6

FARMERS' STRATEGIES AND THEIR SUSTAINABILITY IMPLICATIONS TO MOUNTAIN AGRICULTURE

Historically, people in the mountains have been found to have generated capabilities to tame the mountain environment which is harsh, rough, and fragile in order to derive outputs for satisfying their needs. In this respect, farmers appear to have adopted a number of strategies, either in terms of modifying the characteristics of the mountain environment itself or in the form of modifying their operational measures to converge with the mountain characteristics (e.g., inaccessibility, fragility, marginality, diversity, niche, and human adaptation) so that their readymade or anticipated operational measures match and facilitate the generation of outputs. Hence, the implications of these strategies to the sustainability/unsustainability of mountain farming systems will be discussed in this chapter. Perhaps it may be useful to begin with a prelude on sustainability issues before we discuss different sections under this broad chapter.

Sustainability Issues

Despite its widespread recognition, sustainability is still a debatable issue that has been going on for the last few years. Commissions have been formed at the global level in order to investigate into sustainable development. The Brundtland Commission, for instance, attempted to examine the reasons causing environmental degradation and to identify potential relevant options to reverse the situation and bring about sustainable development.

In this paper the sustainability issues have been adapted from Jodha (1989b).

Conceptually speaking, the focus of 'sustainability' is on the issues of inter-generational equity. This implies equal (or greater) availability of options, in terms of human well-being or production prospects, to future generations as compared to the present one. Theoretical possibilities of such prospects, ensurable through the accumulation of capital stock and technology for use by future generations, are constrained by the capabilities of the biophysical resource base. The latter cannot be stretched or manipulated indefinitely, without initiating processes of irreversible damage. This indicates the primacy of biophysical resources in sustainable development. This is more so in the case of agriculture, the dependence of which on biophysical variables is more direct and crucial.

'Sustainability' is the ability of a system (e.g., the fragile resource-agriculture) to maintain a certain well-defined level of performance (output) over time, and, if required, to enhance the same, including through linkages with other systems, without damaging what Tisdell (1987) calls the essential ecological integrity of the system (Jodha 1989b).

Farmers' Strategies

Based on observations, speculations, and detailed interviews and discussions with concerned and local people, several operational measures that the farmers have been adopting in response to mountain characteristics and the public interventions made by the Government are identified. These measures are then categorised under a set of nine major strategies that are discussed sequentially. Attempts have also been made to examine the feasibility of each strategy in the context of the changing demographic pressures, markets, and various institutional and technological changes.

Extensive Cultivation Practices

This strategy refers to the cultivation of larger areas with less intensity of input (e.g. labour) use per unit of land. It generally indicates monocropping. Under this broad strategy, farmers have adopted various operational measures and the "slash and burn" cultivation practice is one of them (Table 6.1).

"Slash and Burn" Cultivation. This practice is widely known as shifting cultivation. In this system, farmers clear forests, bushes, shrublands, and any unwanted plants and set them on fire. Then potatoes, or potatoes with wheat or buckwheat, are sown on that piece of acquired land which is fit for cultivation without the application of any organic or inorganic fertilizers. This system is locally known as the "*Bukma* System" in the Yelung area. The piece of land is then left without cultivation for a considerable time period (3-5 years), once the first crops are harvested (Table 6.1). This cultivation practice contains a very important element of the sustainability of the farming system, because this practice has the merit of maintaining soil fertility naturally, i.e., without any external input or application of fertilizer or manure. This system is widely practised, particularly in the Yelung study area. The farmers are fully aware of the merits of the practice. The system or practice not only uses local inputs but also low inputs (e.g., seed, manure, labour, etc) per unit of cropped area. For details regarding the *Bukma* system, see Annex 9.

This practice is now under stress due to the population pressure. The time interval between one cultivation period to another on the same piece of land has been shortened from 3 to 4 years now, compared to 6-8 years about two decades ago. Another reason is people's fear that the Government may control and take the ownership of land if it is not cultivated more frequently. People are of the view that this might happen in the very near future once a cadastral survey takes place in the area. Hitherto, farmers did not have any legal ownership rights over the land except some receipts for land taxes paid to a government-appointed local leader or person in the village.

