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MOUNTAIN AGRICULTURE: THE SEARCH FOR SUSTAINABILITY

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INTRODUCTION

An operational meaning of sustainability, as inferred from definitions or descriptions provided by ecologists, environmentalists, economists, and futurologists of different genre (Myers, 1986; Tisdell, 1987; Chambers, 1987; Ruttan, 1988; Lynam and Herdt, 1988; Food 2,000, 1987), and which becomes clearer when related to specific situations, could be stated as follows: Sustainability is the ability of a system (or subsystem) to maintain a well-defined level of performance (output, etc.) over time, and to enhance the same if required. Because of both the involvement of the time factor and the system's responsiveness to changing requirements, sustainability is a dynamic (as against static) phenomenon.

In the more concrete context of mountain agriculture, this "dynamism" translates into the capacities of production factors, mainly bio-physical resources, to respond to changing requirements without damaging what Tisdell (1987) calls the essential ecological integrity of the system. The socioeconomic factors (including man-made institutional and technological developments) contribute to sustainability or unsustainability, largely through influencing and changing the use patterns of the system's natural resource base. Moreover, due to conditions such as inaccessibility, fragility, and marginality, which characterize mountain regions, the sustainability of use patterns and production flows is inseparable from the sustainability of the resource base itself. The health of the resource base and its long-term productivity are affected by how and for what purposes it is utilized. In essence, then, sustainability/unsustainability is the outcome of an interaction between the characteristics of the resource base and the pattern and methods of its utilization. Given its inherent characteristics, the resource base of a system (e.g., mountain agriculture), suits only some uses. Any other usage systems (unless the resource base itself is modified) cannot be productively maintained on it, without either a high degree of artificial support (e.g., subsidy) or damage to the inherent capacities of the resource base itself. In either case, inappropriate use of the resource base is a definite step toward long-term unsustainability. This problem is more serious in regions with relatively fragile and marginal resources, such as mountains and deserts. In

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such habitats unsustainability scenarios emerge more quickly and in a more pronounced manner. In the natural state of things in mountains, the range of options ensuring a proper match between resource specificities and resource use has been very narrow. However, through efforts over the generations, the people have widened the range of such options. The features of traditional farming systems in mountain regions will corroborate this (Forman, 1988; Whiteman, 1988). But these options, having been evolved in the context of low-pressure demand on mountain resources, are becoming increasingly unfeasible or ineffective in the changed context of new pressures generated by population growth, market forces, and public interventions in mountain areas (Rieger, 1981). The consequent measures adopted to meet the situation, such as the extension of cultivation to more fragile hill slopes, or the push toward monoculture induced by promotion of selected HYV crops, or the deforestation of hillsides to collect revenue, etc., often fail to match well with the constraints and potential of the mountain resources (Sanwal, 1989). The not very unexpected result is the emergence of unsustainability scenarios. In such situations reestablishment of a "match" between resource characteristics and their use pattern is an important step for enhancing the sustainability of mountain resources and activities, including agriculture, based on them.

Approaching Sustainability through Unsustainability

At a conceptual level, the above reasoning implies a change in perspective on the sustainability question. Accordingly, to identify and operationalize the components of sustainability in a given system, one needs to examine the unsustainability phenomenon first, and then proceed backward to understand factors and processes contributing to it. This can help to identify practical measures which will reverse the process of unsustainability. A practical first step in the above approach is to prepare an inventory of indicators of unsustainability of a system, and then look into the "why and how" behind them. This approach has some merits. It can help to better operationalize the issues involved in the sustainability debate and more easily relate the involved issues to the land itself where causes and consequences of unsustainability are felt. It can also help identify concrete steps to modify current approaches to development and to the resource use systems. The steps may relate to macro- and micro-level policies and programs as well as to farm-level decisions and actions. The above approach forms the basis of current work on farming systems at the International Center for Integrated Mountain Development (ICIMOD). It is focused on the identification of sustainability elements for incorporation into strategies for agricultural development in the Hindu Kush-Himalaya (HK-H) region in

Nepal. This paper reports some dimensions of the framework developed for the above purpose. The following discussion first identifies indicators of unsustainability found in mountain areas. This is followed by a description of "mountain specificities," or the specific characteristics of mountain environments, disregard of which at different agency levels is primarily responsible for emerging unsustainability scenarios in mountains. Finally, we argue that sensitization of development interventions to mountain specificities can help reverse the unsustainability trends. The rationale behind people's traditional adaptations to mountain specificities can serve as a guide toward this end.

