilities that could direct the mountain farming system towards sustainable development. This paper presents the constraint aspects of agriculture in West Sichuan and discusses the farmers' responses to them.

The basic constraints common to West Sichuan are summarized in Table 18.3. The table lists the constraints as they are commonly identified and understood both by development planners and knowledgeable members of the community. Column 2 of the table lists the relevant mountain specificities (Jodha, Chapter 2) with which these constraints are associated. Operational implications of the mountain specificities and farmers' responses to them, as observed in West Sichuan, are presented below. The constraints as both restrictions and negative processes are elaborated upon. The negative processes could also be viewed as emerging indicators of unsustainability as elaborated upon by Jodha (Chapter 2).

Table 18.3. Constraints of mountain farming systems

Constraints	Relevant Mt. Specificity associated with the constraint	Implication	Farmers' response
Environmental degradation	Fragility	* vulnerable to natural hazards * over use of resources * deforestation	* terracing * afforestation * fallow land * change land-use pattern
	Marginality	* inferior management * illiteracy/ignorance * poor resource position	* tendency to look for short-term gains * small production units * multiplication of options by diversification of activities
	Inaccessibility	* poor mobility * information gaps	* dependence on local resources
Limited land available per capita	Fragility	* population pressure * resource degradation * no intensive use * limited options for production	* out-migration * off-farm employment * increase input on unit of land * change land-use pattern
	Inaccessibility	* isolation from mainstream * low mobility * poor market access	* non-land-based activity
	Marginality	* focus on subsidy * high illiteracy * passive response to family planning	
	Adaptation mechanism	* local resource management system * land-use pattern	
Shortage of energy, water, funds, etc.	Inaccessibility	* long distance/high transport cost * poor market access * low mobility	* save the use * devote time to access * public regulation * increase prices * change land-use pattern * collective management
	Fragility	* low productivity * long cycle of production * population pressure * seasonality of resources	
	Marginality	* poverty * not integrated with other areas	
	Adaptation mechanism	* local conditions disregarded under restriction * local resource centered management	

Contd.

Table 18.3. Contd.

Constraints	Relevant Mt. Specificity associated with the constraint	Implication	Farmers' response
Low capability of small production unit	Fragility	* vulnerable to disasters * limited production options * instability of production	* more labour input * simplifying tools * collective management * reduce cash input
	Marginality	* poor exposure/knowledge	* specialized households
	Adaptation mechanism	* tendency to look for short-term gains * practising choice * local resource management system * lack of incentives by government	* specialized households * exchange labour
Raw material of integrated production	Inaccessibility	* isolation, poor mobility, * information/communication gap	* subsidiary activities * diversified production to ensure the basic needs
	Fragility	* limited production options	* local consumption or integrated management.
	Fragility Marginality	* instability of production * focus on subsidy * inferior quality of labour	* high value cash crop
	Adaptation mechanism	* incentive to the farmers * activity choice	
Frequent change of policies	Fragility	* instability of production * limited production options	* non-production or integrated management * cash allocation * quick return
	Marginality	* farmers' enthusiasm in production * incentive mechanisms	* house construction * yard cultivation
	Adaptation mechanism	* tendency to look for short-term gains * local conditions disregarded under commune system * activity choice * passive response in production * risk adaptation	
Insufficient supply of input	Inaccessibility	* high transport cost * unfavourable terms of exchange * slow transportation development * poor market access * information gaps	* change cropping pattern * change the allocation of available input * elimination of species needing high input

	Fragility	* vulnerable to disasters * limited production options * instability of production	* adjustment of land use * local production techniques * collective management * public regulation
	Marginality	* poor exposure/knowledge	* pricing control * low-input crop
	Diversity	* production structure * gaps in growth rate * different requirement for input * difference in required time * different land types	
	Adaptation mechanism	* activity choice * indigenous method * local resource management system * lack of incentives by Government	
Limited technical support system	Inaccessibility	* cut off from mainstream * low mobility * low development	* readjustment of production * change land-use pattern
	Fragility	* low productivity * limited production options * no intensive land use * instability of production	* traditional method * low technique * invite technicians from outside * go outside to learn
	Marginality	* inferior quality of labour * no integration with other areas * high illiteracy * lack of Government support for R &D	* establishment of technical associations among farmers * specialized activities
	Diversity	* ecological variety * production structure * adaptability * ethnic groups	
	Adaptation mechanism	* land-use pattern * activity choice * mixed source of income * local resource management * risk adaptation	

Source: Study team

Environmental Degradation

Environmental degradation is a common and serious problem in mountain areas such as West Sichuan. According to the case study, there is a lot of evidence of environmental degradation and examples, in terms of the resource base, are given below.

In livestock-dominated farming systems (LDFS), the quality of grassland has deteriorated a great deal. During the period from 1960 to 1980 (on the basis of grassland surveys at county level), the average yield of grass decreased from 316 kg/*mu* to 250 kg/*mu*. In terms of the composition of grasses, the content of poisonous grass increased from 1.5 to 4 per cent. In horticulture-dominated farming systems (HDFS), the frequency of landslides increased. In the period from 1970 to 1980, landslides occurred from three to five times a year to seven to eight times a year (village case study). In crop-dominated farming systems (CDFS), forest land has been gradually replaced by crop land. The forest cover (at county level) decreased from 15 per cent of the total land area in 1970 to about five per cent by the end of the 1980s. In the mean time, floods are becoming less controllable. About 3,000 *mu* of cultivated land have been destroyed by floods during recent years.

Environmental degradation is caused by many factors. On the one hand, the mountain environment is ecologically fragile; natural hazards occur more often in the mountains than on the plains. On the other hand, overuse of resources or irrational use of resources accelerates the process of degradation.

Mountain farmers are well aware of what is happening on their land and the environmental changes in terms of area and time. They have responded both passively and positively to these changes.

Among their positive responses, farmers constructed terraces to stabilize their land, changed the land-use pattern to protect the resource base, and planted trees on marginal lands or slope lands to conserve the soil layers. Because the current production system in mountain areas is on an individual basis, the efforts made by farmers only partly solve or prevent the resource degradation on a very small scale. The local government now encourages farmers to construct terraces and irrigation schemes under an award policy for land construction (e.g., the local government gives 250–300 yuan/*mu* to each farmer for terracing). However, individual households have not enough labour surplus to take advantage of this. Among their negative responses, farmers have to abandon their degraded land, change their land-use patterns (low productivity crops replace high productivity crops), try their best to store food grain to ensure their subsistence needs when the harvest is bad, or migrate out.

Limited Available Land Per Capita

Another common constraint in mountain areas is the limited availability of land. Land is a basic resource, and, although the average land holding is larger than that in the plains, the quality of land is much worse in terms of accessibility, average size, thickness of soil layer, and irrigation facilities. What is more, land availability per capita in mountain areas has decreased sharply due to rapid population growth, land encroachment, irrational land use, and soil erosion.

The case study discovered that in LDFS (at county level), the grassland available per sheep unit decreased from approximately nine *mu*/sheep unit in 1976 to approximately six *mu*/sheep unit in 1986. The grassland available per capita (at village level) decreased from 458 *mu*/person in 1982 to 376 *mu*/person in 1988. In HDFS (at village level), the cultivated land per capita decreased from 1.84 *mu* in 1978 to 1.25 *mu* in 1988. In CDFS (at county level), crop land available per capita reduced from 1.7 *mu* in 1978 to 1.3 *mu* in 1986.

Because of the increasing shortage of land, traditional methods of mountain farming systems cannot produce enough to sustain the increased population and the increased needs of the people. To suit the changing conditions, mountain farmers responded in two ways. First, they increased the inputs per land unit (e.g., in CDFS, the average cash input for 500 kg of paddy increased from 12 yuan in 1980 to 129.5 yuan in 1988), adopted intensive management, reduced fallow land, increased the cropping index, and reduced green manure cultivation in an attempt to increase the total production. Second, they diversified into non-land-based activities or became involved in off-farm employment. So far, non-land-based activities, such as collecting medicinal herbs, or subsidiary occupations (e.g., transportation, baking bricks, small-scale manufacturing, handicrafts, and mining) are being developed. In CDFS, off-farm employment has become very common, and about 20 per cent of the labourers (case study village) are engaged in off-farm employment. Generally speaking, farmers believe that non-land-based activities and off-farm employment are the best outlets for the surplus rural labour force.

Inaccessibility of Resources

Mountain areas are rich in resources, but these resources are not easily accessible, and this results in severe shortages of energy and water. Fuel is a basic daily need and in mountain areas the lack of fuel has resulted in a reduction of inputs into the land. In LDFS, shrubs, grass, peat, and yak dung are used as fuel for cooking and heating. In the 1960s, farmers used grass peat as the major source of fuel, while yak dung was used as manure to spread on the grasslands. In 1980, the use rate of grass peat to total fuel was estimated as 50 per cent, and, by 1988, the use of grass peat had decreased to 10 per cent. Instead of grass peat, yak dung has become the major source of fuel. In CDFS, paddy straws were traditionally returned to the land as manure, but, because of deforestation, firewood collection is more and more difficult and farmers have to use paddy straw for fuel. In 1978, they used 30 per cent of all paddy straw on the land in the case study village; in 1988 the amount had fallen to 5 per cent. In cases of fuel shortage, farmers usually minimize its use by improving stoves, having simple food, or other means. The alternative is to devote their time to collecting firewood over long distances.

Water shortages, especially during the dry season, are a constraint on productivity. In mountain areas, the irrigation systems are inadequate. Farmers normally manage by taking both public and individual measures. In the public sector, the village community establishes certain regulations to allocate the amount of water each household can use and makes the price of water flexible according to the water available. In the private sector, readjustment of the cropping pattern (e.g., planting wheat instead of paddy) is normally the measure adopted.

The shortage of energy and water does not mean that there are no resources. The problem is how to make the resources accessible. In general, the improvement of transportation facilities or construction of irrigation schemes are long-term gain activities and need huge investments. However, individual farmers do not have the ability to afford such investments. So far, the credit system for mountain agriculture has not yet paid sufficient attention to this aspect.

Since 1978, the responsibility system has been adopted in the mountain areas of West Sichuan. This is an economic reform system characterized by:

- giving the right of decision-making to farmers in the management of their land,
- allowing farmers to run their land on a contract basis with tools partly belonging to themselves, while maintaining public ownership of land, and
- relaxing restrictions on privately conducted activities, including ownership of land.

The adoption of the responsibility system is particularly suited to the *diversified development of mountain agriculture.* Since the reform, substantial increases in agricultural production have taken place, although many negative side-effects have appeared gradually. *The major weakness appears to be the low capability of the production unit.*

In LDFS, *sheep raising is the traditional practice.* This tradition is slowly disappearing. The numbers of sheep in this system (village-level survey) declined by about 40 per cent from 1983 to 1989 and now most of the households keep only yaks and no sheep. This change is caused partly by the size of the production unit. Normally, sheep rearing needs labour because the sheep move very fast while grazing, whereas yak keeping is much easier as yaks can be sent out in the morning and collected in the evening. On the other hand, sheep are smaller than yaks and are poor at withstanding natural calamities. Because the current production unit is based on individual households (about four to six persons), activities that do not need much labour are preferred.

Before the introduction of the responsibility system, there were 150 mu of cultivated land for the production of livestock concentrates, by collective management, in the survey village. Grain production partly met the livestock needs. After the introduction of the responsibility system, due to decentralisation of the production system, the cultivated land was abandoned. Consequently, the locally produced concentrate was replaced by supplies from outside.

In HDFS, infrastructure plays a very important role in the farming system. During the 'People's Commune' period, terraces were constructed, irrigation systems dug, and a motorable road connecting the village to the county centre was built through collective efforts (case study village). After the introduction of the responsibility system, nothing has been done to improve the infrastructure. On the contrary, the former works were more or less destroyed. Many terrace walls have collapsed, many parts of irrigation channels have broken down, and the road is poorly maintained. At present, maintenance depends on a limited subsidy from the local government; the road is blocked. In 1978, the village owned 10 tractors, but, in 1989, there was only one left. Mechanical labour has been replaced by human labour now.

In CDFS, the lands are relatively flat, and it is possible to cultivate a large plot of land with machinery. After the introduction of the responsibility system, lands were divided among individuals, and cultivated land became too fragmented (5 to 10 times more than before). Decentralized management on small plots of land leads to difficulties in disease and pest control (for instance the effective area of diseases and pest control decreased from 95% in 1978 to 60% in 1988), and results in declining trends in the use of agricultural implements (e.g., 85% of the land was ploughed by tractor and 100% of the paddy was threshed by machine before the introduction of the responsibility system, whereas now, 40% of the land is ploughed by tractor and 60% of the paddy is threshed by machine). Farmers in the mountain areas realized the weakness of the small production unit and measures such as collectivization in certain activities, labour exchange, and formulating public regulations under village communities for common property were adopted.

Raw-Material-based Production

Mountain agriculture is generally raw-material oriented production. This kind of production needs large areas of land and more labour input. As a matter of fact, mountain farming systems are characterized by *sparsely distributed and diverse products*, and these can hardly be developed into a commercialized, market economy. There are many options in mountain production, such as food processing and medicinal plant processing, but, owing to factors such as poor mobility, poor market access, unskilled labour, and lack of technology, the choices for mountain farming systems are different from those of the plains.

Based on the case study, the input-output balances for several products in the mountain farming system were compared and it was concluded that mountain agro-production is not profitable (Table 18.4).

Table 18.4. Input-output balance of agro-products

Item	Gross input	Gross return	Net return
LDFS			
sheep (units)	30.4	37.3	6.9
yaks (head)	63.3	78.7	15.4
HDFS			
maize	231.5	331.0	99.5
wheat	233.0	288.5	55.5
potatoes	227.0	580.0	353.0
soybeans	101.0	125.0	24.0
pigs (head)	388.5	509.0	120.5
cattle (head)	394.0	268.0	−126.0
apples	407.5	546.0	138.5
CDFS			
paddy	237.5	456.8	219.3
wheat	220.5	287.5	67.0
barley	134.0	239.8	105.8
pigs (head)	248.8	285.0	36.2
buffaloes (head)	631.0	420.0	−211.0

Note: Calculated at current prices (1988–1989). In 1989 there were 4.72 yuan to one US dollar.

Source: Case study team.

According to the investigation, mountain farming is land-based and primary product-oriented, mainly for the purpose of local consumption. In fact, income generation depends largely on non-grain production (HDFS), subsidiary occupations (LDFS), and off-farm employment.

Frequent Policy Changes

Frequent changes in the basic policies resulted in the instability and discontinuity of mountain agro-development. Since the 1950s, mountain agriculture has undergone three phases of agrarian reforms. The first phase (1949–1957) started with the introduction of land reform and ended with the introduction of cooperatives. Land reform focussed mainly upon the redistribution of agricultural land, major agro-assets, and political power. In this period, farmers owned land as private property and managed production individually. The second phase of reform was called 'the People's Commune Period' (1958–1976). Under this reform, the ownership of land and of major assets shifted from individuals to the collectives. Farmers worked under the administration and were paid according to labour input; as a result, they were more workers than owners. The third phase of reform, introduced in 1977, is normally called 'The Responsibility System'. Under this reform, farmers have the right to manage land on a contract basis, and restrictions on the private ownership of assets have also been liberalized.

Farmers have experienced these changes in policies in the form of alternate gains and losses in the right to make decisions about and manage their own land. They experienced uncertainty about the future and looked upon the policy changes as 'policy risks'. Although the present policy stimulated agro-production, it did not stabilize it (e.g., an increasing number of items are taxed). To avoid losing benefits, farmers responded to the responsibility system in two ways. First, they chose activities that gave quick returns, and, as a result, green manure crop cultivation in CDFS (at village level) decreased from 56.3 per cent of the total land area in 1978 to 5.7 per cent in 1988. Green manure cropping has been replaced by wheat production; in the meantime, fallow land decreased sharply and the cropping index increased from 130 per cent to 170 per cent. The second way in which farmers responded was to reallocate the use of their income. In the case study villages, there are few farmers who use their money to purchase agro-machinery or to improve the basic land composition. On the contrary, most farmers are likely to use their money for house construction. Farmers believe that private house construction is the safest investment, because private houses are not considered to be public property.

Insufficient Supply of Input

At present, the input supply system for mountain agriculture is far from sufficient, and this hampers the potential for development. In LDFS, salt and animal feed concentrate are in extremely short supply. Through government channels, livestock farmers can get a few inputs on a quota basis (about one-fifth of the basic needs). In HDFS and CDFS, fertilizers and pesticides are not readily available from State markets. In response to the deficit in supply, farmers changed their land-use patterns, exchanged goods on unfavourable terms in the open market, or even reduced their inputs.

Limited Technical Support

In the mountain areas of West Sichuan, the technical support system was established during the period of the 'People's Commune' and was organized on a collective management basis. After 1978, the responsibility system was introduced. Decentralized management in production made the technical services more complex. Unfortunately, since the establishment of the Responsibility System, the technical support system in mountain areas has not kept up with the changing production system. The main problems are the lack of technicians and the lack of increasingly diversified support.

In LDFS, hybrid animals were introduced during the "People's Commune" period and proved to be productive even though keeping hybrid animals needs special facilities. During that period, collectives managed their livestock in herds according to the kinds of animal kept, and technical support was relatively easy to procure. After the responsibility system, because livestock were divided among individual households, the need for technical support increased and procurement became more complicated. Since farmers could not handle the new facilities and could not receive sufficient support, the composition of hybrid livestock in the farming system shifted from yak/sheep-dominated to yak-dominated. About 60 per cent of the households (in the survey village) were outside of the animal disease control system of the region.

In HDFS, farmers are enthusiastic about planting fruit trees and introducing new species, but, without appropriate technical guidance, the types of disease and pests increased from two, in 1978, to six, in 1988. In CDFS, farmers would like to plant hybrid paddy and to use small farm machines, but owing to the fact that most of the farmers are not provided with technical services, they are restricted to planting native species for which they can use and depend upon manual labour.

In dealing with the limited support system in mountain areas, farmers first choose traditional methods to avoid any possible risk. Low technical requirements and low-input activities are preferred. To improve the technical level is their second choice only. For example, in HDFS, several farmers' associations have been established recently. Farmers exchange knowledge, learn new techniques through demonstration activities, and, most important, acquire outside linkages.

Constraints Typical of Different Farming Systems

Besides the constraints common to each farming system, there are some typical constraints to different farming systems which are closely related to local conditions, production management, and policies adapted in the area. These typical constraints and their implications are shown in Table 18.5.

LDFS are usually located in the high mountain (plateau) and remote areas. Geographically, these areas are far away from the developed regions. For example, the distance from Hong Yuan County (area of the case study) to Chengdu City (the capital of Sichuan Province) is more than 900 km. Normal transportation needs three to four days by road. During the rainy season, landslides often block the roads for days or even months. Socioeconomically, LDFS areas are inhabited predominantly by minority groups. The historical development process, traditional culture, and the standards of living of the local people vary from those of the *Han*, and there is a big difference in methods of production and consumption. Due to remoteness and separation, LDFS are relatively isolated.

In terms of the local marketing system, LDFS areas are underdeveloped in the following ways:

- there are no regular markets in the area,
- terms of exchange between livestock products and industrial products are unfavourable,
- the State market, which is the major source for the local market, is quite far away,
- items available in the State markets are very simple and are not appropriate for production needs or for daily necessities, and
- the necessary inputs for livestock production are normally not available in the markets.

Lack of proper marketing systems in LDFS areas restricts the development of production. The rapid increase of livestock numbers and low rate of commodity production

Table 18.5. Constraints typical of different mountain farming systems

Constraints	Mt. Specificity	Implications	Response
Constraints typical of livestock-dominated farming systems			
Backward marketing system	Inaccessibility	* isolation from main stream * high transport cost * unfavourable exchange terms * low mobility	* self-sufficiency oriented production * collective trading exchange * dry processing * butter making
	Fragility	* slow circulation * limited production options	
	Adaptation mechanism	* land-use pattern activity choice * lack of incentive	
	Marginality	* marketing mechanism	
Constraints typical of horticulture-dominated farming systems			
Widespread pests and diseases	Inaccessibility	* poor market access	* traditional method * use of marginal land
	Fragility	* vulnerable to disease * instability of production	* mixed cropping * storage of food grain
	Marginality	* poor exposure * isolation from outside	* farmers' research association * collective foundation
	Adaptation mechanism	* activity choice * mixed source of income * risk adaptation	* invite technicians from outside * outside learning
Constraints typical of crop-dominated farming systems			
Unfavourable pricing system for grain production	Inaccessibility	* unfavourable terms of exchange	* off-farm employment
	Fragility	* limited production options * no incentives for land use	* reduce grain crop cultivation * selling grain to outside market
	Marginality	* marginal land * focus on subsidy	* reduce input on land * dryland farming to reduce risk
	Adaptation mechanism	* tendency to look for short-term gains * land use pattern * mixed source of income * risk adaptation * multi-cropping	

Source: Study team

(leading to grassland degradation) are partly caused by the lack of access to markets. In response to the limited marketing support system, mountain farmers adapted two kinds of strategies, namely the passive approach and the positive approach. In the passive approach, farmers manage their production not for commercial purposes but for local consumption. In the positive approach, farmers manage collectively and produce for the market, e.g., groups of farmers collect their livestock together and select representatives to sell the livestock. In addition, methods such as the rough processing of meat (as well as livestock hides and wool) and dairy products are also undertaken by most households. Low-weight, high-value products are preferred.

In HDFS, the lack of pest and disease control is the major constraint to production. In recent years, the number of pests and diseases has increased rapidly and this has affected the stability of production and the quality of fruit products. The reasons for the increase in pests and diseases are:

- the limited supply of pesticides and agricultural chemicals,
- the inadequate methods of control,
- the low quality of pesticides available in the local market, and
- lack of technicians to supervise pest/disease control (there is only one technician in the county for horticultural development and the approach to pest and disease control is decentralized).

Traditionally, the farmers rubbed limes on the branches of trees to protect them from pests and diseases. In the case of a serious disease, the farmers used to cut and burn down the trees. Recently, the farmers invited experts from outside the area and organized training courses in horticultural techniques through the farmers' association for horticultural development.

In CDFS, unfavourable pricing systems for grain products do not encourage the farmers to be more productive. Under the regional plan, CDFS areas (normally in the broad valley basins) are designated grain production bases. At the regional level, this programme aims to fulfill the regional needs for cereal crops. In doing so, the local government established a quota system for households for the planting of cereal crops. In comparison to the market-pricing system, the price of grain is lower than the prices of other kinds of crops, while the productivity of grain crops (in weight) is generally lower than that of other crops (e.g., fruit, cash crops). Although the local government provided some subsidies for grain production, farmers still feel that they lose out by cultivating grain. As a matter of fact, the climatic conditions and soil conditions in the area are suitable for vegetables, fruits, and many other cash crops. Overemphasis on grain cultivation without an appropriate adjustment in the pricing system will neither result in optimum use of the resource base nor encourage farmers to support the regional plan. When restrictions were placed on their farming choices, farmers in CDFS areas responded by decreasing their grain producing areas and by reducing input in grain crops, as long as they could harvest enough grain for their own consumption and for land revenue. Those farmers having surplus grain prefer to sell it outside the region where grain prices are higher.

Potentials/Possibilities of Mountain Farming Systems

The potentials/possibilities for mountain farming systems in West Sichuan are diversification, specialization, and productivity as shown in Table 18.6.

Table 18.6. Potentials/Possibilities of mountain farming systems in West Sichuan

Constraints	Mt. Specificity	Implication	Response
Diversification of production	Diversity	* resource base * production flow * management * zonal perspective * choice of production * sources of income techniques * high-value crop * suitable species * indigenous methods	* ensuring the basic needs * income-oriented approach * sectoral linkages * cooperatives * crop substitution * off-farm employment * kitchen garden cultivation
Specialization	'Niche'	* high-value crop or plant * resource availability * demand from outside market * favourable climate * zonal perspective	* use of marginal land * inter-cropping * collective management * incentives to adopt new techniques * specialized households
Productivity	Diversity	* climatic difference * land types or forms * multi-layer cropping	* market- oriented production * ensure the basic needs
	'Niche'	* high-value crop * local varieties * seasonal availability	* change land- use pattern * collective management

Source: Study team.

Conclusions

According to the case study, we can conclude that farmers' strategies in mountain areas are essentially based on a number of specific principles.

Ensuring Basic Needs (Self-reliance, Self-consumption)

Food, fuel, and shelter are the basic needs of the people. In mountain areas, these basic needs depend largely upon the natural resources and sources of income. To ensure the basic needs, mountain farmers manage their land resources by diversified activities and close linkages with different sectors in production (Figs. 18.1, 18.2). Generally speaking, the availability of basic needs affects the production process (inputs on land, improvement of techniques, allocation of farm labour, etc.).

Avoidance of Risk to Safeguard Basic Needs

Mountain environmental conditions are relatively fragile; natural hazards occur more frequently than in the plains. To reduce the impact of natural hazards, mountain people developed indigenous methods of managing land and resources. These involved both individual and collective efforts.

Frequent changes in policies placed the development of mountain agriculture at risk. This resulted in many short-term gain activities which pushed mountain farming systems towards unsustainability. To respond to policies and programmes, farmers adopted positive or passive approaches to protect their interests. Reliable policies and continuity in land ownership (including the right of making decisions about land use) will help in long-term development.

More Options to Generate Income

For a long time, mountain areas did not keep up with the development level of the plains. Because of this, mountain poverty hampered the sustainability of mountain farming systems. It is understandable that farmers should want to adopt an income-oriented strategy. There is no doubt that there are many options for the use of mountain resources; linkages between mountain agriculture and the mainstream of development are also important.

Suitable Techniques

Due to the high rate of illiteracy among mountain populations, the deficiency of the support systems, the fragmentation of lands, and poor infrastructure, mountain agriculture is not suitable for large-scale/high technology farming. Instead, low-input, small-scale, and easily handled techniques are more acceptable. Looking at it from this perspective, it is easy to see that many programmes failed in the mountain areas because planners did not analyse the feasibility of their plans in the context of specific conditions of mountain areas.

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FARMERS' STRATEGIES IN THE MIDDLE HILLS OF NEPAL

S. Shrestha and B. Katwal

Sugandha Shrestha is a member of the professional staff of the Mountain Farming Systems Division of ICIMOD and Bhimendra Katwal is an economist associated with APROSC

CONTENTS

INTRODUCTION

Background

Operational measures adopted by mountain farmers in Nepal have evolved successful resource management and production practices within relatively harsh environmental and socioeconomic conditions. Specific features of mountain areas, such as inaccessibility and diversity, both in topographical and climatic contexts, present formidable challenges. Over the centuries, mountain farmers have made a succession of adaptational responses to the mountain environment through the development and adoption of indigenous technologies and specific strategies. Terraced cultivation is an outstanding example of ethno-engineering. With the passage of time, increased pressure on the limited parcels of land available for agriculture, exerted by a rapidly increasing population, led to severe stress on the fragile environment. Environmental degradation has become a key concern in the search for sustainable development strategies in the mountain areas of Nepal. Of late, several negative changes relating to resource status, production flows, and resource management have been observed. They are often attributed to disregard of specific mountain conditions by public and private intervention agents in mountain areas. Farmers' strategies and responses to changes fall into the latter category.

The sustainability implications of farmers' strategies and responses need to be evaluated within the framework of mountain specificities such as inaccessibility, fragility, marginality, diversity, 'niche', and human adaptation mechanisms. Since many traditional resource management systems were compatible with their environment, it is important to examine these systems, as well as the changes in the responses of mountain farmers over time, in the light of development interventions such as improved accessibility and new technology. Such an assessment will provide a basis for evaluating the positive and negative effects of such changes on the sustainable development of mountain agriculture.

Focus of the Paper

This paper examines the quantitative dimensions of the mountain perspective. This was achieved by analysing the farming systems dominated by crops, livestock, and horticulture, in the light of their responses to the mountain specificities outlined above, in order to assess the relevance, effectiveness, and sustainability implications of farming strategies within these mountain conditions.

DESCRIPTION OF THE STUDY AREAS

Three out of four study areas were chosen from the Central Development Region (CDR); including one (Yelung) from Janakpur Zone and two (Bhadaure, Ekle Gaun) from Bagmati Zone. The fourth (Deupur Tapu) was in Gandaki Zone of the Western Development Region (WDR) (Annex 1).

Bhadaure village consists of about 100 households located east-west of Naubise bazaar which is two kilometres away. The bazaar is at the junction of two major highways (Tribhuvan, Prithvi) connecting Kathmandu with the *Terai* and the Pokhara Valley. The distance between Naubise and the capital is only about 30 km. The *Ekle Gaon* site is east of and about three hours' walk from Bahrabise, a commercial centre located 86 km northeast of Kathmandu Valley. The Arniko Highway, which links Kathmandu and Tibet, passes through Bahrabise. *Yelung* is six kilometres away, located to the east of Jiri bazaar which is connected by an all-weather road to Kathmandu. Development institutions are the government livestock centre, the Agricultural Development Bank, and the Nepal Food Corporation. *Deupur Tapu* is about 10 km from the Parbat District headquarters—Kushma; Lumle Agricultural Centre is nine kilometres from the village. The village is close to the main trekking route from Pokhara (about 40 km away) to Jomsom.

The total number of farm households for each cluster, representing each study site, are estimated at 100, 140, 130, and 70 for Bhadaure, Ekle Gaon, Yelung, and Deupur Tapu respectively.

MOUNTAIN PERSPECTIVE

The mountains are different from the plains due to the presence of certain typical characteristics or conditions of the former. These characteristics create certain adaptations and activities and permit long-term exploitation of resources; concurrently the same characteristics restrict the extent of adaptations and activities. The negative implications associated with the activities restricted by the mountain characteristics also damage the potential benefits ensuing from unrestricted activities. Therefore, a knowledge of mountain characteristics is important for handling the mountain areas in a sustainable manner. Keeping this in mind, the important mountain characteristics of the study areas have been identified and discussed in the subsequent sections.

Mountain Characteristics or Specificities

The important conditions characterizing mountain areas, which for operational purposes separate mountain habitats from other areas, are referred to here as ''mountain specificities'' (Jodha 1990). The prevelant features of the specificities or characteristics (inaccessibility, fragility, marginality, diversity, 'niche', and human adaptation mechanisms) in the study areas are briefly discussed below.

Most of the study areas are remote and are not easily accessible by road. The permanent market centres are far away from the villages. To compensate, there are temporary markets (locally know as 'hath bazaar') in the areas which take place, at the most, once a week. Poor communications and poor mobility are the general norms of the study areas. Therefore, the areas are *inaccessible* in terms of both physical and socioeconomic dimensions. High altitude, steep slope, and coarse and loose soil types, accompanied by high precipitation with skewed distribution patterns, have made the study areas more vulnerable to stress. The increased population pressure and high density of livestock have aggravated resource degradation, and this can be seen by the decreased size of forests and pasturelands as well as the denuded condition of the pasturelands due to overgrazing. The altitude of the study areas ranges from below 1,000 m to over 2,400 m. In addition, cultivation has extended on to lands having 30–45° slopes. These circumstances make the areas very *fragile*.

In this context, marginality appears to be the most important characteristic from the point of view of constraint, and this is followed by *diversity* and *fragility*. In the Naubise study area, inaccessibility has been rated as the weakest constraint, whereas the same characteristic is the greatest constraint in the Yelung and Deupur-Tapu study areas. The underlying characteristics of each mountain specificity not only are interrelated in many ways, but, within the mid-hills of Nepal, show substantial variability. The same applies to the potential of human adaptation mechanisms, which appear to be the most important specificity in Naubise and Dhuskun areas, as is diversity for Yelung and Deupur-Tapu. As far as diversity is concerned, its underlying characteristics result in constraints as well as potentials.

HANDLING OF MOUNTAIN SPECIFICITIES

With consummate or partial cognizance, or even without intention, both individual/private (farmers) and public (government) interventions seem to have responded to the above mountain characteristics. These responses either adapt to or modify the characteristics (specificities) through various operational measures (Table 19.1). The implications of the response can then be realized either in the form of an improved environment or a degraded one depending upon the compatibility or discord between the responses and mountain characteristics. This section focusses on the ways and means through which both the farmers, at micro-level, and the government, at macro-level, are handling mountain specificities in terms of both constraints and potentials.

Responses to Mountain Specificities as Constraints

Inaccessibility

Inaccessibility has created certain conditions that are generally characterized by poor mobility, high transport costs, poor communication and educational facilities, and so on. These conditions have then led to subsistence agriculture which is seen in all the study areas apart from Naubise. The latter is slowly being transformed into a commercial farming centre (on a limited scale) through the cultivation of vegetables, due to the presence of relatively better physical and other institutional infrastructure (Annex 1, Table 19.1). Inaccessibility appears to be the most prominent mountain characteristic, in the form of a constraint, at Yelung and Deupur Tapu. To offset high transport costs, farmers have emphasized the production of high-value low-weight agricultural products; ghee processing at Yelung and radish seed production at Deupur-Tapu are examples. Ghee sales alone account for 80 per cent and 30 per cent of the total farm and the total household income in Yelung. Farmers also cultivate mustard as a high-value cash crop, and this is a major source of cash income (22% of the total farm income) in Dhuskun. Due to poor communications, information (agricultural research and extension), and high transport costs, the people of Yelung have resorted to the use of local cultivars and traditional management practices. Farmers do not use chemical fertilizers, and dependency on external input supplies is almost non-existent. Because of the closed system, created by inaccessibility, there are strong linkages among the three important components (e.g., crops, livestock, and forestry) of the mountain farming system. Unlike in Naubise, where farmers obtain seeds, fertilizers, and agro-chemicals from outside, the people of Yelung and Dhuskun acquire all their inputs from their own farms although these inputs may not

Table 19.1. Farmers' responses to mountain specificities as constraints

Farmers' responses to mountain specificities	Unit	Study areas Naubise	Dhuskun	Yelung	Deupur-Tapu
Inaccessibility					
proportion of HH exchanging labour	%	90	95	50	85
proportion of HH sharing agri. tools and other implements	%	80	90	50	80
composting vs. fertilizer	ratio	1:2.22	1:0.35	1:0.0	1:0.49
local improved seeds	ratio	1:3.86	1:0.19	1:0.17	—
income (of total farm cash income) generated by oil seed, radish seed production	%	1	22	—	—
HH involved in ghee-making,	%	60	60	50	50
area under improved crops (of total operated land)	%	80	16	15	—
Fragility					
level terrace	%	97	95	95	94
sloping terrace	%	3	5	5	6
level terrace with bunds	%	40	30	—	93
level terrace without bunds	%	60	70	100	7
total no. of trees (e.g., fruit,	no./HH	118	19	96	65
fuelwood, fodder, timber)	no./ha	122	28	343	93
area (of total cropped area) under minor crops (e.g., millet, buckwheat, barley)	%	4	57	27	—
under millet with maize	%	4	57	19	—
area under monocropping	%	37	29	69	10
area under double-cropping	%	61	> 1	23	78
forest plantation	ha	50	130	—	5
adoption of improved stoves (of the total HH)	%	20	—	—	—
the present stall-feeding practice (% of total feed)	%	90	80	50	—
increment in stall-feeding over the last 30 yrs or so)	%	100	80	20	—
area under slash and burn cultivation (*bukma* system)	%	—	—	5	—
Marginality					
increased cropping intensity by farm size					
marginal	%	—	186	107	—
small	%	175	170	123	—
medium	%	182	182	116	—
large	%	157	158	—	—
plantation of fodder tree by farm size					
marginal	No./ha	—	10	250	—
small	cult. land	131	13	90	—
medium	cult. land	105	25	292	—
large	cult. land	82	23	—	—

income from high-value cash crops (% of total farm cash income)	%	1	22	—	10
off-farm income (% of total income)	%	45	97	65	40

Source: APROSC 1990 and Katwal and Shah 1990.

be sufficient. This situation is manifested by the high level of improved seed use and of fertilizer application in Naubise and the low level in Dhuskun and Yelung (Table 19.1).

The government has attempted to modify the inaccessibility by constructing a road from Kathmandu to Barahbise, which is four to five kilometres away from Dhuskum, and to Jiri, six to seven kilometres away from Yelung; Deupur-Tapu is about 40 km away from the road. However, apart from Naubise and Deupur-Tapu (to some extent) none of the study areas have easy access to good information services (agricultural extension and support services). The construction of mule tracks at Yelung and the installation of wooden bridges over small rivers are also examples of farmers' attempts to modify inaccessibility.

Fragility

The conditions created by fragility include the vulnerability to degradation of the natural resource base. In this context, the farmers, particularly in Dhuskun, have responded by constructing a long (over 1,000 m) series of uninterrupted and quite stable terraces having 35° slopes. This demonstrates an attempt to convert fragility into infragility (or less fragility). In general, terrace farming is an established norm of crop husbandry, and over 95 per cent of the total area is under level terraces in all the four different study sites. In addition, farmers have adapted to this mountain characteristic by means of several operational measures. Among these, the plantation of perennial crops on private land is increasing in all areas; at present about 100 to 300 trees per hectare of different types (fruits, fodder, fuelwood, and timber) have been grown in Naubise, Deupur-Tapu, and Yelung.

In an effort to increase national revenue through better management of the forests, the government nationalized the forests and pasturelands during the 1950s. Contrary to the objectives, forest encroachment and destruction reached its peak following this measure and more land became barren and degraded, i.e., without or with little vegetation. The Panchayat Government made a provision for Panchayat Forests (PF) and Panchayat Protected Forests (PPF). This approach may be considered to be a process for modifying fragility. It is no exaggeration to say that farmers have responded more positively to measures to prevent the degradation of forests and pastureland through different operational measures. Fodder and fuelwood have been planted in degraded forest areas in Dhuskun, bamboo trees within the protected forest areas in Deupur-Tapu, and improved stoves are used, although on a limited scale, in Naubise. About 20 per cent of the total sample households used improved stoves. In addition, there has been an increase in stall-feeding practices in all study areas.

Over the last 30 years, it is estimated (based on key informants) that the rate of stall-feeding has increased by 20 per cent (at Yelung) to 80 or even 100 per cent (at Deupur-Tapu and Naubise). Despite the population growth and its increasing demand for food, cultivation practices which help degradation are still intact in some parts of the middle mountains of Nepal, for example, in Yelung (Table 19.1).

Marginality

The poor resource base in terms of poor human resources (e.g., low literacy rate), as well as poor land, forests, pastures, and a weak institutional base are the causes of marginality. Farmers have converted marginal, sub-marginal land and even forests into cultivated land in order to meet the growing demand for food. Although there is no strong spatial evidence, the study findings indicate that marginal or small-scale farmers are most likely to have intensified crop production. The cropping intensities of marginal and small-scale farmers are higher by about 10 to 20 per cent than those of large-scale farmers (Table 19.1). This is an example of farmers' strategies in response to mountain characteristics (e.g., marginality) and the increased total of production permitted by marginality. However, this approach has increased the fragility of agricultural land and the degradation of the natural resource base owing to the low level of input into the maintenance of soil fertility. Overextraction from forests and pasturelands is also evident, although there is now an emerging trend towards planting fodder and other trees on private land. As the forest/pasture resources and land productivity declined, farmers began to resort to off-farm activities in order to supplement their incomes. This is evident from the fact that almost all cash income (97%) in Dhuskun, where the majority are marginal farmers, now comes from such off-farm activities (Table 19.1).