Remarks. The historical background of this "slash and burn" cultivation practice, particularly in the Naubise study area which is accessible and is an area newly transformed through the use of improved agricultural technologies, was not available, apart from some anecdotes. Some fading memories about the system were forthcoming in Dhuskun area. Particularly in the mountain areas, the extensive land cultivation strategy can be appreciated from the sustainability point of view. This is because the mountains are inaccessible (both in physical and socioeconomic dimensions), fragile, etc. This option is feasible when there is less pressure on land. Increased demographic pressure alone makes this strategy unfeasible for future generations.

Intensive Cultivation Practices

This strategy relates to the practice that encourages higher use intensity of agricultural inputs per unit of land. Multiple cropping or higher cropping intensity are the major indicators of this practice (Table 6.1).

The practice of intensive cultivation began because of increased population pressure and the availability of new technologies (e.g., HYVs, fertilizers, pesticides, etc). Cultivation of more than one crop per year, even on lowlands that used to be fallow after harvesting the first crop, is becoming the general practice even in relatively inaccessible areas of the mountains, e.g., Dhuskun where farmers are growing maize after paddy. This is a recent trend in the area. In the case of Yelung, although the area under lowlands is minimal, the land is still kept fallow after paddy and is used for grazing animals.

Table 6.1: Farmers' Strategies and Their Operational Measures

Operational Measures of the Strategies	FARMERS' STRATEGIES								
	Extensive Cultivation Practice	Intensive Cultivation Practice	Extensive Management Practice	Intensive Management Practice	Backward and Forward Linkages	Group Efforts	Risk Hedging	Biomass Utilisation	Diversification
1. Farmland									
i. "Slash and Burn" cultivation practices e.g. *"Bukma System"*	*							*	
ii. Existence of abandoned land	*		*		*		*		
iii. Multiple cropping practices		*			*		*		*
iv. Cultivation of local cultivars (with varieties lower but guaranteed yield and resilence to moisture stress and diseases)					*		*	*	
v. Usage of high stalk : grain ratio and salvage potential crops		*		*	*		*	*	*
vi. Higher seed rate application, particularly for maize							*	*	
vii. Trend of fodder tree plantation on private land				*	*			*	
viii. Terrace making or contour farming practices		*		*					
ix. Cultivation of improved cultivars of cereals and horticultural crops		*							*
2. Livestock									
i. Livestock keeping with different combinations of animals				*			*	*	*
ii. Preference for sturdy animals having multiple socioeconomic values					*		*	*	
iii. Preference for low-cost animals with short gestation periods			*	*			*		
iv. Sharing of livestock keeping (steadily emerging)			*		*	*		*	
v. Mobile herd keeping (transhumance)			*	*	*			*	

Contd....

Table 6.1: Farmers' Strategies and Their Operational Measures

(Continued)

Operational Measures of the Strategies	FARMERS' STRATEGIES								
	Extensive Cultivation Practice	Intensive Cultivation Practice	Extensive Management Practice	Intensive Management Practice	Backward and Forward Linkages	Group Efforts	Risk Hedging	Bio-mass Utilisation	Diversification
3. Forest/Pastureland Grazing Land									
i. Preference for extracting fodder, fuelwood, timber, and other biomass and other by-products from the forest even if they are available on private land			*				*	*	
ii. Natural resource management at community level						*	*		
4. Crop-livestock Integrated Farming				*	*		*	*	*
5. Self-help Activities									
i. Sharing of individual assets for usage :									
- use of bullock power			*	*		*	*		
- use of other farm implements			*			*			
ii. Exchange of labour, particularly during peak season, otherwise agricultural farming could seriously be menaced			*	*		*			
iii. Installation of indigenous water mills for grinding cereals at community level						*			
iv. Development of small irrigation schemes under farmers' management									
6. Miscellaneous									
i. Adoption of different 'sideline' activities							*		*

Note: * indicates the presence of an operational measure of the farmers' strategy.