In the following discussion, though, our focus is on mountain agriculture, frequent reference to general development problems of mountain areas is unavoidable.

MOUNTAIN REGIONS: THE DOMINANT SCENARIO

The dominant scenario characterizing most of the mountain regions in the developing countries, particularly in the HK-H region, is the widening gap between development efforts (indicated by investment and public interventions) and corresponding achievements in terms of measurable economic gains and qualitative changes such as the health and production potential of the natural resources base, environmental consequences, etc.

Even in the relatively short period of the last 40 to 50 years, several alarming trends have emerged. There are, in this region, clearly visible and persistent negative changes in crop yields, availability of mountain products, economic well-being of the mountain people, and the overall condition of the environment and natural resources (Rieger, 1981). For instance, as compared to the situation, say, 50 years ago, at present the extent and severity of landslides are higher; the water flows in traditional community irrigation systems are lower, the yield of major crops in the mountain areas (except in highly patronized pockets) is lower; the diversity of mountain agriculture is reduced; the inter-seasonal hunger gap (food deficit period) is longer; the time spent by villagers for collection of fodder and fuel from neighboring uncultivated areas or common property lands is longer; the botanical composition of species in forests and pastures has changed for the worse; and, finally, poverty, unemployment, and out-migration of people from hills is higher. Ives and Messerli (1989) have pointed out some of these trends in the Himalayan context, and, as a part of the studies on sustainable mountain agriculture under the farming systems program at ICIMOD, work is in progress to prepare an inventory of such measurable, verifiable, or objectively

assessable changes, initially for mountain areas of Nepal, India, Pakistan, and China. The methodological details for information gathering, such as benchmark period to see change (e.g., number of years/decades, etc.); unit of observation (e.g., a mountain valley, a cluster of villages, farm, plot, etc.); unit of measurement (e.g., frequency of landslides, crop yield per hectare, time spent and distance covered for fodder and fuel collection, duration of seasonal migration, etc.); relevant sources of information (e.g., records, material from air photographic surveys, oral history, etc.), do vary according to the nature of indicator chosen and the required degree of precision in information. The information is subjected to a number of cross-checks, to establish that it represents only negative change. These persistent negative changes are considered as indicators of unsustainability. Study of the factors and processes contributing to them is considered a first step in the search for measures to reverse the above trends. Inquiring into these factors and processes can also help in the identification of relevant elements for use as policy and program variables in sustainable development of mountain agriculture and mountain areas in general.

Indicators of Unsustainability

The negative changes treated as indicators of unsustainability may relate to (1) resource base (e.g., land degradation, (2) production flows (e.g., persistent decline in crop yields), and (3) resource management/usage systems (e.g., increased unfeasibility of annual-perennial intercropping or specific crop rotation). More importantly, for operational and analytical purposes, the indicators can be grouped in the following three categories on the basis of their actual or potential visibility. Table 1 illustrates them.

1. **Directly visible negative changes:** These include increased extent of landslides or mudslides, drying of traditional irrigation channels (*kools*), increased idle period of grinding mills or sawmills operated through natural water flows, prolonged fall in yields of mountain crops, reduced diversity of mountain agriculture, abandoning of traditionally productive hill terraces, increased extent of seasonal out-migration of hill people, etc.

2. **Negative changes made invisible:** People's adjustments to negative changes often tend to hide these changes. Included are substitution of shallow-rooted crops for deep-rooted crops following erosion of topsoil on mountain slopes; substitution of cattle by small ruminants due to permanent degradation or reduced carrying capacity of grazing lands; introduction of a public food-distribution system due to an increased inter-season hunger gap (local food production deficits); leasing of land by small farmers who must concentrate on wage earning, etc.