Diversity

Diversity is probably the only mountain characteristic that has appeared in the form of both constraints and potentials. This section will deal with constraints.

The higher cost of production of agricultural, livestock, and other products may be the single important constraint that this mountain characteristic has caused. One of the major disadvantages associated with diversity is the low replicability of a given technology. Farmers have evolved various strategies to deal with this circumstance also. In order to avoid a higher cost of production, people use those crops that require only low level and local inputs. An increased use of compost and local seeds are responses to both diversity and inaccessibility (Table 19.1). This has been reflected in the cultivation of millet over a large area (e.g., 60% and 20% of the total cultivated area in Dhuskun and Yelung).

Responses to Mountain Specificities as Potentials

Some of the dimensions of mountain specificities offer unique opportunities for harnessing potentials in a way that permits optimal use of the available natural as well as human resources. Diversity, as a specific characteristic, does not merely act as a constraint, since it also creates diverse opportunities in farm and off-farm sectors through crop diversification, crop-livestock integration, and various off-farm activities. The mountain areas are also endowed with what may be called micro-'niche' for the production of cereals, cash crops, horticultural crops, livestock raising, off-farm activities, and hydropower generation. The harnessing of such 'niche', however, is dependent upon a set of preconditions which include physical (climatic and edaphic), biological, sociocultural, and institutional aspects. These preconditions are affected by prominent mountain specificities acting as constraints. For example, inaccessibility, as a constraint, limits the scope for effective input and service delivery mechanisms which could be preconditions for harnessing a potential 'niche'. The human adaptation mechanism is another mountain specificity acting as a potential. The mountain farmer has not only devised various operational means through adaptation to mountain characteristics but has also been able to modify mountain characteristics through his ingenuity.

The development potentials created by diversity and the mountain farmers' responses to these opportunities, together with the interventions from the government, have been shown in Table 19.2.

Harnessing the Diversity of the Resource Base

Table 19.2 shows that farmers in all the four study areas have adopted diverse crops, which include cereals (6 types), vegetables (5—8 types), and fruits (2—10 types), in response to the varied micro-climatic variations that enable the cultivation of various types of major and minor crops. Similarly, the production of various plant materials, such as fodder (5—10 types), and fuelwood (5—10 types), on private and public land was observed to be an important indicator of farmers' responses. With limitations on the access to forest resources, following establishment of the protected forests, there has been a growing trend towards the planting of fodder and fuelwood trees on private land. A closely integrated crop-livestock farming system was observed at all the study sites, the integration being high in Dhuskun and Deupur-Tapu and low in Yelung and Naubise. The reason behind low integration in Yelung is the unfavourable climate for crop production, and thus livestock farming is very prominent in the area. By contrast, the farming system in Naubise has undergone a transformation from cereal to vegetable production due to the presence of very favourable market forces and due to the fact that the area is completely lacking in grazing land; the forest is also quite far away, degraded, and under the control of the government.

Off-farm activities were observed to be important contributors to both household cash income and employment. Various types of cottage industries (ghee-making, carpentry, bamboo work, metal work, and weaving), business, remittances from family members, wage labouring, portering, and working as guides for mountain tourists are the main off-farm activities.

Public interventions to harness diversity have emerged in the form of the emphasis on horticultural crops in the mid-hills and livestock keeping in the high mountains. However, there has been less emphasis on minor crops. The emerging concept of farming systems research, as implemented in Deupur-Tapu, is an important initiative in the mid-hills. The support to livestock development programmes, through the establishment of the cheese factory at Yelung, is an example of the right kind of public intervention to enable the optimal harnessing of comparative advantages in a relatively inaccessible area in the mountains.

Resource Modification and Upgradation

It is observed that mountain farmers have been able to modify several mountain characteristics (acting as constraints) through generations of endeavour by taming the difficult terrain through terracing and through the development of formal and informal organizations responsive to the needs of development. There have also been adaptations

Table 19.2. Responses to diversity as a potential

Responses	Farmers	Governments
1. *Farm activities*	1. *Use of multiple crops*	1. Emphasis on major cereal crops
— crop diversification	— major crops (maize, wheat, paddy, potatoes)	2. Focus on horticultural crops
— production of various types of plant materials	— minor crops (millet, barley, buckwheat)	3. Emphasis on livestock in high hills (Y)
	— vegetables (5–8 types), fruits (2–10 types)	4. Emerging concept of farming systems research (DT)
— crop-livestock integration		
	2. Fodder (5—10 types), fuelwood (5—10 types), timber (4—8 types), tree plantations on private and public land	
	3. Adoption of integrated crop-livestock farming D, DT— high integration Y, N— low integration	
1. *Off-farm activities*	1. Ghee making (N, Y, DT)	1. Establishment of cheese factory (Y)
— cottage industry	2. Carpentry, bamboo work (D, Y, DT), metal work (D)	
— quarrying (Y)		
— remittance		
— business	3. Weaving (Y)	
— wage labour + portering		
— tourist or expedition guide		

Note: N = Naubise; D = Dhuskun; Y = Yelung; DT = Deupur-Tapu.

Source: APROSC 1990 and Katwal and Shah 1990.

through operational strategies and measures that have enabled mountain farmers to cope with constraints on the one hand and harness production potentials in a sustainable way on the other.

Fragility, which is a unique mountain specificity, has been largely modified through terracing. At all four study sites, cultivation is based on terraced farming and more than 90 per cent are level terraces. The development of community organizations to improve resource management is evident in the form of vegetable growers' associations and alpine pastureland users' groups. These offset some of the disadvantages of inaccessibility and marginality. In terms of human adaptations to mountain characteristics, an important operational measure is the widely adopted practice of sharing private resources, e.g., exchange of labour, and the sharing of draught power, implements, and petty trading activities.

Exploiting 'Niche'

The production pattern followed by some of the farmers demonstrated a gradual transformation towards the exploitation of 'niche'. Such transformations are widespread in the case of Naubise where a transition is taking place from a crop-based to a horticulture-based farming system. The close proximity of Naubise to Kathmandu and accessibility by road has facilitated the harnessing of a 'niche' for commercial vegetable farming. Intensive cultivation practices, indicated by the proportion of double cropped areas, are evident in Naubise (61%), Dhuskun (71%), and Deupur-Tapu (78%) as shown in Table 19.1.

Because the 'niche' of the Yelung area lies in livestock farming, farmers maintain a greater number of animals (livestock units—LSU) per household (7.4 LSU) than in Dhuskun (2.7 LSU), Deupur-Tapu (3.4 LSU), and Naubise (4.2 LSU). This is the reason why farmers in the area derive almost all (98%) farm cash income from livestock.

In Yelung, a large proportion (70%) of the cultivated area is monocropped, and this is basically due to the climatic conditions prevailing in the area.

An important response in the inaccessible area of Deupur-Tapu has been the adoption of low-weight and high-value cash crops (radish seed production) by the farmers in response to the technology, inputs, extension, and marketing services provided as an integrated package by the Lumle Agricultural Centre (LAC). Now about 10 per cent of the total farm cash income comes from selling radish seeds alone. Sale of oilseed (e.g., mustard) fetches about 20 per cent of the total farm cash income in Dhuskun. The successful adoption of radish seed cultivation in Deupur-Tapu shows the positive response of mountain farmers to development interventions that are based on recognition of mountain specificities.

Sectoral Interlinkages

Diversified and interlinked activities, as reflected through farming-forestry linkages, are an important feature of farming systems in all the study areas. The extent of interlinkages and their gradual weakening, due to increased pressure of population and the side effects of commercialization and modernization, were documented in the study villages. These issues have not been covered by this paper as they have been fully discussed in the paper by Yadav (Chapter 6), in this volume.

SUSTAINABILITY IMPLICATIONS

Farmers' Responses

This section is devoted to the implications of responses to the mountain characteristics (discussed in the previous section). Regarding the improvement or deterioration of mountain agriculture in particular and the environment in general, if improvement leads to sustainability[1] then deterioration leads to unsustainability. This will be examined, based on the positive and negative changes that have taken place over the last two or three decades. Hence, each of the four farming systems, namely, horticultural crop-based at Naubise, cereal crop-based at Dhuskun, livestock-based at Yelung, and crop and horticultural farming at Deupur-Tapu, were examined based on the positive or negative changes.

Negative Side Effects

Concerning the widespread negative changes, the crop-dominated farming system is apparently the most critical area in terms of unsustainability. Not only has the production flow (or extraction rate) been seriously affected (since the crop yields and biomass supplies are declining) but the resource base itself has been greatly damaged. Unlike Yelung, all marginal and sub-marginal lands have been brought under cultivation in Dhuskun. The cropping intensity is already considerably high (172%). Due to the lack of soil nutrients, stones and rocks have begun to surface on cultivated land. The supply of compost materials, from both private and public land, and manure from livestock have decreased significantly over the past 20 to 30 years. Due to inaccessibility, farmers cannot replace these with chemical fertilizers despite heavy subsidies.

Nor is the situation of Yelung encouraging either. The sustainability matrix (e.g., production flow, resource base) has been affected by degradation. Because of declining crop yields and population growth, per capita foodgrain production has declined. Therefore, more than one-third of the total foodgrain supply now comes from outside, i.e., through the Nepal Food Corporation branch office located at Jiri.

The time interval between one cultivation of the plot to another in connection with the *bukma* (or shifting cultivation) system has been shortened now to three to five years from six to seven years, and this method is still widely practised. The presence of this extensive cultivation practice may also be an indication that the farming conditions in Yelung have not deteriorated, although it has been realized that the resource base itself is under strain. Because the area under forest and the alpine pastureland is steadily decreasing, over time the genetic biodiversity has been reduced due to the fact that some of the nutritious grasses and fodder tree species are slowly disappearing. Goat flocks and chauri or yak herds are vanishing. Biodiversity, which is one of the important elements of sustainability, is dwindling, and this may lead to unsustainability in the long run. Some negative changes have also taken place in terms of water resources. Water mills (ghatta) that used to run almost throughout the year in the past now run for only eight to ten months. The present open and haphazard grazing practices on alpine pasturelands

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1 Sustainability is the ability of a system to maintain a certain well-defined level of performance (output) over time, and, if required, to enhance the same, including linkages with other systems, without damaging the ecological in tegrity of the system. Sustainability is a dynamic rather than a static concept (see Jodha, Chapter 2).

and meadows will only lead to deterioration of the resource base and this has already been observed in some areas where there has been overgrazing. This seems to have happened because of the public intervention when the resource base was nationalized. However, farmers have now recently begun to manage the pasturelands and meadows through community management systems and this is a sign of sustainability.

The farming system depends on the local resource base in Yelung, an indication of sustainability, particularly in remote areas. Similarly, the natural resource base is not degraded as in the Dhuskun area. However, the presence of some negative changes will lead to unsustainability unless public policies and programmes compatible with mountain characteristics intervene to halt the process.

The farming system at Naubise has dramatically changed from being cereal crop-based to being horticultural crop-based over the past 10 years or so. Fruit and vegetable farming are becoming increasingly popular in the area, and this is bringing several positive changes to the system. Such changes include the increased level of nutrition of the people and the accumulation of assets (e.g., buying more land for cultivation and purchasing improved breeds of animals). This is all happening due to increased crop yields and fruit and vegetable production.

Weakening of Linkages

Despite the fact that linkages with one of the vital components of the farming system—forestry—have broken down to a great extent, the horticulture-dominated farming system is the most promising among the three systems studied. This is due to the presence of strong market forces which are supplementing or even replacing the forest biomass required for compost with chemical fertilizers, accompanied by improved farming practices and the planting of fodder and fuelwood trees on private land.

Dependency on forests is highest in Yelung and lowest in Naubise. Almost all the biomass required for crop production and livestock keeping comes from private land in the latter area. This has enabled farmers to practise stall-feeding. The situation has, in fact, brought some positive changes even in herd compositions. Farmers have begun to replace cattle with buffaloes which are more productive animals. Over the last two decades the buffalo-cattle ratio for a herd in Naubise has been improved by about 25 per cent in favour of buffalo. The ratio now is estimated to be 1:2.02 as opposed to the previous ratio of 1:2.66. Due to the increased level of fodder production, the intensity of stall-feeding is very high. Almost all of the total feed supply comes from stall-feeding. Even the firewood and fuelwood supplies from the farms are now quite substantial.

Some negative changes have also taken place, however. Nearby forests and grazing lands have been converted into cultivated land. Fragmentation of land is increasing, mainly due to population pressure, and the size of each parcel of land has been reduced (see Annex 2, Table 2). The volume of water in each kuwa (small well) has been decreased by almost one-third during the last three decades, although the same number of kuwa are still in existence. However, the changes in the resource base are generally positive and encouraging (Table 19.3).

Positive Changes

Similarly, some changes in production flow and utilization/management practices have been realized. The increased application rate of chemical fertilizer (from zero to

Table 19.3. Dominant characteristics of changes over time as indicators of sustainability and unsustainability in mountain agriculture

Dominant characteristics	
Sustainability	Unsustainability
1. Increased area under perennial crops (e.g., fruits, fodder, fuelwood trees)	1. Increased rate of converting marginal, sub-marginal land for cultivation
2. Decreased level of herd size	2. Extended land cultivation practices on steep slopes
3. Replacement of cattle by buffaloes	3. Reduced size of parcels and increased amount of land fragmentation
4. Increased rate of stall-feeding practices	4. Encroachment on forest, grazing, and pasturelands
5. Increased area under cash crops (e.g., oilseeds, vegetable seeds, and fresh vegetables)	5. Increased time for fetching water, fodder, fuelwood, and other plant materials
6. Increased level of biomass production on private land	6. Reduced level of compost and manure application
7. Improved management of natural resource base (e.g., forest, pastureland) through community participation	7. Increased use of chemical fertilizers
	8. Declining trend in crop yields
	9. Increasing process of marginalisation (differential access to credit, widening hunger gap, increased proportion of landless and marginal farmers)
	10. Reduced level of biodiversity

Source: APROSC 1990 and Kanwal and Shah 1990.

94 kg of nitrogen per ha of cultivated land in Naubise within two decades) and the use of agro-chemicals for storing grains are encouraging. Due to this external input supply, intensive cultivation practices (e.g., multiple cropping) are becoming more and more feasible (Table 19.1). Keeping in mind the population pressure, intensive cultivation practices are considered to be necessary. However, this option can be debated, particularly in mountain areas, because of the consequent high intensity of resource use. This practice could be feasible in the future as the supply of inputs (e.g., improved seeds, fertilizers, agro-chemicals, and support services) appears to be guaranteed and sustainable, because the Naubise area is not only accessible but also exposed to new agricultural technologies. Moreover, the largest market (Kathmandu Valley) in Nepal is just 30 km away from the study area.

Many of the changes taking place in Deupur-Tapu have positive implications in the context of sustainability. The increased production of biomass from private land can be expected to improve sustainability, especially when the extraction rates of fodder and compost materials from the forest have declined; and this is partially due to depletion as well as to the restrictions placed on protected forests. The tendency to plant fruit and fodder trees on private land has increased. The increased area of land under tree crops has the potential to reduce fragility. New cropping patterns, especially those in which leguminous crops are introduced, are a positive change which will help to improve the condition of the soil. Lentils broadcast on standing rice crops, just before harvest for instance, require no tillage and no additional labour at a time when farmers are busy harvesting rice. This type of practice (which is increasing) will certainly help to minimize fragility.

The other positive changes have been realized through the improved situation of food supplies due to increased crop yields. Cash income also has increased because of increased ghee production. On the other hand, this has caused more dependence on external inputs, especially chemical fertilizers, particularly for vegetable production and for the production of cereal crops. The sustainability of this practice is debatable because of the inaccessibility of the area. Timely availability of fertilizers and agro-chemicals is a problem commonly faced by the farmers in Deupur-Tapu, although there are institutional facilities (e.g., a cooperative) nearby. The present marketing and input supply problems may improve once the proposed road linking Pokhara and Baglung (which passes close to the village) is completed. In this context, vegetable seed (e.g., radish) production and sale provide an important source of cash income (10 per cent of the total farm cash income) and is the right kind of response to inaccessibility.

Unfortunately, the forestry-farming linkage, which is one of the vital elements of sustainability, is weak in this area.

Development Interventions

Negative Side Effects

The discussions in the previous section indicate that farmers' strategies or responses have brought both negative and positive effects and changes in the agricultural production patterns which directly influence the livelihood of mountain people. The strategies and responses that have evolved over the time period examined are due to two factors. The first involves their understanding of mountain characteristics and adaptations, and the second involves exogenous forces (e.g., population pressure, technology innovations, and other public interventions) that heavily affect the farming system. The second set of factors is beyond the farmers' control. Nationalization of the forests, for example, led to the disintegration of the community resource management system, and, consequently, the degradation of forest/pastureland because of haphazard use and lack of protection. Unlike in the past, villagers retained no feelings of ownership for the forest/pastureland once the government took over. This circumstance, in fact, encouraged people to convert common property resources into private property. Overgrazing, loss of biodiversity, and soil erosion as a result of some of the institutional interventions of the government surfaced conspicuously.

Another example of faulty public interventions can be seen in the case of irrigation management. When the government initiated the construction of irrigation channels without considering traditional management practices, farmers' traditional irrigation management practices just disappeared. This intervention invited a lot of conflicts among water users and such problems had not existed previously. Similarly, the government's emphasis on cereal crops (which are basically Terai crops) in the mountains was not successful. Public interventions must evolve from an examination of farmers' strategies and responses and from consideration of the inherent mountain characteristics.

Incorporation of the Mountain Perspective

Regarding the internalization of mountain characteristics, it is worthwhile to recall here that mountain specificities demonstrate variability from one area to another

(Table 19.2). The operational implications of variability are that we cannot generalize about mountain perspectives in the context of effective development interventions. Fragility will be the predominant characteristic in the Dhuskun area, whereas elsewhere this might not be the case. Hence, more effort should be given to minimizing fragility as a constraint in this area. In this context, perennial crops (e.g., fodder, fuelwood, and timber) and horticultural crop cultivation on private land will not only ameliorate the 'fragility' constraint but also generate cash income.

Similarly, development efforts should be directed towards solving the problem of marginality. In this context, 'marginality' can be alleviated by focussing on those activities that can improve the poor resource base (private or public). Emphasis on formal and informal education to increase the literacy rate, increasing fodder/fuelwood tree plantations on both private and public land to improve the land resource base, and cultivation of high-value cash crops in order to raise cash income from small pieces of land are some of the operational measures that are effective development interventions for tackling 'marginality'. Provision of cooperatives, formal credit, either through the establishment of an agricultural development bank or mobile banks, and an insurance system for crops and livestock are other important interventions. Assistance to farmers to reorganize in groups such as in the Small Farmers' Development Programme (SFDP) will increase both the resource base (human, land, livestock, and others) and accessibility in terms of required inputs (e.g., credits) and other information (e.g., agricultural extension). In the same way, diverse micro-'niche' or 'diversity' create conditions suitable for the localized and limited production of a number of agricultural and other products. The cost per unit of production tends to be high, and this damages the feasibility in terms of markets. Hence, development strategies should encourage farmers to cultivate crops requiring a low intensity of inputs. Maize, millet, buckwheat, and barley are possible options provided the climate is suitable. Research and development is also essential for the development of appropriate agricultural technologies.

'Inaccessibility' appears to be an important mountain characteristic in Yelung and Deupur-Tapu and not very important in Naubise and Dhuskun. Because of its closeness to the road and other institutional infrastructures, Naubise is a relatively accessible area in comparison to the other three study areas. Therefore, development interventions should improve the accessibility to remoter areas by improving or constructing trails and tracks or roads; establishing agricultural/livestock sub-centres, and stationing extension agents in these areas. Besides these improvements, interventions should strengthen the existing, appropriate production pattern of low-weight and high-value products (e.g., high-value cash crops, cardamons, vegetable seeds, purified butter). The installation of processing units for converting low-value, high-weight commodities into high-value, low-weight products would be the appropriate development intervention for harnessing benefits even in accessible areas. Similarly, the provision of mobile agricultural banks, trade schools, postoffices, and so on will improve the farmers' access to resources and information and reduce the intensity of this constraint, even without road construction, the conventional method of improving accessibility. Agricultural research and development should also be geared to the development of technologies (e.g., agroforestry) that provide backward and forward linkages among different components of the farming system, i.e., crop-livestock-forestry. For instance, farmers should be provided with high grain-straw ratio cultivars which will not only help to meet the increasing food demand but will also increase fodder supplies. This type of intervention will be effective, particularly in an area where the natural resource base is degraded. Naubise is one example of an area where such interventions have been successful.

Harnessing 'Niche'

The 'niche' or comparative advantages of any given area depend upon those activities or economic sectors that can perform to advantage in that area or region in comparison to other areas. Livestock, horticultural and other high-value cash crops, tourism, mining, and hydropower generation are well-known 'niche' of mountain areas.

'Niche' are based on biophysical characteristics and the potentials are there whether they are harnessed or not. The harnessing of 'niche' depends upon the creation of suitable conditions, and these may include improved access to new technologies, inputs, extension, credit, and linkages with the wider market economy through the development of a marketing system. Institutional and other support services play a crucial role in creating favourable conditions for various 'niche'. A brief description of comparative advantages existing in the four study areas and the prerequisites for harnessing them is given below.

Naubise

Naubise is an area suitable for cereals, vegetables, and livestock (cattle and buffalo). The area is now in a stage of transition towards commercial vegetable farming. Due to its proximity to Kathmandu, the major market centre, and access to institutional support services (Sajha, Agricultural Development Bank), favourable conditions exist for harnessing these 'niche' by adopting new production technologies such as improved seeds and fertilizers. Vegetable cultivation and raising improved breeds of livestock are also extremely viable in this area.

Dhuskun

This area has potential for the cultivation of cereal crops, both major (paddy, wheat, and maize) and minor (millet and buckwheat). Although most of the terraced land in Dhuskun has a high degree of slope, the land is stable and has good water retention qualities; hence it is suitable for irrigated rice farming. Dhuskun also has the potential for cattle raising and enhanced crop-livestock integration in the farming system.

Yelung

Yelung has a comparative advantage in livestock raising, especially sheep, goats, and yaks or chauri. The development of livestock in Yelung would require improved access to extension and support services (credit and inputs). The potentials of livestock development can be harnessed if suitable conditions in terms of breed improvement, provision of fodder saplings and forage crop seeds, and veterinary services are created. Yelung has the potential for growing high-value cash crops (e.g., cardamon) and temperate fruits.

Deupur-Tapu

In Deupur-Tapu, cereals, vegetables, fruits, and buffalo raising are the potentials. Paddy is the most important crop in terms of development, as most of the land in Deupur-

Tapu consists of bunded terraces for irrigated rice farming. Maize and wheat are other suitable crops, although limited access to irrigation in winter is a constraint for wheat. The conditions in Deupur-Tapu are suited to growing various types of vegetables and fruits. Vegetables grown in the off-season offer comparative advantages as they fetch higher prices. To fully exploit the potential for fruit production, a processing facility should be established, given the current inaccessibility of the area. Buffalo keeping is also a potential activity in Deupur-Tapu.

CONCLUSION AND RECOMMENDATIONS

With or without knowledge, farmers have responded effectively to mountain characteristics either by modifying them or adapting to them through various operational measures. The public interventions, which have also contributed to increasing crop yields and vegetable production in some areas, in general appear to have disregarded mountain specificities.

In this context, several negative changes have taken place in all the mountain farming study sites. Most of the forests and pasturelands either have disappeared (due to their conversion into cultivated land) or are degraded beyond regenerative capacity (at least in the short run) in some areas, resulting in a reduced level of compost and manure supplies for crop production. These circumstances have led to declining crop yields. Therefore, the increased out-migration rate and widening hunger gap are general outcomes of unsustainability in the study areas. This situation persists and it implies that mountain agriculture, in general, is becoming unsustainable.

Hence, it is recommended that several responses or strategies of farmers, associated with traditional resource management and farming systems and relevant for sustainable mountain agriculture, even in a changing environment brought about by increased demographic pressure, should be introduced along with appropriate technological innovations. Finally, any public intervention should evolve out of consideration of farmers' strategies and full awareness of mountain characteristics.

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ANNEX 1

Table 1. Details indicating inaccessibility characterizing the study areas

Characteristic	Unit	Study area Naubise	Dhuskun	Yelung	Deupur-Tapu
Distance to nearest road	km	1–2	4	6	30
Distance to nearest bus terminal	km	1–2	4	6	30
Frequency of diurnal bus service	no.	>10	4–5	2–3	—
Distance to nearest market centre	km	2	4	6	3
Distance to Kathmandu	km	30	90	>100	250
Distance to nearest telephone or other communication centre (e.g., post office)	km	3	4	6	10
Distance to agriculture/livestock sub-centres	km	3	1–4	6	0
Distance to support services' centres (e.g., inputs, credit)	km	2	4	6	2–10
Literacy rate	%	64	49	48	54
Proportion of small and marginal farm households	%	33	43	93	28
Average size of landholding	ha	0.97	0.54	0.28	0.7
Distance to cultivated land					
—average	km	0.5	3	0.5	0.2
—range	km	(0–1.0)	(0–4)	(0–2)	(0–1.5)
Agriculture/livestock staff (JT/JTA)* stationed in the village	no.	1	1	—	3
Leader/progressive farmers	no.	—	2	—	3

Note: JT= Junior Technician; JTA = Junior Technical Assistant.

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 1

Table 2. Details indicating fragility characterizing the study areas

Characteristic	Unit	Study area: Naubise	Dhuskun	Yelung	Deupur-Tapu
Altitude —main settlement	m	1,000	1,650	1,800	970
—range	m	970–1100	1,050–2,200	1,600–2,600	800–1,000
Slope —dominant	0°	20	35	25	15
—range	0°	10–30	20–45	15–40	10–20
Soil type	texture	loam-silty loam	loam	silty loam	loam, silty loam
Soil depth	cm	—	50–100	—	—
Proportion of flat land	%	5	—	—1	2
Proportion of cultivated land				—	—
under terracing	%	100	100	100	100
Proportion of land under sloping				—	—
terraces	%	3	5	2	6
Proportion of land under level				—	—
terraces	%	97	95	98	94
—with bunds	%	40	30	—	93
—without bunds	%	60	70	100	7
Proportion of uncultivated[a] land				—	—
to total private land	%	5	4	1	6
Fragmentation of land				—	—
—average	no.	5	4	12	n.a.
—range	no.	1–8	1–10	1–28	n.a.
Average size of parcel	ha	0.2	0.13	0.02	n.a.
Rainfall distribution pattern				—	—
(proportion of rainfall					
occurring in June–Sept.)	%	85	85	85	80
Temporal temperature variation					
—minimum	0°C	7–21	6–19	(−1–17)	(6–22)
—maximum	0°C	19–35	18–29	13–25	21–33
Number of hailstorms					
—average	year	3–4	2–3	3	2
Drought frequency					
(interval period)	year	2–3	2–3	2	—
Flooding frequency/excess					
rainfall (interval period)	year	3–4	2–3	—	—
Vegetative cover of forest,					
pastureland, etc	%	70	50	>70	60
Landslides					
—area affected	ha	—	30	10	—
—frequency	year	—	2–3	4–5	—
Perennial crops (e.g., fruit,					
fodder, and other trees) per farm	no.	118	14	96	65
—trees/ha cultivated land	no.	122	26	343	93

[a] Indicates *kharbari* (land under thatch, trees and other plant materials).

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 1

Table 3. Details indicating marginality characterizing the study areas

Characteristic	Unit	Study area: Naubise	Dhuskun	Yelung	Deupur-Tapu
Proportion of small and marginal farm households	%	33	40	90	28
Proportion of landless households	%	—	3	7	—
Distance to accessible natural resource base					
—forest	km	3–5	3–5	1–2	1
—pastureland/grazing land	km	5	3–5	1–2	—
—water (e.g., river)	hr	0.5	1–2	0.3	0.5
Distance to agriculture/livestock sub-centres	km	3	1–4	6	0
Distance to other support service centres (e.g., inputs, credits)	km	2	4	6	2–10
Literacy rate	%	64	49	48	54
Programmes under community management (e.g., forest mgt, vegetable association)	No.	4	20	1	1
Forest and pastureland area under community management	ha	2	25	300–500	n.a.
Farmer-managed irrigation schemes	no.	1	1	—	1
Proportion of off-farm employment (of the total)	%	32	18	13	n.a.
Proportion of off-farm income	%	45	97	65	40
amount of credit borrowed					
—institutional	Rs	2,960	787	3,367	2,492
—non-institutional	Rs	2,858	1,116	777	646
Three major cereal crops with percentage of total cultivated areas		maize 62% paddy 43% wheat 27%	maize 78% millet 57% paddy 32%	wheat 38% maize 28% potato 28%	paddy 88% maize 40% wheat 15%

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 1

Table 4. Details indicating diversity characterizing the study areas

Characteristic	Unit	Study area Naubise	 Dhuskun	 Yelung	 Deupur-Tapu
Elevation range	m	970–1,100	1,050–2,200	1,600–4,000	800–1,000
Range of steepness (landscape)	0°	20	35	25	15
Types of soil	texture	loam to to silty loam	loam to sandy loam	loam	loam to silty loam
Variation in micro-climates,					
—range		tropical to sub-tropical	sub-tropical to cool temperate	warm tem-perate to alpine	sub-tropical
—no.		2	3	4	1
Variation in types of vegetation					
—different types of cereal crops	no.	5	4	6	4
—different types of cash crops	no.	2	1	—	2
—various horticultural crops					
—vegetables	no.	8	—	—	5
—fruit trees	no.	10	2	3	10
—different kinds of fodder trees	no.	10	5	8	6
—different kinds of fuelwood trees	no.	10	5	8	6
—different kinds of timber trees	no.	5	6	8	4
—berseem/cocksfoot forage grass	no.	—	—	2	2
—different economic farm groups (based on farm size)	no.	3	5	4	3
various ethnic groups	no.	6	6	3	1
		Brahmin 75%	Chhetri 35% Thami 40%	Sherpa 90%	Brahmin

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 1

Table 5. Details indicating 'niche' characterizing the study areas

Characteristic	Unit	Study area: Naubise	Dhuskun	Yelung	Deupur-Tapu
Crop diversification					
—different crops grown	No.	10	5	6	14
—proportion of monocropping	%	37	29	69	10
—proportion of double cropping	%	61	71	23	78
—proportion of triple cropping	%	2	—	—	12
—fallow land	%	—	—	8	—
Livestock farming					
—animals raised[a]					
—head	no	7.5	5.8	11.8	5.5
—LSU	no.	4.2	2.7	7.4	3.4
—types of animals kept	no.	3	3	5	4
Proportion of cash crops cultivated (sugarcane and mustard)	%	9	2	—	4
—water resource utilization					
—water mills (ghatta)	no.	1	11	5	—
—proportion of cultivated land under irrigation	%	52	31	—	88
—hydropower generation	kw	—	—	—	—
—cottage industry					
—proportion of households involved in weaving	%	—	5	10	—
—proportion of households involved in capentry, bamboo work	%	—	5	5	18
—rice mills	no.	3	—	—	—
—proportion of households involved in ghee processing for sale	%	10	—	20	50

[a]Poultry are excluded.

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 1

Table 6. Details indicating human adaptions in the study areas

Characteristic	Unit	Study area			
		Naubise	Dhuskun	Yelung	Deupur-Tapu
Modification of mountain characteristics					
Terracing					
—level terrace	%	97	95	98	94
—sloping terrace (proportion of total land)	%	3	5	2	6
—level terrace with bunds	%	40	30	—	93
—level terrace without bunds	%	60	70	100	7
Organizing farmers' groups		3	19	1	1
—SFDP	no.	—	16	—	—
—farmers/vegetable growers' association	no.	1	—	—	1
—alpine pastureland users' group	no.	—	—	1	—
—forest management group	no.	2	3	—	—
Adaptation to mountain characteristics					
Crop diversification					
—crops grown	no.	10	5	6	14
—integrated crop-livestock farming (proportion of households adopting it)	%	100	100	100	100
—sharing of private resources proportion of household)					
—exchange of labour	%	90	95	50	85
—sharing of draft animals	%	90	90	30	25
—sharing of farm implements	%	80	90	50	80
—petty trading (proportion of households)	%	100	100	100	100
—commercial trading (proportion of households)					
—vegetables	%	80	—	—	70
—farmer-managed irrigation schemes	no.	1	1	—	1

Source: APROSC 1990 and Katwal and Shah 1990.

ANNEX 2

Table 1. Range of quantified indicators of inaccessibility by study area

Characteristic	Unit	Range of quantitative terms			
		Low 1	Medium 2	High 3	Very high 4
Distance to nearest road	km	< 2	2–5	5–10	> 10
Distance to nearest bus terminal	km	< 2	2–5	5–10	> 10
Frequency of diurnal bus services	no.	> 8	5–8	2–4	1
Distance to nearest telephone or other communication centre (e.g., post office)	km	< 2	2–5	5–10	> 10
Distance to agriculture/livestock sub-centres	km	"	"	"	"
Distance to support services centres (e.g., inputs, credit)	km	"	"	"	"
Literacy rate	%	> 60	50–60	40–50	< 40
Proportion of small and marginal farm households	%	< 30	30–40	50–70	> 70
Average size of land holding	ha	> 1.0	0.51–1.0	.20–0.5	< 0.2
Distance to cultivated land	km				
—average	km	< 0.5	0.5–1.0	1–3	> 3
—range	km				
Agriculture/livestock staff (JT/JTA) stationed in the village	no.	3	2	1	—
Leader/progressive farmers	no.	> 5	3–5	1–3	—

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 2

Table 2. Range of quantified indicators of fragility by study area

Characteristic	Unit	Range of quantitative terms			
		Low 1	Medium 2	High 3	Very high 4
Altitude	m	<900	900–1500	1500–3000	>3000
Slope	0°	<10	10–20	20–30	>30
Soil type	texture	loam to silty loam	loam to sandy loam	sandy loam	silt sandy
Soil depth	cm	>50	30–50	10–30	<10
Proportion of flat land	%	>20	10–20	5–10	<5
Proportion of cultivated land under terracing	%	>95	90–95	80–90	<80
Proportion of land under level terrace	%	>95	90–95	80–90	<80
Proportion of land under sloping terrace	%	<5	5–10	10–20	>20
Fragmentation of land —average	no.	<4	4–6	6–8	>8
Average size of parcel	ha	<0.5	0.3–0.5	0.1–0.3	<0.1
Rainfall distribution pattern (proportion of rainfall occurring June-Sept.)	%	<50	50–70	70–80	>80
Temporal temperature variation (gap between min and max)	0°C	<10	10–15	15–20	>20
Number of hailstorms —average	year	>3	2–3	1–2	1
Drought frequency (interval period)	year	>3	2–3	1–2	1
Flooding frequency/excess rainfall (interval period)	year	>3	2–3	1–2	1
Vegetative cover of forest, pastureland, etc	%	>70	50–70	30–50	<30
Landslide —frequency	year	>5	3–5	2–3	1
perennial crops (e.g., fruits, fodder, and other trees) at farm —trees/ha cultivated land	no.	>200	100–200	50–100	<50

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 2

Table 3. Range of quantified indicators of marginality by study area

Characteristic	Unit	Range of quantitative terms			
		Low 1	Medium 2	High 3	Very high 4
Proportion of small and marginal farm households	%	< 30	30–50	50–70	> 70
Proportion of landless households	%	< 3	3–5	5–10	> 10
Distance of accessible natural resource base					
—forest	km	< 1	1–3	3–5	> 5
—pastureland/grazing land	km	< 1	1–3	3–5	> 5
—water (e.g., river)	hr	< 0.5	0.5–1.0	1–1.5	> 1.5
Distance to agriculture/livestock sub-centres	km	< 2	2–5	5–10	> 10
Distance to other support service centres (e.g., inputs, credits)	km	< 2	2–5	5–10	> 10
Literacy rate	%	> 70	50–70	30–50	< 30
Programmes under community management (e.g., forest mgt, vegetable association)	no.	> 10	5–10	3–5	< 3
Forest and pastureland area under community management	ha	> 100	50–100	25–50	< 25
Farmer-managed irrigation schemes	no.	> 75	3–5	1–3	1
Proportion of off-farm employment (of the total)	%	> 40	30–40	20–30	< 20
Proportion of off-farm income	%	> 40	30–40	20–30	< 20
Ratio of institutional and non-institutional credit	ratio	> 1.0	0.75–1.0	0.5–0.75	< 0.5

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 2

Table 4. Range of quantified indicators of diversity by study area

Characteristics	Unit	Range of quantitative terms			
		Low 1	Medium 2	High 3	Very high 4
Range of elevation	m	< 900	900–1500	1,500–3,000	> 3000
Range of steepness (landscape)	0°	> 10	10–20	20–30	> 30
Various types of soil	texture	silty sandy	loam	silty loam	silty loam
Variation in micro-climates,	no.	< 2	2–3	3–4	> 4
Variation in types of vegetations					
—different types of cereal crops	no.	< 3	3–5	5–8	> 8
—different types of cash crops	no.	< 2	2–3	3–5	> 5
—various horticultural crops					
—vegetables	no.	< 3	3–5	5–8	> 8
—fruit trees	no.	< 3	3–5	5–8	> 8
—different kinds of fodder trees	no.	< 5	5–8	8–10	> 10
—different kinds of timber trees	no.	< 5	5–8	8–10	> 10
—berseem/cocksfoot forage grass	no.	< 2	2–3	3–5	> 5
Different economic farm groups (based on farm size)	no.	< 2	2–3	3–4	> 4
Various ethnic groups	no.	< 3	3–4	4–5	> 5

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 2

Table 5. Range of quantified indicators of 'niche' by study area

Characteristic	Unit	Range of quantitative terms: Low	Medium	High	Very high
Crop diversification					
—different crops grown	no.	< 3	3–5	5–10	> 10
—proportion double cropping	%	< 30	30–50	50–70	> 70
—livestock farming					
—animals raised[a]					
—head	no.	< 5	5–8	8–10	> 10
—LSU	no.	< 3	3–5	5–7	> 7
—types of animals kept	no.	< 2	2–3	3–5	> 5
Water resource utilization					
—water mills (ghatta)	no.	1	2–4	4–6	> 6
—proportion of areas under irrigation	%	< 20	20–40	40–60	> 60
—cottage industry					
—proportion of households involved in weaving	%	< 10	10–20	20–30	> 30
—proportion of households involved in bamboo work	%	—	5	5	18
—rice mills	no.	3	—	—	—
—proportion of households involved in ghee processing for sale	%	10	—	20	50

[a]Poultry are excluded.

Source: APROSC 1990 and Katwal and Shah 1990.