The level of land use intensity appears to be higher in Dhuskun and Naubise areas where the cropping intensities are calculated at 172 and 165 per cent respectively. Population pressure is the biggest single factor for inducing higher cropping intensity in Dhuskun, where the population density per hectare of cultivated land is just over nine persons. The figure for the same in Naubise is over seven persons. Due to climatological factors and the unavailability of suitable technologies, the cropping intensity in Yelung appears to be very low (115%), despite the fact that the population density per hectare of cultivated land is extremely high (20 persons). This is the reason why the people in the area have to depend heavily upon foodgrain supplies from outside. About 40 per cent of the total nutrition supply comes from outside the farm (Annex 7). People purchase foodgrains from dealers or from branch offices of the Nepal Food Corporation located at Jiri.

Remarks. Intensive cultivation practices imply frequent disturbance of the soil, resulting in loose soil and thus stimulating erodability. This situation makes the land fragile. However, there are some operational measures that can improve the fragile resource base by undertaking soil conservation strategies through an emphasis on biomass production (e.g, fodder, fuelwood tree plantation on private/public land, terrace farming, etc). The intensive cultivation strategy seems to be a feasible option for the future, particularly in areas that are accessible and have relatively less steep slopes (e.g., Naubise) and which can depend on some outside inputs (e.g, seeds, fertilizer, etc). With efforts for more biomass production (e.g., fodder and bedding materials for animals and compost for manuring), the intensive land cultivation strategy will not be a less viable option even for the Dhuskun and Yelung areas.

Extensive Management Practice

This management practice relates to the labour use pattern. If the highest intensity of labour use per unit of land refers to intensive management practice then the lower intensity indicates extensive management practice.

The extensive/intensive cultivation and management strategies or practices appear to be synonymous and seem to be mutually inclusive, however they are not so in reality because one can observe intensive management practice in an extensive cultivation setting and vice versa. For example, the farmers in Yelung employ the highest labour intensity which is computed at about 205 mandays per hectare of crop cultivation for extensive cultivation practices compared to the 173 and 169 mandays in the case of Dhuskun and Naubise respectively, where intensive cultivation practices are common.

There are not many examples or operational measures that farmers are employing under this extensive management strategy. However, sharing of livestock-keeping (among neighbours, relatives, friends, or those who trust each other), mobile herd keeping, and the "*bukma* system" can be considered to be some of the measures (Table 6.1).

Remarks. In general, the extensive management strategy that bears some elements of sustainability, particularly from the premise of low input use practice, cannot be considered a viable strategy anymore in the context of the increased demand for farm produce. This remark is most applicable in case of the *bukma* system. The sharing of livestock keeping has some positive aspects because this sharing practice, in general, implies shifting animals from low to high fodder resource bases. Similarly, the transhumance livestock management system (e.g., mobile herd-keeping) inherits the merits of lowland-upland linkages, in which case both areas avail themselves of outputs/commodities for consumption that are otherwise not available in either of the areas. However, these operational measures are becoming increasingly less feasible due to intensive cultivation practices, particularly in lowland areas. This implies scarcity of fallow land which otherwise usually attracts mobile herds (e.g., sheep, goat, *chauri*) from the high mountains (upland) to the low mountains (lowland) in search for compensation during times of feed shortage during the winter season. This is the reason why this traditional practice is slowly disappearing.

Intensive Management Practices

As referred to in the extensive management strategy this practice basically relates to the high intensity of labour use per unit of land or cropped area.

Under this strategy, farmers are resorting to a number of operational measures, e.g., multiple cropping, terrace farming, cultivation of improved cultivars, livestock-keeping with different combinations of animals, etc (Table 6.1). Because of technological innovations and their availability, farmers have recently started to resort to labour intensive farming by superseding millet with the upland rice variety - CH 45. Vegetable farming, again a labour intensive farming system, is slowly replacing cereals, particularly in the Naubise area. Similarly, stall-feeding practices in the case of livestock farming are becoming increasingly acceptable to farmers, particularly in the Naubise and Dhuskun areas where there is demand for more labour per unit of livestock. Also, the high intensity of labour use associated with the practice is attributed to reduction in the size of livestock holdings. This operational measure particularly stipulates the long-term sustainability implications because this type of livestock management practice has already brought some positive changes by encouraging the maintenance of smaller but qualitative units of livestock. Therefore, based on the information from the field survey, the size of livestock holdings is declining over time while the proportion of improved animals is increasing.