Table 1. CLASSIFICATION OF NEGATIVE CHANGES AS INDICATORS OF UNSUSTAINABILITY OF MOUNTAIN AGRICULTURE

Visibility of change	Changes related to:[1] Resource base	Production flows	Resource use/management practices
Directly visible changes	Increased landslides and other forms of land degradation; abandoned terraces; per capita reduced availability and fragmentation of land; changed botanical composition of forest/pasture; reduced water-flows for irrigation, domestic uses, and grinding mills.	Prolonged negative trend in yields of crop, livestock, etc.; increased input need per unit production; increased time and distance involved in food, fodder, fuel gathering; reduced capacity and period of grinding/saw mills operated on water flow; lower per capita availability of agricultural products, etc.	Reduced extent of fallowing, crop rotation, intercropping, diversified resource-management practices; extension of plow to submarginal lands; replacement of social sanctions for resource use by legal measures; unbalanced and high intensity of input use etc.
Changes concealed by responses to changes	Substitution for cattle by sheep/goats; deep-rooted crops by shallow-rooted ones; shift to non-local inputs; substitution for water flow by fossil fuel for grinding mills; manure by chemical fertilizers.[2]	Increased seasonal migration; introduction of externally supported public distribution systems (food, inputs);[2] intensive cash cropping on limited areas.[2]	Shifts in cropping pattern and composition of livestock; reduced diversity, increased specialization in monocropping; promotion of policies/programs with successful record outside, without evaluation.[2]
Development initiatives, etc. — potentially negative changes[3]	New systems without linkages to other diversified activities; generating excessive dependence on outside resources (fertilizer/pesticide-based technologies); ignoring traditional adaptation experiences (new irrigation structure)	Agricultural measures directed to short-term results; primarily product- versus resource-centered approaches to agricultural development, etc.	Indifference of programs and policies to mountain specificities, focus on short-term gains, high centralization, excessive, crucial dependence on external advice ignoring folk wisdom.

[1] Most of the changes are interrelated and they could fit into more than one block.

[2] Since a number of changes could be for reasons other than unsustainability, a fuller understanding of the underlying circumstances of a change will be necessary.

[3] Changes under this category differ from the ones under the above two categories, in the sense that they are yet to take place, and their potential emergence could be understood by examining the involved resource-use practices in relation to specific mountain characteristics.

3. **Development initiatives with potentially negative consequences:** A number of measures are adopted for meeting present or perceived future shortages of products at current or increased levels of demand. Some of the measures (changes), while enhancing productivity of agriculture in the short run, might jeopardize the ability of the system to meet the increasing demands in the long run. The probability that measures will have negative long-term effects is directly linked to the interventions' insensitivity to specific conditions in the mountains.

To illustrate the above, any farm technology that increases mountain agriculture's crucial dependence on external inputs (e.g., fertilizer) or adds to mass production of high-weight, low-value products with a largely external market, and ignores the inaccessibility and related problems, may eventually make agriculture unsustainable. Similarly, any measure that disregards the fragility of mountain slopes and ignores linkages between diverse activities at different elevations in the same valley (e.g., farming-forestry linkages) to promote monocropping may not prove sustainable.

Under categories 2 and 3 above, there are several changes which might bring positive results in the long run and enhance sustainability of mountain agriculture. To separate them from the negative changes, one needs a fairly disaggregated analysis of the involved components. The approach involves examining the implications of interventions in terms of their compatibility with the relevant characteristics and conditions of mountain areas—the "mountain specificities" which are identified and discussed at length below. As a part of farming systems work at ICIMOD, efforts are in progress, through knowledge reviews and field studies in the selected mountain areas of Nepal, India, Pakistan, and China, to assess the sustainability implications of a number of interventions by examining their sensitivity to mountain specificities.

Identification, quantification, and documentation of the indicators of unsustainability is only a first step in the process of understanding the problem. The operational utility of the effort will depend on the ability to identify and manipulate the factors and processes contributing to persistent negative trends. While talking of the factors and processes causing unsustainability, it is not uncommon to refer only to symptoms of the problem. Such statements as "farmers' planting of crops on hill slopes is causing landslides and rapid soil erosion," "non-application of chemical fertilizers and reduced use of manure is causing decline in yields of hill crops," "overgrazing of pastures is causing their degradation," etc., frequently appear in descriptions of the current mountain situation.

At a slightly deeper level of understanding, population pressure, the

increased role of market forces, and side effects of public interventions in the recent decades are identified as basic factors causing and accentuating the negative trends mentioned earlier (ERL, 1989; Repetto, 1986; Banskota, 1989). However, without questioning the negative role of the above factors, two points need emphasis. First, in today's context neither markets nor public intervention (and even population growth in the near future) can be wished away. Second, it is not so much their presence but their interaction-patterns with mountain resources and environment that matter. Understanding of the latter calls for identification of the operationally relevant major characteristics and conditions of the mountains and examination of how they are affected by the exogenous factors and pressures, causing changes in the use patterns of mountain resources.