Annex 2

Table 6. Range of quantified indicators of human adaptation by study area

Characteristic	Unit	Range of quantitative terms			
		Low 1	Medium 2	High 3	Very high 4
Modification of mountain characteristics					
Terracing					
—level terrace	%	< 80	80–90	90–95	> 95
—sloping terrace	%	> 20	10–20	5–10	< 5
—level terrace with bunds	%	< 20	20–30	30–40	> 40
—level terrace without bunds	%	> 80	70–80	60–70	< 60
Organising farmers' groups	no.	< 3	3–5	5–10	> 10
Adaptation to mountain characteristics					
Crop diversification					
—(crops grown)	no.	< 3	3–5	5–10	> 10
Integrated crop-livestock farming (proportion of households adopting)	%	> 70	70–80	80–90	> 90
sharing of private resources (proportion of households)					
—exchange of labour	%	< 50	50–70	70–90	> 90
—sharing of draft animals	%	< 50	50–70	70–90	> 90
—sharing of farm implements	%	< 50	50–70	70–90	> 90
Petty trading (proportion of households)	%	< 50	50–70	70–90	> 90
Farmer-managed irrigation schemes	no.	1	2–3	3–5	> 5

20

DIVERSITY OF FARMING SYSTEMS AND FARMERS' STRATEGIES IN THE MOUNTAIN VALLEY OF CHITRAL, PAKISTAN

Masood ul Mulk

Masood ul Mulk is a Regional Programme Monitoring Officer of the AKRSP, Chitral, Pakistan

CONTENTS

INTRODUCTION

This paper presents a descriptive account of Chitral District as being representative of a mountain area in the North West Frontier Province (NWFP) of Pakistan. The focus is on the presentation of features of the region in terms of mountain specificities, their implications, and farmers' and government's responses to them. The latter is done by describing specific farming practices which represent both traditional farming systems and adjustments to them resulting from pressures imposed by population increases, technology introductions, and changes in institutions.

The data which reflect features of these mountain farming systems were collected through intensive village studies conducted in a collaborative effort between the Aga Khan Rural Support Programme (AKRSP) and ICIMOD in 1990. The details of the procedure and methodology followed in these case studies are described elsewhere (Mulk 1990).

Of over 600 villages of Chitral, three were selected to represent varying types of farming systems characteristic of the agro-ecological zones of the NWFP. These three types are crop-dominated, crop-cum-livestock-dominated, and livestock-dominated farming systems. The features of these zones, as found in the villages of Chitral, are summarized in Table 20.1.

Table 20.1. Features of the three agro-ecological zones

Zonal characteristics	Zone 1	Zone 2	Zone 3
Altitude (m)	<1800	1800–2100	2101-2300
Rainfall (av/mm)	48	10	70
Soil type	Sandy loam, relatively fertile	Sandy loam with stones, poor in nutrients	Bare and shallow soils with very poor nutrients
Land holdings per household (ha)	1.0	.8	.5
Dominant activities	crops, horticulture	crops, livestock	livestock
Major crops	wheat, maize vegetables	wheat, alfalfa barley	alfalfa, wheat
Livestock/household			
number	6	25	29
type	cattle, goats	goats	goats, sheep
Representative village	Kesu	Marthing	Besti

Differences in village/farm characteristics, listed in items (4) to (7), represent farmers' adaptations to the varied conditions of the ecological zones, and can be further described as their strategies.

Source: Mulk 1990.

In Lower Chitral, below 1,800 m land holdings are larger, the climate allows cultivation of double crops, and rich forests of holly oak and deodar exist on higher mountain slopes. Better means of communication and the presence of a small urban market have produced significant changes in the crops grown. This farming system is a combination of crop and horticultural production, and is represented by Kesu Village.

Upper Chitral, with less rainfall, poor forest cover, single crop cultivation, poor means of communication and absence of an urban market, can be regarded as a crop-cum-livestock farming system. This system is represented by Marthing Village.

Some parts of Chitral, in the upper belt, have rich pastures, allowing larger numbers of livestock to be maintained per household. In such areas, land is extremely scarce and agriculture is only possible after bringing very difficult mountain slopes under cultivation. This is represented by Besti Village.

FEATURES OF THE STUDY AREA

Chitral District has an area of 14,850 square miles and a population of 266,000 (1989 estimates). The district is characterized by a rugged topography, with high mountain ranges penetrated by steep-sided, narrow valleys and rivers. Land access is via a number of high passes, the lowest of which is at an elevation of about 3,000 m. Vehicle access is via the Lowari Pass, and this is usually closed to vehicular traffic for six months in a year.

Settlements and agriculture are concentrated in the valleys and streams of the Chitral river system. The valleys attain a maximum width of 5 km. The land types of the area indicate that only 4 per cent is available for agriculture and 24 per cent is forest and grazing area. The rest is all barren mountain ranges.

The climate of the district is distinctly continental with summer temperatures ranging from very hot in the lower elevations of the main river valleys to warm in the uplands and cool at higher elevations.

The features of Chitral District can also be described in terms of mountain specificities (Jodha 1990).

Inaccessibility

Inaccessibility is the most dominant characteristic of Chitral. For centuries Chitral remained an isolated, independent state because of the harsh nature of its terrain. Accessibility, it may be pointed out, in the context of Chitral, has two aspects, first internal and secondly external.

In the past, inaccessibility, both within the district and outside it, has played a leading role in the evolution of farming systems. Communication between villages was an arduous task necessitating the evolution of subsistence-oriented farming systems. Every village strove to become self-sufficient in food. Irrigation channels were dug across difficult terrain to bring water and all possible land was placed under cultivation. These channels were difficult to build, giving rise to cooperative systems of ownership and management of channels. Each village had its own crop lands, forests, and pastures. The latter would be at considerable distances from the village and would provide grazing grounds for livestock in the summer months, thus saving invaluable fodder resources back home. This also explains why the villagers were growing crops as diverse as wheat, maize, millet, rice, and cotton. Fruits grown were largely those that could be stored for the winter.

In the last three decades, a network of roads has been laid down within the district. Today, except for Yarkhoon Valley, all other valleys are accessible by jeep. This has had a profound effect on the farming systems, which are now moving towards commercialization by exploiting each valley's comparative advantages.

Chitral, however, remains isolated for six months in a year when Lowari Pass closes in winter. This inaccessibility to the outside world remains a major constraint to development. Fruit production cannot be carried out on a large scale as the surpluses cannot reach markets outside the district.

Fragility

Chitral's environment is extremely fragile. It has been sparsely endowed with natural forests. Scanty rainfall does not permit the growth of luxurious vegetation to bind the soil. In the absence of dense population pressures and through careful preservation by communities, the environment was protected in the past against hazards such as soil erosion by rivers and floods. Similarly, over-grazing of forests by livestock and indiscriminate cutting of forests pose a serious threat to the environment. The farmers, whose livelihoods depend on crops and livestock systems, tend to keep many animals, causing over-grazing and denudation. Heavy downpours cause devastating floods. The in-migration of nomadic herdsmen, who seem insensitive to the environmental scenario, also threatens the sustainability of the farming systems.

Marginality

Chitral, in many respects, is a marginal area in comparison to other areas of Pakistan. The major resource of the area is land: almost 90 per cent of the population is dependent on agriculture for its sustenance, yet only 4 per cent of its total area is available for agriculture. Ninety per cent of the population has a landholding of less than 3 ha, and 70 per cent less than 1 ha. The district is poorly endowed with forests and pastures. The former face extinction at the hands of exploiters from both public and market forces. The quality of soil is poor, lacking in nutrients and nitrogen. The use of chemical fertilizer is leading to higher yields, but, in the long run, in the absence of crop rotation, the cost of these higher yields could be heavy.

The quality of both physical and economic infrastructure is poor. Investment levels in the social sectors are low. The people of Chitral have lived isolated lives for centuries. Lacking an innovative, competitive spirit, they generally find themselves outpaced by outsiders. The desire for off-farm employment inspires many to migrate seasonally but they end up with menial jobs in big cities.

Diversity

The area has tremendous diversity in terms of climate and topography. The diversity explains how pastures, forests, and croplands have been integrated into the farming systems to enable residents to make a living in the harsh environment and to make the best use of its ecological resources.

'Niche'

The area has an abundance of water flowing from the mountains which could be tapped for irrigation and for generating hydro-electricity; it also has spectacular scenery which attracts tourists. Fruit production benefits from the market demand for produce that is out of season in the plains. Many high areas offer ideal environments for wild animals such as markhors and snow leopards.

Adaptation Mechanisms

Over the centuries, the people of Chitral have evolved institutions, both formal and informal, which have enabled them to survive in this harsh environment. These institutions were for building and maintaining roads and irrigation channels, for providing collective labour at harvest time, and for common grazing arrangements in forests and pastures during the summer. The idea of a gram or 'collective will' of the community, expressed around the place of worship, overrode individual or selfish interests for the good of the community.

Over a thousand irrigation channels were constructed by illiterate people, using local technology, with no engineers to guide them. Similarly, fields on mountain slopes were terraced to prevent soil erosion. The crop rotation system ensured fertility of the soil.

PEOPLE'S ADJUSTMENTS TO MOUNTAIN AREAS

Differences in the features of farming systems among and within different regions are an indication of peoples' adaptations to environmental differences. These differences may be reflected in:

- demographic features
- occupation patterns
- position of assets, ie landholding, livestock holding
- farm operations
- land utilisation
- livestock composition
- land abandonment
- uneconomic and fragmented land
- responses to resource crisis
- indigenous practices
- cropping patterns
- income/expenditure patterns

These are described below.

Demographic Features of the Sample Households

The poor resource base of the area faces a rapidly increasing population. Forty-two per cent of the population is below 15 years in Kesu, 43 per cent in Marthing, and 50 per cent in Besti.

The literacy rates show significant trends. In Kesu the literacy rates are 33 per cent, in Besti 7 per cent, and in Marthing 21 per cent. The literacy rates are closely related to how early a village became accessible. These literacy rates, for a remote district, compare very favourably with general literacy rates in Pakistan. One reason which accounts for the high literacy rates is the desire for education among farm households with a view to finding off-farm employment for some of its members (Table 20.2).

Table 20.2. Demographic features of the sample households

Sites and farm size	Family size (no.) Male	Female	Total	Economically Active Male	Female	Total	Dependency Ratio	Literacy percentage Male	Female	Total
Zone 1 (Kesu)	119	82	201	64	52	116	1.73	26	18	33%
Zone 3 (Besti)	140	114	254	71	56	127	2.00	11	2	7%
Zone 2 (Marthing)	122	117	239	75	60	135	1.78	29	14	21%

Source: Mulk 1990.

Occupation of Economically Active Members of Sample Households

An analysis of the data reveals that 55 per cent of the economically active population in Kesu find work at salaried jobs or business more important and profitable for family sustenance. This carries important implications for farm management. In Kesu Village, where 100 per cent of the farmers own less than 2 ha, 73 per cent of the farms are either cultivated on a share-cropping basis or given out to tenants. The consequences of the kinds of trends one sees in Kesu Village are far-reaching for the traditional collective management systems for irrigation channels and livestock. The absence of large numbers of people from the villages undermines these systems (Tables 20.3 and 20.4).

Table 20.3. Occupations of the economically active members of the sample households

Sites and farm sizes	Main occupation: Agriculture M	Agriculture F	Salaried Job M	Salaried Job F	Secondary occupation: Business M	Business F	Labour M	Labour F	Contractor M	Contractor F	Pensioner M	Pensioner F	Business M	Business F	Labour M	Labour F
Zone 1 (Kesu)	30	52	22	0	7	0	3	0	2	0	7	0	1	0	0	0
Zone 3 (Besti)	58	55	13	1	0	0	0	0	0	0	0	0	1	0	16	0
Zone 2 (Marthing)	66	59	8	1	0	0	1	0	0	0	0	0	0	0	22	0

Source: Mulk 1990.

Table 20.4. Distribution of households by land ownership patterns (No. of households)

Site and farm sizes	Total no. of households	Exclusive owner operators	Share cropping operators	Exclusive tenant
Zone 1 (Kesu)	30	8	17	5
Zone 3 (Besti)	30	30	0	0
Zone 2 (Marthing)	30	30	0	0

Source: Mulk 1990.

Land Size, Distribution, and Use at Household Level

Land holdings are very small. In Kesu Village, 100 per cent of land holdings are less than 18.50 *chak*, or 2 ha. In Besti and Marthing, 97 per cent of the households have less than 2 ha of land.

The average land holdings and use patterns show that the lowest land holding group in Kesu has 5.81 *chak* (0.63 ha) of land, while in Besti this figure is 4.05 *chak* (0.44 ha), and in Marthing 7.12 *chak* (0.77 ha). The cultivable land is even smaller, being 4.83 *chak*

(0.52 ha) in Kesu, 2.62 *chak* (0.28 ha) in Besti, and 4.55 *chak* (0.49 ha) in Marthing. Table 20.5 gives the average land-use pattern of all 30 households in the village.

Table 20.5. Average land use at household level (*chaks*)

Sites and farm sizes	Total land	Homestead and wool	(%)	Crop culti-vation	(%)	Fodder and trees	(%)
Zone 1 (Kesu)	9.68	0.86	8	8.87	89	0.38	3
Zone 3 (Besti)	7.45	1.00	19	4.72	63	1.73	24
Zone 2 (Marthing)	9.33	0.67	7	5.92	64	2.68	29

Source: Mulk 1990.

Uneconomical and Fragmented Nature of Land Holdings

The number of irrigation channels handled by a household is an important indicator of the economical nature of land holdings. In Besti Village, the pressure on land is most intense; the average number of irrigation channels handled by a household varies from 8 to 20 among different farm sizes. In Kesu, the variation is between one and two irrigation channels per household while in Marthing Village an average of two irrigation channels are handled by each household.

Land fragmentation is another indicator of pressure on existing farming systems. In Besti Village, a journey of over one and a half hours on foot was required for 27 per cent of the households to travel between two fragments of land.

Land Abandonment

In Kesu Village it was found that over 30 per cent of the households had given up cultivating some of their lands because of higher yields on other parcels of land. In the recent past, to meet the growing needs of the population, marginal lands, which could only be cultivated if there was rainfall or moisture, had been given up after the introduction of chemical fertilizer and improved seeds.

In both Kesu and Marthing villages, a lack of water in the irrigation channels, despite water being available at the source, is a major reason for land abandonment.

Livestock Holdings

Livestock ownership is widespread, and constitutes an important part of farm production.

The average livestock holding in Kesu Village is about 6 animals, while it is 29 in Besti, and 25 in Marthing. The mean does not give a correct picture for the number of goats held by a household, as the data show considerable variation. A few households tend to have almost three times as many goats as others. There is not much variation in the data for cattle and sheep.

In both Besti and Marthing villages, the number of goats and sheep per household is still very high, showing the importance of these in the livestock system. At Kesu, the number of cattle has decreased considerably. As this village is easily accessible, tractors and threshers reached the village some years back. Most households reduced the number of cattle after the introduction of tractors and threshers. This has helped to improve animal health and nutrition as there are less animals to feed (Tables 20.6, 20.7, and 20.8).

Table 20.6. Livestock holdings of total households by farm size and study site

Sites and farm sizes	Cattle	Goats	Sheep	Donkey	Horse	Poultry
Zone 1 (Kesu)	93	62	4	7	0	372
Zone 3 (Besti)	336	687	681	0	0	885
Zone 2 (Marthing)	182	383	195	9	0	179

Each goat, sheep, donkey, horse and head of cattle has been considered a single livestock unit.

Source: Mulk 1990.

Table 20.7. Average livestock unit per household by farm size and study site

Farm sizes	Study Sites: Kesu	Besti	Marthing
0 to 9.25 *chak*	4.00	29.90	19.59
9.26 to 18.50 *chak*	7.73	24.38	40.14
> 18.50 *chak*	0.00	58.00	57.00
Average	5.53	29.36	25.63

9.25 *chak* = 1 hectare
Each animal is treated as a livestock unit. Poultry are excluded.

	Sample Size: Kesu	Besti	Marthing
0 to 9.25 *chak*	15	21	22
9.26 to 18.50 *chak*	15	8	7
> 18.50 *chak*	0	1	1

Source: Mulk 1990.

Table 20.8. Trends in livestock per household over a five-year period (no. of households)

Villages	Trends: Increase	Decrease	Same
Zone 1 (Kesu)	0	5	25
Zone 3 (Besti)	17	4	9
Zone 2 (Marthing)	0	0	30

Source: Mulk 1990.

Goats and sheep do not form an important part of the livestock holdings in Kesu. This is a trend in Lower Chitral where, because of the breakdown of indigenous management systems and because of opportunities for off-farm employment and education, households are keeping fewer goats and sheep (Tables 20.6, 20.7, and 20.8).

No new breeds of livestock have been introduced in any of the study villages. This, in itself, is not bad, New breeds find it difficult to adapt to this environment. The government has used the bull system for improving breeds in the district, but its benefits have been restricted to a few villages that lie in the neighbourhood of the veterinary dispensaries.

The use of medicine and vaccines for livestock is popular in both Marthing and

Besti, both of which are at considerable distances from veterinary hospitals. The system whereby livestock specialists are nominated by villagers, trained by the AKRSP, and paid and maintained by village organization members is very successful. This innovation is effective because these areas lie at a considerable distance from the road. The villagers have to develop self-sustaining systems for livestock protection against disease because the government can do very little to help them.

The stall-feeding of animals is increasing as the feed situation improves because of higher yields in crops after the introduction of chemical fertilizers.

Indigenous Livestock Management Systems

The indigenous management systems play an important role in enabling villagers to keep large livestock holdings. In both Besti and Marthing, we find that the indigenous management system is intact. Under this system, one individual from each household has to help in grazing the goats and sheep each day, irrespective of his herd size. The system, while apparently inequitable, benefits the villagers through what could be termed as an 'economy of scale', as only a few individuals are involved in looking after the collective animals.

In Lower Chitral (Kesu) 87 per cent of the households have an individual system of management, while the remaining 13 per cent use nomadic herdsmen. In contrast, in Besti, 100 per cent of the sample households use a collective management system. In Marthing, 87 per cent use a collective management system (Table 20.9).

Table 20.9. Goats/sheep management

	System of management		
	Individual herdsmen	Village	Nomadic
Zone 1 (Kesu)	26	0	4
Zone 3 (Besti)	0	30	0
Zone 2 (Marthing)	4	26	0

Source: Mulk 1990.

The breaking down of the collective management systems has played an important role in reducing the numbers of sheep and goats at the village level in Kesu, and, therefore, looks like a blessing as it reduces the pressure on natural resources. In actuality, what happens is that the villagers, unable to look after the livestock, hand over their management to nomadic herdsmen[1] These nomadic herdsmen living far away from the village gradually start misappropriating the animals. After a while the villagers start giving up their animals as they are unable to sustain the losses. The nomadic herdsmen become economically powerful, buy land, and start maintaining larger and larger herds.

1 Nomadic herdsmen, or 'gujars' as they are locally known, do not speak the local Khowar language as their mother tongue. At some stage in Chitral's history they must have been invited to come and look after the livestock herds of important feudal officials. They did not possess landed property. In many places they took the livestock of different people to pastures and paid a tax called 'qalang' to the right holders. The nomadic herdsmen are considered to be very hardy people as their living conditions are extremely harsh.

Once they buy land, they possess the same rights to the natural resources as the rest of the villagers. Since they live outside the village, the traditional, informal village institutions which regulated the sustainable use of natural resources, with the help of social pressure, are unable to influence them. They show less reluctance to destroy pastures and forests.

It needs to be understood that as education levels rise, and off-farm opportunities increase, fewer individuals will be willing to contribute to these traditional systems, unless the villagers institutionalize their relationship on an equitable basis. If this is not done in the next decade, the nomadic herdsmen will take over all the pastures in other parts of Chitral too.

Livestock Feed

Goats and sheep are dependent on grazing in the pastures, the former in the more distant pastures. Cattle are sent to the pastures for about four months in the summer. These pastures, as indicated in Table 20.10, are at considerable distances from the villages. During winter, the period of stall-feeding has increased as the feed situation has improved over the years.

Table 20.10. Distance from village of summer pastures (no. of households)

Villages	Hours		
	3 Hours	5–7 Hours	8–12 Hours
Zone 1 (Kesu)	0	17	12
Zone 3 (Besti)	15	15	0
Zone 2 (Marthing)	0	30	0

Source: Mulk 1990.

The feed situation has improved in recent years in all the villages. Fewer households face feed problems now, and the number of months over which they occur has been reduced considerably. However, the need to improve the situation exists, as a considerable number of households report scarcity in winter months. Anecdotal evidence indicates that the shortage of livestock feed was a major cause of livestock deaths during winters in the past.

Cropping Patterns

Crops, besides providing grains for human consumption, also supply the feed for livestock.

In all the three villages wheat occupies over 31 per cent of the total cultivated area. It forms the staple diet and its straw is an important livestock feed. In Kesu, winter wheat is grown. In Marthing, an attempt has been made to introduce winter wheat, but its germination and yields have been poor. At present, out of the 36 per cent of cultivated area devoted to wheat, 31 per cent is for summer wheat. At Besti, 100 per cent of wheat grown is summer wheat. No new wheat seed has been introduced here. This emphasizes the need for research in to introducing new varieties (Table 20.11).

Maize, barley, and pulses occupy important positions among the crops grown.

In recent years, vegetables have become an important cash crop in Kesu Village.

Table 20.11. Crop area of total households and its distribution as a percentage of cultivated area (crop area in *Chak*)

Crops winter/ spring	Kesu		Besti		Marthing		Total	
	Crop area	% of cult. area	crop area	% of cult. area	Crop Area	% of cult. area	crop area	% of cult. area
Winter wheat	79	32	0	0	14	5	93	12
Spring wheat	0	0	81	31	80	31	161	21
Barley	18.50	8	15.50	5.70	32.50	12	66.50	9
Maize	52.50	22	10	4	20	8	82.50	11
Rice	2.50	10	0	0	0	2.50	1	
Pulses	14	5	1.00	0.30	0	0	15	1
Alfalfa	0	0	*148	57	74	28	222	28
Clover	16.50	7	0	0	27	10	43.50	6
Summer vegetable	30.50	13	0	0	0	0	30.50	4
Winter vegetable	29.50	12	0	0	0	0	29.50	4
Millet	0	0	4.50	2	15.50	6	20	3
Total cultivated area (1).	243.00	100	260.00	100	263.00	100	766.00	100
Total cropland available (2)	251.00	—	141.50	—	177.50	—	569.50	
Cropping intensity (2/1)	98%	—	79%	—	107%	—	96%	
Total land of all households	290.25	—	223.50	—	280.00	—	793.75	
Cropland as a % of total land	86%	—	63%	—	63%	—	72%	
Fodder and trees as a % of total land	4%	—	23%	—	30%	—	19%	
Homestead as a % of total land	10%	—	14%	—	7%	—	9%	

*97% is grown on marginal lands where crops can grow, although very poorly. For this reason, the area under alfalfa has not been used for calculating cropping intensities.

Source: Mulk 1990.

Refugees camped in the neighbourhood of the village were instrumental in introducing commercial vegetable growing and innovations in cultivation techniques. A large proportion of the labour involved in cultivating vegetables is provided by the refugees who are working on leased land. The trend is spreading, but the market remains limited as no surpluses can be transported out of the area at economical prices (Table 20.11).

Fodder crops receive low priority. Clover is grown in Kesu and Marthing but does not exceed 7 per cent of the cultivated area. Alfalfa is grown on a considerable area in Marthing and Besti, but only on the poorer sloping land, fed by irrigation channels where other crops could not be grown. For this reason returns are low.

Cropping intensities are still low. In Kesu Village, cropping intensities could be as high as 140 per cent, as the climate is favourable, but this is not possible because there is a shortage of water for irrigation during the summer. While water is available at the source, the irrigation channel does bring this water to the fields. This explains why the total crop land available exceeds the cultivated area. In Besti Village, where the area under alfalfa has been ignored because it is grown on marginal lands, cropping intensities are even lower. The pressure on resources in Besti was explained earlier as being due to a shortage of land. The cultivable land is of poor quality and 100 per cent is not cultivated every year. Another factor contributing to low cropping intensities at both Besti and Marthing is the climate, which does not allow a second crop (Table 20.11).

Seed rates are high in the higher belts because of poor germination, poor quality of seeds, and the need to obtain fodder through thinning excess vegetation. Most farmers retain their own seed for sowing but occasionally purchase seed from neighbours or get it from the Agricultural Development Authority of the NWFP (ADA) or the AKRSP, as they do in Marthing.

Considerable amounts of farmyard manure are used by farmers. During the summer months when livestock move to distant pastures, invaluable manure is lost. Animal wastes and crop residues form the important ingredients of farmyard manure.

RECENT CHANGES

Improved Varieties

Improved wheat seed (Pak-81) has been widely disseminated in Kesu Village. The dissemination has been gradual, and has been helped by the proximity and accessibility of the village to Chitral (ADA outlet) where these seeds are available. The sample households were unaware of frequently changing seeds or how to secure new seed. At Marthing, the AKRSP has been able to supply seeds of new varieties (Pak-81 and winter wheat), but they are not widely adopted because they require successful demonstration. Lack of adjustment to the taste, as well as germination problems, have hindered progress. In Kesu, maize seed is also of the new varieties, and clover and alfalfa seed from the area is considered to be of good quality. A breakdown of average yields of local and improved varieties of seeds is given in Table 20.12.

Chemical Fertilizers and Farmyard Manure

Insufficient farmyard manure was a major constraint in increasing crop yields. At Kesu, the introduction of chemical fertilizer about 10 years ago, and at Marthing and Besti in the last five years, has increased yields of both grain and straw significantly. The two main chemical fertilizers used in the area are urea and di-ammonium phosphate (Table 20.13).

At Kesu, there was little evidence of any liquidity problem in purchasing fertilizer as there are a considerable number of individuals in salaried jobs or off-farm employment.

The AKRSP has assisted the villagers of Besti and Marthing, which are comparatively poorer villages having low surpluses, by making fertilizer credit available against the savings of the village organizations. At Marthing Rs 70,000 and at Besti Rs 97,000 worth of credit has been taken by the village organizations in the last few years.

The government has also helped in the process by subsidizing and making fertilizer

Table 20.12. Average yields of local and improved varieties of seeds at different study sites (*maund/chak*)

Crops	KESU		BESTI		MARTHING	
	Local	Improved	Local	Improved**	Local	Improved**
Wheat	5	10*	4	6	4	8
Wheat Straw	7	10*	6	9	6	12
Barley	7	10	5	7	6	9
Barley Straw	7	10	5	7	6	9
Maize	8	12*	—	—	2	5
Maize Straw	24	36*	—	—	6	15
Alfalfa	17	—	14	—	17	—
Clover	20	—	—	—	15	—
Rice	12	15	—	—	—	—

*Improved varieties and use of chemical fertilizers account for increases in yields of wheat and maize only. In other crops, improved yields are due solely to the use of chemical fertilizers.

**No improved varieties. The improved yields are attributed to the use of chemical fertilizers.

One maund = 40 kg. There are 9.25 *chak* in a hectare

Source: Mulk 1990.

Table 20.13. Percentage of cropped area using chemical fertilizer (*chak*)

Crops winter/ spring	Kesu		Besti		Marthing		Total	
	Crop area	% of cult. area	crop area	% of cult. area	Crop Area	% of cult. area	crop area	% of cult. area
Winter wheat	79	100	0	0	14	100	93	100
Spring wheat	0	0	81	100	80	100	161	100
Barley	18.50	84	15.50	100	32.50	60	66.50	81
Maize	52.50	89	10	0	20.50	95	82.50	60
Pulses	14	0	1.00	0	0	0	16	0
Alfalfa	0	0	148	0	74	0	222	0
Clover	16.50	0	0	0	27	0	45	0
Summer vegetables	30.50	100	0	0	0	0	30.50	100
Winter vegetables	29.50	100	0	0	0	0	29.50	100
Millet	0	0	4.50	0	15.50	0	20	0
Rice	2.50	0	0	0	0	0	2.50	0

There are 9.25 *chak* in a hectare.

Source: Mulk 1990.

available at sales points near the village, paying transportation costs. The government spends Rs 2 million on the subsidy and transportation of fertilizer annually.

Farmyard manure is used by all farmers. The manure consists of livestock excreta, crop residues, and household wastes. A major expense in using farmyard manure is that of collecting it from livestock sheds and transporting it to the fields.

Pesticides

Pesticides are not widely used, although in Kesu all farmers used them while growing vegetables.

Crop Rotation

Crop rotation patterns have changed in the last two decades. In the past, prior to the introduction of chemical fertilizers, crop rotation was widely practised, as farmyard manure could be applied to a limited number of fields only. In Besti and Marthing, clover, millet, and barley were grown in alternation with wheat. In Kesu, barley was widely grown in the past. Farmyard manure was applied to the barley crop, making the soil rich and fertile in preparation for the wheat crop to be grown in the next season. Cultivating millet cleared many of the fields from weeds, but with the introduction of chemical fertilizer, more area is devoted to wheat and crop rotation is reduced. While crop yields have gone up, there are problems of excessive weeds in the fields.

In Kesu, some of the crops whose cultivated areas have been reduced over the years include rice, cotton, and barley. Cotton was the earliest to go out of fashion when cloth became available from outside. Less rice is grown as the village faces water shortages and the crop requires intensive labour. Barley was once an important ingredient of the diet. The area under barley had fallen, but it has risen again after the influx of refugees whose horses and cattle require feed. As it is not subsidized, it fetches a good price.

In Besti and Marthing, the area under barley has been reduced and that under wheat has increased. In the past, prior to the introduction of chemical fertilizer, barley was widely grown, as its straw yields are higher than those of wheat.

Natural Forests

Natural forests are found in Lower Chitral. They are sources of fuelwood and timber. Very small loads of grass are obtained from them for livestock. Holly oak trees provide fuelwood, and their leaves are used as fodder for goats. Timber from pine and deodar forests is extracted by the government on a commercial basis, and the local right holders are given 60 per cent of the revenues as royalty.

At Kesu, there are considerable oak forests that belong to the village as a whole. The villagers cut wood from these forests and use it as fuelwood. There are some households that have possessed exclusive rights to the forests across the river from feudal times and exclusively extract wood from it for commercial sale. All the villagers show an eager interest in watching the Forest Department cut the deodar 'State' forests to which they are right holders. Since it is uncertain how long the government will recognize these rights before withdrawing them, speculators play on the right holders' fears and buy their rights by paying them 20 per cent of their actual value immediately and reaping benefits later. Since even the largest land holders are not very sound financially, they easily fall prey to such temptations.

Some households do not have the labour force to get fuelwood from the forests. Others do it for them if they pay the price of the wood.

At Besti Village, there are no timber forests, but the villagers still get a great portion of their fuelwood from scattered, old trees of juniper and birch in the mountains. The government takes little interest in such forests, and villagers regulate their use. Considerable numbers of birch and willow trees grow along the streams in the village at Besti. At Marthing the forests, which were few, are now almost extinct.

The average number of trees per household is quite high in Besti and Marthing villages (Table 20.14), where the absence of any major natural forests has encouraged people to be active in planting on both private and public lands. At Kesu, the holly oak forests have not been counted as they are at considerable distance from the village and grow naturally.

Table 20.14. Change in the number of trees per household

	At present			5 years ago		10 years ago	
	Fodder/ fuel timber	fruit trees (no.)	Fruit bearing	Fodder/ fuel timber	Fruit trees	Fodder/ fuel timber	Fruit trees
Zone 1 (Kesu)	2,837	1,391	1,007	1,519	602	2,206	339
Zone 3 (Besti)	26,654	514	282	28,265	263	7,495	135
Zone 2 (Marthing)	30,398	906	547	24,587	662	31,015	438

Source: Mulk 1990.

The pattern over the years is indicative of the change in outlook (Table 20.14). At Kesu, the initial fall in the number of trees shows the cutting down of holly oak trees near the village, and the rise reflects plantings carried out recently by the government to compensate for fuelwood extracted by Afghan refugees. At both Besti and Marthing, well-organized village organizations had spear-headed plantation campaigns. The details of plantations at Besti and Marthing indicate that they planted 14,000 and 20,000 forest trees, respectively, between 1985 and 1990. The process has been aided by the action of village organizations at Besti to ban the free grazing of livestock on crop fields after the autumn harvest: the renewal of a past tradition. This has enabled new seedlings to survive and grow.

The valuable species of forest trees grown alongside irrigation channels indicate that timber trees, like poplars, are important in areas like Marthing where natural forests have died out.

In Chitral there are hardly any fodder trees on farms. In Kesu Village, holly oak trees are used for this purpose.

Fruit Trees

Fruits have been grown in Chitral Valley for centuries, but, in recent years, the availability of new varieties, whose fruits last longer, and a small but growing market have encouraged villagers to plant a variety of fruit trees. Apples, apricots, and pears are the major fruits produced. The fact that households have attempted to grow grapes in villages situated at high altitudes in Marthing and Besti is indicative of this enthusiasm.

Fruit cultivation is not labour intensive, and the returns are very high per *chak* compared to crops, but poor means of communication and high transport costs have hindered commercialization. Very few households use pesticides, and fruits are susceptible to many diseases.

New varieties of fruit trees have only been introduced in Kesu, mainly through an individual effort. New varieties of trees for higher altitudes have not been introduced. There are a few nurseries for fruit trees run by the government in the area. The AKRSP has distributed 32,552 fruit trees to Village Organizations between 1986 and 1990.

Labour Shortages

In an area where land holdings are small, and the population growth rate rapid, it is expected that labour shortages will be minor. But in Kesu, 33 per cent, in Besti, 100 per cent, and in Marthing, 40 per cent of all households reported labour shortages during some time of the year. Most households identified the wheat harvesting time as the period in which labour shortages occur. The introduction of tractors and threshers has helped to ease the problem.

Average Time to Fetch Forest Products

At Kesu Village, as the natural forests have been cut down, the time required for the collection of forest products has increased (Table 20.15). This pattern is also visible in Besti. But in Marthing, as plantations around the village have increased, dependence on the naturally growing trees in the mountains has decreased, reducing the time used in fetching such products.

Table 20.15. Average time taken per household to fetch forest products (wood and grass)

	Time Period (hours)		
Study sites	Present	10 years ago	20 years ago
Zone 1 (Kesu)	7	6	4
Zone 3 (Besti)	6	5	4
Zone 2 (Marthing)	3	5	5

Migration

Migration has been one way of reducing pressure on natural resources. Permanent migration outside the district hardly exists, but there is considerable movement within the district. At Besti, the pressure on land and river erosion have forced a considerable number of individuals to move into the village. In Marthing, too, a number of individuals have moved in. Seasonal out-migration outside the district is very high from Marthing, where individuals move outside the district in search of labour or education. At Kesu, where other opportunities for income earning exist, such movement is on a smaller scale. An analysis of trends in migration over a period of time in the study villages revealed that migration starts when a place becomes accessible.

Migration, as can be seen in Table 20.16, is mainly seasonal, and directed outside the village. The bulk of it takes place in winter from the villages of Besti and Marthing where hardly any crops grow at this time of the year. It is seen that most people working outside their village try to return on leave from their work at times when labour demand is at its peak on the farms. Out-migration, was seen to increase the work loads of elderly people, women, and children.

Seasonal migration for work means increased incomes in those households involved, enabling households to use new technologies such as threshing machines.

Table 20.16. Migration (no. of individuals)

	Out				In			
	Seasonal		Permanent		Seasonal		Permanent	
	Within	Outside	Within	Outside	Within	Outside	Within	Outside
Zone 1 (Kesu)	1	4	0	1	1	0	0	0
Zone 3 (Besti)	1	7	0	0	14	0	6	0
Zone 2 (Marthing)	0	23	0	0	6	0	0	0

Source: Mulk 1990.

Income

A study of the household incomes at the three case study sites indicates that at both Besti and Marthing the per capita income comes to about Rs 2,343 and Rs 2,525 respectively. At Kesu, the income is higher at Rs 5,047.

However, the farming sector still plays a significant role in the three villages and is a major contributor to farm income. It contributes 47 per cent of the income at Kesu, 66 per cent at Besti, and 62 per cent at Marthing. A major portion of this contribution is in non-cash form. Non-cash income at Kesu is 68 per cent, about 77 per cent at Besti, and almost 96 per cent at Marthing. The cash income generated on-farm at Kesu from the sale of vegetables is almost 96 per cent. Very small amounts of barley and maize are sold. The cash incomes in Besti from the farming sector are generated from the sale of livestock and *patti* making from sheep wool. At Marthing, the on-farm cash income comes from the sale of livestock products (Table 20.17). At Kesu, besides the off-farm opportunities for employment, a number of households sell wood from the forests.

Table 20.17. Income (Rs)

	Farm*			
	Non-cash	Cash	Non-cash	Total
Zone 1 (Kesu)	321,033	149,640	543,710	1,014,383
Zone 3 (Besti)	302,603	88,915	198,920	590,438
Zone 2 (Marthing)	357,670	16,242	230,000	603,912

* Wood from the forest is not fully accounted for because of insufficient data. Incomes would be higher if fully accounted for.

Source: Mulk 1990.

Expenditure

The expenditure patterns show that the per capita expenditures at Kesu, Besti, and Marthing come to Rs 1,388, Rs 1,011, and Rs 1,292, respectively. Average expenditure per household at Besti comes to Rs 9,300 per year. The farm sector generates a cash surplus of Rs 88,915 while the actual cash expenditure for 30 households exceeds Rs 279,000. Similarly, at Marthing, the expenditure per household comes to Rs 8,500 per year. The total cash generated on-farm comes to Rs 16,242, while cash requirements exceed Rs 255,000. At Kesu, the expenditure per household comes to about Rs 10,300 per year. The cash generated by the farming sector annually comes to Rs 149,640, while expenditures exceed Rs 309,000.

This shows that in all the farms in Chitral, there is a considerable need to work off-farm to generate the necessary cash required for purchasing commodities such as wheat, sugar, tea, and ghee and to pay education costs.

GOVERNMENT POLICIES AND THEIR IMPLICATIONS

An appreciation of mountain specificities means acknowledgement that mountains are a different habitat and require a different kind of attention. Mountain areas had preserved their environment and habitats in the past because of decentralized local governments which recognized and were sensitive to their needs. These have now been replaced by centralized structures which look upon the mountains as extensions of the plains.

In the past, except for constructing irrigation channels, the Government of Pakistan did not engage itself in agricultural development activities. Today, government departments in almost all fields of human activities exist in Chitral. Nevertheless, their whole approach is a centralized bureaucratic approach, indifferent to local realities.

The government policy in the plains is to extend the areas of agricultural land through highly visible, large-scale irrigation projects. This policy was initially applied to the mountain regions as well. Stress was laid on large schemes. In doing so, planners failed to realize that in an area like Chitral, there are over a thousand irrigation channels which supply water to small tracts of agricultural land which support a sizeable population. These irrigation channels have supported a large beneficiary base, and were previously entirely self-maintained. The new projects supplied water to land belonging to fewer individuals. As a result, although the irrigation projects were completed, it took years before land development could take place, and benefits be realized, as only a few took interest in it.

The policy of providing subsidised chemical fertilizer has helped increase the yields of crops in Chitral. But the tendency to overuse has also increased. The nutrient content of soil in Chitral is poor, and there is fear that it could be depleted. As a result of higher yields of wheat, through the use of chemical fertilizers, crop rotation has been given up in many areas. In the introduction of chemical fertilizers, the fragile characteristic of the mountain area was ignored.

As far as agricultural research goes, there has been no attempt to treat Chitral as a separate agro-ecological zone. The physical terrain, topography, climate, livelihood, and culture of the area are unique. Agricultural research has been dependent on an agricultural research station situated in a different agro-ecological zone, i.e., Swat. Chitral is administratively part of Swat, but agro-ecologically it is part of the Northern Areas. Both the government structure and policies ignore this. As a result, Chitrals particular needs go unattended.

The policy of reducing inaccessibility within the district, without doing it outside the district, has made the area dependent on outside inputs without its benefiting from its comparative advantage in fruit production.

The highly fragile nature of the environment has not won government sympathy. The destruction of forests by commercial logging, as is done in other regions of Pakistan, should not have been allowed here, as poor rainfall and over-grazing by goats do not permit the regeneration of forests. But, instead, the Forest Department thinks in terms of generating revenues.

Activities such as terracing which prevent soil erosion, but which require considerable labour and time, should be encouraged through incentives. The desire for off-farm employment does not allow people to get involved in these activities. But their contribution towards preservation of the environment is self-evident.

The human adaptation mechanisms expressed in local institutions and traditions have been ignored as a thing of the past. These institutions were based on the idea of cooperation and self help. They are extremely important for survival in these harsh environments. The government, by not investing in these institutions, fails to realize that they have a very important role in the preservation of the mountain habitat. The AKRSP has established village organisations with their capital base in 50 per cent of Chitral's villages. The government could use these village-level participatory institutions for its development work and help make them viable. Since, to make these institutions viable, it is essential for them to appreciate their obligations, the government would be contributing towards the long-term sustainability of agriculture if it avoids 'soft programmes', or programmes which do not place obligations on the communities.

Despite its physical and geographical isolation, Chitral enjoys no special rights in the Constitution. Many other backward regions of the country are given special quotas in federal services. The provision of such rights could help reduce the pressure for off-farm employment in the district.

The paucity of land has been a major constraint for agriculture in the region. An adaptive strategy adopted in the past by the farmers was to build their houses on mountain slopes and save the best land for agriculture. The big government complexes being built in the area try to buy the best land for their constructions. A major mountain specificity is thereby ignored.

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DIVERSITY OF MOUNTAIN FARMING SYSTEMS IN HIMACHAL PRADESH, INDIA

J.P. Bhati, R. Singh, M.S. Rathore and L.R. Sharma

J.P. Bhati is a Professor in the Department of Economics, Himachal Pradesh University, Shimla; R. Singh is a Research Officer at the Agro-economic Research Centre of Himachal Pradesh University; M.S. Rathore is a Senior Research Fellow at the Institute of Development Studies, Jaipur; and L.R. Sharma is an Assistant Professor in the Department of Economics and Extension, Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India

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CONTENTS

INTRODUCTION

The two important features of conventional development approaches in mountain areas are: (1) the low priority accorded to mountains in comparison to the plains and (2) the specific situation of the mountains (Jodha 1990). The latter disregards the diversity or heterogeneity of mountain ecosystems and concentrates on a sectoral approach to development. Ineffectiveness or the uneven impact of public interventions has been the consequence of this approach. It would not be wrong to say that the farmer, who has to live with constraints and harness available opportunities, seems to understand mountain conditions better than policy makers and development experts. This is reflected by both the structural and the operational features of farming systems in different ecological zones within the mountains.

These features also represent different dimensions of what may be called strategies in mountain areas. The present paper, based on village-level and farm-level studies in different regions of Himachal Pradesh, illustrates the same.

The paper first presents a sketch of the diversity of the mountain areas in Himachal Pradesh by comparing broad characteristics of different ecological zones. This is followed by a discussion on structural and operational features of farming systems in these regions, as revealed by field studies in the selected villages. In particular, the paper emphasizes the inter-dependencies of different activities at the farm level that help sustain the farming systems.

The paper summarizes some of the public measures taken and describes farmers' responses to specific mountain conditions, such as inaccessibility, fragility, and marginality. It concludes with the enumeration of practices and measures adopted by the farmers to harness opportunity and to manage constraints in the study villages.

AGRO-CLIMATIC ZONES OF HIMACHAL PRADESH

On the basis of altitude, temperature, topography, rainfall, humidity, and crop diversity, the State Directorate of Agriculture has divided Himachal Pradesh into the following four zones.

(1) low hills: sub-tropical zone,
(2) mid hills: sub-humid zone,
(3) high hills: temperate wet zone, and
(4) high hills: temperate dry zone.

The salient features of these zones are shown in Table 21.1.

Table 21.1 clearly shows the differences in natural resource endowment of different zones along with human adaptations to them in terms of choice of land-use systems, dominant agricultural activities, and their constraints and opportunities. For analyses of the above issues and their quantification through enquiry into dominant farming systems in these zones, a detailed study on selected villages was conducted.

SAMPLED VILLAGES AND SAMPLE SIZE

By way of a brief on the methodology of the village studies it should be stated that in each of the zones described above, a village cluster was selected for detailed study. In

Table 21.1. General features of agro-climatic zones of Himachal Pradesh, India

Particulars	Low hill zone	Mid-hill zone	High hill wet zone	High hill dry zone
Altitude (m)	350–650	650–1800	1,800–2200	2,000–3500
Rainfall (cm)	80–150	150–300	100–150	<25 (No crops without irrigation)
Soils	Sandy loam, poor water retention capacity	Clay loam, acid and deficient in N and P	Shallow, acidic silt loam, deficient in N and P	Sandy loam, alkaline and low in fertility
Population density per km^2	234	143	63	5.6
Cultivated area (%)	37.4	25.1	20.2	3.0
Area under forests (%)	13.9	40.4	23.3	7.4
Area under pastures (%)	26.0	28.6	49.9	79.8
Livestock density/ km^2 (whole H.P.)	214	219	153	35
Livestock density per km^2 of forests and pasture land only	542	317	211	40
Major food crops	Wheat, maize, rice, oilseeds, sugarcane	Wheat, rice, maize, blackgram, ginger, oilseeds, pulses, off-season vegetables	Maize, wheat, pulses, millets, seed potato, temperate vegetable seeds, off-season vegetables	Barley, wheat, buckwheat, pea, seed potato, vegetable seeds
Fruit crops	Mango and citrus fruits	Stone fruits and citrus fruits	Apple and other temperate fruits	Dry fruits, hops, nuts
Key constraints	Severe pressure on agricultural land, land ratio declining below desired levels. Moisture stress in hot summer season.	Infertile, slopy lands and increasing human pressure on agricultural lands, to support land ratio falling below desired levels, limited water resources and irrigation.	Arable land scarcity, cold winters, limited water resources for irrigation on slopy lands.	Cold, dry climate, cultivation without irrigation, fragile lands, scarce natural vegetation.
Key potentials	Accessibility, snow-free, mild cold winters allowing multiple or double cropping. Suitable for mixed farming dominated by grain crops.	Accessibility, snow-free mild cold winters, allowing multiple or double cropping, rangelands available. Suitable for grain crops, livestock, and local resource-based industry. Mixed farming systems.	Cool, temperate climate. Balanced farm-forestry land ratio, fruits and vegetable cash focus on farming.	Dry summer cropping season allowing disease-free seed potatoes and cultivation. Low human pressure. Good for vegetable seed production.

N = Nitrogen, P = Phosphates.
Source: Compiled by author.

the mid-hill zone, two different farming systems were observed, hence two villages from this region were selected, one of them Narang Village, which practises a mixed farming system. This village is situated at an altitude of about 1,400 masl and lies in a *Tehsil* in the District of Solan. In the low hill zone, Gharyana Village, which is situated at an altitude of about 700 masl and lies in the Suni *Tehsil* of Shimla District, was selected for the study.

In the high hill temperate wet zone, Thanadhar Village in Shimla District, situated at an altitude of 2,100 masl, was selected. In the high hill, temperate dry zone, Chitkul Village, which lies at an altitude of 3,400 masl on the right bank of the River Baspa, at a distance of about 25 km from Sangla *Tehsil* in Kinnaur District, was selected.

From each village, 75 households, probably proportional to the sizes of the total landholdings of the village, were randomly selected for detailed survey. Data for the year 1987/88 were obtained on structured schedules on the basis of personal interviews. Detailed reports on all the five villages have been prepared and submitted to ICIMOD and are in the process of revision and finalization.

FARMING SYSTEMS IN DIFFERENT ZONES

In this section, we present an overview of the farming situation in each zone. Various types of farming system exist in Himachal Pradesh, but there are five main systems: mixed farming, remittance-supported mixed farming, vegetable-based farming, perennial plantation farming, and agro-pastoral farming. Each of these systems may vary in terms of input intensities and scale of operations. These, in turn, are influenced by climate, soil, vegetation, and other ecological factors, and by socioeconomic factors including access to market and relevant public interventions.

Level and Composition of Income

One of the ways to demonstrate differences in the farming systems is their net outcome, e.g., household income and its contributing activities. The data presented in Table 21.2 show that there are significant differences in the sources and magnitude of household incomes in different sub-zones of the Western Himalayan region. In the low hills, a mixed subsistence farming system exists, heavily supported by off-farm income (basically remittances). In the mid-hills, a mixed farming system, where livestock, farm forestry, vegetables, and off-farm activities are equal contributors to household income, prevails. The climate of the mid-hill zone is suitable for off-season vegetables and stone fruits. Fruits and vegetables are relatively more profitable and have higher employment potential than compared to cereal crops (Rathore et al. 1975, Singh and Bhati 1988, Tewari 1990). Wherever the weather is favourable and there is easy access to roads and markets, these activities have emerged as the main sources of household income and employment. Hence, in such locations, a farming system based on vegetables and stone fruits has become prominent.

Fruit cultivation (mainly apples) predominates in the high hill wet zone. In the high hill dry zone, livestock and off-farm activities are the main sources of sustenance. Due to the dominance of commercial crop cultivation (mainly apples) in the farming system, the per capita income in the high hill wet zone is much higher than in other zones where

Table 21.2. Per household source-wise income in different zones of Himachal Pradesh, India
(Amount in Rs)

Particulars	Low hill zone	Mid-hill zone		High hill zone	
	Mixed farming	Mixed farming	Veg-based farming	Wet zone	Dry zone
A. Income (Rs/family)					
1. Farm income	9,625 (45.7)	14,350 (78.0)	25,114 (26.2)	73,701 (7.4)	10,482 (43.7)
a) Cereal crops	(8.1)	(4.6)	(5.9)	(–)	(2.7)
b) Fruit crops	(3.2)	(3.1)	(21.1)	(78.3)	(0.4)
c) Vegetables	(1.8)	(12.4)	(21.5)	(–)	(–)
d) Livestock	(15.9)	(32.1)	(19.1)	(–)	(–)
2. Off-farm income	11,422 (54.3)	4,039 (22.0)	8,921 (26.2)	5.859 (7.4)	8,133 (43.7)
3. Total income	21,047 (100.0)	18,389 (100.0)	34,035 (100.0)	79,560 (100.0)	18,615 (100.0)
B. Total income (Rs/person)	2,748	2,842	4,862	13,194	2,482
C. Crop income (Rs/ha)	1,265	1,667	7,208	62,307	470
D. Farm size (ha)	2.19	2.22	2.29	1.00	1.24
E. Family size (persons)	7.66	6.47	7.00	6.03	7.50

Note: Figures in parentheses denote percentages to total family income.
Source: Field survey.

commercialized production is lacking. In 1987/88, per household agricultural income in the low hills was Rs 9,625 and this constituted 46 per cent of the total household income. In the mid-hill zone, where mixed farming is practised, the annual agricultural income was Rs 14,350 (78% of the total), and in the vegetable-based system, the annual agricultural income was Rs 25,114 (74% of the total). In the high hill wet zone, the annual agricultural income was Rs 73,701 (93% of the total) and in the high hill dry zone the agricultural income per farm household was Rs 10,482 or 56 per cent of the total annual household income. Hence, it is clear that in the low hill zone and in the high hill dry zone, 54 per cent and 44 per cent of the household incomes respectively are derived from non-agricultural sources.

Due to unfavourable weather conditions in the high hill dry zone, the productivity of crops is very low (Swarup and Singh 1988). In the low hill zone and the high hill dry zone, the rainfall is low and unreliable making crop cultivation risky, but sometimes it falls with such intensity that it causes soil erosion and imposes an expensive burden on soil conservation activities. Farming in the low hill zone and the high hill dry zone is, on the whole, subject to a greater degree of natural risks than in the mid-hill zone and the high hill wet zone, owing to the greater incidence of droughts and floods. Therefore, the low hill and the high hill dry farmers need (but rarely have) especially large capital reserves to enable them to surmount these disasters. The degree of risk is reduced in some areas by providing irrigation facilities.

Farm families rely on non-farm income and remittances to stabilize their annual incomes and consumption. Moreover, livestock rearing is the only feasible activity where there is uneven relief or a different climate (as in the case of the high hill dry zone) and where food production or the production of other agricultural products (e.g., wool) is difficult (Negi 1990, Swarup and Singh 1988). In the high hill temperate, dry zone the transhumance farming system is followed. Since the resource base is poor and the area remains snow-bound for about six months in a year (November to April), the farmers shift their livestock (sheep and goats) to the lower hills for grazing.

Family Size and Workforce

The average family size in the five farming systems under study ranges from 6 to 7.6 persons. The number of workers per family ranges from 3.3 (in the mixed farming system) to 4.4 (in the high hill dry zone). The proportion of household workers working on farms ranges from 83.3 to 92.5 per cent (Table 21.3).

Table 21.3. Per household family size, workforce and literacy rates in different zones of Himachal Pradesh, India

Particulars	Low hill zone	Mid-hill zone		High hill zone	
	Mixed Farming	Mixed Farming	Veg-based Farming	Wet zone	Dry zone
Family size (no.)	7.66	6.47	7.00	6.03	7.50
No. of workers per family	3.64	3.35	4.13	3.64	4.36
Literacy rate (%)	75	66	77	80	47
a) Males					
b) Females					
c) Total					
Occupational distribution of workers					
a) Farming	83.3	91.6	91.2	92.5	87.8
b) Services	16.3	7.6	7.3	6.8	10.6
c) Business	0.4	0.8	1.5	0.7	1.6

Source: Field survey.

The literacy rate was 66 to 80 per cent. It is clear that households earning substantial incomes from fruit farming, in the high hill wet zone, have small families, are more literate, have a greater degree of commercialization, and have a higher dependency on farm income, whereas households in the low hill zone and in the high hill dry zone have bigger families, lower incomes, a lower degree of literacy, and less dependency on farming.

Size of Land Holdings

The average land holding in the apple-based farming system (high hill wet zone) is one hectare, in the livestock-dominated farming system (high hill dry zone) it is 1.2 hectares, and in the remittance-based mixed farming system (low hills) it is 2.2 hectares. In the

Table 21.4. Comparative percentage-wise distribution of total land holdings

Percentage

Particulars	Low hill zone	Mid-hill zone		High hill zone	
	Mixed farming	Mixed farming village	Veg-based farming village	Wet zone (apple farming village)	Dry zone (livestock-based farming village)
Marginal (<1 ha)	24.3	36.0	41.1	66.1	56.4
Small (1–2 ha)	29.7	22.7	19.6	16.9	23.0
Medium (2–4 ha)	35.2	28.0	27.5	10.4	15.0
Large (>4 ha)	10.8	13.3	11.8	2.6	6.6
Total	100.0	100.0	100.0	100.0	100.0
Average size of holding (ha)	2.19	2.22	2.29	1.00	1.24

Source: Field survey.

mid-hill zone the land holding per household is about 2.2 hectares (Table 21.4).

The proportion of marginal-sized land holding to total holdings is higher (above 56%) in the high hill zone than in the low hill zone and the mid-hill zone (Table 21.4). The proportion of marginal-sized farms is 24 per cent in the low hill zone and 36 to 41 per cent in the mid-hill zone. The proportion of small farms accounts for 17 to 23 per cent of the total holdings in the high hill zone, for 20 to 23 per cent in the mid-hill zone, and for 30 per cent in the low hill zone. The proportion of large holdings (i.e., holdings above 4 ha) varies from 3 to 13 per cent of the total holdings in all the zones. In the low hill zone 35 per cent and in the mid-hill zone 29 per cent of the holdings are of medium size (i.e., of 2–4 ha). Nevertheless, the overwhelming majority of land holdings fall under small and marginal farm categories. Thus, viewed from the criterion of size of holding, the bulk of the households were characterized by economic marginality and it was obvious that the land alone could not sustain them.

Operational Dimensions

Crop Diversification

Cropping patterns under different farming systems are shown in Table 21.5. The important cereal crops are maize, wheat, and barley. Vegetable crops grown include potatoes, peas, capsicum, cauliflowers and tomatoes, and these are grown during the offseason period, in the plains. Millet is also an important crop in the high hill dry zone and only apples are grown in the sampled villages of the high hill wet zone. The 'niche' (comparative advantage) for fruits and vegetables was fully exploited by the farmers wherever natural conditions and the socioeconomic and institutional environment (prices of inputs and outputs, farm size, credit, extension services, and marketing facilities) were favourable. Furthermore, with a rise in elevation, crop diversity and the area under mixed crops decline. The area under sole (pure) cropping in the low hills was 32 per cent, in the mid-hills (mixed farming) 62 per cent, in the vegetable-dominated system of the mid-hills, it was 78 per cent, and in the high hills almost 100 per cent of the total cropped area.

Table 21.5. Distribution of gross cropped area to sole, mixed, and perennial crops in different zones of Himachal Pradesh, India

Crops and mixtures	Low hill zone	Mid-hill zone		High hill zone	
	Mixed farming	Mixed farming	Veg-based farming	Wet	Dry
Sole crops					
1. Maize	6.6	20.0	19.5	—	13.1
2. Tomato	5.9	5.5	13.2	—	—
3. Capsicum	—	0.1	3.8	—	—
4. Peas	—	—	16.1	—	2.7
5. Wheat	9.4	16.4	11.0	—	16.4
6. Barley	4.1	8.0	4.2	—	15.4
7. Millet	—	—	—	—	29.9
8. Potatoes	—	—	0.7	—	6.4
9. Others	5.9	12.2	10.3	0	14.4
10. Total	31.9	62.2	78.8	—	98.3
Mixed crops					
1. Maize + pulses + Sesame	32.5	10.4	—	—	—
2. Wheat + oilseed + peas	31.2	18.2	—	—	—
3. Peas + coriander		5.7	—	—	—
4. Potato + coriander	1.3	—	—	—	—
5. Others	1.56	—	—	—	—
6. Total	66.6	36.5	—	—	—
Fruit crops	1.5	1.3	21.2	100.0	1.7
Gross cropped area	100.0 (1.73)	100.0 (1.74)	100.0 (0.93)	100.0 (1.02)	
Cropping intensity	187	188	169	200	109

Note: Figures in parentheses denote per farm gross cropped area in hectares.
Source: Field survey.

Modern/Market-Purchased Inputs

As the proportion of cash crops increases, the per farm and per hectare application of fertilizers and pesticides increase. The proportion of the area under high yielding varieties (HYVs) of food crops also increases as farm incomes and cash crop production increases (Table 21.6). It should be pointed out that while the HYVs of wheat and rice have been adopted, the HYVs of maize evolved so far have not been adopted by the hill farmers. Local varieties of maize are more tasty and give higher yields than the HYVs of maize released in the region. The HYVs for maize, like those for wheat and rice, were developed in the plains, but, unlike the wheat and rice varieties developed, the maize varieties developed were not suitable for hill areas, and this suggested the need for local research on maize for the hills.

Table 21.6. Comparative annual application of modern inputs

Modern inputs	Low hill zone: Mixed farming	Mid-hill zone: Mixed farming	Mid-hill zone: Veg-based farming	High hill zone: Wet (apple farming	High hill zone: Dry (livestock-based farming
Fertilizer (kg):					
Per farm	15	57	557	296	12
Per ha of of GCA	9	33	295	318	12
Plant protection material (Rs)					
Per farm	6	370	797	2,500	–
Per ha of GCA	3	213	422	2,689	–
HYV seeds (% area)					
Maize	33	48	100	N.A.	35
Paddy	84	84	N.A.	N.A.	70
Wheat	99	84	100	N.A.	95

N.A.= Not applicable. GCA = Gross Cropped Area
Source: Field survey.

In the commercial farming systems (i.e., in the vegetable-based and the apple-based systems) the use of pesticides and the application of plant protection materials are quite high. Due to reduction in cropping diversity and the replacement of traditional crops by new crops, the incidence of diseases, insects, and pests has increased. This has led to adoption of chemical plant protection measures on a large scale. Increased dependence on external sources and greater management complexity are other features of the scientific farming processes represented by the above two systems. The degree of risk and uncertainty (market risk and production risk) have also increased and this makes both these farming systems relatively unsustainable.

Observations of the farm households in commercial farming systems (i.e., in the apple-based system of the high hills and the vegetable-based system of the mid-hills) suggest that, as farmers adopt new methods of farming, their ideas also change. This is part of the transformation process in rapidly modernizing areas of the state.

Changes can be seen in terms of the attitudes of the farmers towards agriculture, towards natural environment, towards themselves, and towards their traditional partners; e.g., traders and government agencies. Such households no longer suffer from social, economic, and political marginality.

Livestock Numbers and Composition

Livestock numbers and composition in different zones are shown in Table 21.7. Differences represent adaptations to the diversity of different zones. In the high hill dry zone, 82 per cent of the livestock population consists of sheep and goats. On average, farmers keep 88 sheep or goats and the herds are of a migratory nature (transhumance). In winter, they move to the low hills and in summer they return to the high hill pastures, thereby making fuller use of resource diversity. In the high hill wet zone, (apple-based farming system) farmers of sample villages keep cross-bred cattle (each one having about two cows) and these are mostly stall-fed. Cross-bred cows are high-value animals and require high input and quality fodder; hence, only rich farmers can afford them (Negi 1990). The grazing of cross-bred cows is limited due to heavy body weight and risk of higher loss due to possible accidents (compared to low-value, local cows).

Table 21.7. Composition of livestock in different zones of Himachal Pradesh, India

	Low hill zone	Mid-hill zone		High hill zone	
Types of livestock	Mixed farming	Mixed farming	Veg-based farming	Wet	Dry
Cattle	53.2 (6.03)	69.4 (5.24)	68.3 (6.17)	98.4 (2.46)	6.0 (5.31)
Yaks	—	—	—	—	0.4 (0.30)
Buffaloes	10.4	16.2	18.0	—	—
Sheep and Goats	36.4 (4.13)	14.4 (1.09)	13.0 (1.18)	1.6 (0.04)	93.1 (81.94)
Mules and others	—	—	0.7 (0.06)	—	0.5 (0.45)
Total livestock	100.0 (11.34)	100.0 (7.55)	100.0 (9.04)	100.0 (2.5)	100.0 (88.00)

Note: Figures in parentheses are the number of livestock per farm.
Source: Field survey.

In the mid-hills, on average, a farmer keeps about eight animals out of which cattle account for about 70 per cent of all livestock. Buffaloes and sheep/goats respectively account for about 17 per cent and 13 per cent of all livestock. In this zone, animals are partly grazed and partly stall-fed. In the case of the low hills, the number of farm animals kept per farm is 11.3, out of which cattle account for 53 per cent, buffaloes 10 per cent, and sheep/goats 37 per cent.

Except for the high hill dry zone, the number of large animals in the livestock possessed by farmers is higher in all farming systems. Both manure and draft power are important needs necessitating the possession of large-animals. Under each of these systems a few small animals (sheep and goats) are also kept by farmers to meet their clothing and meat requirements and also as an asset that can easily be sold in times of emergency. Overstocking of animals and denudation of common grazing resources are two of the main problems of the livestock sector in the region (Bhati 1981, 1983).

INTERDEPENDENCY AMONG DIFFERENT FARMING SUB-SYSTEMS

Despite differences in the relative importance of the different components of the farming systems, the very presence of multiple components in all the zones illustrates the farmers' adaptations to diverse environmental and resource situations in the mountains. Furthermore, it is not only the diversity of land-based activities (cropping, animal husbandry, horticulture and farm forestry), but also their interlinkages which help to sustain these activities. The dependence of cropping on livestock, for manure and draft power as well as cash income, animal husbandry's dependence on crop by-products; and the role of the forests in reinforcing the above are well known in mountain areas. Use of forest land or common land as sources of fodder and other products is widespread despite the decline in or degradation of these resources.

The linkages indicated above finally lead to stability of farm income and consumption levels. Of course, with modernization of mountain agriculture some of these linkages are also disrupted or transformed. In the following discussion quantitative evidence on some dimensions of the above interdependencies are presented. The linkages of different production sectors are presented by indicating (1) the values of outputs generated by one sector and used as inputs by other sectors and (2) the ratio of such input values to per rupee of output generated by the input-using sectors. The situation is illustrated with reference to the dependence of farming systems on the livestock and forestry sectors only.

Dependence on Livestock Sector-generated Inputs

Table 21.8 provides details on the use of livestock inputs (such as manure and draft power) in different sub-sectors of farming in different zones of Himachal Pradesh. On the whole, the requirement of livestock input per rupee of output (i.e., input-output ratio) in the case of cereals is higher than in the case of vegetables. The input-output ratios also indicate that the requirement of livestock input in cereal and vegetable production is relatively higher in the mid-hill mixed-farming system and lower in the mid-hill vegetable-based, mixed farming system.

Table 21.8. Per farm annual imputed value of livestock sector generated inputs used in different sub-sectors

Sectors using input (manure draft power)	Low hill zone	Mid-hill zone		High hill zone	
	Mixed farming system	Mixed farming systems	Veg-based farming systems	Wet (apple farming systems)	Dry (livestock-dominated farming system)
Cereals	22.96 (0.34)	1,849 (0.40)	906	— (0.36)	1,297 (5.31)
Vegetables	209 (0.19)	1,012 (0.13)	2,199 (0.09)	—	—
Fruits	—	—	31 (0.001)	980 (0.01)	10 (0.03)
Total/farm	2,505 (0.29)	2,861 (0.22)	3,136 (0.11)	980 (0.01)	1,307 (0.34)
Total/ha	1,144	1,289	1,369	980	1,054

Note: Figures in parentheses denote input-output ratio, i.e., livestock sector-generated input per rupee of output in the other sector.

Source : Field survey.

In terms of absolute amount, mid-hill vegetable-based farms are observed to be using the highest amount of livestock input per farm (amounting to Rs 3,136), followed by the mid-hill mixed farms (worth Rs 2,861), the low hill mixed farms (worth Rs 2,505), the high hill dry zone farms (worth Rs 1,307), and the high hill wet zone farms (worth Rs 980). The same trend can also be observed in the case of per hectare use of livestock input by different farming systems. But as the input-output ratios show, the highest requirement for livestock sector-generated input use per rupee of output is found in the case of the high hill dry zone, livestock-dominated farming system. This is followed by the low hill mixed farms, the mid-hill mixed farms, the mid-hill, vegetable-based farms, and the high hill wet zone farms. On an average, the annual requirement of livestock sector-generated inputs per hectare of operated land is Rs 1,144 in the low hills, Rs 1,289 in the mid-hill mixed-farms, Rs 1,369 in the vegetable-based farming system, Rs 980 in the high hill wet zone and Rs 1,054 in the high hill dry zone. Seen in the context of the earlier discussion the sub-system's dependence on livestock-generated inputs declines with the degree of commercialization of the activity requiring greater use of marketed inputs.

Dependence on Forestry Sector-generated Inputs

Dependency on farm production activities on inputs obtained from farm and forestry, common property resources, and government forests is high (Table 21.9). Per farm annual value of inputs obtained from these resources (i.e., inputed value of grass and grazing, leaf fodder, and wood for implements, packing cases, and staking), were Rs 5,562 in the low hill zone, Rs 8,964 in the mid-hill mixed-farming zone, Rs 16,857 in the mid-hill vegetable-based farming zone, Rs 42,604 in the high hill wet zone (apple-based farming), and Rs 7,849 in the high hill dry zone (livestock-based farming).

It is quite clear that commercial farming (based on fruits or vegetables or both) requires more inputs from forests and common property resourçes. Since these resources are already showing signs of degradation, a rapid shift from traditional farming to commercial farming, due to the latter's 'servicing needs', will put more pressure on the natural (vegetation) resources unless some substitute for wood (used for packing and staking) is found. This may make the new and commercial farming systems unsustainable in the long run.

Examination of sector-wise dependence on natural resources shows that the livestock sector hèavily depends upon common property resources (CPRs) in all the zones. Cereal crops are not so dependent on forests or CPRs, except for farm implements (e.g., ploughs, hand tools, etc).

The comparison of the use of forest and CPR-generated inputs per rupee of farm output in different farming systems reveals the following. The input-output ratio in the low hills is 0.25, in the mid-hills mixed farming system 0.32, in the mid-hills vegetable-based farming 0.27, in the high hills apple farming 0.42 and in the high hills dry zone 0.39. Viewed differently, 25 to 40 per cent of the input contribution, from the natural resource sector to the per rupee of output from different farming systems, indicates the undiminished role of the commons and public resources in the farming systems in Himachal Pradesh. Furthermore, persistent over-dependence on these resources and their rapid depletion, due to overexploitation, may make both traditional and commercial farming systems unsustainable in the long run.

Table 21.9. Per farm annual imputed value of inputs obtained from own trees and grassland, government forests, and community resources in different study areas in Himachal Pradesh, India

	Low hill zone	Mid-hill zone		High hill zone	
Sectors using inputs	Mixed farming	Mixed farming	Veg-based farming	Wet (apple farming)	Dry (livestock-based farming)
Livestock	4,972 (0.37)[a]	4,614 (0.32)	9,829 (0.58)	3,495 (0.26)	7,439 (0.46)
Cereals	540 (0.08)	333 (0.07)	182 (0.04)	—	260 (0.07)
Vegetables	35 (0.03)	3,881 (0.49)	3,582 (0.15)	—	—
Fruits	15 (0.02)	13 (0.02)	3,264 (0.19)	39,109 (0.45)	150 (0.53)
Total/farm	5,562 (0.25)	8,964 (0.32)	16,857 (0.27)	42,604 (0.42)	7,849 (0.39)
Total/ha	2,540	4.038	7,361	42,604	6,330
Dependence on public sources (%)[b]	23	68	82	97	100

[a]Figures in parentheses denote input-output rate, i.e., input per rupee of output.
[b]Indicates non-private resources, e.g., common property resources (pasture, community forest, and drainage), government forest.
Source: Field survey.

Pressure on natural common resources (forests and pastures) must be reduced. Emphasis should also be put on agroforestry so that the provision of wood and fodder becomes the responsibility of the farmers themselves. At present, the proportionate dependence on external resources for wood and fodder (government forests and CPRs) is 23 per cent in the low hill zone, 68 per cent in the mid-hill zone (mixed farming), 82 per cent in the mid-hill zone (vegetable-based farming), 97 per cent in the high hill zone (apple farming), and 100 per cent in the high hill dry zone (livestock-based farming). It is also clear that as commercialization increases, the dependence on external sources (which are beyond the control of the farmer) increases. This means the degree of uncertainty for these inputs also increases, which will make farm enterprises more vulnerable and unsustainable.

ADAPTATION AND ADJUSTMENT TO MOUNTAIN SPECIFICITIES

The types of farming systems and their structural and operational features represent farmers' adaptations to constraints and opportunities available in the mountain ecosystems. However, the above discussion on farming systems can be supplemented by specific measures constituting farmers' adjustment mechanisms. The field studies generated a number of qualitative observations in this respect. These have been summarized in Tables 21.10 to 21.12 while listing farmers' responses to selected mountain specificities (e.g., modification of a mountain specificity or adapting to it). We have also listed the public responses (i.e., development interventions) in relation to different mountain specificities. The three mountain specificities covered are inaccessibility, fragility, and marginality (Jodha, Chapter 2), which are major sources of constraints in mountain areas.

Table 21.10. Responses to inaccessibility as constraint through modification and adaptation

Inaccessibility and its implications and responding agency	Modification	Adaptation
Poor mobility and high transport costs		
a. Farmers' responses	1. Construction of mule tracks and wooden bridges	1. Self-help activities 2. Use of local materials 3. Head load/and/or use of pack animals 4. Local trading 5. Self-sufficiency in food items 6. High-value, low-weight produce for sale (e.g., ghee, woollen cloth, oilseeds)
b. Govt. responses	1. Construction of roads and bridges 2. Ropeways 3. Provision of growth centres 4. Public transport	1. Transport subsidy (for input/output). 2. Local processing facilities. 3. Storage, public distribution system.
Weak agricultural extension and support services		
a. Farmers' responses	1. Provision of informal credit 2. Obtaining new information from local progressive farmers	1. Use of local breeds and seeds and indigenous knowledge for farm management 2. Acquisition of radio for farm news and other information.
b. Govt. responses	1. Establishment of schools, banks, post offices, and agri/livestock centres 2. Establishment of growth centres on area basis	1. Farmers' training programmes 2. Local research stations

Source: Field survey.

Tables 21.10 to 21.12 briefly sketch the government and farmer responses to constraints generated by three mountain characteristics. The government responses also take the forms of measures to harness positive features of mountain situation (e.g., diversity, 'niche'). Verma and Partap (Chapter 26) discuss most of these measures and their impacts. In the following discussion we elaborate on farmers' response vis-à-vis different opportunities and limitations created by mountain conditions. This listing of farmers practice is based on observations in the study villages (some of them are quantified also).

- Grasses are grown on the marginal and fragile portions of land holdings.
- Where moisture uncertainty is acute, mixed cropping is common.
- Where 'niche' or comparative advantages are clear-cut, farmers have adopted high-

Table 21.11. Responses to marginality (poor resource base) as a constraint through modification and adaptation

Inaccessibility (poor resource base) and its implications and responding agency	Modification	Adaptation
Human resource		
a. Farmers' responses	1. Access to new information and resources 2. Establishment of schools 3. Establishment of formal and informal schools 4. Anti-poverty programmes	1. Continue with traditional subsistence strategies
Land resource		
a. Farmers' responses	1. Conversion of marginal land into cultivated land, upgrading through irrigation, structural changes	1. Increased cropping intensity 2. Use of HYV seeds, fertilizers and other management practices to increase productivity 3. Cultivation of cash crops (e.g., fruits, vegetables)
b. Govt. responses	1. Public programme for land development,irrigation, etc.	1. Provision of improved agricultural technology
Livestock resources		
a. Farmers' responses	1. Adoption of improved animals. 2. Cattle replaced by buffaloes for milk production in low hills	1. Reduction in herd sizes 2. Stall-feeding 3. Plantation of fodder trees
b. Govt. responses	1. Support to livestock development (e.g., cross-bred cattle) 2. Support system for dairying, etc.	1. Provision of improved animal husbandry
Forest/pastureland		
a. Farmers' responses		1. Reduction in herd sizes 2. Stall-feeding
b. Govt. responses		1. Closure of forests from grazing land lopping
Institutions		
a. Farmers' responses		1. Informal credit system 2. Irrigation management committees
b. Govt. responses	1. Establishing banks and co-op. credit societies 2. Establishing agri/livestock extension centres 3. Establishing markets and marketing societies	
Income		
a. Farmers' responses	1. Shift towards high pay-off activities	1. Off-farm income (e.g., remittances, business, wage labour, cottage industry)
b. Govt. responses	1. Establishing small-scale industrial estates to generate off-farm employment 2. Anti-poverty programmes	

Source: Field survey.

Table 21.12. Responses to fragility (vulnerability to degradation of natural resource base) as a constraint through modification and adaptation

Fragility and its implications and responding agency	Modification	Adaptation
Cultivated land		
a. Farmers' responses	1. Terrace farming 2. Irrigation	1. Composting and manuring of land 2. Mixed cropping 3. Plantation of perennial crops
b. Govt. responses		1. Emphasis on soil conservation work 2. Emphasis on horticultural crops and farm forestry
Forest/pasture land		
a. Farmers' responses		1. Adoption of improved stoves 2. Using electricity for cooking 3. Stall-feeding 4. Reduction in herd size and improving breeds of livestock
b. Govt. responses	1. Forest regeneration programmes	1. Protecting forests by stopping entry of livestock and restriction on lopping

Source: Field survey.

value, remunerative activities, e.g., fruit and vegetable production, seed potatoes, cross-bred cows.

- When accessibility and rapid transport increase, farmers are encouraged to commercialize crop production.
- The choice of crops depends upon the suitability of agro-climatic conditions for particular crops. If the suitable crop has relatively less risk and less labour requirements then it results in total monoculture, as is the case with apples.
- Where the climate is such that crops alone cannot provide sufficient income, diversification of enterprises (crop, livestock, off-farm jobs) is more important. In the low hills, men move out to take up non-farm jobs, whereas in the high hill dry zone, animals are moved in search of new pastures.
- Where income is high, farmers avoid hard labour and less remunerative animals. They prefer few but better quality animals which are mostly stall-fed.
- Farmers in the low hills and mid-hills keep relatively more animals to provide sufficient manure for the crops. This is essential because, due to the washing away of top soils from slopy fields, most soils are poor in humus material.
- Farmers apply heavy doses of manure on vegetable crops, less on cereal crops, and least on fruit crops.
- Where water is scarce, efficient water management methods are used, e.g., applying water with plastic pipes and buckets and storing water in tanks near the fields.
- Farmers collect fodder and store it for the lean season. First, they collect fodder from CPRs and keep their own sources in reserve.
- Small and marginal farmers (having inadequate land holdings) increase their incomes by keeping more livestock that depend on CPRs for fodder.