MOUNTAIN SPECIFICITIES

The important conditions which, for operational purposes, separate mountain habitats from other areas are referred to here as "mountain specificities." The six most important mountain specificities (some of which might be shared by other areas such as deserts in plains) are considered here. The first four, namely inaccessibility, fragility, marginality, and diversity or heterogeneity may be called first-order specificities. The availability of "niches," or areas which naturally suit, or have been adapted by people to suit, particular products or activities, and "human adaptation mechanisms" in mountain habitats are two second-order specificities. The latter are different from the former in that they are responses or adaptations to the first-order specificities. But they are specific to mountains nevertheless (Jodha, 1989).

Before describing the major mountain specificities, it should be noted that these characteristics are not only interrelated in several ways, but within the mountains they show considerable variability. For instance, all locations in mountain areas are not equally inaccessible or fragile or marginal. Nor do human adaptation mechanisms follow uniform patterns in all mountain habitats. With full recognition of such realities we may briefly introduce the mountain specificities.

Inaccessibility: Due to slope, altitude, overall terrain conditions, and periodic seasonal hazards (e.g., landslides, snow storms, etc.), inaccessibility is the most obvious feature of mountain areas (Price, 1981; Allan, 1986; Hewitt, 1988). Its concrete manifestations are isolation, distance, poor communications, and limited mobility. Besides the dominant physical dimension, it has sociocultural and economic dimensions (Jodha, 1989). The sustainability implications of the relatively "closed" system created by

inaccessibility will be discussed later.

Fragility: Mountain areas, due to altitude and steep slopes, in association with geologic, adaphic, and biotic factors which limit the former's capacity to withstand even small degrees of disturbance, are known for their fragility (DESFIL, 1988). Their vulnerability to irreversible damages due to overuse or rapid changes extends to the physical land surface, the vegetative resources, and even the delicate economic life-support systems of mountain communities. Consequently, when mountain resources and environment start deteriorating due to any disturbance, it happens at a fast rate. In most cases the damage is irreversible or reversible only over a long period (Eckholm, 1975; Hewitt, 1988). The sustainability implications of this mountain characteristic, to be discussed later, are not difficult to perceive.

Marginality: A "marginal" entity (in any context) is one which counts the least with reference to the "mainstream" situation. This may apply to physical and biological resources or conditions as well as to people and their sustenance systems. The basic factors which contribute to an area or a community's receiving such status are remoteness and physical isolation, fragile and relatively unproductive resources, and several man-made handicaps which prevent participation in the "mainstream" patterns of activities (Chambers, 1987; Lipton, 1983). Mountain regions, being marginal areas as opposed to prime areas in most cases, share the above attributes of marginal entities and suffer the consequences of such status in different ways (Jodha, 1989). Marginality shares with fragility a number of sustainability implications, as will be discussed later.

Diversity or heterogeneity: In mountain areas one finds immense variations among and within eco-zones, even at short distances. This extreme degree of heterogeneity in mountains is a function of interactions of such different factors as elevation, altitude, geologic and adaphic conditions, steepness and orientation of slopes, wind and precipitation, mountain mass, and relief of terrain (Troll, 1988). The biological adaptations (Dahlberg, 1987) and socioeconomic responses to the above diversities also add a measure of heterogeneity of their own (Price, 1981; Jochim, 1981). This diversity or heterogeneity applies to all characteristics of mountains being discussed here. Diversity acts as a positive attribute for interlinked activity patterns which can enhance sustainability in mountains.

"Niche" availability or comparative advantage: Owing to their specific environmental and resource-related features, mountains provide a "niche" for specific activities or products. At the operational level, mountains may have comparative advantages over plains in these activities. Examples may include a specific valley serving as habitat for special medicinal plants, mountains

acting as a source of unique products (e.g., some fruits, flowers, etc.) and mountains serving as most known sources of hydropower production. In practice, however, a niche and the comparative advantage it offers may remain dormant unless circumstances are created to harness it. However, mountains, owing to their heterogeneity, have several often narrow but specific niches which are used by local communities, through their diversified activities (Whiteman, 1988; Brush, 1988). Proper harnessing of niches can support sustainability, while their reckless exploitation can result in the elimination of niches.