- When growing a particular crop becomes difficult (due to diseases or shortages of staking material) farmers shift to the next best alternative crop for the same season.
- To avoid risk, due to fluctuations in prices and yields, farmers dispose of their prospective fruit crop in advance at blossoming time to pre-harvest contractors.
- When the surplus of milk, wool, cereals, or vegetables on a particular farm is small, the farmer sells the surplus produce to intermediaries, e.g., a village trader or other farmers, who transport it and sell in nearby or distant markets. However, as the total surplus increases, the farmer sells his own produce in the marketplace in order to get a better price. In some areas, cooperative marketing societies are becoming popular.
- When prices in the local markets are not remunerative, farmers individually or jointly send their produce to distant markets. In this context, market prices announced on the radio, during the agricultural information services, are very useful in helping farmers decide where to market a particular product.
- When green grasses are in short supply, farmers mix tree leaf fodder with dry grasses before feeding. The farmer gives good fodder to milch and draft animals while dry animals get the lower quality fodder (generally dry grasses) and are grazed throughout the year, although due to over-grazing, most pastures are heavily degraded. Milch animals receive supplemental stall-feeding.
- Commercialization of crops depends heavily upon external markets (both for obtaining inputs and for selling outputs), hence the degree of uncertainty increases and most farmers do not like this. They want higher incomes with least uncertainty.
- Larger family size increases the demand for food and this results in an extension of cropped areas by bringing grasslands (unsuitable lands) under the plough.
- Because of mutual dependence, farmers' decisions are greatly influenced by attitudes and relationships within the local communities in which they live. Members of rural communities commonly cooperate to do things that would be difficult or impossible for individuals working alone (e.g., making village paths or roads and small bridges, operating local irrigation facilities, and integrated pest management for fruit crops).
- Migratory shepherds face fodder shortages during the winter months when they migrate to the lower hills. Here, fodder on government pastures is scanty. Therefore, the shepherds hire panchayat lands on contract for grazing and also use private fallow lands. To supplement poor fodder supplies during this season, they feed salt and mustard oil to their flocks.
- The owners of small flocks send their flocks of sheep and goats to graze with other large flocks on a tenancy basis.
- Whenever there is a need for cash to buy food or other items, migratory shepherds sell their animals. Hence, animals are a form of capital savings for them.
- To remove the problem of inaccessibility, villagers themselves have built small roads and bridges to connect the village with nearby roads.
- Where transportation is a problem, farmers produce low-weight, high-value products (e.g., woollen clothes, dry fruits).
- At times of need they help each other by providing credit, labour exchange, and farm inputs (seed and manure).

The farmers' practices enumerated above provide a mix of measures designed to meet both the known and the unknown circumstances created by environmental features of the mountains as well as the demographic, institutional, and technological changes.

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22

ANDEAN FARMING SYSTEMS: FARMERS' STRATEGIES AND RESPONSES

A. Camino

Alejandro Camino has been working on issues related to Andean Agrarian Ecology since the late 1970s, is associated with the Department of Anthropology of the Pontificia Universidad, Catolica del Peru, and is the Director of Development of the Fundacion Peruana para la Conservacion de la Naturaleza, Lima, Peru

CONTENTS

INTRODUCTION

Within the Andean Ranges, running from the extreme north to the southernmost tip of the South American continent, the Central Andes—stretching between the Equator and the Tropic of Capricorn—exhibit extreme conditions of heterogeneity and biodiversity, turning it into one of the most varied biomes on earth. Despite having numerous characteristics that set constraints and limitations for human utilization and which should have made it a marginal area for human subsistence, the region was an early cradle of civilization, supporting a peculiar and complex Amerindian imperial society with major achievements in all fields of culture. Most notably, farming and pastoralism attained an unsurpassed, all time height and substantial levels of productivity and production were achieved, as reflected by the massive accumulation of food and commodity surpluses.

By the time of the Spanish Conquest under the expanding rule of the Inca Empire, Andean society had evolved into an elaborate complex civilization based on a non-monetary redistributive economy (Murra 1975) which has been characterized as a stratified welfare state (Rowe 1946). Besides the magnificence of urban architecture and the wealth of the temples and the ruling classes, what most impressed the European conquerors, perhaps, was the vast amount of stored foodstuffs and manufactured goods, mostly kept in State warehouses (Garcilaso de la Vega 1959). Struck by the living conditions in the Andes, an early chronicler wrote that, as opposed to his former European experience, in these lands, hunger was unknown (Cobo 1964).

For years after the conquest, storehouses kept supplying feuding conquerors with food and cloth. Nearly 500 years have past, and, since then, the Andean countries have become net importers of food. In order to explain this dramatic change we need to understand two interrelated processes that characterized the colonial and republican experiences resulting from conquest and domination: socioeconomic change and the subsequent transformation of the traditional Andean subsistence system.

After nearly half a millennium of European colonization and contemporary modernization, the region has and is experiencing environmental degradation, encompassed by a significant drop in production and productivity with subsequent deterioration of human standards of living. Paradoxically, this process takes place side by side with the modernization and development of formerly marginal areas (Pacific coastal deserts and Amazonian tropical rainforest). In the context of this trend, the Andean mountainous region has been perceived as backward, traditional and unmodernised, and marginal to the economic mainstreams. Agronomic potential has been mostly disregarded in favour of the promotion of mining, in accordance with the perspectives of an export-oriented economy.

Only during the last two decades have academic researchers become interested in the Andean traditional farming and herding systems. The resulting increase of information triggered applied programmes aimed at both the recovery of paleo-technologies and the salvage and promotion of native food crops. Only most recently have government agencies started reconsidering their farming development policies for the highlands.

After reviewing some basic aspects of the Andean traditional subsistence strategies and their current status, this paper will examine the configuration and outcome of some pilot experiences for the development of mountain productive systems and review some of the changing national policies and their impact on mountain environments. Finally, we will attempt to define some broad guidelines to be considered for the promotion of alternatives addressed to assure sustainable development in the Andes.

THE CENTRAL ANDES: HETEROGENEITY AND BIODIVERSITY FROM A MOUNTAIN ENVIRONMENTAL PERSPECTIVE

Framed by the coastal desert and the world's largest tropical rainforest, along its north-to-south ranges, the Central Andes are subject to weather conditions set by the South Pacific and South Atlantic anticyclones. Above parallel 5°S, the coast receives increasing rainfall, gradually turning from desert to deciduous shrub forest and to tropical rainforest. South of 5°S, the narrow littoral becomes a dry, rocky sand dune desert interrupted every 20 to 60 km by seasonal rivers flowing from the highlands. Across the ranges, on its eastern piedmont facing Amazonia, high humidity and intensive precipitation predominates culminating in a gradual transition from high cloud forest to lowland rainforest.

In between this lie numerous high mountain ridges, upland plateaux, and broad and open, as well as deepend narrow valleys—all subject to a variety of meteorological conditions affected by longitude, latitude, and altitude. A gradient of life zones can be found at different altitudes along the east-west transect. Making this panorama still more complex, latitude accounts for further variation. Towards the Equator, rainfall becomes more abundant and, in general, mountains have a more gentle relief and become lower. In contrast, as one approaches the Tropic of Capricorn, the cordillera widens, rises to higher altitudes and becomes rougher and drier. Thus, while *paramo*[1] vegetation characterizes the northern biogeographical province, a dry area of desert-like *Puna*[2] dominates the landscape in the southwest. On the average, precipitation diminishes from north to south and from east to west. Mountain relief, range directions, and slope orientation dramatically intensify the degree of meteorological variability.

Originating in the Paleozoic Era, the Andes emerged during the Pliocene Pleistocene uplift. Active geological processes still keep remodelling and shaping the topography, forging a highly heterogeneous and fractioned distribution of soil types.

In terms of life zones, the Central Andes perhaps hold a world record. Bowman noted: 'Nowhere else in the Earth are greatest physical contrasts compressed within such small spaces' (1916). To this statement Carl Troll added (1968b): 'Nowhere else in the world have I seen a more striking example of climatoecological differentiation than in the Andean valleys'. Due to their location, the Central Andes do not experience significant seasonality, with less than 5°C of thermal variation on the average (Troll 1968b). However, diurnal nocturnal oscillations (as great as 20°C) are pronounced, particularly above 3,000 masl.

Enclosed by the South Pacific and South Atlantic anticyclones and subsequent wind movements, the region does experience a seasonal pattern of precipitation, particularly south of 5°S, with rainfalls intensifying from November through March, followed by a dry season which corresponds to the South American winter. Rainfall precipitation is heavier on the north eastern slopes (on the average, over 1,800 mm) and scarcer in the dry southwestern piedmont (less than 300 mm) as exemplified by the Upper Maraon

[1] *Paramo*—moor or wasteland.

[2] *Puna*—a high bleak plateau in the Peruvian Andes. The word is also used to refer to climatic zones.

(one of the wettest areas in the world) and the Atacama Highlands less than 3,000 km southeast (one of the driest spots on earth).

One of the most particular characteristics of Andean meteorological conditions is the rather short-term and long-range lack of regularity: rains may come in early or late, abundantly or in short supply, scattered or concentrated (Dollfus 1982, Guillete 1981, and Earls 1989). Floods, droughts, frost, hail, etc may come unexpectedly affecting both programming of productive activities and productivity. In addition to annual local variations, overall climatological conditions are cyclically affected by regional meteorological phenomena, such as *El Nino*, causing total disruption of biogeographical processes, provoking geological instability, and thus, dramatically affecting human populations.

Rugged topography, poor and unstable soils, limited biomass productivity, biogeographical heterogeneity, and meteorological unpredictability all constitute major obstacles for human adaptation to the Central Andean environments. As elsewhere in mountain contexts, these factors should have restricted this region to a marginal habitat for human subsistence. However, as mentioned previously, this was not the case. Furthermore, sociocultural evolution went through one of its main stages in the Andes, and this can be explained in terms of adequate environmental management and successful adaptation. Anthropological and environmental research in the last two decades have demonstrated that 'Andean technological evolution was not obstructed by environment, but actually accelerated in response to it' (Earls 1989:39, author's translation). Andean subsistence patterns took advantage of limiting factors that otherwise could have been severely restrictive. As noted elsewhere, 'the Andean environment may be understood as the local responses to such environmental constraints as low energy availability, cold, and hypoxia' (Baker and Little 1976). Actually, as we will review here, environmental restrictions in the Andes are complex and innumerable.

ANDEAN SUBSISTENCE STRATEGIES: DIVERSIFICATION IN TIME AND SPACE

Prehistoric Evolution of Subsistence Patterns

Early hunters and gatherers, who arrived in the Andean region some 15,000 to 20,000 years ago, found a highly diversified environment with abundant game resources discretely distributed in distinct habitats which, depending on each region, guaranteed their year-round sedentary exploitation (Rick 1983). Limited short-distance transhumance provided direct access to complementary resources, while interzonal trade and barter facilitated a broader resource base.

Population growth and the depletion of faunal resources caused by overhunting, among other interrelated factors, stimulated increased dependence on a more stable and reliable resource base, triggering the gradual domestication of two Andean camelids (the llama for transportation and the alpaca for wool), native tuber potatoes (*oca, olluco, izano*, etc.), and grains (chenopods, lupinus, and amaranthus). This gradual process possibly took place simultaneously in different zones along the neighbouring biomes, ultimately resulting in the full domestication of a substantial number of plants, all of which underwent further selection into a myriad of locally adapted cultivars. Furthermore, foreign crops (maize) were later adopted and equally diversified into many cultivars (Table 22.1). By

Table 22.1. Native Andean foods

Food	Botanical classification	Quechua term	Aymara term
Cereals			
Maize	*Zea mays*	*Sara*	*Tonko*
Quinoa	*Chenopodium quinoa*	*Kinua*	*Hupa*
Canihua	*Chenopodium pallidicaule*	*Qanawi*	*Qanawa*
Achita	*Amaranthus caudatus*	*Quihuicha*	*Koyo*
Legumes			
Common bean	*Phaseolus vulgaris*	*Purutu*	*Purutu*
Jack bean	*Canavalia ensiformis*	*Inchis*	*Pallar*
Lima bean	*Phaseolus lunatus*	*Pallar*	*Pallar*
Peanut	*Arachis hypogaea*	*Inchis*	*Chokopa*
Lupine	*Lupinus mutabilis*	*Tarwi*	*Tauri*
Tubers			
Achira	*Canna edulis*	*Achira*	*Achira*
Oca	*Oxalis tuberosa*	*Oqa*	*Oqa*
Mashua	*Tropaelum tuberosum*	*Anu*	*Isano*
Arracaba	*Arracacia xanthorrhiza*	*Raccacha*	*Rakacha*
Manioc	*Manihot utilissima*	*Ruma*	*Ruma*
Papa	*Solanum* sp.	*Papa, Akshu*	*Papa*
Ulluco	*Ullucus tuberosus*	*Ulluku*	*Colluku*
Sweet potato	*Ipomea batatas*	*Apichu*	*Apichu*
Yacon	*Polymnia sonchifolia*	*Yakon*	*Yakuma*
Fruits			
Chirimoya	*Annona cherimolia*	*Masa*	
Guanabana	*Annona muricata*	*Massasasamba*	
Avocado	*Persea americana*	*Palti*	
Pacae	*Inga feuillei*	*Paqay*	*Paqaya*
Passion fruit	*Passiflora linularis*	*Ccjoto*	*Apinkoya*
Tumbo	*Passsiflora mollissima* *P. quadrangularis*	*Tumpaka*	
Guava	*Psidium guajava*	*Sawintu*	*Sawintu*
Lucuma	*Lucuma obovata*	*Ruqma*	*Lukuma*
Pepino	*Solanum muricatum*	*Kachan*	*Kachuma*
Squashes and vegetables			
Zapallo	*Cucurbita maxima*	*Sapallu*	*Tumuna*
Achokcha	*Cyclanthera pedata*	*Achokcha*	
Condiments			
Paico	*Chenopodium ambrosiodis*	*Paiko*	*Paiko*
Chile	*Capsicum annum* *C. frutescens*	*Uchu*	*Waika*
Chile	*Capsicum pubescens*	*Rocoto*	*Chinchi*
Huacatai	*Tagetes minuta*	*Wacatay*	*Wakatay*
Narcotics			
Coca	*Erythroxylom coca*	*Coca*	

Maize was probably introduced into the Andes from its Mesoamerican centre of domestication. (Adapted from Gade 1975.)

2000 B.C., a fully developed agro-pastoral subsistence strategy characterized rural life in the Andes (MacNeish 1977).

Archaeological evidence demonstrates the success of the evolving subsistence strategies which repeatedly led to the emergence of developed civilizations. By 1000 B.C. a fully complex, stratified imperial society, with significant surplus production, existed throughout the Central Andes (Lanning 1967). Major social achievements were supported by a wide, ecologically diversified resource base, either directly exploited by highland states or controlled through exchange and trade. Whatever the case, the efficiency of the productive system was expressed in terms of substantial surplus production, transformation (through a freeze-drying technology), and storage of tuber crops. Equally important was the accumulation of alpaca fibre and cloth and low energy cost transportation on llama caravans of foodstuffs to feed full-time imperial armies (Troll 1935 and 1968a).

Andean Traditional Subsistence Strategies

Although highland subsistence patterns in the Andes exhibit some local and regional variation in specific aspects of their production systems, they all have overall characteristics common to peasant society throughout the region. The Andean subsistence strategy, based on simultaneous exploitation of differentiated production zones, primarily along the altitudinal axle, is usually referred to as 'vertical ecology' (Troll 1935 and Murra 1975).

According to the vertical ecology paradigm, direct control of as many ecological 'niche' across the vertical landscape is an ideal of Andean rural society (Murra 1975). Vertical zonation of camelid herding and agrarian activities is a response to highland constraints on production and to natural biogeographical conditions, and could have had its roots in the prehistoric origin of plant and animal domestication, and possibly even earlier (Murra 1985). Archaeological evidence suggests that State formation and expansion during the middle and late horizons (800–1100 B.C. and 1300–1500 B.C.) enhanced and consolidated the system, mostly through State-sponsored, direct control of distant resources.

Despite the great range of variability in the verticality patterns in the Andes, three basic types of system have been suggested (Brush 1974).

(1) Compact type: characteristic of steep valleys with acute environmental variations at short distances across the vertical gradient. This was mostly the case of peasant communities in the western and eastern piedmont valleys, where the latter persists, such as in Q'ero (Webster 1971), Uchucmarca (Brush 1977), and Cuyo-Cuyo (Camino et al. 1981) among others. Here, production zones, lie within a walking distance of one to three days.

(2) Archipelago type: structured around a human nucleus in highland valleys or plateaux with extensions in distant resource based 'islands' under its control and exploitation through satellite populations. This case has been well documented by ethno-historical research and is usually linked to centralized State administration (such as the Lupaqa Kingdom in the Titicaca Plateau or the Chupaycho Chiefdom in Huanuco).

(3) Extended type: typical of large inter-Andean valleys with a rather gentle gradient allowing continuous exploitation of contiguous altitudinal production zones. Here, rural communities distributed throughout the valleys tend to specialize in specific production zones and to participate in trade networks and weekly markets. The Vilcanota-

Urubamba (Gade 1975) and Mantaro valleys (Altamirano 1974) are good examples of this type.

Specific contemporary research on the 'vertical control' has emphasized functional relationships with other dimensions of social life such as kinship (Brush 1975), marriage (Platt 1976), political decisions (Bradby 1982), and rituals and ceremonies (Vallee 1972, Barrette 1972, and Isbell 1974).

Current research on Andean agro-ecosystems has conclusively clarified that 'verticality' is but the spatial expression of a specialized subsistence system adapted to the Andean highland tropics and aimed at diversification and risk minimization. Furthermore, the strategy is directed to increased diversification not just at the space axle but to temporal dimensions as well. I have stated elsewhere that 'time and space... in the Andean context [are] two intimately related variables, continuously interacting and intensively articulated' (Camino 1982:32).

The Spatial Dimensions

Andean subsistence systems organize space in clearly delineated production zones, a 'man-made thing on top of the natural variation of the environment' (Mayer 1985:47). Mayer states that rather than 'adaptations' to the environment, production zones 'are created, managed, and maintained, simplifying natural diversity'.

Distribution of productive activities in the rugged Andean landscape is partly determined by natural constraints and potentials, as well as by the opportunities offered by native domesticates and those of foreign origin but locally adapted, and also by the traditional appropriated technology to manage this. Zonification is the traditional, communal organization of space for productive purposes.

Barometric altitudinal criteria only provide a rough picture of zonation. It is the specifics of topographical relief, soil, and weather conditions, in each case, that determine the type of production zone.

In an attempt to schematize the common characteristics of Andean traditional zonification, six discrete production zones can be found throughout the Central Andes.

Pasture Lands

Pasture Lands distributed below the year-round permanent snow line (about 5,000 masl) and the uppermost limits of cultivation (4,000 to 4,300 masl). Traditionally devoted to camelid herding, nowadays they are open to adapted sheep and bovine cattle as well. Pastures are always communally owned and managed except for *haciendas* or large private land holdings.

Bitter Potato Production Zone (about 4,000 masl)

This rather narrow strip is usually intercalated with the lowermost parts of pastoral areas and the main tuber crop zone. This area is devoted to cultivation of bitter potatoes (*shiri*) which require transformation through traditional freeze-drying to make them edible and, simultaneously, storable. Sometimes *izano* or *mashua* (*Tropaeolum tuberosum*), barley, and, in some areas, the Andean chenopods (*quinoa, canihua*, and *maca* (*Lepidium meyenii*) are also cultivated. Sectoral fallowing determines one year of cultivation followed by five years of rest (*purun*). During fallowing, the area is open for grazing, thus enriching its soils with *taquia* (manure).

Tuber Crop Zone (3,800–4,000 to 3,000–3,200 masl)

This is the main production zone for the Andean staple potato (*Solanum tuberosum* sp.) and other secondary but not less important tuber crops (*oca: Oxalis tuberosus, olluco* or *illaco: Ollucus tuberosus*, and *izano* or *mashua: Tropaeolum tuberosum*). They are grown in many adapted cultivars following different patterns of crop association (Camino 1978 and Camino et al. 1981). European broad beans (*Vicia faba*), barley, and wheat are also grown in this zone in some regions.

This production zone is usually divided into six rotational cycles (*mandas, turnos*, and *o laymes*). Sectorial fallowing could take, depending on several factors, from one to three years, and, as in the previous case, offer the possibility to cyclically dedicate the area to grazing and enriching the soil.

Although potatoes predominate in the first rotational cycle, they are usually sown in association with *izano*. After the second year, crop associations are intensified. A third and, eventually, fourth year can be dedicated to broad beans, wheat, or barley, planted primarily as monocrops.

In the case of tuber crops, cultivar heterogeneity is emphasized and always desirable. A traditional Indian family may grow 20 to 50 potato cultivars, as well as a diversified stock of *ocas, ollucos*, and *izano*. A peasant community can keep 300 to 500 potato cultivars out of the total count for the Central Andes, which nowadays exceeds 13,000.

Depending upon the species, variety, and stage of rotation, tubers produced in this zone are mainly destined for direct consumption and secondarily freeze-dried for storage (*chuno, ccalla, lingli*, etc). Part of the crop is saved for seed and eventually a portion is traded or sold. The tuber zone is the most important agricultural area for Andean communities, as exemplified by the extensive terracing which can be found throughout this zone.

Transitional Zone/Home Orchards

Below the main tuber-growing zone, a narrow transitional zone precedes the lower maize fields. Human settlements are quite often located in this transitional area, and, therefore, family orchards for vegetables, medicinal plants, and experimental crops are enriched with human refuse and household animals' manure (conspicuously from the edible *cuy: Cavia porcellus L.*). These bonafide plots are intensively cultivated with a combination of elaborate forms of crop associations, bringing together highland and lowland cultivars. The area is not subject to fallowing, and, therefore, fields have to be carefully walled to prevent the unexpected intrusion of cattle.

Maize Production Zone (3,200 to 3,000 and 2,500 masl and below)

Whether grown under irrigation (western piedmont), rainfall (eastern slopes), or a combination (inter-Andean valleys), highly prized maize is intensively grown, normally without fallowing, thus demanding different strategies to assure soil fertility. As in the other zones, corn is always cultivated in association with other traditional crops: Andean squash (*Cucurbita* sp.), beans (*Phaseolus*), broad beans (*Vicia faba*), *yacon* (*Polymnia* *sorchifolia*), and *racacha* or *virraca* (*Arracacia xanthorriza*), among others of less relevance.

The Andean cultural importance of maize cultivation and ceremonial corn beer (*chicha*) has been noted (Murra 1975), and a fact which is reflected in the magnificent terrace systems which, were built for this crop, in the pre-Columbian period. As previously mentioned, native crops, germplasm variety, and plant heterogeneity were highly valued in indigenous society, a trait that helps explain the high degree of genetic diversification which maize attained in the Central Andes.

Coca Production Zone (below 2,000 masl)

Even if well outside our immediate concern, this area is of crucial importance. Coca (*Erythroxylon coca*, a mild stimulant, traditionally chewed) was, and is, a plant with a principal role in religion and ritual as well as in interzonal trade and barter (Instituto Indigenista Interamericano 1976). Highly esteemed, coca leaves acted as a quasi coin assuring ecological complementarity for those indigenous communities that, for some reason, had restricted access to one or more production zones.

Current international demand for cocaine, one of the 14 alkaloids of coca leaf, has seriously disrupted the Andean social patterns of coca use with drastic consequences for the traditional subsistence system (Camino 1989).

It should be noted that the vertical ideal of the Andean peasant, in addition to land division caused by inheritance, usually results in an extreme pattern of *chacras* (plot) dispersion. In order to assure the ideal self-sufficiency, the average peasant family tries to have direct access to land in each of the production zones as well as in each one of the rotation cycles of the zones with sectoral fallowing. To assure food crop self-sufficiency, the peasant family has to grow each crop, or a mixture of crops, through crop associations. Furthermore, due to constant risks, as exemplified by frequent crop losses due to frost, hail, drought, landslides, etc., the autarkic family attempts to hold as many discrete *chacras* as possible, in as many locations as possible, for each one of the rotational cycles of each production zone. Thus, ideally, one family will hold more than one tiny plot for every specific crop or crop association, at every stage of rotation, in each production zone. As we will examine later, this has an effect on the length of vegetative cycles and on the programming of the many agricultural tasks throughout the multivaried agro-ecosystem.

The vertical zonation of crops, as previously described in broad and general terms, is based on a supra-household system of production organization, clearly stipulated in tradition and strictly sanctioned in the regular communal administration of the system. *Ayllu*, the Andean traditional lineage, sets the criteria and rules of zonification, rotational cycles, use and management of pastures, and other communal lands to which all the peasant families have to adjust their herding and farming strategies and activities. It also plays a basic role in the design and execution of communal works for agriculture (irrigation canals, ditches, terraces, etc.) and other civil constructions (bridges, roads, etc.). It has been noted that 'there is a specific Andean collective form of organisation of production that, under varying and changing social and ecological conditions, will constantly generate technological solutions that bridge the gap between desired crops and the local environmental conditions that favor, limit, or impede production' (Mayer 1985:48).

The Time Axle

Altitude affects temperature, precipitation, and humidity. Temperature drops (on the average, 6°C for every 1,000 m of elevation), thus limiting productivity and slowing the growth rates of flora.

On the other hand, incoming solar radiation increases with altitude. Higher levels of cosmic radiation may explain the abundance of certain endemic plant life forms or the high index of variability within cultivated plant populations. Altitude increases unpredictable threats to agriculture in the form of frost, hail, drought, etc. Crop dispersion across vertical zonation, as explained earlier, becomes a way to reduce risk. Each crop, and in some cases each one of its cultivars, will be simultaneously grown in different sectors under varying geographical and meteorological conditions (slope and soil, sun exposure, humidity, precipitation) and, particularly at different altitudes, avoiding concentrations of the crop in just one homogeneous and contiguous sector, thus diversifying exposure to the recurrent risks of high altitude agriculture.

The ideal of spatial diversification and distribution of crops responds to a risk minimization strategy. Elsewhere, it has been pointed out that verticality is 'just a landscape architectural expression of a broader and more complex ideal which is directed to the diversification of the subsistence base in an unstable and unpredictable environment' (Camino 1982:29).

Along its temporal dimension, this same ideal is expressed in an equivalent manner. According to this temporal axle, effective and absolute limits for crop sowing and harvest affect the scheduling of the agricultural calendar. In the Bolivian and Peruvian Puna, over 4,000 masl, night frosts occur throughout the year (Troll 1968b:22). Agriculture, based on adapted cultivars, can only be conducted, taking this limit into consideration, where nightly frosts gradually diminish. Thus, effective and absolute limits along the time axle are determined by the natural growth cycle of cultivars.

In the process of plant domestication, Andean peasants selected short maturing varieties (*chauchas*) as well as others with frost-resistant traits, resulting in the extension of vegetative cycles. Some Andean agronomic practices are also directed to shortening or expanding vegetative cycles in order to adapt these to varying altitudes and to unpredictable delays or early presentation of rainfalls (or water availability in the case of irrigation agriculture).

Depending on these factors, the life-cycle of crops will vary accordingly, affecting production programming, and scheduling. Diversification along the temporal axle is also a desirable strategy as a response to risk due to unpredictable weather conditions.

For the purpose of sowing, harvesting, and other agricultural tasks in between, Andean tradition determines the scheduling of activities using the religious ritual calendar (a syncretic Andean-Christian blend). The ceremonial calendar operates as an agricultural calendar, fixing referential dates for the initiation and conclusion of each production zone. In this way, ritual festivals mark minimum and maximum limits for the onset and termination of each agricultural activity associated with a specific production zone and crop. However, in the context of unpredictability, a calendar that does not take into account and deal with predictable variations, and even chance, will not be effective or trustworthy. In both irrigated and rainfall agriculture, it is necessary to foretell, with some degree of certainty, the expected precipitation. This poses a major difficulty, due to Andean meteorological irregularity and the unpredictability of atmospheric phenomena and their impact on each zone and altitudinal level. This is the case when traditional Andean concepts, such as *tinkuy*, are invoked. *Tinkuy* refers to predestined encounters (rivers that meet, marriages, etc.). It also refers to the inevitable encounter of the sprouting plant and weather conditions (Fonseca 1966). In a pragmatic way, the concept is manipulated when applied to agricultural practices; spacing over time for sowing of tubers on a plot, even if it has a reduced surface. In this way, *tinkuy* will happen for each plant at a different stage of its growth cycle, assuring that, in the case of threats from hail or frost, at least a portion of the planted crop will be saved.

Each production zone has its peculiar characteristics and requirements, and, consequently, the scheduling of farming activities varies from zone to zone. To the diversity of vegetative cycles for each cultivar, usually grown in association with others, the modification that altitude will affect the duration of the maturation period is another factor to be added. In addition, we need to assess additional impacts: amount or opportunity of rainfall or water from irrigation, hours of sunlight, and eventual frost and hail. All of these will accelerate or slow down growth. Depending upon these factors and depending upon traditional criteria for weather prediction, peasants will move ahead or delay each agricultural activity.

Throughout the Central Andes, the peasants' lore identifies three discrete growing periods.

(1) *Naupa tarpuy*, or early sowing period (usually falls in August, depending upon the region).
(2) *Chaupi tarpuy*, or regular, middle sowing period (September).
(3) *Q'epa tarpuy*, or late planting period (October).

Accordingly, subsequent agricultural tasks follow each one of the periods. However, harvesting usually proceeds upwards from the lower areas, due to prolonged growth periods along the vertical gradient.

Concentration of sowing for potatoes or any of the other crops, in one or the other of the three planting periods, will depend upon weather forecasts which are normally formulated before the initiation of the agricultural year. Concentration of sowing activities will vary from year to year, depending upon these predictions.

If the forecast announces early rains, the bulk of sowing will take place in *Naupa*; if the rains are regular, most of the sowing will be done in *Chaupi*, and, subsequently, a prediction for late rains will transfer most of the sowing to the *Q'epa* period. In this way, through weather forecasts the agricultural calendar is constantly adjusted to changing meteorological conditions. However, some planting is always done, although with less intensity, in the other two periods. This operates as a mechanism to ensure at least some crop returns in the case of sudden changes or wrong forecasts.

Weather predictions are very important throughout the traditional peasant society. These are based on astronomical observations made on specified dates, careful monitoring of natural indicators (meteorological phenomena, fauna, and flora), or other cultural mechanisms (Camino 1982, Antunez de Mayolo 1976, and Cuba de Nordt 1971). Weather predictions not only allow for the programming of agricultural activities, but also facilitate the careful planning of extended family workforce distribution throughout production zones.

There are years in which all the production zones do not experience similar or homogeneous weather conditions, with the precedence of rain in one zone, delays in the other, and irregular hail distribution in yet another (Camino 1981), turning programming into a complex endeavour.

Andean subsistence strategies cannot operate on the basis of rigid calendars. Just as diversity characterizes the Andean environment, meteorological irregularity has demanded the development of flexible calendars, where a vast range of options facilitates the manipulation and management of temporal criteria in a way similar to the handling of diversity in the spatial transect.

ANDEAN TRADITIONAL TECHNOLOGY

Andean populations were capable of establishing major civilizations, achieving high and sustainable production, and maintaining vast and dense populations (Yamamoto 1985 and Dollfus 1982). This was possible through four basic and interrelated achievements:

(1) a comprehensive fine knowledge of the environment; its natural resources, their limitations, and potential;
(2) the breeding of a vast array of adapted domesticates;
(3) the development of innovative and appropriate technologies; and
(4) the consolidation of an adaptive social system which put a premium on austerity, severely sanctioning deviations from tradition.

As noted previously, diversification along time and space, a vital adaptation to a heterogeneous and unpredictable environment, is reflected in elaborate patterns for the spatial and temporal distribution of crops, adequate domesticates, appropriate management, and efficient programming. For successful adaptation, technologies had to be developed in several areas. Let us briefly examine the most prominent.

Soil Building and Management

The Incas and their predecessors were superb soil builders, as attested by their magnificent achievements in agricultural engineering. Terracing, in its many patterns and forms, attained full development on diverse types of relief, in diverse soils, and in diverse production zones (particularly the tuber, maize, and coca). Terraces, in addition to their contributions to erosion control and to the expansion of the agrarian frontier, created local micro-climates (Earls 1989), enhancing the potential of high altitude environments to sustain a variety of crops. Current estimates put the terraced slopes of Peru at one million ha, two-thirds of which are nowadays abandoned (Denevan 1986).

Other major developments were the vast ridged fields (*huaru-huaru*), still visible on the Lake Titicaca Plateau (3,803 masl), which, in the prehistoric past, covered 82,056 ha (Smith et al. 1981). These mounds were built on the annually flooded plains neighbouring the great lake. Archaeological estimates suggest that they supported dense populations (Denevan 1982 and Garaycochea, no date), by creating rich soils and special micro-climatic conditions which helped to drastically reduce the repeated effects of frosts on the plateau.

Cochas, or artificially ridged and drained natural depressions on the same plateau, were another device to expand agriculture beyond natural limiting conditions (Flores and Paz 1986 and Rozas 1986). An area of 384 km, north of the plateau, is still being farmed with *cocha* technology. Soil conditioning and management was not restricted to agricultural pursuits. Palacios (1977) has described the purposeful flooding of the high plateaux to create pastures for alpaca herding.

Use of manure and other natural fertilizers was common throughout the Andes. Different fertilization technologies for varied crops and production zones have been described for various regions (Camino 1982, Yamamoto 1985, Tapia and Flores 1984, and Winterhalder et al. 1974).

Irrigation

As indicated earlier, water availability and its appropriate timing is essential for high altitude agriculture, whether in the form of irrigation, rainfall, or both. Water availability becomes more critical on western slopes, where irrigation technology and management has attained greater development and where practices are strictly sanctioned by communal ceremonial rites. In the inter-Andean valleys, irrigation facilitates the temporal management of crops, making water available to plots before the onset of the rainy season in order to accelerate growth. On the eastern slopes, irrigation is mostly absent, the concern being rainfall prediction and the appropriate control of floods and droughts.

Water management, a complex Andean technology with substantial diverse regional patterns, is crucial and has received careful attention from researchers (Mayer 1985, Zegarra 1978, and Mitchell 1981). Canals, aqueducts, reservoirs, and other hydraulic constructions are still much in use wherever traditional agriculture persists.

Agricultural Tools

After four centuries of neglect of the traditional Andean agricultural tools in favour of European oxen-driven ploughs and motorized tractors, in recent years, investigative research on mountain agriculture and soil management has started reconsidering the role of the traditional Andean foot plough (*chakitaclla*), which has shown itself to be an adequate and versatile tool well suited to the Andean turf type of soils, assuring their conservation and preventing soil runoff (Donkin 1970). The type and direction of ridges and furrows opened with the *chakitaclla* (following the gradient contour or across it) vary from year to year according to water availability.

Different methods of turning the soil, planting seeds, banking soil on plants, etc, depend also on the type of soil and crop, the specific needs of each production zone, and weather conditions. Turning turfs upside down several weeks before sowing, on top of furrow, facilitates nitrogenation of the soil through the decomposition of grass-like cover vegetation.

As with many Andean technologies, *chakitaclla* ploughing is intimately linked to traditional social work arrangements (foot ploughing is done by pairs of kinsmen), and is deeply imbedded in the religious system and the spiritual significance of *Pachamama* (mother earth).

Native Crops

As indicated before, the Andean region has been one of the most fertile cradles of crop domestication. In addition to several tuber and root crops and their many cultivars, chenopods and a diversity of fruits and seed crops (*Phaseolus* sp., *Lupinus* sp., *Amaranths* sp., etc.) provide the peasant household with a rich and varied food base. Through directed selection for specific traits (agronomic, culinary, and symbolic) on either vegetatively or sexually reproduced crops, the Andean agriculturalists gradually developed an enormous variety of locally adapted cultivars that respond to specific requirements and conditions. Non-native crops of pre-Hispanic origin (i.e., maize) or of later introduction (broad beans) also became subject to this process.

With colonization, diversification of the cultivar base reversed with the traumatic substitution of mining for agriculture for mining as an economic priority. The process intensified with the development of urban monetary markets and their narrow range of demand for a limited variety of food crops.

Social Management of Production Systems

As stated throughout this paper, the Andean subsistence system is organized at the communal, supra-household level where nuclear and extended families, as members of an ethnic lineage (*ayllu*), have to adjust and participate in its social management (Mayer 1985 and Guillete 1981). Herding in communally owned pasture lands follows strict rules and severe sanctions are applied to transgressors. The same applies to the organization of the sectoral fallowing of tuber crops, the scheduling of agricultural activities in all production zones, irrigation, and the organization of communal work (*faena* or *minga*), among others.

Due to the complexity of the adaptive strategy, individual households cannot venture into an independent strategy, when aware of the risks involved. The whole productive system is intimately tied to all aspects of traditional culture and social life, and change can only take place successfully through consensus.

However, village organization is not static and, over time, it gradually adapts to changing conditions. One of the foremost authorities on Andean culture has conclusively stated: 'Without an understanding of local village organisation, the complexities of the verticality model cannot be completely understood... the household alone cannot by itself deal with all the technical and organisational problems of production in a given zone; it needs the concurrence of 'supra-household' organisation' (Mayer 1985:48).

DEVELOPMENT INTERVENTIONS: POLICIES, PROJECTS, AND CONCLUSIVE GUIDELINES

As has been stated before, colonization and the republican history of most Andean countries resulted in the neglect of highland habitats and their agro-pastoral traditional experiences. Viceroyalties and their administrative units and, later, emerging contemporary countries switched the introverted character of the Andean society into export-oriented, extrovert economies. Mining and other extractive interests became the dominant activities.

Simultaneously, new crops were introduced, some of which fitted adequately into the traditional adaptive strategies (broad beans) while others (forage grasses) brought disruption and environmental degradation. In some areas, substantial changes in inland tenure patterns and production strategies brought about the total collapse of the traditional subsistence system. In others, partial changes affected some aspects of the system and prompted adjustments, as in the case of the introduction of European livestock.

The last part of the previous century witnessed, for the first time, an increased world demand for an Andean commodity, in this case wool (sheep and alpaca), a phenomenon that had rather restricted duration and limited impact (Orlove 1977). After the 1930s, none of the Andean agro-pastoral products had any significance in the export economy, with the possible exception of alpaca wool.

Successive governments regarded the highland regions as marginal habitats for economic development, favouring plantation agriculture on the forested northern coast or, through irrigation, in the oasis type of valleys south of 5°S. The Amazon rainforest, erroneously perceived and promoted as the future bread basket of the region, suffered the consequences of State-promoted deforestation for colonization. It was only in the late 1960s that two simultaneous processes of academic reassessment of the Andean subsistence potentials initiated the reconsideration of what had formerly been an undiscussed paradigm. This resulted in two distinct research disciplines.

The Social Sciences, Particularly Anthropology

It was the anthropologists and the ethno-historians who, after intensive fieldwork and archival research, described the strategy that, as 'vertical ecology', explained the traditional Andean patterns of subsistence. Its rationale created an impact on agricultural researchers and developers. *Minifundismo* (the extreme division of properties), which had formerly been explained exclusively in terms of inheritance, suddenly acquired a new dimension. The autarkic orientation of Indian communities, previously perceived as a purely cultural trait and as a lack of market incentive, required an explanation that only ecological anthropology was able to provide.

Agronomy

A new generation of agronomists, some of whom had experienced the limitations and high energy costs of plantation agriculture in the lowlands, started turning their research interests to formerly neglected native crops which they saw as having the potential to solve the food problems of the region.

Both academic traditions had their *tinkuy* in the mid-1970s, giving birth to a new fertile paradigm: Andean traditional subsistence systems are worth consideration, since they may be able to solve the problem of food shortages in our contemporary nations.

However, due to the usual Latin American divorce between academicians and policy makers, this new perspective had, at first, very little impact on government policies, which remained resilient to change. Governments promoted a straightforward European style of modernization of agriculture in the highlands. The main concerns were to introduce new crops and technologies that had had successful histories elsewhere, without much consideration for the natural and social environment on which they were being imposed. An ideology of 'progress' prized and valued innovations, associated with foreign crops and technology, and rejected tradition which was associated with backwardness. This overall trend had very few exceptions, some of which existed as a result of isolated and restricted experiments.

During the late 1970s and early 1980s, Bolivia, Ecuador, and Peru started their first, significant applied experiments in development from a mountain environmental perspective. These began as pilot projects, promoted by scientists who had been researching on traditional crops and technologies. Some were privately funded by foreign development agencies and a few were able to receive a basic subsidy from the State. Let us review the main areas in which these experiments were conducted.

The Revigoration and Promotion of Native Crops

Aware of the nutrition potential of Andean chenopods (*quinoa* and *canihua*), a few projects for seed selection, improvement, and promotion were started with promising results on the Titicaca Plateau. The interest in these high-altitude crops expanded north, into Cuzco and Ayacucho, and south, into Bolivia, and gradually they attracted the attention of foreign researchers, mostly North Americans who started promoting their cultivation in the United States and Canada.

Tarhui or *chochos* (*Lupinus mutabilis*) soon followed because of its nitrogen-fixing properties and for the industrial production of oil. Breeders promptly developed 'sweet' varieties whose seeds are almost free of bitterness and need almost no washing. During the 1980s, *kiwicha* (*Amaranthus caudatus*), one of the most nutritious foods grown, was popularized by peasant farmers and gained the attention of decision makers.

Despite massive research on potatoes, apart from their use for germplasm purposes, nearly 14,000 Andean cultivars have been totally disregarded in the effort to salvage and promote native food crops. Genetic engineering and trait selection, conducted by the International Potato Centre in Lima, have assured the laboratory conservation of germplasm despite the alarming decline in the cultivation of native cultivars. The availability of engineered varieties, with a diversity of favourable traits, is drastically reducing the number of native varieties in the countryside while ensuring increased productivity. This is the factor which has probably led to the abandonment of any attempts to ensure the conservation of traditional cultivars in the field. However, the other Andean tuber crops, *oca, olluco*, and *izano* (see Table 22.1 for botanical identification), have not only received research attention but some benefit as well from the applied agrarian development programmes. Due to the fact that they have not been subject to any important genetic breeding, native cultivars remain vigorous in the rural Andes. Other Andean crops received less attention in the context of agricultural development. Their vast potential has recently been made public to a wide audience (Popenoe et al. 1989).

One of the main drawbacks of the numerous valuable attempts to salvage and promote native crops is the usual de-contextualization of the agronomers' or developers' efforts. In most cases, native crops are in little or no demand in urban markets, making it difficult to get the peasant or farmer interested in their cultivation for reasons beyond self-consumption. Urban dwellers are not familiar with them and do not even know their culinary uses or nutritional qualities.

Furthermore, promotion faces the constraint of the lack of seeds, mostly due to the restricted cultivation of these crops. In some cases, their traditional cultivation has already disappeared with subsequent ignorance on the part of the peasants concerning their cultivation.

Finally, their limited, but rather exclusive, demand (health stores, specialized exports) turns them into highly prized foods. However, the advances in the knowledge and promotion of Andean native crops certainly assure their of a promising future, with the possibility of their becoming once again important productive crops in high-altitude agriculture.

The Relaunching of Andean Paleo-technologies

Another significant development during this last decade has been the applied programmes to salvage and re-apply Andean traditional technologies which earlier research had proven to be valuable and promising. One of the outcomes of 'verticality' research was a renewed interest in terrace farming. Numerous field studies had proven the benefits of *andenes, cochas*, and *huaru-huaru* from the perspective of soil utilization and management, as well as from their potential in the expansion of the Andean agrarian frontier. It was previously stated that, out of the estimated one million ha of pre-Columbian terraces in Peru, 600,000 were abandoned. Furthermore, in contrast to the high costs of irrigation on the coast, or jungle colonization programmes in Amazonia, the cost for terrace rehabilitation was, on the average, quite low. While recovering one hectare of terrace has a cost of US $750 to US $1,000, the irrigation of a similar amount of land on the dry coast is US $15,000 to US $20,000 (CEPAL 1988).

Several experiments on terrace rehabilitation have been conducted in recent years (de la Torre and Burga 1986), all of which, despite difficulties and drawbacks, have proven fruitful. Among the many advantages and benefits, terrace agriculture:

- expands the agrarian frontier at a comparatively low cost,
- increases slope productivity,
- protects and regulates watersheds, and
- increases work opportunities for the unemployed or underemployed rural labour force and creates better production conditions promoting highland settlement and preventing migration to urban slums or to Amazonia for coca cultivation.

In general terms, the same benefits can be extended to the rehabilitation of ridge fields (*huaru-huaru*) and *cochas* on the Titicaca Plateau.

However, soil rehabilitation, through terrace or ridge field reconstruction, has several problems that need to be solved. Among them, the most recurrent have been:

- the lack of global macro-economic policies in support of agricultural activities,
- the involvement of rural communities through active participation in the planning and execution stages,
- the need to ensure that complementary engineering works are also integrated into the rehabilitation strategy (i.e., irrigation canals, water reservoirs),
- the proper cultivation of adequate crops, and
- the provision of technical advice in the architectural aspects of terrace reconstruction, particularly in those communities where traditional knowledge on the subject has been lost.

A few projects have focussed on the evaluation and reintroduction of traditional tools as well as on adequate technologies, some of which have succeeded and others of which have failed depending on several factors related to agronomic or social conditions. Agricultural tools, as with all technological devices, do not operate in environmental or social vacuums and need to be carefully evaluated from an integral perspective. Efficiency needs to be measured, not just in terms of environmental adequacy but in terms of productivity and social acceptance as well.

Recent years have seen an increased concern on the part of governments and international organizations in adapting development policies and actions to existing natural and social conditions in mountain environments, and this, it seems, will be the trend for the coming decade. Success or failure in promoting development, from a mountain perspective, will ultimately depend upon both the formulation of adequate policies to suit characteristic mountain environmental conditions and upon their consistency with the social and cultural context in which they are meant to operate.

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23

INDIGENOUS FARMING TECHNOLOGIES AND ENVIRONMENT: EXPERIENCES IN BHUTAN

A.K. Gupta and K. Ura

Anil Gupta is a Professor at the Centre for Management in Agriculture, the Indian Institute of Management, Ahmedabad and Karma Ura is a Senior Planning Officer, Planning Commission, the Royal Government of Bhutan, Thimphu

CONTENTS

INTRODUCTION

How did an unmodernized, isolated mountain country succeed in keeping 64 per cent of its area under forests? How did it succeed in avoiding widespread deprivation and maintain a fairly sustainable ecological balance? What problems does it face in its anxiety to keep its cultural core intact and at the same time improve the living standards of its people? Buddhism plays an important role in blending culture with technology.

This chapter deals with the experiences of Bhutan, a relatively small, land-locked Himalayan country which has established common property and other collective institutions for resource management.

The text is divided into seven parts. Part 1 deals with the culture of conservation and Buddhist ethics. Part 2 includes a discussion on the framework of institutional emergence in mountain societies. Rules and principles have to be established while dealing with the boundaries of moral and ethical responsibilities towards the environment. Examples of specific institutions for managing water, grazing land, forests, and labour contributions for public and common works are provided in Part 3. The institutional innovations are related to technological innovations. The culture of this innovative ethic is reviewed in Part 4. Specific examples based on water-driven prayer wheels, architecture, education, alignment of irrigation channels, movement of livestock, prevention of the diffusion of animal diseases, generation of cropping systems, and management of shifting cultivation are covered in this part. Part 5 includes issues that are emerging in the process of technological transfers within the above context.

The major risks and how they are perceived by the people are discussed in Part 6. The role played by collective institutions, moral responsibilities, and non-monetized reciprocities are highlighted. The policy implications for sustainable mountain development are listed in Part 7.

We believe that bureaucratic or market institutions have often failed to conserve natural resources everywhere in the world. The Western concept of resource conservation through complete closure is neither scientifically nor environmentally sustainable. The principles of maintaining social and environmental diversity and complexity through innovative institutions are available in the framework of Buddhist ethics. The rules that can guide the behaviour of individuals and groups have to be developed in the changing technological and political and economic environment. Bhutan's experience can be helpful even for developed countries.

Why do formal development models tend to 'destroy the only cultures that have proved able to thrive in these (isolated and harsh) environments?' (McNeely 1989). The question, raised in the recent report of the World Commission on Environment and Development, has been asked in Bhutan ever since the programmed efforts to reduce isolation started a few decades ago. Blending indigenous technology, which has evolved in the crucible of culture and local environment, with alien concepts, techniques, and tools requires adapting institutions as well. The relationship between natural sources and the people has been forged within moral, cultural, politico-economic, and ecological boundaries. Respect for these boundaries, by different communities and social groups, was ensured historically through a set of formal and informal rules and norms. It is obvious that the same rules will not help regulate human 'needs' and 'wants' in characteristically different economic and institutional environments. The experience of Bhutan offers lessons for late 'starters' and early 'stoppers' in the game of sustainable development. Bhutan seeks to resolve the creative conflicts in policy choices in the light of Buddhist ethics and values.

New institutional arrangements sometimes mirror these values but occasionally fail to do so. The choice of technology and the definition of sustainability are pursued in the manner illustrated in the Zen story—a simple and subtle beginning and an enigmatic ending, leaving enough scope and opportunity for multiple interpretations. The basic belief is that there is no need to rush through the so-called transformative (and modernizing) modes of development. The regenerative, interdependent, and eco-adaptive alternatives must have precedence. But these alternatives do not always have precedence and problems are resolved experimentally, intuitively, and, at times, through debates in the national assembly and at local level.

PART ONE: CULTURE OF CONSERVATION–BUDDHIST ETHICS

There is, in general, a great distaste in Bhutan concerning the killing of animals to gratify one's tastes. Buddhist culture requires its followers to recognize that animals have the capacity to suffer and that one should not differentiate between the human and the non-human species as far as suffering goes. It is a philosophically refined culture, which, in principle, rejects differentiation among species, i.e., putting the status of human beings above that of other animals. This is not tolerated even for propitiatory purposes. After the advent of Buddhism, animal sacrifices were replaced by symbolic rituals that used, if required, animal forms made of flour or other edibles. Any erosion of this principle leads directly to the exploitation of the animals in our interest. Given that taking life for food is considered mostly repugnant, the society has a tendency to hold those who raise beef and pork in low esteem. In modern Bhutan, the meat industry is, by and large, inhibited by this principle of not taking life, although there are signs that such beliefs are yielding to commercial considerations.

Eating meat, vital for survival amidst a harsh climate, poor soil conditions, and a very limited scope for agriculture produced guilt (Ekvall 1989). Giving back to nature in some form what has been taken away was thus institutionalized as a compensatory or purifying ethic. The concept of accumulating virtues (be it by retreat into a monastery for a few years or by contributing land, labour, or wealth for the common good) provided an ethic that counteracted or counterbalanced the compulsion to kill animals for their meat.

There are various other strands in the national culture that allow some degree of culling. The semi-nomadic yak herders (the *Brockpas*) do not frown upon culling a few male yaks during the year. Yak meat and dairy goods are the only basis of exchange for cultivators, and piggeries are accepted as a part of subsistence animal husbandry. There is often also a gulf between the ideals of the religion and the pragmatism of daily life. In what is perhaps a device to have one's cake and eat it too, non-vegetarianism is not a taboo but the slaughtering of animals is. It can be argued that the interaction of the demand and the supply of meat unites the butcher and the consumer into one single moral persona. Their economic and moral existences appear interwoven.

The paddy farmers in Paro Valley used to enter into contracts with the pastoralists of Ha, a hilly district, to exchange paddy for cheese, butter, and meat. The ecological context provided a basis for economic exchanges across space and time. The interdependence, therefore, between not only butcher and consumer but also cultivator and pastoralist, monk and ordinary people, constituted several layers of consciousness or a number of multiple interfaces underlying the conservation ethic. The retreat into monasteries could regenerate the individual consciousness. Leaving lands fallow under swidden cultivation systems permitted the regeneration of the natural system. The system required both social sanctions and faith in the natural and spiritual order.

The principle of respecting life in all forms extends to wildlife. Protecting the natural environment in which wildlife occurs is the reverse side of the same coin. The Bhutanese have seldom been keen on trapping, hunting, and shooting animals and game-birds. Wildlife has never been regarded as game. Very rarely do trophies of prize catches adorn the walls of private or public mansions. These conservationist attitudes were, in an Asokan move, legally formalized and reinforced by restrictions on the hunting and killing of wild animals. One may kill a wild animal if it poses a threat to life and property and if the fact that it is a threat to life and property can be proved. Even this narrow latitude in the rules is not often applied given the prevailing aversion to killing. Farmers have sleepless nights when they make noises to keep off wild boars, deer, and bears and prevent them from destroying their crops, but they would rarely resort to killing them.

However, when farmers do attack wild animals causing repeated damage to crops, they are in a moral dilemma if the animals do not die in the field but run away into the forest. International advisors have suggested that people inform the forest departments if shooting an animal becomes necessary (Laushe 1987). The faith that administrative policing can provide more safety for wildlife than a voluntary conservation ethic is perhaps misplaced. The issue of protecting the habitats of wildlife to the extent of totally excluding human beings has been debated. IUCN shares the belief that '*even the ecosystems which appear most natural*' have been significantly altered by humans at some point in the past. Exclusion of 'human influence from the "natural" ecosystem, as in the strictly protected national parks, can lead to a situation that has not occurred for thousand of years' and, it is feared, might 'have unknown ecological implications; the devastating fires that hit Yellowstone National Park in 1988 are a dramatic example of what can happen when nature is allowed to take her own course without human intervention.' (McNeely 1989). The Buddhist ethics of cohabitation and peaceful coexistence might thus need reinterpretation and reassertion in the light of international advice for wildlife protection parks exclusive of any human interface. Retribution for greed and reward for restraint are inherent in a genuine conservation ethic. IUCN studies show that this ethic may even be superior on scientific grounds.

The Bhutanese have been conscious of their green heritage and its distinctiveness, compared to Tibet for example, for a very long time. Epithets such as 'the southern land of medicinal herbs' and 'the land of cypresses' characterized this distinction. Both Buddhist and pre-Buddhist (Bon and Animism) beliefs promoted a cautious attitude to the environment. They suggested that there were spirits inhabiting 'three parts of the world—the sky, atmosphere, and the earth.' (Vigoda 1988). The mountains, rivers, lakes, streams, forests, rocks, and soil were believed to be the domains of different spirits. Pollution and disturbance to these sites were believed to be the cause of deaths and diseases.

It might be surmised that nature conservation was part of the traditional Bhutanese culture. The religious basis of traditional life bred in the people a respect for life in all its forms and for their ecological 'niche'. The constant interaction of the people with the natural environment would have naturally sharpened their intuitive insight into the use of resources from the environment, and this tended to make them practitioners of sustainable resource use.

PART TWO: RULES, PRINCIPLES, AND CULTURE—A FRAMEWORK FOR INSTITUTIONAL EMERGENCE IN MOUNTAIN REGIONS

Jodha (1990), while outlining the mountain perspective, has highlighted two important interlinkages among mountain specificities: (1) commonality of causative factor and (2) shared consequence of disturbance to each other. In the first case, it is suggested that besides the climatic factors, 'degrees of diversity, fragility, marginality, human adaptation, and inaccessibility are, in different measures, directly linked to factors such as elevation, slope angle, slope orientation, and exposure.' The second interlinkage is the 'externality' imposed by disturbance in one sub-system over the rate and extent of regeneration of other sub-systems.

The relationship between objective, ecological conditions and subjective, human perception and response is mediated by the cultural and institutional memory of society. Which consequences of disturbances are considered to be externalities is in fact the outcome of cultural consciousness.The boundary of responsibility towards the shared consequences, we could argue, is one of the important outcomes of historical institutional development. Once the State and its authority supersedes the authority of religion, village, or community institutions, conflicts between the historically desired perception of this boundary and the legally, administratively, or politically legislated limits of these boundaries are bound to arise.

How these conflicts are resolved can be studied only after the relationships interlinking culture, institutions, technology, and ecology are properly appreciated (Gupta 1986). The socio-ecological perspective makes two assumptions: (1) ecological conditions define the range of economic enterprises managed by different classes of households and (2) the scale and mix (or portfolio) are determined by the access to factor and product markets, non-monetized kinship, and other exchange networks; public, private, or communal risk-adjustment strategies; and the perception of and response to various environmental and social risks. The stakes that different classes have in environmental preservation are modified by the surplus, subsistence, or deficit condition of the household budget on one hand and by the institutional context on the other.

Once beliefs about what is considered 'natural' or even 'spiritual' are shared widely, cultural codes are institutionalized. Thus, certain conflicts about choice of technology or scale or mix of resource use do not arise because duality between cause and effect is resolved through oneness with the phenomenon. Thus, if the share of birds in the crops is considered as justified as men's own, the historical selection of varieties with loose-set grains, easy for birds to pick, can be understood.

In other cases, technological and institutional innovations help generate rules and principles (Khalil 1989), cemented through social sanctions, individual repentance, and sometimes accidental (but believed to be mythical or godly) dispensation of justice or retribution. Rules do not have to be devised always. They could arise, at least in certain cases, through the logic of circumstances. Khalil cites the case of traffic rules. If there were no rules, the result might not be chaos. Anyone who has seen a huge congregation around religious centres on festive occasions will have noticed how crowds arrive at an order through a period of adjustment. It is suggested, 'pedestrians or cars interact for no purpose (when they move on a rule-less road); rules arise because they are in each other's way.' (Khalil 1989, 11).

The principles are supposed to specify purpose. The destination of pedestrians is determined by the purpose. The possibility of reaching a given destination may of course depend upon the evolution and observance of rules. The grammar, syntax, vocabulary, and style facilitate communication. It is the idea, will, and need for a relationship between sender and receiver that constitutes communication. Buddhist ethics are 'an ideology with a set of principles dressed up as rules'. The ideology could spell out the limits or boundaries of communal or individual rights irrespective, as Khalil says, of the substantive principle at hand. A scheme of rationalization is considered necessary for achieving this. Scientific theories may serve such a purpose in modern times. It is argued that religious mythology served these needs in pre-modern times. We, however, believe that, even in the current context, proper bridges between so-called scientific theories (generalizable, consistent, and verifiable) and a set of historical beliefs or cultural codes (be they of religious or mythological origin) are necessary.

The restraint on individual wants and the acceptance of social and ecological limits in deference to the claims of the next generation may become difficult to institutionalize through simply using only the so-called rational rules.

The long time frame within which returns should be appraised and the multiplicity of vectors on which utility is assessed become acceptable, perhaps through what Jodha calls the limits or potential of shared consequence or externality.

The public choice theorists often equate principles with rules and emphasize a narrow definition of justice, i.e., procedural fairness. Their contention is that 'as long as the rules of the game are fair, one should not manipulate the outcomes. Distribution of income, for instance is one of those outcomes which the State should not tamper with' (Khalil 1989). The substantive principles such as primacy of equality over an unequal system or of collective rights over the need for an individual autonomy can not be resolved mathematically. Under what circumstances the State should circumscribe individual rights and autonomy would thus be resolved politically and not 'scientifically'.

The legitimacy of such restrictions on individual needs or wants, our contention is, may spring from respect for ecological principles and the cultural basis of generating a socio-ecological ethic. It justifies the primacy of these principles over certain other rules dealing with individual preference in life-styles.

Thus, an affluent person cannot justify the violation of certain rules regarding the clearance of areas near roads to establish apple orchards or the killing of animals or the killing of trees as long as he or she can pay the necessary taxes or penalties. Such a procedurally just system, we submit, may violate the substantative principles that sustainable development, in a high-risk mountain area, requires that priority be given to (1) the rights of the community over the individual, (2) the non-consumptive over the consumptive use, (3) a consistent consumption below maximum sustainable yield (also called internal bioethics) over a consumption up to the maximum, and (4) a slow, steady growth rate with a homeostatic advantage over a high, volatile, and unstable growth rate in resource use.

Mountain societies have evolved unique ways of maintaining social amity amidst conflicting resource demands and experiences. In the transhumant community of Meraak, a festival is celebrated every year in honour of their patron deity *Ama Jomo*. It is a peculiar feature of this occasion that normal inhibitions are temporarily disregarded so that bawdy jokes can be shared, even between a father and his daugher. Catharsis at the community level is a traditional institution for settling *emotive* accounts in the short run so that *moral accounts* can be settled over the long term.

Cultural norms can help to counteract some of the 'rational' (in the short term), but non-sustainable, resource-use strategies. A pastoral group can evolve the norm of spending the most time on patches with the highest rate of return; or it can evolve norms of mobility even if resource supplies do not warrant it. Norms can be guided by the need to avoid intermixing yak herds with cattle herds (as we shall see later) in order to prevent disease transfer. In some cases, hunting tribes have used a randomization rule to overcome the tendency to hunt where the maximum game is likely to be found (Stocks 1987). For instance, there may be a water source to which animals come at a particular time in the day. 'Rational' strategy might imply hunting the animals when they come there. Some tribes use different ways of deciding in which direction to hunt by circulating a stone tied to a sling of rope and then throwing it. The direction for that day's expedition would be the direction in which the stone went. Such norms dictate that hunting groups consider the periods of scarcity and the periods of abundance with equanimity. It is also expected that norms of sharing will emerge to take care of the hardship periods.

Centralized exchange networks sometimes compensate for geographic diversity. In a study of Torbel, a small mountain village in Switzerland, the adaptations of the community to the diversity of resources and the uncertainties of the environment have been explained through expansive, intensive processes of regulation (Sahlins 1988). Building irrigation channels though inter-village coordination was the expansionary strategy. The fertilization of meadows, the repair or modification of irrigation channels, and the recovery of washed away soils were described as the intensification processes. Regulation referred to preventing outsiders from settling in the village, limiting the numbers of grazing stock, limiting wood cutting, and establishing democratic methods of centralizing power.

Mixing fluctuating scarcities with geographic diversities and resource concentration can lead to complex social structures. This is seen among three groups of people in the Zagros Mountains of Pakistan: Pathan farmers, Kohistani farmers, and Gujar herders. The farmers using rich soil and water resources exchanged goods with the herders who exploited dispersed grasslands. Two of the groups shared a resource. The Gujar herders used Kohistani pastures in the winter when the latter fed their cattle from other resources (Barth 1956). Mutual dependence among cultivators and herders, in some cases, can be mediated by State control as in the Middle East (Bates 1974). A segmented, polycentric, integrated network on the other hand concedes the autonomy of different sub-groups, the diversity of their goals, and the multiplicity of leadership or potential for leadership. Gerlach and Palmer (1981:350) suggest several possible ways in which strategies of environmental adaptation can be classified. e.g., diversification, mutual sharing, self-regulation, selective specialisation etc.

The Bhutanese experience not only illustrates the use of several of these strategies but also expands the framework of adaptation through interdependence. As with Japanese villagers, the Bhutanese may not rely entirely on socialization as a means of ensuring behaviour that avoids the tragedy of the commons (McKean 1984). They do not rely only on material incentives or disincentives.

The maintenance of law and order, in the past, was achieved through reflection on a total of 26 deeds—10 good, fruitful deeds and 16 livelihood deeds. Every family considered it a privilege to have a *lama* in one's family. Bonds between the religious (the other-worldly life) and day-to-day life were forged through unresolved contradictions between ideals and the programmatic imperatives of survival. The doctrine of omission or passive indifference thus permitted acquiescence to the killing of animals by others and the eating of meat. However, other features of Buddhist logic required compensatory measures to appease the nature gods so that one set of compromises were off-set (now or in the next life) by another set of good deeds. The calculus of survival imposed the need for conservation as intensely as it provided a practical way out of the contradictions.

The conservation ethic has been often defined inadequately, leading to the inappropriate design of reinforcement mechanisms. The re-emergence of the conservation ethic after various religious symbols, signs, and restraints fail to check resource depletion. It is observed that the game shortage was dealt with not by controlling invaders, nor by 'developing' the conservation ethic, but by moving out. The error here seems to be that 'moving out' is not considered to be a part of the conservation ethic.

The cyclical nature of natural forces and their interaction is a fundamental concern of Eastern philosophy. The search for existence, absence, dormancy, or activation of different rules will suffer if this dimension of resource management institutions is missed. Not all rules can be invoked at all times for all types of resources.

There are 'episodic' institutions that differ from 'concurrent' institutions. The episodic institution may surface only under certain critical circumstances. Certain principles may be transformed into rules, if the purpose has been served. In any case, these rules may also mutate as the changes in the supply of resources or availability of technology take place. The transmutation of rules, and of associated social organizations, in Bhutan, has occurred in different ways in various resource situations. The spatial, seasonal, sectoral, and social variabilities in different resource regimes illustrate how the pressures of contemporary social values fuse with or contradict the traditional norms and institutions.

PART THREE: INSTITUTIONAL CONTEXT FOR RESOURCE MANAGEMENT—WATER, LAND, LABOUR, LIVESTOCK, AND FORESTS

Notwithstanding the efforts of some scientists to divide mountain regions into different agro-ecological zones, we feel that ecological variability within a valley or slope is so high that any broad centralization on this basis will be meaningless. Micro-ecological 'niche' have to be considered an inalienable feature of any mountain region. The correspondence between these 'niche' characteristics and the norms of institutional governance of resource use is complex. It would be difficult to predict or suggest, with the knowledge available to those institutions, how rules would vary among different 'niche'.

However, available evidence does indicate that study of this relationship could be quite rewarding in terms of designing experiments for sustainable mountain development.

Water Management

Availability of water seems to have been one of the main bases for settlement distribution in the past. There are instances where once the stream dried or diverted, due to landslides or other factors, the people abandoned the settlements. The abandoned ruins can still be seen. The need to manage water distribution, whether in a community of dispersed households or in a densely clustered settlement, can be considered to be one of the prime movers behind societal evolution.

The emergence of leaders to organize social groups for the cooperative use of a resource was one consequence of water-based technological change. Synchronization of farming needs, due to a given terrain and climate imperatives, was another.

Depending upon the scarcity or sufficiency of water, cooperation in following certain rules for harnessing and maintaining water management structures, such as channels, became critical. There are instances where villagers have even brought water from streams located 25—30 km away from a particular settlement. The rules for maintaining water channels and distributing water may vary sometimes within valleys and among valleys a short distance away, due to micro-environmental variation in the nature of the resource, the availability of labour, or just the difference in power structure of respective social groups. Rules have emerged for the following operations:

- desilting canals before farming season,
- repair of minor breaches or major dislocations due to landslides or disturbances by animals,
- distribution of water over space, seasons, crops, and for varying operations,
- waste disposal in streams or rivers, and
- transportation of wooden logs in rivers or streams.

Institutional arrangements for different functions have varied in different places. Each household may supply equal labour (one or two persons per household) for annual maintenance functions, or the contribution of labour may be in proportion to the land holdings within the command area and the distance of the fields from the canal outlet.

The bases for water-sharing, identified after a study of 21 farmer-managed irrigation systems in Nepal (Pradhan 1989), were as described below:

- Allocation on the basis of original investment or shares purchased; water is sold or purchased independently of land ownership. The transaction has to be registered with the irrigation committee. The obligation to contribute resources towards the maintenance of a channel is determined on the basis of the size of the share.
- The number of hours of water received is proportional to the investment made.
- Allocation of water on the basis of the size of the command area; the size of the notch in the proportioning weir servicing each field or set of them is fixed according to the size of command area.
- Water-sharing on the basis of labour contributed for maintenance by a village or household.
- Distribution on the basis of type of land.
- Distribution on demand in systems where wat r is not scarce.

In Bhutan, several more innovative, institutional arrangements have been noticed. In a village with very limited water, the need for providing standing water in different paddy fields, almost at the same time, was met by an imaginative use of the rule of randomization. Conflicts were anticipated due to synchronicity of demand. The farmers collected as many sticks as the number of claimants. After writing or etching a serial number on each stick, they were shuffled and each person was asked to pick one. The lottery system determined the sequence of users.

Each received water for a fixed duration, in some cases, one day, and in other cases less or more. The cycle is repeated in the same sequence. There are also situations where the sequences are written into contracts so that people know with certainty when their turn is due. Pooling or exchange of labour, bullocks, and implements is also facilitated through known sequence.

In another village, the elders met and decided the sequence, duration, and labour supply for maintenance and protection. One person was elected to monitor the distribution. The size of the hole in the weir varied depending upon the allocation. New settlers were generally given the last turn.

Conflicts did arise once in a while. The defaulters could be asked to (1) give a gift to the persons who suffered and (2) miss their turn in favour of the aggrieved parties. If the offense was repeated, the village people would destroy the contour bunds in the paddy field of the offender.

In another case, supervisory duty was assigned to different people all along the canal length. Each person had to complete his turn and place a flag signifying the completion of his task. The next person began where the previous one left off.

Conflicts also arose over the terracing of new fields in the command areas of old channels. The punishments for laxity in monitoring could be as severe as for the offense of stealing water. In general, people reported that the collective institution of water-sharing and canal maintenance was respected. Whenever a conflict went to court or to the higher level officials, an attempt was first made to persuade people to arrive at a solution among themselves, even though they may have already tried once or twice to do so. Arbitration was avoided until it was absolutely necessary. There were of course areas where these traditional institutions were coming under strain.

There were instances where a local person was attached as an apprentice to the fitter while an irrigation system was being laid out. The idea was that this person would be able to show the people how to repair the structures whenever the need arose.

Pasture Management

The role of livestock in hill farming systems has been recognized as very crucial for sustainable resource management (Hardwood 1989, Richards 1985). While cultivation dominates at altitudes between 7,000 and 10,000 feet, livestock is the major means of livelihood in settlements above 10,000 feet.

Several factors influence the evolution of property rights and have a bearing on choice of technology and environmental stability. Because of the widespread prevalence of livestock in rural Bhutan, a large number of rules and institutions have evolved around animal management. Trespassing on cultivated lands by animals and the vulnerability of crops to livestock are negative sides in an otherwise complementary interaction between crops and livestock. Animals have to be confined, or watched closely, if the farmers do not fence their land. Fencing land is capital intensive and full-time animal tending is labour intensive. Neither of these options is economically attractive for the small, rural farmers in Bhutan.

The problems created by stray animals on cultivated fields are very serious and a social institution has developed to deal with them. Two or three households are elected every year as 'crop police', and it is their function to monitor the movements of livestock straying into crops. The crop police round up the animals caught in a field and maintain a register of estimated damages to be compensated for by the owner of the animal. A part of the fines levied on the owner of the animal accrues to the 'crop police' as service charges and the remainder is paid to the injured party. The revenue from service charges increases according to the number of 'catches' and the amount of fine imposed. Households that round up the stray animals get a share of the fine money. Revenue for the service increases as the frequency of catches increases. This feature gives an incentive to the crop police to maximize their catches. The accounts are often settled at the end of the year. At higher altitudes there are hardly any problems caused by animals and thus there is not much need for protection. At lower altitudes, however, there are serious problems.

The gathering of leaves from a common grove for composting of animal manure or for bedding for animals is a regular activity. Here again, individuals cannot strip the forage unilaterally. Forage is collected from a common grove only on a publicly declared day so that all community members get fair shares.

Institutions evolve when the conflicts in resource use are inherent in the nature of the demand and supply situation, and there are considerable externalities involved. In general, we have found some evidence for the evolution of such institutions more often than not in higher-risk environments. The case of *auran* lands, left for gods and goddesses in Rajasthan, is a good example. While *aurans* did exist in other places, they were still being maintained in more arid parts of the region when they had begun to disappear elsewhere.

The boundaries of the grazing territories of different villages and individuals within them were demarcated by cliffs, rivers, or streams. A village could lie within the domain of the grazing rights of another (even non-resident) individual. However, the villagers could object if the grazing rights were leased out to outsiders without consulting the villagers.

The herders moving through the territories of different villages lying on a migration route needed permission for passage as well as for stays of varying durations. If the fields were sown with crops, the herders had to send advance intimation to the villagers so that the latter could organize protection. Damages had to be paid for any loss of crops.

Yak herds always graze in alpine regions (strictly speaking the term 'yak' is used for the male of the species). Cattle migrate over vast distances to sub-tropical regions in the winter and back again to the alpine region around the fourth Bhutanese month. As the cattle arrive from the sub-tropical regions, yak herds must vacate the pastures by going still higher up. The yak herds must leave about a month before the cattle arrive, to avoid contact between yaks and cattle. This serves two purposes: (1) the grasses can regenerate and (2) the possibility of certain diseases being transferred from the cattle to the yaks is minimized. The movement of yaks and cattle is based on tacit information and annual routine. Cattle herders need not inform yak herders of their arrival.

Breeding was a common activity for which institutions had sprung up. In some places, e.g., the *Sambhaka* and *Yabobhog gewogs* (blocks), people are not allowed to bring in bulls of any breed except Siri. A pure strain of the Siri has been maintained here for a long time.

Disease control is another area in which village institutions have evolved. A person can be fined for bringing a diseased animal near the village before it is sufficently clear of infection. Foot and mouth disease has been a very serious source of mortality in cattle. Arrangements have been worked out, e.g., in Komatanga Village of Wangdi District, to prevent its diffusion. If the village cattle were infected with this disease, two outposts were set up outside the village at locations that outsiders had to pass to enter the village. People from the village took turns to man these posts. No amimals from the outside were allowed to enter the village lest they also become infected. This was a case of an institution emerging not to optimize returns to the individual or the village but to generate positive externality. Obviously, if everybody used such methods the diffusion of disease would decrease.

Other traditional methods of disease control are also used. In some villages, rancid pork (two to five years old) was boiled and fed to cattle and also used as an ointment. Perhaps this acted as a vaccination measure. A few of the large herds of cattle kept male goats which were supposed to prevent a particular kind of epidemic. The smell of the goat was assumed to keep away the vectors of this disease.

Trade and potential and intensity of resource use along migratory routes during different seasons have not been adequately studied. The scope for using market instruments for encouraging sustainable resource use can be identified only if barter markets and the money exchange system are studied.

There are private grazing rights in the names of individuals. One household in Central Bhutan could have such rights in different places in the east and south of Bhutan. These rights do not imply any right over trees, rocks, or soil. People living in villages where northerners have pasture rights in effect can request the owners for permission to use these resources in exchange for gifts or a small fee. There are several reciprocal arrangements arrived at by visiting pastoralists and settled land and livestock owners. The herders offer to use the grazing land and in return look after the livestock of pasture owners. Conflicts around grazing rights have frequently arisen in different places. Some of the most celebrated court cases deal with conflicts about pasture and grazing rights.

Fencing by the Government Forest Department was also not accepted easily by the people. In some cases, the level of degradation was intense and animals were considered to be the major culprits. The farmers living in the valleys or on the lower slopes felt that fencing would obstruct water sources and the repair of stream channels. Social fencing, which worked for so long, was becoming weaker in several places due to the pressures of the commercial economy and imbalances in public policies.

Forest Institutions

There are several positive and negative interactions among forests, crops, and livestock. For instance, rights and responsibilities towards the forest among cultivators and pastoralists include cleaning the *Sokshing* (community forest); collecting firewood on a particular day *(ashi)*; prevention and control of forest fires; the sustainable management of *tsheri* lands (shifting cultivation practices); prevention of the intrusion of cattle herds into reserve forests; the protection of wildlife; the lopping of trees (with prior permission) for domestic use; collection of shingles (flat thin pieces of wood cut for roofing) every few years to replace and repair the roof (the old shingles are piled in the field to decompose as manure or burned to prepare fields for the cultivation of buckwheat); and the collection of leaves and pine needles to prepare bedding for animals.

It was noted in the National Assembly a few years ago that large-scale outbreaks of fire had become frequent. The forest guards were found inadequate. It was suggested that a person from each village be appointed as a fire-watcher to work under the village headman. The fire-watcher would not be obliged to contribute compulsory labour. People found responsible for starting fires were to be imprisoned for three years. If the villagers could not locate the culprits or did not help to extinguish the fire, they could be penalized.

There is no doubt that the fires caused a lot of damage to the forests, no matter whether they were started to clear land for apple orchards or for crops. However, doubts have been expressed about the damage caused since the 1860s and it has been suggested that it may well have been the practice to burn parts of the forests that were suitable for grazing.

H. Cleghorn, in a 'Report upon the Forests of the Punjab and the Western Himalaya', in 1862, observed:

With regard to the conflagrations which are universally described as being so destructive, according to my observation they are almost in every instance, wilfully caused. The practice is very common in all parts of India, where there are extensive tracts of waste or prairie land used for grazing. At the end of the rains the ripe grass dries up, forming an innutritious fodder upon which the cattle soon fall off, and the most ready remedy is to apply fire, and burn the withered straw in order that the young grass shoots, which spring up immediately after, may be accessible for browsing. Firing the grass jungle is universally practised in the prairie 'khadur' lands along the Terai, where bullocks and buffaloes are grazed and wherever binjarahs take their cattle in the cold weather. The same object leads to it in the hill districts. The paharees will bide their time patiently for wind and weather suited to a favourable spread of the conflagration. In very many instances, the dry withered grass is an evil, for which burning is the only cure. Under these circumstances, it appears to me questionable whether any amount of injunction, or penal enactment will be effective against a practice which is ingrained with the wants and the immemorial usages of the people. The best plan would be to have the plantations in situations not liable to the risk of fire and the sites best adapted in other respects for planting would be of that character.

Another British officer, writing on the forests of Kullu, observed, in 1851, that the dry grass was fired to produce new tender shoots of grass and in the process killed myriads of young trees. He suggested that the old sites of certain important forests could be marked and saved from this hazard. He favoured conservation over plantation and added, 'we must trust to the law of nature, which constantly provides for the maintenance of any products by efforts, increased in proportion to the danger of extension....' The suggestion was that villagers should have the charge of the forests and be allowed to collect an *ad valorem* tax on wood cut provided they did not burn the grass and prevented the trees from being cut before maturity (Thornton 1968).

Pastoralists in Bumthang observed that less fire burning of the soil means less productivity. Land was burned to fertilize the soil for growing buckwheat. After that, the fields were converted into pastures, followed by shrubs, and then wheat was cultivated. The practice of growing buckwheat on such soils was actually quite regenerative. Even in cultivated fields, the wood was collected and burned with mounds of sand over twigs in the winter before sowing buckwheat.

It is true that public policy, at present, assumes that forest fires are an unmitigated disaster. Therefore, a series of measures are provided to prevent them. At the same time, historically, fire-setting was a part of resource management strategy. There may be a case for scientific analysis of the conditions under which the burning of forests used for pastures can be treated as a part of management practices and, at the same time, other forests might be protected from this practice.

The relationships (tested by regression equations) between such variables as terrace cultivation, population, pine forest, and degraded forests show that yaks are found to be predominant in the regions dominated by blue pine forest. Cattle are found in regions having a high population density and terrace cultivation (Ura 1988).