Human adaptation mechanisms: Mountains, with their heterogeneity and diversity even at micro-level, offer a complex of constraints and opportunities. Mountain communities, through trial and error over the generations, have evolved their own adaptation mechanisms to handle them (Pant, 1935; Guillet, 1983; Jochim, 1981). Accordingly, either the mountain characteristics are modified (e.g., through terracing and irrigation) to suit their needs, or activities are designed to fit the requirements of mountain conditions (e.g., by zone-specific combinations of activities, crops, etc.). Adaptation mechanisms or experiences are reflected through formal and informal arrangements for management of resources, diversified and interlinked activities to harness micro-niches in specific eco-zones, and effective use of upland-lowland links (Allan, 1986; Forman, 1988; Brush, 1988; Whiteman, 1988). These adaptation mechanisms helped in sustainable use of mountain resources in the past. However, with the already indicated changes related to population, market, and state intervention, a number of adaptation mechanisms are losing their feasibility and efficacy. As will be elaborated later, understanding the rationale behind adaptation mechanisms can help in the search for sustainability.

Operational Implications of Mountain Specificities

There is a rich body of literature in which students of mountain ecology, mountain ethnosciences, and mountain geography in particular have described the above features for different mountain systems (Price, 1981; Ives and Messerli, 1989; Allan, Knapp, and Stadel, 1988). However, to enhance the direct usability of this literature in the search for sustainable development in mountain areas, one needs to spell out its operational implications. This is essential to influence the decision processes affecting agriculture and other activities in mountains. The operational implications in turn could be described as objective circumstances which could be easily understood and incorporated into policy and program designs.

Objective circumstances imply a set of constraints and potentialities which influence the choice and pattern of activities in mountains. Distance, physical isolation, high transport cost, poor mobility, difficulties of logistics and infrastructure, vulnerability to risks due to human action and natural hazards, limited input absorption capacities, limited production opportunities, limited exposure to and limited replicability of experiences from plains, are some of the important elements of objective circumstances in mountain areas. Such mountain features as inaccessibility, fragility, and marginality contribute to them in different ways. On the positive side, the presence of often narrow but unique high-potential areas and activities is also a part of the objective circumstances in mountain areas.

Understanding the objective circumstances or complex of constraints and opportunities created by mountain specificities on the one hand, and required resource management practices acceptable to them on the other, may help in an effective search for sustainability for mountain agriculture. In other words, mountain specificities can serve as a useful tool for the identification of options which can or cannot serve the goal of sustainability. This will be clear from the following discussion. However, before we discuss the sustainability implication of mountain specificities, a few preconditions associated with processes enhancing sustainability of agriculture and other activities in mountains may be reiterated.

Though the determinants of sustainability include both biophysical and socioeconomic factors, in the mountain context the former assumes primacy. At the operational level, the crucial factor is the capacity of these factors, not only to maintain, but if needed, to increase the flow of products and services. Raising the flow may imply responding to interventions (including manipulation of the resource base itself), without losing what Tisdell (1988) calls the essential ecological integrity of the system. Socioeconomic factors largely consist of conscious or unconscious modifications in the resource base and its use patterns. These modifications are aimed at ensuring the capacity of the natural resource base to provide an uninterrupted and undiminished flow of output despite periodic disturbances and to withstand higher use intensity to raise the level of performance when required. The latter may also involve higher input absorption and responding positively to expansion of the scale of operation and infrastructural logistics.

The sustained performance described above is often facilitated by a given system's linkages with other (wider) systems. This helps in the absorption of the consequences of periodic "shocks," the relaxation of specific resource constraints faced by the farmer, and the enhancement of the gains associated with spatial and te[illegible]al specialization. This implies linkages through

exchange between different systems, mountains and plains in our case.

Table 2 summarizes the above factors with reference to mountain specificities in order to highlight their sustainability implications. Accordingly, due to features such as fragility, marginality and even inaccessibility, mountain agriculture has a very narrow production base and production possibilities. Because of these very factors, scope is limited for manipulations by higher input use and higher use intensity of land resources. Vulnerability of land resources to rapid degradation (as reflected by soil erosion and landslides) as a result of even small disturbance is also linked to fragility.