The rights of people, in not merely conserving forests but also enhancing the productivity of their farms and herds, go hand in hand with their responsibilities in the matter. A country with 64 per cent of its area under forests, and with a clear policy of maintaining it at that level, has to blend culture, technology, and environment in a socially and administratively acceptable manner.

Labour Contributions to the Creation of Public and Common Goods

One of the most important features of mountain societies throughout the Himalaya is the traditional practice of voluntary contributions of labour for the management of common properties such as water tanks, irrigation channels, pastures, and mule tracks. The Bhutanese Government has made it absolutely clear that the entire development process has to take place with a clear understanding that potential consumers of facilities must pay, at least partially, for them in the form of labour or cash. While cash crops fees are levied in urban settlements, labour taxes are still in vogue in rural areas. Several types of labour taxes were instituted in Bhutan; a few are mentioned here.

A Tax for Local Public Utilities (Shabto Lemi)

Potential users of public utilities such as the domestic water supply, basic health unit, and primary schools are expected to contribute labour for construction. Non-attendance is fined.

Renovation of Administrative Buildings (Dzongsel Woola)

The seats of the administrative and religious authorities are located in the same building in each regional unit. For maintenance of this building, every household is expected to contribute at least one day of manual labour per year for which a compensatory wage rate is also paid.

Renovation of By-ways (Chusel Lamsel)

The community takes care of the irrigation channels, mule tracks, bridges, etc. A few days of labour, depending upon the magnitude of the work, must be contributed. This labour is used under the guidance of the village chief.

Housing Tax

Housing tax is charged at the rate of 15 man-days per year per household for creating or maintaining a public utility but not necessarily a local public utility. Since it is payable in cash at the rate of Nu 25 per day, most urban house-owners do not contribute in labour.

Roughly speaking, each household contributes about 41 days per year, amounting to approximately 43 million *Nugtrum* worth of contributions from the people (Ura 1988). This would amount to an excess of 10%—a significant proportion over and above cash taxes—of domestic revenue in 1986/87. This practice not only ensures the people's participation and reduction in the wage component, but it also ensures minimum reliance on immigrant labour. In addition to this, labour contributions also reinforce cultural values that can only be cemented through collective work for the common good. Most developing countries, by delinking the creation of public or common utilities from their maintenance and regulation by the local communities, have faced tremendous problems in maintaining these investments. On one hand, maintenance requires large bureaucracies, and, on the other hand, people become more and more dependent upon the State for the provision of various services. For a country that does not have much to export or that cannot generate much revenue from internal taxes such an approach inevitably leads to a high budget deficit often accompanied by high foreign debt. This, in turn, not only compromises the autonomy of a society but also limits the extent to which the State can subsidise essential public services. More and more revenue is spent by such countries on maintaining their own public bureaucracies, and this inevitably alienates the people from the State.

Bhutan has very consciously decided to avoid such an eventuality. It has not merely decentralized the majority of functions but has also reduced exemptions from paying this labour tax to different categories of people. Given the labour scarcity in several parts of the country, the choice of a slow, eco-adaptive path of economic development seems the only sustainable alternative.

However, notwithstanding the merits of labour tax, labour tax is a system that is biased against rural people. The bias would be increased over time as labour costs rise and the opportunity cost of labour rises. Indeed, urban residents are not subject to any of the labour taxes, except the housing tax (*Gungda Woola*), and it is a tax haven, in addition to having utilities and amenities constructed at the government's expense (Ura 1988).

PART FOUR: CULTURE OF INNOVATION

Sustainability in high-risk environments requires both technical and institutional innovations. We have looked at only a few of the institutional innovations so far. The technical innovations provide a clue as to how a society generated an ethic that was progressive but not necessarily guided by the pursuit of accumulation.

Water-driven Prayer Wheels

Use of wind and water energy to keep prayer wheels moving led to very innovative mechanical improvements. The energy of streams and small rivers is harnessed through the alignment of horizontal and vertical gears. The chants are block-printed on Bhutanese Daphne bark paper and Hrolled in cylindrical shapes. Reams of chants are encased in a bronze or leather cover and placed on water wheels to be turned by the running streams. It is difficult to suggest whether this led to the development of water-driven flour mills or vice versa.

Architecture and Education

The construction of *Dzongs* (fort-monasteries) seems no less than a miracle given the limited availability of building materials and absence of scaffolding, pulleys, pins and nails, formal survey techniques, and blueprints.

Some of the more innovative school teachers have used these buildings to impart basic skills to children about reading, writing, arithmetic, and resource literacy. The children are taken to these buildings and asked to measure them. In the process of measuring, they are shown the use of different types of woods in different parts of the building. The relationship of this wood to the tree it came from and the soil and slope on which the tree grew is made obvious to the students. It is not surprising, therefore, that such students develop a great pride in their culture, one which provides rules for respecting religion, environment, and common institutions.

Tangible evidence of the enculturation process is the almost cent per cent return rate of the students who go abroad for higher education. Apart from a few, all the students have come back to Bhutan—an achievement which perhaps no other country can claim. Lest the fusion between modern ideas and traditional values not take place, every student who returns is expected to spend about six months in a village assignment to unlearn and realign his or her coordinates of the cultural maps of the country. The new education policy is re-emphasizing the relationship between resources and their place in one's life.

Bridges

Isolated settlements on the far sides of the rivers have always had difficulties of accessibility and transportation. Since long-distance trading for material exchange plays a lesser role in the mountain environment, 'niche'-specific adaptive strategies had to be developed to fulfill all the cultural needs. The degree of interaction is highly compromised by intercommunal isolation. These problems lead to various technological solutions. One of the most remarkable engineering feats, promoted by the mountain condition, was the construction of iron-chain and wooden bridges across the country as early as the 15th century. George Bogle, who visited Bhutan in 1774, noted that 'the bridges were either entirely of wood or entirely of iron. The wooden bridges are very common and are from 30 to 70 feet long'' (Clements 1986). The iron-chain bridges were attributed to Saint Thangthong Gyalpo (1395—1464). Building them became as much a religious task as a technical one. Bridge building is considered a virtuous act because it removes people's obstacles.

Handloom Textiles

Almost all the raw materials for the handloom sector, which was once thriving in Bhutan, were derived locally. This sector is now subjected to great competition from manufactured clothes. Rural women generate substantial income from this activity. The traditional skills of dyeing and designing were based on local wool, tree cotton, and sericulture. Slightly rough but lasting materials were also woven from a species of nettle. For fine clothes endi-silk is used, and a wide variety of natural dyes such as rubia and *zhim* are used.

Alignment of Irrigation Channels

The science underlying the techniques of aligning channels across different terrains, soil types, and slopes remains to be properly understood. While there are channels constructed by the government which have failed after a few years, traditional channels have been maintained, in some cases, for several hundred years. The institutional context of this technology is an important basis for the sustainability of the channels. The same technology without the support of common property institutions might fail as easily as the modern irrigation channels. The variety of materials which are used, ranging from tree trunks to various kinds of lining, also show extremely innovative efforts.

Mobility of Livestock and Feed and Fodder Practices

As mentioned earlier, movement across altitudes and of different species is essentially organized by two different occupational groups: the semi-nomadic pastoralists in Laya, Linghsi, Mera, and Sakteng and the sedentary agriculturalists in other parts of Bhutan. In addition to the institutional arrangements guiding the movements of cattle and yaks, there are several other innovative indigenous practices of veterinary medicine, food and fodder mixtures, and livestock management. Given the fact that providing medical facilities to large numbers of people in the interior mountain regions has been so difficult, the possibility of building up an animal husbandry health infrastructure is quite remote in the near future.

Therefore, reliance on indigenous knowledge systems is necessary. Some studies have been undertaken to find out the scientific basis of traditional fodders. For instance, it was found that willow leaves (*Salix babylonica*), when eaten by sheep, support the energy and protein requirements for body maintenance as well as growth. Willow leaves are recommended as the most suitable fodder for ruminant livestock in and around Thimphu and the temperate regions of Bhutan. The leaves are so rich and palatable that they can sustain the animals without any additional supplement. There is no significant difference between the metabolizable energy concentration of willow leaves and that of lucerne, vetch, fodder maize, and fodder oats. It is unfortunate that development programmes for the mountains often ignore the accumulated wisdom of centuries of experimentation. In this case, out of a large number of possible leaves and grasses, only a few have been selected by people living in different regions. The emphasis on cultivated fodders should, in fact, be less than on tree fodders in fragile regions, because tree ecology is more sustainable than the cultivated crop ecology for higher altitudes as well as steep slopes. In the sub-tropical parts of Bhutan, leaves from fodder trees complement grazing. In sub-alpine and alpine regions, wheat is grown as green fodder for cattle and horses. The animals go through nutritional stress during the long winter in the alpine regions. Buckwheat straws and even some crops are used as supplementary feed.

Cropping Systems

Several innovative uses of weeds and other materials have been attempted for fertilizing the crops, plant protection, or seed storage. The farming systems in Bumthang District in North Central Bhutan are discussed first followed by descriptions of some other innovative practices. In Bumthang, agriculture and animal husbandry are closely intertwined. The grazing of livestock appears secondary to cultivation in the lower settlement valleys, while at higher elevation the reverse is the case. Potato cultivation is expanding rapidly and replacing buckwheat, which, in addition to wheat and barley, is the major crop at higher elevations in Bumthang. Wheat and barley are grown in the flatter parts of the valley and buckwheat on its steep slopes. Potatoes can be grown on any gradient but there is a preference for the roadside land and land closer to the houses. Turnips, radishes, onions, and cabbages are also grown.

Irrigation plays a very limited role in these farming systems. There is a limited use of fertilizer for winter wheat, barley, and buckwheat. The soil needs to have a sufficiency of phosphorus and, of course, nitrogen. Soil fertility is enhanced by collecting mounds of soil over twigs, branches, and dung, and these are then burned to produce ash.

While the normal land holding is about 20 acres per household, only a fraction of this is cultivated in any given year. A plot is cultivated only once between 6 and 10 years and there is a regeneration of weeds on such plots in the intervening period. It is in this context that some people have argued for differential norms for land holdings, in different parts of the country, by taking into account the productivity and the frequency of cultivation.

Diversity of crops is one aspect of risk adjustment, and diversity of livestock species is another. The agriculture is predominantly labour intensive and seeds are replaced every third year or so. Wheat and common buckwheat are alternated in the same field every year. Common buckwheat is a short duration crop and is known to deplete soil nutrients. Buckwheat is rotated with wheat, which requires less nutrients. Compost is applied for buckwheat plantation but the residual effect is obtained by the wheat planted in the same field next year without adding compost.

The crops in the highlands attract a large numbers of pests, including bears and wild boars. Buckwheat is exceptionally vulnerable to bears. To protect everyone's crops, all the farmers collectively cultivate buckwheat in one single area. During the maturation period, it is not uncommon to hear shrieks and howls from the farmers to scare the wild animals away. There are reports of several experiments on farmers' fields, conducted in different locations, that have been destroyed by wild animals.

Winter wheat is sown in November, weeded in April or May, and harvested in September. Bhutan has three species of buckwheat. The common buckwheat, or bitter variety, is sown in April, weeded in July, and harvested in August. Common buckwheat needs a very short maturation period. It is obvious from the overlapping growing period, between wheat and buckwheat, that none of the areas in Bumthang have double cropping. This particular crop combination, besides being consistent with the agro-climatic conditions, allows the labour, draft animals, and management to be spread fairly evenly over time. Planting and weeding of both wheat and buckwheat are staggered so that labour resources are used more efficiently.

Since the early 1970s, potatoes have been cultivated as a cash crop. They are planted in March/April and harvested in August/September. Weeding is done twice, the first time in May and the second time in June. In terms of labour, management, and draft power requirements, potato cultivation competes with buckwheat cultivation and thus the expansion of potato cultivation is taking place by partially displacing buckwheat.

Preparation of Manure

The dung found on the communal grazing land is collected by the communities and divided among themselves. Dung on private pastures is collected exclusively by the owner. The ash of the burnt dung is applied back on to the soil. The cattle or the flock of sheep are penned on the fields to enrich the soil by their droppings. There are customary exchanges among visiting herds and the owners of cultivated land in some areas.

Animal sheds are built on the ground floor of two- to three-storeyed buildings for keeping horses, swine, cattle, and their livestock. The straw leaves collected from the forest or pasture lands are spread on the floor of the cattle shed and are mixed with cattle urine and dung. Farmers have recognized the difference in the quality of different manures. Oak leaves are considered to make the most potent compost, followed by pine needles. Waste from horses is the preferred manure. While the waste from swine is considered quite fertile, it creates a problem. The swine often excrete undigested seeds and thus their manure encourages the growth of weeds when applied to the field. A combination of horse waste and oak leaves forms a superior compost.

The leaves of wormweed (Artemesia) are chopped and used for mulching and composting with chillie plantation. It is also assumed that they have some plant protection properties. The boiled extract of green leaves of this weed is given to the animals to control flatulence.

Shifting Cultivation

A study on this practice carried out in Pemagatshel District in Eastern Bhutan has revealed the socio-ecological compulsions that lead to the dominance of shifting cultivation. The district is the most backward district.

The majority of farmers in this district consume 90 per cent of their grain produce. About 30 to 50 per cent of the foodgrain is converted into liquor for domestic consumption. Farmers have permanent houses and shifting cultivation is practised either individually or by groups of households. The land may also be owned or leased. It was estimated that about 32 per cent of the total cultivated land was under some form of shifting cultivation in Bhutan, although in the case of Pemagatshel District it goes up to 79 per cent of the cultivated land. The importance of shifting cultivation can be assessed by looking at the following figures: only one per cent of the cultivated land is under paddy (irrigated) cultivation and 20 per cent of cultivated land is under permanent dryland (rain-fed) cultivation, maize and buckwheat being the two principal crops grown. Farmers also grow wheat, barley, pulses, mustard, and potatoes as winter crops.

The burning of slashed vegetation, after the land has lain fallow for three to eight years, is organized by one or several fire specialists (*mesungpal*). Farmers recognize the correlation between soil fertility and the duration of the fallow period. The land is not ploughed and seeds are either broadcast or dibbled into the soil. The output of this system is considered to be higher than that of dryland cultivation and labour and other input requirements are lower than for any other system. There are reports that the productivity of these lands is declining because of factors such as heavy grazing of fallow land, deterioration in the composition of vegetation on fallow land, shortening of the fallow period, erosion, and the depredations of wild animals. Policy makers, however, realize that there is no sustainable alternative to shifting cultivation in the near future. The government appreciates that reverting these lands to forestry without generating alternative sources of livelihood would impoverish the farmers a great deal.

Local Technical Innovations in Agriculture

While no systematic inventory exists of the innovative practices evolved by farmers—men and women—in Bhutan, a very limited listing of practices is presented here to suggest the potential of this knowledge base.

- Before potato tubers are sown they are divided into two sections, strong and weak. The section with more buds is considered strong and the section with less buds is considered weak. The seeds are planted according to the soil fertility in different parts of a field. The possible difference in productivity is also assessed by the difference in the shape. The round tubers are planted on the hillsides and the oval-shaped ones elsewhere. While planting, some people follow the practice of planting four sections of potato seed in a circle with another section in the centre. After sowing, the field is covered with manure and mulch which are burned to control pests and increase soil fertility.
- A rope is taken through the paddy field either to dislodge the dew on the leaves into the soil or to dislodge the eggs of certain insects which may die after falling on to the soil.
- Chillie seedlings are covered with paddy straw and the mulch so formed is burned. The ash is assumed to help in controlling late blight disease.

Local knowledge systems evolve not only about local crops but also about exotic varieties or crops. In some cases, farmers have discovered that hybrid maize plants can withstand strong winds better than the local varieties. Several changes are being brought about in the associated components of the farming system in parts of Tashigang District where strong winds are a problem.

Technological change influences culture just as much as cultural factors influence technology. Further, the teething troubles that are being faced by farmers in the process of technological change indicate that a policy on this topic should be sensitive to the ecological and cultural limits. Several studies pursued by Western scholars in Bhutan have confirmed that most of the ill-designed, rushed efforts for technological change have not been very encouraging. There are studies that have shown that considerable yield potential exists within the local varieties, provided management conditions can be marginally improved.

PART FIVE: TECHNOLOGICAL TRANSITION: EMERGING ISSUES

Bhutan's capabilities for carrying out research, whether in research stations or on farmers' fields, are growing slowly. Part of the problem lies with the way in which technology development and dissemination has been propagated in the recent past. It was hoped that one or two centres, located in the fertile valleys, would be able to generate technology that could be transferred through the training and visit system. Recently, an Australian company, providing assistance for the Tashigang/Mongar Area Development Project, emphatically advocated a case for ecologically balanced, low external chemical input agriculture. It was observed, 'there is no great pest/disease problem in East Bhutan, and your eco-system still seems to be well balanced. Don't fall into the trap of chemical overuse, the only beneficiaries from this are the chemical companies and your balanced eco-system is likely to become unbalanced very quickly' (Thomas 1989).

Agronomic research carried out on several crops is demonstrating that experiments designed without analysing the basis of diversity in the existing cropping systems may not make the best use of time and critical resources—human or material. It was found that seed rates or methods did not make much difference to the yield of mustard. Likewise, line sowing over broadcasting made hardly a difference of 100 kg/ha, which, given the cost and unavailability of labour, was not remunerative.

Most of the new maize species, introduced by the International Wheat and Maize Improvement Centre, have an unacceptably high number of exposed ears and a higher incidence of rot under wet conditions besides the problem of lodging. Only a few species merited further testing. Irrigation research for maize crops was not considered necessary. In the absence of fertilizer, most improved varieties did not outyield the local ones. The technological package tried in Western Bhutan could not be replicated in the eastern or southern parts. The mustard fields not harvested on time face the problem of shattering with the result that the seeds germinate in the next season.

In addition to the technical aspects, the gender aspects deserve serious attention. In most mountain regions, male emigration is almost a rule. Therefore, technologies that build upon the strength of women and help to overcome their limitations need to be carefully screened. Women play a major role in fuel and fodder selection, water collection, handloom activities, and agricultural and livestock management.

Power tillers (about 80 to date) were introduced because labour was thought to be scarce. However, a survey of its use reveals that most of them are used for transportation, being unsuitable for other purposes on terraced fields. It should be possible to involve the companies concerned, supported by international aid agencies, in carrying out research on proper designs, instead of taking the easy option of transferring existing designs. It is natural that given the low-level purchasing power in most mountain regions, the private corporate sector does not have much interest in designing equipment or technologies specifically suited for these regions. This is an issue in which International Centres for Agricultural Research and other donor agencies should become involved. Bhutan's experience shows that, despite the lack of adequate training and skills, appreciable technological changes can, indeed, take place through imaginative policies. For instance, the Royal Government of Bhutan decided that, instead of importing computers and remaining dependent upon the repair services of external consultation, they should try to assemble computers within the country. Today almost all offices in Thimpu have computers asembled in that country at a very low cost and of very high quality. Similar breakthroughs can be achieved in other sectors as well.

Medicinal Herbs: Preserving a Unique Wealth of Knowledge

There has been some concern expressed in the National Assembly on the issue of regulated access to medicinal herbs from the forests and pastures. The mountain regions abound in these herbs. There is a need for an international thrust towards preserving this knowledge reserve. In the absence of a careful strategy aimed at managing the selective collection of herbs, some herbs might disappear because of the ecological principles of succession and dominance. For instance, if elephants are killed in a particular forest, then the grasses and herbs which grow in the micro-environment produced by the trampling of grasses by elephants will not be available. Likewise, in certain forests, livestock browse and when that stops suddenly it also affects the dominance patterns of different species. The result would be excessive growth of some species and total suppression of others. This is a subject that requires very careful monitoring. ICIMOD should collaborate with the IUCN and national governments to form a programme to monitor the changes in ecological succession and dominance patterns due to closure or other major changes in socio-ecological environments.

PART SIX: ENVIRONMENTAL RISKS AND SOCIAL RESPONSE

Farmers, pastoralists, and artisans face several risks which vary over space, season, sector, and social groups. The southern area of Bhutan receives heavier rains and some regions face the problem of floods. In the northern regions, landslides, snowfall, hailstorms, and strong winds cause various types of damage. Damage by wildlife is more serious in the central and lower parts of the country. A repertoire of responses to different types of risk reflects the strengths and weaknesses of indigenous institutions as well as of the modern market and public institutions.

In an informal panel enquiry, we identified nine risks which people had to face; and they are heavy or too little rain, damage by wildlife, hailstorms, snowfall, landslides leading to road blockage, choking of irrigation channels, or dispersal of stones on grazing pastures, strong winds, disease or epidemics, fire, and the drying up of streams. It may be useful to ascertain the composition and order of risks perceived by different social groups and stockholders, such as *lamas*, administrators, and members of the National Assembly in different parts of the country.

Traditional Risk Adjustments: Animal Disease

Yaks are found at approximately 2,500 m above sea level. This would be the lowest height to which yaks descend, even during the winter. They move to pastures at much higher elevations during the summer, giving way to cattle who are driven up after winter grazing in the sub-tropical parts of Bhutan. The migratory cattle naturally mingle with other herds from the South, and, during their grazing, they cross paths with other herds on their route. While doing so they pick up diseases and transmit them to yaks, which are more delicate than cattle. To avoid transmission of any diseases from either side, yaks are moved to the higher pastures a month ahead of the arrival of the cattle. Herders of yaks and cattle do not exchange messages about their movement. They coordinate their behaviour with almost ritualistic precision through ecological signals or other means. The yak-herder expects the cattle-herder to be there on time and the cattle-herder expects the yak-herder to have gone.

Coping with Lean Harvests: Risk Adjustments against Famine and Food Shortages

Within living memory, there has been no famine, on the scale of community or nation, in Bhutan. This may have to do with pure good fortune, with a greater production stability of the farming system, or with the elaborate traditional food security system operated by the State. Probably all of these factors diminished the effects of any incipient famine, but which of these factors played a more dominant role remains to be examined.

Until the 1950s, the State maintained enormous grain silos in each of its massive *dzongs*, i.e., district headquarters. The ultimate use of the kind-taxes, including grain taxes, was to build up reserves to support the State officials and the monasteries, in order to avoid crop failures. The food stock—butter, cereals, meat, mustard oil, etc.—was replaced with new grains by exchanging the old stock with that of the farmers every six years or so. Until the kind-taxes were commuted to cash taxes in the 1950s, farmers suffering from crop failure could get grains either free or on an interest-free loan basis from the State grain silos. There were also remissions of taxes in bad years.

There are localized bad harvests of varying degrees. One hears about insects destroying the crops and hailstorms dislodging them with distressing frequency through the newspaper (*Kuensel*). The households historically maintained a buffer stock from which they could draw during bad periods. This may still be true for households that are more remote. The first course of action is to call on kith and kin for gifts of food on the basis of reciprocity. Grains can also be borrowed from those who have larger food stocks.

Farmers can travel to other places on alms rounds or work for food for villagers in distant places. According to some observers, there always seems to be enough work in exchange for food. It is considered unusual for farmers to take such drastic measures as disposing of their animals, jewels, or other assets to tide them over a period of food insecurity. Strong contingency mechanisms are supposed to prevent them from becoming assetless in the aftermath of a bad harvest. In recent years, the government has begun to build food security stocks equivalent to six weeks of the country's total requirement of essential commodities such as wheat and rice. The actual efficacy of these measures remains to be properly evaluated.

Gathering wild food is an important means of supplementing food shortages in some parts of Bhutan. In some districts of Bhutan, such as Kheng, yields from the forest contribute substantially to the food basket. There are wild yams, wild avocadoes, wild taro, young fronds, young bamboo shoots, orchids, and various kinds of mushrooms, to name just a few edible species. Wild yams, which grow to giant sizes—as long as four feet—are collected even as a normal part of the diet. Since they lie a metre or two below the surface, appropriate extractive tools are used for wild yams. Nowadays, forest food gathering is a growing petty business for some farmers who live within easy reach of the urban markets. Some entrepreneurs have begun to export edible forest products. Farmers are encouraged to scour the forest floors for certain kinds of high-value mushroom. The commercialization of food from the forest, on which the community partially depends, has the danger of excessive depletion.

House Construction and Other Non-monetized Reciprocities

A community is bound by norms of reciprocity and sharing. The members of a community have a network of obligations that includes one's extended family, fellow villagers, and others. Indeed, these social networks of obligations and reciprocity are something of a mixed blessing. Redistribution and equality seem to be a natural outcome of such a social system where the better-off kin must assist the worse off. The levelling effect of such a sharing society is summed up in this ironic Bhutanese saying: 'Relatives will prevent me from becoming destitute; relatives will prevent me from becoming rich.'

There are a large number of norm-oriented customs, among which contribution of labour for the construction of private houses is a good example. The size of houses, especially in the alpine settlements of Bhutan, are in excess of what one could afford to build normally without the community's free labour contribution. The reasons for comparatively larger structures are probably the availability of timber, stones, and mortar, but stronger norms of reciprocity and cooperation possibly grew more easily in clustered settlements in the alpine regions. It remains to be seen whether all the labour contributed for such purposes was voluntary.

Each household usually allocates one person for some part of the construction. Strong norms of reciprocity ensure adequate housing for all. Any family in the village can build a house beyond its means because others help with the work. The average housing conditions in the villages are much better than in places without the norm of reciprocity. It is also a social adjustment to labour shortage and a non-monetized labour market. While the wealthier may choose to build bigger houses and thus benefit more from the norms of reciprocity, on the whole it seems to be a strategy for collective optimization.

The norms of cooperation have been relied upon for a variety of civil works ranging from the upkeep of highways, footpaths, and bridges to the construction of monasteries. In the repair of roads or bridges, the burden of maintenance need not be equally shared by all since the route may not be used equally. In such cases, only special client groups will be bound by the norms of cooperation. It is of course easy to appeal to community labour for the construction of a community temple. There is no apparent differential benefit or vested interest for any section of the village. The benefits are diffused, incomputable, and intangible.

Such solidarity in terms of shared labour would be less spontaneous without a leader to do the organization and without the occasional threat of social sanction.

PART SEVEN: POLICY FRAMEWORK FOR SUSTAINABLE MOUNTAIN DEVELOPMENT

Livestock

The crucial dependence of crop cultivation on livestock because of manure and draft power is well understood. However, livestock are viewed as the most serious threat to the environment today in most parts of the world, particularly in fragile desert and mountain regions. Augmentation in the prices of dairy products should give impetus to the increases in herd size. Improved vaccination and other disease-control programmes also increase the population pressure. At the same time, closure of certain forest areas and pastures (estimated at about 25 per cent) for livestock, burning, and collection of leaves, etc., shifts the pressure on to more marginal grazing lands.

In the short run, the number of livestock is unlikely to go down. Thus, the supply of manure to fields may remain at the existing levels, except on certain migration routes that have been modified due to closure.

The supply of high-yielding exotic breeds such as Jersey and Swiss Brown, together with improvement in the quality of pastures, is making slow progress. The ultimate policy aim of replacing migrant herds of local breeds by sedentary herds of improved breeds does not take the manure problem into account. Nor does it deal with the issue of biodiversity and stability. Whether it is feasible at all in the unique geophysical and cultural setting of Bhutan remains to be seen. We doubt it.

It may be added that cultures that have evolved through movement and exchange of livestock have also provided legitimacy to the efforts of the State in regulating the different resource-use strategies of the people. The ecological basis of this exchange may not be any less vital for the sustainability of society. Politically, pastoralists have suffered in most societies in the process of economic transition. However, the Bhutanese culture and environmentally conscious public administration might resolve this problem provided international aid agencies can invest in the learning and experimentation process. The biodiversity of forests and pastures, influenced by livestock movements, is a global heritage. The cost of maintaining them should not be borne by the poor pastoralists alone. (It should be noted that the majority of herders throughout several regions do not own any pastures.)

Agriculture

Mountain societies generally do not depend upon cereals as the primary source of consumption. Some of the most popular dishes of Bhutan require cheese, potatoes, chillies, maize, *kharang* and buckwheat—ingredients that could continue to be in sufficient supply if the policy shifts in favour of cereals especially rice, are adjusted. Bhutan's cereal food basket has 50 per cent rice, 13 per cent wheat, 24 per cent maize, and 13 per cent other cereals. Rice was never a major staple food. The import of cheap rice has led to this shift.

Self-sufficiency in cereals, particularly rice, as the preferred food, is the main focus of agricultural policy. How the self-sufficiency programme is pursued in practice (and this has not been decided yet) will have ramifications for the land-use patterns in Bhutan. The policy package includes fiscal and institutional measures to change the consumption patterns. Input supplies as well as extension programmes and training of the farmers are being given increased emphasis in every plan period to increase productivity. There is also some possibility that new lands will be brought under cultivation. On the other hand, some agricultural land was lost to urban settlements and industries, before the National Assembly passed a resolution, in 1988, prohibiting construction on wet lands. There is considerable pressure on the forests because of the expansion of orchards. The ecological implications of expanding apple orchards on to steep slopes and lands close to the roads need analysing.

Agricultural research is yet to be reoriented towards the strength of the comparative advantages of the organic, agricultural technological base: less diseases and pest problems, higher yield potential of local varieties through better management, and a very strong institutional base for managing common properties such as irrigation channels, pastures, and forests. Some efforts have been made to identify the scientific basis of eco-adaptive fodder, mulching practices, crop mixtures, etc. Much more remains to be done.

The genetic wealth of the country is unique in several respects. We do not know where else wheat varieties that are suitable as fodder are available. The Consultative Group of International Agricultural Research Institutions has not contributed adequately towards building up dispersed, decentralized germplasm banks. The aid for this must be available as an investment in the global heritage and in the security of genes required in the future. Participatory research approaches do not necessarily require advanced degrees.

Forests

Core policies regarding the forests are embodied in the Forestry Act of 1969 and many other legislations such as the Land Act, the Pasture Grazing Policy, and other National Assembly Resolutions. The National Forestry Policy, 1974, rules that the country should have a minimum forest cover of 60 per cent. Remote-sensing surveys actually show that the country has 64 per cent of forest users. Forest cover and croplands are estimated to cover 8 per cent of the country. About 20 per cent of the country is designated as national parks and reserves, although there are no effective management strategies because of the ever-present constraints of resources and manpower. Bhutan has launched a wildlife and forest conservation programme from a much stronger basis.

The policy of the government is to afforest the degraded areas and harvest the forests close to the road heads on the basis of sustainable yield. A few companies that extract timber for raw materials are required to carry out planting at the same rate as felling. In view of the tendency of private companies to overexploit the forest resources, logging is monopolized by a public sector corporation (Bhutan Logging Corporation).

Debates in the National Assembly between conservationists and revenue maximizers have been quite intense. When foresters demand a further decrease in revenue extraction, the revenue maximizers consider it to be an excuse to mask their alleged inefficiency. On the other hand, the fact remains that timber extraction rates have been considerably slashed.

The conflicts between Western advice for conservation without people and the Bhutanese cultural ethos that holds conservation to be a way of life are becoming stronger. Bureaucratic barriers have seldom proved helpful in insulating natural resources from human greed. Indian and Nepalese experiences are quite instructive in this respect. With the best of technical skills, trained manpower, and coercive authority available with the State, degradation has continued to increase over time in these countries. If a culture can generate indigenous technologies and institutions capable of maintaining forests, water streams, biodiversity, and ecological balance for so long, why should it be found wanting now?

Some people consider the ban on the culling of livestock a rare case of an unsustainable feature of an otherwise sustainable Buddhist ethic. They miss the point altogether. Disease and death balanced, in nature's own way, the population sizes for a long time. However, improved health changed the growth rate. Yet, if consumption patterns and social institutions are not renewed, the imbalance becomes inevitable. The 'principles' and 'rules' must be distinguished. Non-culling is a principle. The sanctity of non-violence remains. The rule is concerned with limiting culling to the degree necessary for survival. There is a need for debate and discussion in monasteries and *dzong*, schools, and pastoral groups about the new rules required to uphold cherished and eternal principles.

CONCLUSIONS

The whole range of institutional norms and social values has regulated the behaviour of people regarding the use of renewable resources without compromising their long-term availability. To some extent, these norms and institutions evolved in recognition of (1) individual behaviour being subordinated to the community's welfare and (2) human beings having rights at par with other components of nature. The homeostasis inherent in the norms of one group was contingent upon respect for the boundaries of norms and institutions of another group. Thus, a very complex network of inter-institutional interactions guided conservation efforts.

A consumerist culture and commercial interests are indeed making sharp inroads into the traditional culture of conservation. Some of the ethnic groups, which compare themselves with other cultures in the plains, perhaps do not appreciate the need for restraint on wants. Questions have been asked about the ability of traditional institutions to withstand the pressure of increasing imbalance in certain parts of the environment. To us, the answer seems to be obvious. We believe that, if policies require careful study of the variability in institutional arrangements and ethical norms across different ecological regions, it should be possible to revitalize the technological and institutional basis of society.

The global concern for sustainable development and the conservation of biodiversity is dominated by the strategies and styles suitable for degraded environments. Since degradation of the environment inevitably is accompanied by the degradation of institutions, these policies presume upon the absence of institutions. Much greater reliance is placed on public interventions which in turn means bureaucratic interventions. In Bhutan's case, the government has already realized the need for limiting the size of the bureaucracy and decentralizing more and more, so that variability in the local socio-ecological systems has been taken into account while designing policies and programmes. However, the problem is one of taking awareness not to the grassroots but from the grassroots. A recent Convention on Environment, organized with the help of the UNDP, identified a long list of measures that were required to maintain environmental variability. However, this was within the context of degradation and consequent cautions. Relatively speaking, the strengths were given much less attention.

How much danger do forests and forest-based agriculture face from livestock? This has to be compared with the danger emanating from private, forest-based industries. While, in the case of other resources, there is some community control available, these industries lie outside the sphere of traditional, regulatory community institutions. It is believed that discouragement to otherwise profitable but extractive enterprises, in areas where they pose a danger to the environment, is necessary if efforts aimed at altering the micro-economic behaviour of small subsistence and deficit-budget farmers and pastoralists have to carry conviction.

The continued functioning and strength of institutions that protect the environment depend on how successfully the future citizens of the country are introduced to the heritage which generates respect for these institutions. The viability of these institutions depends upon the inculcation of these values into the children, especially in schools and urban areas. Environmental studies are now a part of the primary school syllabus in the so-called New Approach to Primary School. Among its many objectives are the understanding of 'the importance of forest and wildlife and appreciating the need for taking proper care of them' and the identification of 'various plants grown in their locality and their classification into food, cash and fodder crops'.

'Education' of the next generation has of course to be accompanied by 'unlearning' by the present generation. Certain paths of development are not sustainable. Administrations and policy makers in several countries are recognizing it belatedly. The need for correspondence between spatial, sectoral, seasonal, and social institutional vectors is slowly being realized.

Culture provides a 'grammar' while technology provides new 'words'. The meaning of a life that is ecologically sustainable and economically just can be discovered only through the blending of both.

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FARMER-MANAGED IRRIGATION SYSTEMS IN THE MOUNTAINS OF PAKISTAN

E.J. Vander Velde

Dr. Edward J. Vander Velde is associated with the International Irrigation Management Institute (IMMI), Pakistan.

Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.

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INTRODUCTION

The small irrigation schemes in the less developed regions, such as Baluchistan, Federally Administered Tribal Areas (FATA), Azad, Jammu and Kashmir (AJ&K), Kohistan, and the Northern Areas (NA) are as important as the integrated development of large irrigation systems in the settled areas of the Indus Basin (The Government of Pakistan [GOP], The Sixth Five-Year Plan).

This paper will focus upon irrigation management: a poorly understood and largely unstudied aspect of agriculture in Pakistan's mountain environments. Given the concentration of national agriculture in the Indus Basin, and the crucial importance of the enormous irrigation infrastructure that has been established to sustain agricultural production, it should not surprise us that most irrigation research in Pakistan has focussed upon the Indus Basin irrigation systems and their problems. After all, Pakistan's mountain environments are found to be peripheral to the 'heart' of the nation; they are not readily accessible and distances are great. Their population is sparse and dispersed as well as contemptuous of, if not hostile to, outside interventions. The cultivated areas are small relative to spatial extent and irrigation systems are decidedly small-scaled, often having more the appearance of meandering watercourses. Altogether, this is the sort of agricultural environment that has attracted comparatively few research professionals and even less research resources—scarcely any of which have focussed upon irrigation systems and their management.

Current signs would seem to indicate that part of the void of past neglect is rather rapidly being filled by ambitious development programmes. National and provincial agencies, supported by both indigenously and internationally mobilized resources, are actively initiating projects designed to establish and/or improve the agricultural infrastructure in the mountain environments of Baluchistan, the North West Frontier Province, the Northern Areas, the Federally Administered Tribal Areas, and Azad Kashmir. Some projects are irrigation development focussed, e.g., the Baluchistan Minor Irrigation Development Project, whereas others are multifaceted, but with a significant irrigation development component, e.g., the Chitral Area Development Project. In virtually all instances, however, detailed, reliable information about the performance of existing irrigation infrastructure, institutions, and irrigation management practices in these mountain environments is absent or seriously deficient.

A potentially undesirable consequence of this condition is that development interventions planned to improve the productivity and sustainability of irrigated agriculture in Pakistan's mountain environments may fail to achieve their objectives in any of several ways. For instance, new irrigation infrastructure may be established using inappropriate design criteria and, thus, fail to deliver water in sufficient amounts at desirable times for planned service areas or cropping patterns. Management requirements for new or rehabilitated systems may not match existing institutional capabilities or practices. Scarce resources may be poorly utilized or wasted as government agencies assume responsibilities for irrigation management, activities previously done by farmers and, perhaps, best done by farmers.

How best to proceed to examine the subject of farmer-managed irrigation systems in Pakistan's mountain environments? First, there will be a brief examination of the general state of our knowledge of mountain irrigation systems in Pakistan. This will be followed by a review of some recently completed research to identify the general characteristics of surface irrigation systems and their management in the mountains of Northern Pakistan as well as changes stimulated in them by recent interventions. Finally, we will conclude with some suggestions as to how continuing gaps in these environments might be expeditiously and effectively filled, in order to provide a more substantial base for development activities that seek to sustain the productivity of irrigated agriculture in Pakistan's mountainous periphery.

EXTENT OF MOUNTAIN IRRIGATION IN PAKISTAN

Small-scale irrigation systems dominate the developed irrigation potential in the mountainous environments of Pakistan, meeting the irrigation requirements of small farmers in the country's least developed and, heretofore, most isolated areas. In a real sense, they constitute the 'veins' whereby the greater productivity potential of irrigated agriculture is made available to the extremities of the national agricultural system. In addition to their comparatively small command or service areas, these systems commonly reflect characteristics that contrast sharply with those characterizing the large-scale irrigation systems of the Indus Plains. Typically, they are farmer-constructed, often have articulated forms of group ownership and management, and usually possess cooperative mechanisms for distributing water and minimizing conflicts.