However, owing to heterogeneity of mountain habitats, mountain agriculture is also endowed with a complex of varied opportunities for land-and water-based activities. Mountain communities skillfully harness them. But being too diverse and narrow and having been constrained by inaccessibility, they cannot impart the benefits of large-scale operations. Gains from experiences of other ecological zones are also less likely, because the heterogeneities restrict the replication of external experiences.

Niches or specific situations/products, with their potential comparative advantage for mountains over plains, are also a product of the heterogeneity characterizing these regions. Some of them are quite narrow and often harnessed to support petty trading despite inaccessibility problems. Special horticulture products, flowers, medicinal plants, etc., may serve as examples.

Mountains are also endowed with niches which are so huge and complex (e.g., potential for large-scale irrigation and hydropower production) that harnessing them is often beyond the capacities of mountain communities. Often when such niches are harnessed through external initiatives, they attract resource-extractive focus, with little sensitivity to their backlash effects on sustenance systems of mountain communities. Moreover, owing to the socioeconomic and political marginality of mountain people, the terms of resource extraction are unfavorable to mountain regions, which consequently become net exporters of resources to the plains.

Except for the above type of upland-lowland linkages, the scope for exchanges between mountains and plains is quite limited due to inaccessibility. This restricts the scope for higher surplus generation and the exchange of products, production experiences, and markets with plains areas.

The mountain specificities and their implications described above present a complex of constraints and opportunities, treatment of which forms the essence of farming systems and other adaptation strategies evolved by mountain communities. Various measures designed to adapt (or amend) mountain specificities to suit production requirements or to adapt requirements to mountain conditions could be put into various categories.

Table 2. MOUNTAIN SPECIFICITIES

	Sustainability implications in terms of:						
	Inherent production potential & modification possibilities through:					Abilities to link with wider system	
Mt. specificities (and objective circumstances)	Resource use intensity	Input absorption capacity	Infra-structural logistics	Gains of scale	Resilience to shocks	Surplus generation & exchange	Replicability of external experience
INACCESSIBILITY: (Remoteness distance, closeness, restricted external linkages, etc.)	(-)[1]		(-)	(-)		(-)	(-)
FRAGILITY: (Vulnerability to irreversible damage, low carrying capacity, limited production options, high overhead cost of use, etc.)	(-)	(-)	(-)	(-)	(-)	(-)	
MARGINALITY: (Cut off from mainstream, limited production options, high dependency, etc.)			(-)	(-)	(-)	(-)	(-)
DIVERSITY: (Complex of constraints & opportunities, interdependence of production bases & products/ activities, etc.)	(+)[1]	(+)	(+)	(-)	(+)	(+)	(+)
"NICHE" AVAILABILITY: (Small and numerous specific activities with comp. advantage; use of some beyond local capabilities, etc.)	(+)	(+)	(+)	(+)	(+)	(+)	(-)
ADAPTATIONS MECHANISMS: (Folk agronomy, ethno-engineering, collective security, diversification, self provisioning, etc.)	(+)	(+)	(+)	(-)	(+)	(-)	(+)

[1](-) indicates extremely limited possibilities, while (+) indicates greater scope for sustainability through production performance and linkages with wider systems (e.g., upland-lowland interactions).

They may be termed as folk agronomy, ethno-engineering, diversification strategies, self-provisioning systems, collective survival mechanisms, etc. These measures in their respective ways help in raising use intensity and protection of land resources despite fragility and marginality, multiplying and diversifying options despite limited production possibilities, generating and exchanging surpluses despite accessibility problems. Human adaptation mechanisms in mountain habitats need further comment, as they could help identify elements usable in strategies for sustainable development of mountain agriculture.

TRADITIONAL ADAPTATION STRATEGIES

Some of the strategies developed by people to ensure their subsistence in mountain habitats are summarized in Table 3. They could be viewed as responses to different mountain specificities. Accordingly, local resource-centered diversification is one important approach. It is based on interlinked activities (e.g., annual and perennial crops, livestock, forestry, etc.). It is supported by systems of self provisioning, on-farm storage, and recycling. This approach not only serves sustenance needs in a relatively closed system (due to inaccessibility), but has potential to benefit from heterogeneity of the resource base without damaging the fragile and marginal resources.

Ethno-engineering, covering such practices as terracing mountain slopes and harnessing the runoff and developing small drainage systems, is also designed to treat marginality and fragility of natural resources and harness their specific potentialities. A number of agronomic practices, such as rotations, fallowing, etc., also help in this respect.

The choice of crops with different attributes (to meet food, fodder, fiber, and cash needs) and integration of systems based on annuals and perennials (to ensure balanced land use) are important components of folk agronomy (Whiteman, 1988; Forman, 1988). They help in management of fragility and marginality of resources and in harnessing diversity and the specific niches created by it.

In the face of individuals' incapacities and possible individual irrationality in handling specific problems, a variety of collective arrangements have evolved. Such provisions as common property resources, collective risk sharing, and contributions to community asset creation/maintenance, etc., are examples of this (Guillett, 1983; Pant, 1935). They not only help in handling constraints imposed by inaccessibility, fragility, and marginality, but also facilitate creation and harnessing of niches in the diverse mountain situations.

Despite inaccessibility, the mountain communities manage specific

Table 3. PEOPLE'S STRATEGIES IN RESPONSE TO MOUNTAIN SPECIFICITIES

	Mountain specificities				
	Inaccessibility	Fragility	Marginality	Diversity	Niche
Diversification and self provisioning:					
- Spatially, temporally interlinked activities	x	x		x	x
- Local resource-focussed recycling, self-provisioning		x		x	x
- Scattered settlement patterns	x		x		
Folk agronomy:					
- Annual–perennial plant complementarities (farming forestry linkages etc.)		x	x	x	
- Cultivars of varying attributes	x	x	x	x	x
- Fallowing, rotations, topo sequencing, intercropping		x	x		
Ethno engineering:					
- Slope management (terracing, etc.)		x	x		
- Protective vegetation, contour farming		x	x		
- Traditional irrigation/drainage management			x	x	x
- Small-scale transport logistics (ropeways, etc.)	x				
Collective arrangements:					
- Common property resources		x	x	x	
- Social regulation for use/protection of fragile resources		x			
- Community irrigation systems, etc.			x	x	x
- Crisis period sharing systems	x	x	x		
Upland-lowland linkages:					
Petty trading in specialized mountain products (with high value, low weight, etc.)	x			x	x
- Periodic migration	x	x			
- Transhumance	x	x			
- Externally planned extraction of mountain niches					x

linkages with plains. Petty trading in specific products, especially those with low weight, high value, and low perishability, and which occur only in mountain niches, is a common feature. Periodic and permanent out-migration of hill people is a well-known device to manage local pressure in a rather closed system due to accessibility problems. Transhumance is also practiced both to facilitate the use of diverse ecological niches and as a mechanism for releasing local pressure and linking the mountain economy to that of the plains (Bjonnes, 1983).

Though not directly relevant to the present discussion, there is yet

another category of mountain-plain linkages which operate through the modern public interventions for harvesting timber, exploiting hydropower potential, etc. However, most of them are externally conceived and planned. They are often quite insensitive to mountain specificities (Paranjpye, 1988; Repetto, 1988). Consequently, they have several backlash effects on mountain habitats and traditional adaptation strategies (Sanwal, 1989).

Reduced Feasibility and Efficacy of Traditional Strategies

As mentioned earlier, due to changed demographic, economic and administrative circumstances, most of the above measures are becoming unfeasible or ineffective in handling mountain specificities. For this reason alone, we included "resource management practices" as one of the categories to classify the indicators of unsustainability.

In the first place, increased pressure on land has made it difficult to continue such land-extensive practices as long fallows, specific rotations, and balanced land use involving annual-perennial complementarities. Extension of cropping to submarginal areas, rapid decline of forests and common property resources, and overgrazing of pastures have made the current situation insensitive to fragility and marginality of land resources (Rieger, 1981; ERL, 1988; Sanwal, 1989).

Public interventions for infrastructural development and their subsequent impacts on resource use also have similar consequences. The public interventions in terms of new agricultural technologies, focusing largely on selected crops and selected crop attributes, have also contributed to reduced diversity and resiliency of mountain agriculture. The new highly centralized administrative systems and other institutional arrangements (including those for input supply and marketing) have bypassed and marginalized the traditional collective systems and folk knowledge about resource management (Sanwal, 1989).