In the rugged mountains of Pakistan's Himalaya-Karakoram-Hindu Kush, nearly all irrigation is done through *kuhls*, small, often lengthy channels usually constructed and maintained through the collective efforts of farmers and villagers. *Kuhls* carry water directed through a crude intake 'structure' from mountain streams fed by snowmelt, glacial melt, and/or springs for distribution through watercourses to clusters of small, often terraced fields, planted with food grains, vegetables, fodder, orchards, and trees. In basic physical appearance and characteristics, these *kuhl* systems differ little from thousands of others encountered throughout the Indian and Nepalese Himalaya.

As one moves southwest from the Karakoram-Hindu Kush along the mountain periphery of Western Pakistan into Chitral, the Tribal Areas, and the North West Frontier Province (NWFP), elevations decline; the terrain is interrupted by larger valleys drained by such rivers as the Swat, Kabul, and Kurram; and annual precipitation diminishes significantly. Changes in the physical environment and accessibility are mirrored in variations in irrigation development. Larger government-constructed canal systems, such as the Upper Swat Canal and the Warsak Canal, sustain the agricultural economies of the larger intermontane valleys. Smaller 'civil canals'—older systems, usually farmer-constructed and managed but now maintained by public agencies—are also found there and in other lesser valleys. The familiar *kuhl* systems are increasingly restricted to higher elevations and the upper ends of those favourably exposed tributary valleys where small perennial water sources are most likely to exist.

Further south into Baluchistan, the mountains of Pakistan's western borderlands—the Toba Karar, Sulaiman, and Brahui Ranges—continue to decline in elevation and conditions of greater aridity are encountered. Here, the indigenous *karez* systems of irrigation are found. Shafts are sunk in the alluvial fans, linked by galleries to form a tunnel that may tap a spring or, more commonly, collect subsoil water which is then delivered to fields at a lower elevation. Increasingly, tubewell development threatens the continued viability of many traditional *karez* systems here.

How extensive is the irrigated agricultural area in the mountains of Pakistan? Collectively, what is the command area of irrigation systems in this region? The answer to these questions would seem to be anyone's best estimate, considering the fact that formal surveys to assess the cropped, irrigated area or the command area of irrigation systems in this environment have never been done. Irrigation in Pakistan is dominated by the large canal systems prevalent in the Indus Basin, and readily available irrigation and irrigated agricultural statistics mirror this dominance. WAPDA's (Water and Power Development Authority) Irrigation Directories for the provinces give detailed service area data for the Indus Basin systems, but completely omit any reference to irrigation outside that region.[1] The most comprehensive review of irrigated agriculture in Pakistan in the past decade, the Revised Action Programme for Irrigated Agriculture, makes no mention whatsoever of irrigation systems or irrigated agriculture in Pakistan's mountain zones in either the main or supporting reports.[2] Regrettably, the recently published (1988) Report of the National Commission on Agriculture is equally silent on the subject.

The absence of reliable data on irrigated area, system type, and other relevant irrigation statistics for mountain agriculture in Pakistan virtually defines one priority research issue for this workshop, or namely, an accurate inventory survey of irrigation systems and their command areas in the mountain periphery of Pakistan. In the meantime, we must fall back upon the existing, partial data from a variety of sources, supplemented by the estimates of experienced observers, to gain some measure of insight into the extent of irrigated mountain agriculture in Pakistan. We must keep in mind, however, that our data are limited, occasionally contradictory, and subject to unknown error.

For example, in Gilgit District in the Northern Area, nearly 19,000 ha were classified as cultivated area by the 1980 Agricultural Census, virtually all of which can be assumed to be irrigated. More than 9,000 ha of irrigable area apparently has been added to this figure by the irrigation system development activities, covering 166 irrigation schemes supported by the Aga Khan Rural Support Programme (AKRSP) initiatives throughout 1987 (AKRSP 1987). Investigations recently carried out by WAPDA identified another 30 feasible irrigation schemes with the potential of adding a further 4,000 ha to the irrigable area in Gilgit (WAPDA 1988).

In Chitral District, more than 1,000 small, communally owned irrigation channels reportedly irrigate more than 18,000 ha and larger NWFP Irrigation Department Schemes command another 1,500 ha. The proposed irrigation development activities over the next 10 years, through the Chitral Area Development Project, target the addition of 11,000 ha

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1. See Mohammad Ashraf and Mohd. Asif Khan, *Irrigation Directory: Sind and Baluchistan (1978)*, *Irrigation Directory: NWFP (1981)*, and *Irrigation Directory: Punjab (1984)*. In the case of the NWFP, civil canals that have been linked into larger agency-managed canal systems and their command area are identified.
2. See WAPDA, *Revised Action Programme for Irrigated Agriculture* (1979), for extensive discussions and supporting documentation of Pakistan's water and resources management; irrigation programmes, policies, and projects; and programme recommendations in support of irrigated agriculture for the 1980s, all focussed upon the environment of the plains of the Indus Basin. The recent definitive study on irrigated agriculture in Pakistan by Nazir Ahmad and Ghulam R. Chaudhry contains numerous tables of data and statistics on irrigated systems and irrigated agriculture. However, not a single statistic pertains to irrigation in the mountain regions of Pakistan.

to this total (IFAD 1986). AKRSP is assisting 105 small-scale irrigation projects already underway and their completion will bring about 8,000 ha of cultivated land under irrigation command (AKRSP 1987).

In Baluchistan, the area irrigated by *karez* and springs is reported to be 58,800 ha and wells and tubewells command an additional 113,000 ha (Kahlown et al. 1988). At least 50 per cent of this total irrigated area lies within the mountain environment of the province. If the more than 30 small systems to be developed through Baluchistan Minor Irrigation Development Project in the mountainous districts of Zhob, Loralai, Quetta, and Khuzdar are implemented, over 15,000 ha of new irrigation command area will be created. The total area irrigated by private canals in the North West Frontier Province is reported to be 360,000 ha (GOP 1986a). Again, an assumption that 50 per cent of this area is in the mountain regions of the province would not be unrealistic.

Federally Administered Tribal Areas were reported to have slightly more than 62,000 ha irrigated in 1983, and the Sixth Plan targeted an increase in the irrigated area to nearly 101,000 by 1988 through small surface system and tubewell development (GOP 1986b). The irrigated area in Azad Kashmir was 10,000 ha in 1983, estimated at about 6 per cent of the cultivable area; several new irrigation schemes were to be developed through the Sixth Plan, adding perhaps 8,000 ha to the irrigation command area (GOP 1986b).

To sum up, we can tentatively conclude that the existing irrigated area in Pakistan's mountains is about 380,000 ha. This is probably an underestimation, insofar as we know that the area irrigated by small-scale, farmer-managed systems in other countries in the Himalayan zone is poorly demarcated and surveyed, and there is scant reason to assume a different condition for Pakistan. Irrigation development activities planned or already underway would seem likely to increase this total by at least 55,000 ha in the next few years. True, this extent is dwarfed by the nearly 15 million ha of area commanded by the Indus Basin systems; nevertheless, in absolute terms, the amount of irrigated area in Pakistan's mountain region is not a trifling sum.

MOUNTAIN IRRIGATION SYSTEMS IN NORTHERN PAKISTAN

The literature on mountain irrigation systems in Pakistan, their characteristics, performance, management, and problems, is not extensive. In terms of system 'types', available evidence suggests that small-scale surface irrigation systems, *kuhls* predominate, but in the larger intermontane valleys, large-scale public and private systems are more important. *Karez*, traditional wells, and 'hill torrent' systems are probably less numerous as well as more environmentally specific than *kuhl* systems. Modern tubewell systems, also highly localized, are rapidly growing in number. In the following discussion, the focus will be upon the *kuhl* systems common to the Himalayan-Karakoram environment of Northern Pakistan where a substantial programme of mountain irrigation development has been underway for more than six years.

Water and Agriculture in the Karakorum Mountains

The deep valleys cut by the Gilgit and Hunza rivers and their tributaries, as they drain the Karakorum Mountains, are the locus of permanent settlements in Gilgit District, in villages perched precariously on river terraces or the sides of alluvial fans often threatened by unstable talus just above. The climate is dry continental, characterized by a great range in average temperatures (45°C or more between January and July) and meagre annual precipitation averaging 145 mm/year in Karimabad and 132 mm/year in Gilgit. Moreover, annual variability anywhere in the world is high in regions that are largely in the rain-shadows of the greatest concentration of mountains in excess of 6,000 m. Only at higher altitudes (above 3,000 m), where more precipitation falls and is accumulated as snow, do annual amounts substantially exceed 500 mm.

Throughout Gilgit District—and elsewhere in the Northern Areas and Chitral District—agriculture depends upon irrigation water supplied through small, farmer-constructed, gravity-fed systems. Water in these irrigation systems is derived primarily from snow or glacial melt. Less frequently, they are fed by perennial springs, the scarcest but most reliable water source, or by small rivers.

Generally, glacier-fed irrigation channels show the least year-to-year variability in discharge. However, water from glacial melt often carries large quantities of suspended silt much of which is subsequently deposited in the farmers' fields as a mixed blessing. During the period of seed germination and seedling growth, there is the risk that seeds will become buried too deeply to achieve a satisfactory germination rate or that seedlings will become coated with silt, inhibiting normal metabolism (Saunders 1983). On the other hand, silt is often important in the soil-building process, especially for improving soil structure.

Although channels supplied by springs dependent upon winter-spring recharge reflect some discharge variability, perennial spring water has several advantages over other irrigation sources. It is free of silt, it does not experience great variability, and, as noted by Whiteman (1985), it may be 'up to 5°C warmer, and this has a significant advancing effect on spring growth' of crops. Springs, however, are a scarce source of irrigation water in the region.

The greatest flow variation is found in channels exclusively dependent upon snowmelt, the least reliable irrigation source. Farmers from snowmelt-dependent villages report a severe shortage of irrigation water once every four to five years and general problems of considerable year-to-year streamflow variability.

River-fed irrigation systems are also more vulnerable to annual variations in precipitation and are affected by seasonal fluctuations in river flow as well. A channel intake structure constructed to divert river water for irrigation during crop planting in March may be inundated or washed out when glacial melt subsequently increases river discharges in May-June. Later in the summer, the river diversion may have to be relocated further upstream to sustain irrigation supplies as river discharge diminishes.

Capturing water for irrigation is only part of the task of establishing and sustaining agriculture in Hunza-Gojal. Equally, perhaps even more arduous, is the concomitant and longer process of land development. In bringing land under the cultivation of principal crops for human and animal consumption—grains (wheat and barley), vegetables, potatoes, fruit trees (apricot and apple), fodder (alfalfa), and trees for fuel and fodder (poplar, willow, and Russian olive)—soils have been drastically modified.

In this region, irrigated crops are largely confined to three landform environments and their associated soils. In the valleys of the Hunza River and its tributaries, river terraces and alluvial fans have the greatest agricultural significance. The deeper and better developed soils found on old river terraces are more important than those on terraces of more recent origin. The lower portions of alluvial fans, formed by small streams and hill torrents, are more intensively cultivated than the upper areas, because of the small proportion of coarse soil materials found there. In either instance, better soils are commonly the locus of grain and vegetable crops as well as orchards. Poorer, less developed soils tend to be used for fodder crops and trees for fodder and fuel.

Cone-shaped scree slopes produced by mass wasting of the surrounding barren cliffs and hills below 2,100 m are another locus of irrigated agriculture. However, because of the inherent instability of these slopes, their agricultural development presents special problems and tends to be both more recent and slower. The upper portions where finer materials are concentrated are cultivated first, usually with slope-stabilizing trees and fodder crops.[3]

Village Irrigation Systems in Hunza-Gojal

Initial irrigation system development in Hunza was a highly localized activity, concentrated in locations where water from glacial and snowmelt sources was easily developed by small groups of farmers using locally available technology and resources. Later, traditional chiefs, such as the *Mirs* of Hunza, began to exercise their growing feudal authority to mobilize a larger population for the construction of new *kuhls* in more difficult locations, rehabilitation of older systems, and development of new land. Although a portion of the increased production resulting from enhanced and more reliable water supplies was extracted by a compulsory agricultural tax, the *Mirs* did initiate the irrigation development and modest settlement expansion where smaller, isolated group efforts could not. Following the arrival of the British-supported Dogra administration in Gilgit in the 1980s, a gradual decline in feudal authority began, accompanied by a reduction in the development of irrigation system. This trend continued after the independence of Pakistan until 1974 when the authority of the *Mirs* was formally abolished.[4]

Beginning in 1982, the AKRSP has had an active programme of rural, institutional, and physical development (subsequently expanded to include Baluchistan District, Chitral District, and the North West Frontier Province), which has renewed irrigation development activities in the region. In Gilgit District alone, 166 irrigation projects—improvements on older systems or development of new systems—have been initiated in villages through AKRSP-supported interventions.[5]

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[3] Seasonal agricultural activities also occur at higher elevations, but usually do not involve irrigation. Between 2,100 and 3,300 m, soils have developed in widely scattered locales from physical, chemical, and biological processes acting upon parent material. These locations support trees and grasses and serve as summer pastures for the animals of villages at lower elevations.

[4] Kreutzmann (1988:246–250) provides the best historial overview of the origins and development of irrigation systems in Hunza.

[5] The primary objective of the AKRSP is to facilitate the development of strong, broad-based village organizations that can continue to undertake a wide range of rural development activities on a permanent, locally sustainable basis. This objective is accomplished through a unique intervention strategy that encourages each village to identify and propose a single 'productive physical infrastructure' (PPI) project which will increase the incomes of most village households. Implementation is then funded by a grant from AKRSP.
Irrigation-focussed PPI projects have proven to be effective foci for the institutional development process. Because agriculture in Gilgit, Baluchistan, and Chitral depends almost entirely upon irrigation,

A recent survey of the Water and Power Development Authority in Gilgit District of 25 localities in the Gilgit River sub-basin and 34 localities in the Hunza-Hispar River sub-basin identified 221 *kuhls* supplying irrigation water to developed agricultural lands (WAPDA 1988).[6] So far, most *kuhls* have perennial flows, but seasonal discharge variations between low and high flows as great as 20 times were reported, reflecting that in more than 85 per cent of the surveyed localities, the water source for *kuhl* systems was a combination of snow or glacial melt and springs.

Kuhls identified in the survey varied greatly in channel length between source of water supply and command area, from a more typical 2 to 3 km to as much as 18 km in the case of *Parri kuhl*.[7] They also varied substantially in size. The discharge range between the smallest *kuhl* and the largest was 7 lps (0.25 cusec) to 425 lps (15 cusec), although more than one-half of the *kuhls* carried discharges between 7 lps and 28 lps (1 cusec).[8].

For systems in the 44 villages covered in the survey, it was possible to calculate the relationship of water supply per unit of cultivated area. In slightly less than one-half of these villages, *kuhl* systems delivered less than 0.75 lps per cultivated hectare (< 6.5 ha/mm/day), reaching as low as 0.13 lps/ha (1.1 ha/mm/day).[9] At such water supply levels, water is apparently scarce relative to land, and one would expect the system and field-level water management practices to reflect such conditions. For seven other villages, the systems supplied between 0.75 lps/ha and 1.25 lps/ha (10.8 ha/mm/day). In general, *kuhl* systems in Hunza-Hispar villages varied more widely in the Gilgit River sub-basin. Also, for roughly one-third of all the villages, *kuhl* systems apparently supply water in relatively abundant amounts. This suggests that in those locations, land suitable for agriculture is more scarce than water.

In 1987, a rapid field survey of irrigation systems was conducted in the upper Hunza River Basin, a part of Gilgit District known as Gojal. The survey was confined to seven villages—Soust, Gircha, Jamalabad, Morkhon, Ghalapan, Khaiber, and Passu—in Gojal.

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developing and sustaining irrigation systems in this difficult environment continues to require a high degree of organization and collective management. Irrigation systems more frequently meet the AKRSP's criterion of consensus support than any other potential infrastructural development and they comprise about 60% of projects assisted by the AKRSP in Gilgit, Chitral, and Baluchistan. The average cost to the AKRSP for small systems developed in Gilgit has been Rs 139,000 (about US$ 8,175) per project.

6 *Kuhls* also supply water for domestic uses, to meet livestock needs and to deliver water to small-scale hydropower units as well.

7 The total length of channel and all field ditches in these irrigation systems is easily a great deal more. For example, the Hopar community of five village settlements in the Hunza-Hispar River sub-basin is reported to have more than 300 km of irrigation channels supplying melt water to 440 ha (Butz 1987:7).

8 Data reported in the WAPDA survey must be approached with considerable caution, although they may still reasonably reflect the range of irrigation system conditions in Gilgit District. Cultivated area data for villages were taken from tehsil records—a sometimes unreliable source. Unfortunately, it is not known whether or not reported *kuhl* discharge data were based upon actual measurements, and, if it was, where in the system measurements were made. Nor is it possible to be confident that these data are consistently related to either minimum flow or maximum flow conditions. In the discussion that follows, minimum flow condition was assumed to be the case in calculating relationships of water supply to cultivated area which were otherwise unknown

9 By way of perspective, in the Lower Chenab Canal System of the Rechna Doab, Punjab, the sanctioned allocation of irrigation supplies ranges from 0.26 to 0.35 lps/ha, for a water deficit designed system. These figures have been doubled or trebled by supplies from public tubewells in fresh groundwater areas.

Results of this survey provide a more detailed insight into some of the characteristics of *kuhl* systems in Gilgit (Vander Velde and Husain 1988).[10] A total of 25 irrigation channels was identified in these villages, of which 20 predate AKRSP's activities (Table 24.1).[11] Between 1983 and 1987, AKRSP-initiated village organisations (VOs) in these villages completed seven irrigation projects—five new *kuhls* and two improved *kuhls*—adding more than 500 ha of potential agricultural land which will approximately double the previously irrigable area once the time-consuming process of new land development is completed.

Table 24.1. Survey villages, irrigation channels, and water sources

Command area	Channel	Source
Soust [60 hslds]		
Soust (old)		
	1. Aziz Baig's	
	2. Main	Soust *Nullah*
Nazimabad (old)	3. Upper	Glacier + Snowmelt
	4. Main	
Soust (new)	5. New	
Gircha [27 hslds]		Sarteez *Nullah*
Sarteez (old)	6. Sarteez	Snowmelt + Spring
Lower Gircha (imp)	7. Main	Spring
Morkhon [45 hslds]		
Morkhon (old)	8–10. Three left banks	Morkhon *Nullah*
Morkhon (new)	11. High left bank	Glacier, snowmelt
Morkhon (old)	12–13. Two right banks	+ Spring & flow from
		7 small *Nullahs*
Ghalapan [10 hslds]		
Ghalapan (old)	15. Jurjurkhon *Nullah*	Snowmelt
Ghalapan (new)	16. Vundergar *Nullah*	Snowmelt (more)
Khaiber [55 hslds]	Khaiber *Nullah*	
Khaiber (old)	17. Lower	Spring
	18. Upper	Glacier + snowmelt
Imamabad (old)	19. Main	Glacier + snowmelt
	20. Small	Snowmelt + spring
		(less)
Khaiber (new)	21. New	Hunza River
Passu [67 hslds]		
Passu (old)	22. Main	Passu glacier
	23. Nobod	Glacier + snowmelt
	24. Yashvandan	
Passu (new)	25. Batura Glacier	

[10] The objective of this survey was to learn more about adaptations, institutional changes, and technical innovations in irrigation management practices in the Gilgit *kuhl* system as a process of managing the expansion of irrigation capacity and realizing its benefits and proceeds. Developments here may have potential for wider dissemination and adoption in other *kuhl* systems elsewhere in the mountains of Northern Pakistan.

[11] Of the 20 older systems, at least five *kuhls* were initiated by the former *Mirs* during the last 100 years. Those developments made possible the settlement of about one-third of the total number of households now resident in the villages under study, on the land thereby supplied with irrigation.

Channel Construction

Successful irrigation channel construction in Hunza now involves a combination of local wisdom (knowledge derived from generations of experience) and contemporary engineering technology. Alone, neither the source of knowledge nor skill is any longer sufficient to guarantee success. Instead, the failure to utilize both frequently leads to the construction of poorly performing or failed systems, typically after an expenditure of substantial and scarce resources. The traditional method of determining the slope of a channel was the use of water as a level. Beginning from the source, water flowed along the channel as it was dug on a carefully estimated but unsurveyed line, with the objective of achieving the desired command. The approach 'worked' as long as the scheme was physically possible. Thus, village elders were commonly consulted for advice on past glacial movements, avalanche and mudflow paths, and streamflows from glacial and snowmelt or springs. However, if an impassable outcrop was encountered during construction, or the velocity of water flow dropped so low that command was lost (conditions often discovered only after kilometres of channel had been constructed), the project had to be redesigned or abandoned (Hudson 1983).[12]

Alone, modern engineering science frequently has produced scarcely better results. In the mountainous environment of the Northern Areas, where physical conditions vary greatly within short distances, or from one season to another, the failure of engineering surveys and irrigation designs to draw upon detailed local knowledge greatly increases the probability of failure. The high proportion of unsuccessful irrigation channels in Gilgit District, designed and constructed by the Northern Areas' Public Works Department since 1974, without local consultation or participation, substantiates this conclusion.[13]

In its intervention strategy of assistance to develop farmer-managed irrigation systems, AKRSP purposely links local knowledge with modern engineering skills in the planning, design, and construction of new *kuhls*. Joint surveys of new systems or improved systems sites are done by engineers and knowledgeable farmers from the village and may involve several field visits. During channel construction, frequent consultation continues between farmers and AKRSP engineers to solve unanticipated problems. This collaborative approach has resulted in the successful implementation of several irrigation projects in Gilgit District, previously thought too difficult to implement. Two such projects have been constructed in the surveyed villages of Passu and Soust.[14]

Managing Water Distribution

Warabandi, the practice of irrigation turns, taken according to an established roster, is used in Gojal systems, as it is elsewhere in Gilgit District, to equitably allocate water and ensure irrigation turns during periods of water scarcity in the irrigation system, notably between March and May. When the period of water scarcity is over, or where water

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12 For example, Passu villagers reported seven earlier failed attempts at channel construction using such techniques to tap the Batura Glacier melt.

13 Of the 20 schemes undertaken by the Northern Areas PWD, at an average cost of Rs 1.85 million, only one is reportedly still functioning (Hussein et al. 1986:3).

14 Out of the 166 AKRSP-assisted irrigation projects implemented to date in Gilgit District, only one channel is identified as a complete failure.

scarcity is not a problem (e.g., in the older irrigation systems in Passu), water distribution generally follows a relatively informal system of irrigation turns as and when needed. Field observations confirm that the *warabandi* generally remains a durable, not easily changed, irrigation management practice in Gilgit.

Under the *warabandi* system, each household in the *kuhl* command takes its irrigation turn on a specific day, at a specified and equal period of time.[15] Between farmers whose turns are closely proximate to one another, there may be frequent, informal trading or exchange of turns. Generally, food crops are given first priority in water use, followed in order by fodder crops such as alfalfa, and finally by trees. Thus, where night irrigation is practised, it is usually for trees (food and fodder crops are commonly irrigated during the daylight hours). Among food crops, vegetables typically take priority over food grains, even to the point where an operating *warabandi* can be interrupted out of turn should a farmer plead the necessity of water for a vegetable plot.[16]

Managing Channel Maintenance

Maintenance of irrigation systems reflects their common property origins and a continuing collective management basis. Traditionally, the general principle followed for maintenance of the common portion of the irrigation channel was an annual contribution from all farmers served, in the form of labour or produce. The principle continues to be applied, albeit nowadays a farmer may also contribute cash instead of labour or produce. Normally, spring is the time for general annual maintenance, before the first irrigation for the new crop year and when water flows are low or non-existent. On channels where silt loads are heavy, all the farmers may also participate in a one- or two-day mid-season desilting operation. Maintenance of lateral or field channels not common to the system is the responsibility of individual farmers.

Some villages employ a *chowkidar* or watchman during the irrigation season to patrol the common portion of the channel to adjust and clear debris from the channel intake, plug leaks, repair small breaches, and otherwise monitor water supply conditions.[17] In sys-

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15 For example, in the *warabandi* for the command area of the old Soust *kuhl*, 24 households are divided into two equal groups. One group irrigated between 06:00 and 12:00 hrs, the other from noon to 18:00 hrs. On Nazimabad *kuhl* a four-day rotation is followed with nine households irrigating during each 24-hour period; two groups of four or five farmers each irrigated cereal and vegetable crops daily, one in the morning and the other in the afternoon. The orchards and fodder/fuel trees of each group are irrigated at night. Irrigation turns are longer here because landholdings are somewhat larger on Nazimabad *kuhl* and soils newer and relatively less well formed. The *warabandi* is in force throughout the entire season. All 60 Soust and Nazimabad households have land in two locations in the command of the new Soust *kuhl* which is allocated water on alternate days. On each day, 30 households in one location get their irrigation turn, one-half in the morning and the other half in the afternoon. Thus, in a four-day period, all holdings can be irrigated.

16 (Hussain Wali Khan, personal communication, November, 1987). Interestingly, vegetable plots traditionally are the active focus of cultivation and irrigation for women who otherwise do not share in the common management of irrigation water in Hunza-Gojal.

17 In such cases, the entire water user community on a channel will employ the *chowkidar* with each household making an equal contribution to salary, usually on a seasonal basis. Payment is typically in kind, a combination of foodgrains (wheat) and fodder. At 1987 market prices, the value of such payments ranged from Rs 900 to Rs 1400 per season.

tems where *chowkidars* are not employed, farmers will take regular turns patrolling and maintaining the common channel, usually at the time of their irrigation turn. Whenever a major breach or other maintenance emergency occurs, all the farmers on the channel will participate in its repair.

The rationale for the presence or absence of a *chowkidar* during the irrigation season is somewhat uncertain. There are several possible explanations for the practice, e.g., channel length, the amount of silt load in the channel, and whether or not night irrigation is done. An examination of these conditions for the surveyed systems (Table 24.2) suggests that channel length is the most common variable in the use of *chowkidars*. Insofar as channel length reflects both the quantitative nature of the likely maintenance requirement and the cost of walking to the head to regulate the discharge at various times during the day as well, this is not surprising.[18] For new *kuhl* systems, whether or not there previously was a *chowkidar* in the village also appears to be significant. Conditions of other systems seem to be somewhat less important.

Table 24.2. Variables in the presence or absence of *chowkidar* for irrigation channel maintenance

Irrigation command	*Chowkidar* present	Lengthy channel	Irrigation at night	Significant silt load
Soust (old)	Yes	No	No	Yes
Nazimabad	Yes	Yes	Yes	Yes
Soust (new)	Planned	Yes	No	Yes
Sarteez	No	No	Yes	No
Lower Gircha	No	No	?	No
Morkhon (old)	No	No	No	No
Morkhon (new)	No	Yes	No	No
Jamalabad	Yes	Yes	Yes	No
Ghalapan (old)	No	No	No	No
Ghalapan (new)	Planned	Yes	?	No
Khaiber (old)	Yes	Yes	No	No
Imamabad	Yes	Yes	No	No
Khaiber (new)	Yes	Yes	No	No
Passu (old)	No	No	No	Yes
Passu (new)	No	Yes	No	Yes

Other Physical Infrastructures

The physical infrastructures of other systems are generally straightforward and not elaborate. Sets of flat(ish) stones are often used as channel and field ditch-drop structures. Rudimentary, but functional, turn-outs generally are constructed from selected rocks; occasionally carefully fitted wooden turn-out gates or small pine outlets are encountered along channels. Sedimentation tanks or stilling basins have been built at the head of

[18] A weir at the head of a *kuhl* system usually requires modification when the melting rate of snow or glacier increases the discharge at the source (early afternoon) or when the irrigation demand is minimal (after sunset).

the main channels in *kuhl* systems in Soust and Passu to reduce heavy silt loads carried by the glacial-origin water. The tanks on Soust *kuhl* are meant to trap rock debris carried in the glacial melt as well, and they must be desilted from time to time during the irrigation season—a task done collectively by the irrigation community. Several farmers in Soust have dug shallow stills close to their fields. Here, removed silts are mixed with animal manure and spread on the fields to improve both soil structure and fertility.

In two older *kuhl* systems in Soust and Nazimabad, overnight storage tanks have been built. These permit the augmentation of channel flows during day-time irrigation. However, such infrastructure is not as widespread among Hunza *kuhls* as might be anticipated, perhaps because inexpensive construction of tanks that will not leak, and at the same time will be of sufficient size for irrigation water, is difficult (Hudson 1983).[19]

CHANGE IN MOUNTAIN IRRIGATION SYSTEMS

After a generation or more of comparative quiescence, the 1980s have heralded a period of renewed activity and change for farmer-managed irrigation systems in Northern Pakistan, primarily in response to the AKRSP's rural development programme. Although there is evidence from systems surveyed in Hunza-Gojal of the continued vitality of proven ways to solve problems, and of carefully adjusting new systems to fit environmental conditions, it is also clear that there has been both institutional innovation and considerable farmer-initiated experimentation to modify the previous irrigation management practices or techniques. In the following discussion, a few examples that substantiate these observations will be described.

Innovation in System Design Parameters

From the perspective of agency intervention in, and technical assistance to, small-scale mountain irrigation systems in Pakistan, the AKRSP's success in using a strongly participatory strategy that draws upon local knowledge and experience is possibly the innovation with the greatest long-run significance. The design criteria for irrigation channels assisted by AKRSP illustrates the value of such an approach. Following a survey and measurement of bed slope and conditions in older farmer-managed *kuhl* systems in Gilgit District, empirically based parameters were adopted and used as basic design criteria for new systems (AKRSP 1987).[20] The stimulus for this change, at least in part, was the visible evidence of the failure of previous government-constructed irrigation systems in the Northern Areas where engineers had used textbook standards that were more appropriate to environments outside this region. The general farmers' satisfaction with and apparent absence of failure in AKRSP-assisted systems is firm evidence that studying existing *kuhl* systems and skillfully drawing upon farmers' past irrigation experiences

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[19] Night irrigation, of course, is the commonly practised alternative to overnight storage during periods of water scarcity.

[20] To obtain a discharge of about 28 lps per 40 ha of command area, a bed slope of 1:300–400 was found to be appropriate.

are valuable complements to modern engineering science in developing new mountain irrigation systems.

Adjusting New Systems

Along with the substantial increase in command area created by renewed *kuhl* development, considerable attention has been focussed upon the process of bringing new land into actual production. Some observers have thought the process inefficient and perhaps too slow (World Bank 1987). The new system in Passu illustrates the situation. A *kuhl* completed in 1985 commands at least 273 ha, an area sufficient to increase fivefold the average landholding in Passu. However, more than three years after channel construction, less than 10 per cent of the command was actually developed. Northern Area farmers know from experience that, regardless of how well-designed and constructed a new irrigation system is, it will not immediately fit its environment. An initial period of adjustment is commonly required and farmers in the new system at Passu are engaged in that process. Since the construction of the new *kuhl*, they have relocated the intake to compensate for glacial retreat and to improve the bed slope condition in the upper reach of the channel; because of substantial leakage, which affected the Karakoram Highway, a 100 m reach of new channel had to be lined with cement and stone. Lastly, the new channel required stabilizing or 'hardening', a process encountered elsewhere in new systems in Hunza-Gojal.

Each year, as silt from glacial melt fills soil interstices along a longer reach of the bottom and sides of the main channel, discharge at the system head is gradually increased. Stabilizing or hardening the *kuhl* in this way reduces the likely occurrence of major breaches that would be difficult and costly to repair.[21] Clearly, new land cannot be brought under irrigated agriculture ahead of adequate water supplies, and Passu farmers estimate that it will be another four or five years before they can confidently operate their new system at full supply levels.

Irrigation Specialists

The *chowkidar* is a traditional and familiar figure in *kuhl* irrigation systems in Northern Pakistan. Over time, a *chowkidar* develops a highly detailed knowledge of the irrigation system in which he works. He is accountable to the farmers and they willingly pay him because he provides economies of specialization for an essential service. However, should he fail in his duties, they also are likely to replace him quickly. In three Gojal villages—Soust, Morkhon, and Passu—land not immediately adjacent to the already developed command area is supplied water through lengthy new channels. Rather surprisingly, none of these villages yet has a *chowkidar* for its channels, although farmers on the Soust *kuhl* say they plan to hire a *chowkidar*. Older systems in Morkhon or Passu do not have *chowkidars*, thus their absence on the new *kuhls* may be related to this fact.

On the new channel in Khaiber, however, a variation of the *chowkidar* system has emerged in conjunction with another innovation: the VO's decision to collectively develop

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21 Another element in the process of hardening a channel is the planting of saplings of fast-growing willow and poplar along the embankments to establish reinforcing root systems.

the command area for at least the first five years of operation. The new Khaiber *kuhl* commands land located 2 to 3 km from the village. Because new land remains in collective ownership, there are no specific individual responsibilities for irrigation, and this situation required Khaiber farmers to devise a new approach to manage irrigation of the new land. Of the two obvious possible solutions, namely, irrigation done by small groups of farmers on a rotational basis or a modification in the traditional patrolling and maintenance responsibilities of hired *chowkidars*, Khaiber farmers chose the latter. At a monthly salary somewhat equal to the local wage labour rate, three men were hired for the four-month agricultural season to do daily field irrigation activities in the new command area. These 'specialist *chowkidars*' also continue to perform other tasks traditionally associated with them.

Changes in Water Allocation

It was noted earlier that *warabandi* is one of the most durable water management techniques in farmer-managed irrigation systems in Gilgit. Although in its details the *warabandi* often varies from system to system and is poorly understood, it also can be rather flexible. Both characteristics are revealed in the *warabandi* adopted for the new Soust *kuhl*. Here, within the same time of the channel's operation, a different water allocation procedure is followed for the smaller, terraced fields of fruit trees and intercropped fodder on steep slopes than for the larger, more level fields below planted with annual grains, although both are irrigated simultaneously! In allocating water for the command area of the new Soust *kuhl*, there also was an unusual revision in water rights of the two older systems in Soust and Nazimabad. Formerly, in periods of water scarcity, these two *kuhls* received water on alternate days; now, when water is scarce, each command area receives its turn every third day.

Field-level Water Management Experimentation

In general, and in contrast to land-use patterns in older, irrigated areas, most of the developed land commanded by new *kuhl* systems in Gojal has been planted with trees and fodder. This situation undoubtedly reflects the present physiologic environment of many newly commanded areas (e.g., steep slopes or newer river terraces) that have poor soil structure with high infiltration rates and low fertility, the conditions of which can only be changed rather slowly. Plantation of fuel trees, fodder crops, and orchards on the scale now underway is also an unusual phenomenon in Hunza-Gojal, and there is interesting evidence of farmer innovation and experimentation on field-level water management practices that fit the current conditions better.

In Morkhon and Jamalabad, farmers have adopted a different technique for the irrigated cultivation of crops planted on the scree slopes in the new *kuhl* command. Instead of constructing the usual and costly stone-walled terraces and using basin irrigation practices, they constructed field ditches along the contour to deliver irrigation water to trees and alfalfa planted on shallow reverse slope terraces. This appears to be an adaptation of the furrow irrigation practices already used for potato cultivation on less steeply sloping fields. In several locations in the command area of the new Soust *kuhl*, another modification of furrow irrigation is evident on steep slopes. There, in a few individual holdings, field irrigation ditches have been made as a series of linked S's down slope, and small drops have been fabricated from stone and polyethylene to reduce soil erosion as water is carried from one terrace level to the next one below.

CONCLUSIONS

To the casual observer or non-specialist, the foregoing discussion may appear to have focussed unduly upon modest developments. However, it is clear that the changes described therein reflect the significant initiative and willingness on the part of farmers in this mountain region to improve or fine tune their use-efficiency as well as management of scarce water and land resources. It also demonstrates the resilience and flexibility of some traditional institutions in adapting to an environment of rapid social and economic change. This leads us to one important, initial conclusion, perhaps even a principle: the existing irrigation systems and farmers who managed them are a critical resource to be used in any effort to develop irrigation potential in Pakistan's mountain environments.[22] The AKRSP's programme in the Northern Areas already has demonstrated the utility of grasping this point. Unfortunately, in the case of Pakistan's formal irrigation bureaucracy, one can not be confident that it is yet even perceived, much less understood and heeded.

On the other hand, it is clear that many gaps remain in our knowledge and understanding of small-scale surface irrigation systems in Northern Pakistan. For example, although recently several surveys have been made of irrigation systems in Gilgit District, there continues to be an absence of systematic information about how well the older *kuhl* systems perform, either physically or institutionally, in sustaining productive irrigated agriculture.[23] The inference is that these systems perform reasonably well within their environmental contexts, but that does not leave us with much insight as to their potential for sustaining more productive irrigated agriculture. Nor do we know anything about how long it may take before such a system begins to perform reasonably well—a matter of considerable importance in the context of new system development activities in Northern Pakistan.[24]

In general, we can conclude that there are three priority needs that must be filled in the near future if successful irrigation development strategies that fit the mountain ecosystems of Pakistan are to be designed and implemented.[25] One of these was alluded to much earlier in this paper, namely, an inventory of mountain irrigation systems that would provide reliable information on system type and service area. Rapid appraisal

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[22] Rapid appraisal methodologies adapted to gathering such information for irrigation systems are readily available and already tested in mountain environments (e.g., see Yoder and Martin 1985).

[23] The recent thesis study by Butz (1987), judging from an abstract, may very well have begun to fill this gap for Gilgit systems. Unfortunately, it is unpublished as yet and copies are not easily available in Pakistan.

[24] In collaboration with the AKRSP, The International Irrigation Management Institute (IIMI), Pakistan, will begin a research project designed to measure the performance of farmer-managed irrigation systems in Hunza-Gojal in March, 1989. Both the old and the new systems will be selected for a comparative study of their irrigation efficiencies.

[25] I have drawn here considerably upon a thoughtful general overview of research issues in farmer-managed irrigation systems in Martin, Yoder, and Groenfeldt (1986) and on a recent working paper by Coward, Johnson, and Walter (1988) that focussed upon ways to improve government policies and programmes for small-scale irrigation systems in Asia.

reconnaissance studies, combined with careful interpretation of aerial photographs and, perhaps, remote sensing imagery analysis, provide a ready and fairly rapid means of filling this knowledge gap.

The second need is for a modest set of studies that would systematically examine how farmers manage their irrigation systems in different mountain environments in Pakistan. Some of the studies should be comparative examinations of each type of irrigation system, focussing upon three sets of management activities, those for water (e.g., allocation, distribution), those for physical structures (e.g., design, construction, maintenance), and those for organization (e.g., resource mobilization, communication, conflict management). Of course, there is interaction between these sets of activities and the processes for those interactions need to be clarified as well.

Finally, there is a need for a more intense body of knowledge on how well irrigation systems are managed in the mountains of Pakistan. Research that ascertains system performance and system constraints is needed if we are to accurately identify potential foci for improvement. These studies of different mountain systems should include measurements of water flows, determination of irrigation efficiencies, assessments of crop yields, and evaluation of institutional arrangements. Such studies will demand a set of multidisciplinary competencies in both research design and implementation that, in itself, will break new ground in irrigation management research in Pakistan.

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