The market, which traditionally operated as a facility for siphoning off the local pressures and trading local surpluses, has now acquired different characteristics in the mountain context. Encouraged by factors such as public interventions for extraction of mountain niches, improved accessibility in some cases, and changed qualitative characteristics of mountain populations (e.g., rise of individualism), the market has penetrated quite deeply into mountain areas and people's psyches. This has undermined several measures which needed adherence to social sanctions and respect for collective decisions, a high premium placed on self provisioning and recycling, a preference for conservation as opposed to extraction, etc. The importance of markets has also dramatically changed the nature of upland-lowland linkages.

Distant market signals in plains, which are indifferent to mountain specificities, dictate the pattern of resource extraction in mountains.

A WAY OUT: THE SEARCH FOR SUSTAINABILITY

Both the preceding comments and the earlier discussion on indicators of unsustainability present a rather discouraging scenario regarding mountain agriculture. A utopian solution would call for restraining market and state and, of course, stopping population growth in mountains. The last is unlikely in the near future. The other two are also impossible, as in today's world one cannot wish away markets and states despite their failures. For one thing, along with their negative side effects, the market and public interventions have helped make some improvement in the conditions of mountain people. Hence, the solution lies in minimizing their negative side effects. This in turn could be achieved by sensitizing public interventions and market forces to mountain specificities. Jodha (1989), by analyzing the mountain specificities and their development imperatives, has presented a framework for attempting this. The basic need is to incorporate the mountain perspective as a contextual factor in the decisions made and actions taken in respect to mountains.

An additional and more concrete approach is to identify the rationale of traditional adaptation strategies and incorporate it into interventions for agricultural and other developments in mountain areas. However, before looking at the specific areas in which the rationale of traditional adaptation strategies can be found, the problem may be restated in the following manner.

The unsustainability scenarios in mountain areas have emerged largely because the current use intensities of mountain resources are higher than the ones permitted by the inherent characteristics of those resources. This has happened through both changed use patterns and an increased use of resources for new purposes. In the context of the present pressure of demand, the high resource-use intensity cannot be avoided. The crucial challenge is to reconcile high-use intensity and protection of resources against degradation. This calls for both technological and institutional measures.

Technological elements from traditional adaptations which require a high land-man ratio are no longer relevant in the present context. Similarly, unless collective consciousness is strengthened, the institutional measures involving adherence to social sanctions and informal norms have little chance of success. With full recognition of these realities, one can nevertheless look to the traditional practices for some insights. Tables 4 and 5 present relevant details.

Table 4 summarizes the potential attributes of crop-centered and resource-centered technologies. These technologies incorporate the rationale of traditional strategies without adopting their land-extensive features, which are not feasible in today's context of high pressure on land. The table also indicates specific features of crops and varieties (e.g., low weight, high value, etc.), which can impart a comparative advantage to mountain agriculture, despite the problems associated with inaccessibility. A focus on bioengineering, soil- and water-management systems, and new technologies is suggested, which can help increase input-absorption capacities of fragile and marginal lands without damaging them.

Table 4. TRADITIONAL ADAPTION STRATEGIES AS A GUIDE FOR SEARCHING TECHNOLOGICAL OPTIONS FOR SUSTAINABILITY

Traditional strategies and their key elements	Imperatives for new options
Diversification and interlinkages of agricultural components (forestry/farming, cereal legume complementarities)	Systems approach with focus on multiple-use species for annuals and perennials for food, fodder; with focus on wider adaptability, wider range and complementarity with other crops and activities
Balanced land-extensive and land-intensive agricultural activities	High-yielding, short-maturity annuals and perennials, to increase land-use intensity, without discarding their complementarities for balanced land use; activities (e.g., apiculture, aquaculture) not competing for land
Local-resource orientation of folk agronomy, other technologies	Agricultural products with high value, low weight, low perishability, local processability, recyclability, lower crucial dependence on external inputs and high use of the comparative advantage of mountains, to combat inaccessibility and marginality constraints
Land-extensive crop rotations, nutrient cycling through cropping systems	Plants to build and bind soil; biological control of yield reducers; legume-based systems to reduce need for fallowing
Ethno-engineering for resource management, conservation	Bio-engineering and mechanical devices for slope stabilization, soil and drainage management; agro-forestry systems, use of folk knowledge in fragility management

At present the hill farmer, in spite of his concern for sustained productivity and conservation of his land, finds sustainability difficult to achieve because he does not have alternative new components (e.g., crops with specific attributes listed in Table 4) to incorporate in his strategies to satisfy the above concerns. Part of the blame for this should rest with those

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