Terrace farming, which is a traditional practice (labour intensive farm management), bears a great sustainability implication for mountain farming systems by preventing soil erosion. Similarly, fodder/fuelwood tree plantation on the bunds and ridges of cultivated land is not a recent version of farm management practice, nevertheless the intensity of plantation and the maintenance of trees have been intensified, particularly in the Naubise and Dhuskun areas.

However, the situation in the high mountains is different because extensive management strategies are being practised. Stall-feeding practices are non-existent where open grazing systems still exist in large areas under alpine pastureland and meadows. People's dependency on forests/pastureland for fodder, fuelwood, and other compost materials is very high (see Tables 5.1, 5.2, and 5.3).

Remarks. In general, the intensive management strategy can be a feasible option in order to reverse the unsustainable farming system to a sustainable one, although the strategy may require high use intensity of the resource base. There is nothing wrong in doing so if the enhancement and maintenance of the regeneration capacity of the resource base is taken care of. The existing situation in Yelung, in terms of a relatively high level of resource endowment, associated with extensive resource management practice will not remain for long. The situation between now and even ten years earlier has already undergone conspicuous changes in terms of increased time allocation to fetch forest and natural resource products, including several other parameters. Therefore, the present changing picture of the whole farming system, within a time period of 20-40 years, clearly communicates the message that an intensive management strategy, against the backdrop of a changing environment, will be a necessary precondition for maintaining mountain agriculture in a sustainable manner in all the areas of the region, (e.g., population pressure, technological innovation, etc).

Backward and Forward Linkages

This terminology refers to a situation in which the 'give' and 'take' from one activity to another or from one component to another of a farming system exists. The presence of strong backward and forward linkages within a system helps reduce outside dependency, thereby facilitating smooth functioning of the system which is the essence of sustainability.

Farmers in the mountains are well conversant with the merits of this strategy and are excersising it by undertaking various operational measures, e.g., presence of abandoned land, higher seeding rates, and multiple cropping (Table 6.1). Farmers in the region have been maintaining an integrated (crop-livestock-forestry) farming system for centuries, although the third component is the latest inclusion (in terms of realisation) in the system. This is mainly guided by the strategy of backward and forward linkages. Despite the higher yield potentials of improved crops, farmers have not completely renounced the cultivation of local cultivars which normally destroy the strains having a high stalk: grain ratio even in more accessible and relatively new technologically influenced mountain areas like Naubise. This is because they also need fodder for livestock, compost for manuring, and roofing materials to protect houses and cattle sheds from rain and sun and these are available from crops. Farmers appear to have selected and cultivated even improved crops by employing this strategy. This is corroborated by discoveries in the Naubise study site. It has been already recognised that the area enjoys the highest level of technological innovations in agriculture (in terms of improved crop cultivation and management practices). Along with highest yields in main crop products, the yields of crop by-products (e.g., dry fodder, compost, bedding, and roofing materials) per hectare of cropped area are also the highest (2,620 kg) in the Naubise area followed by Dhuskun (2,130 kg) and Yelung (1,785 kg). The Yelung site is virtually unexposed to new agricultural technologies. For example, the area under improved crops and the use of chemical fertilizers are either extremely low or non-existent in both the Dhuskun and Naubise sites (Annex 3, Tables 4 and 6).

Remarks. This strategy is, however, also losing its grip, primarily due to exogenous factors. Good data on resource management and extraction rates are not available. However, observations showed that the strong and tight linkages between and among different components of the farming system that existed in the past are now breaking down. For instance, the per unit fodder supply to livestock and compost materials to crops which come from the forests/pastureland have been decreasing and the resulting reduced supply of manure from livestock to crops has led to reduced levels of foodgrain and livestock production. Since again there is limited scope for supply of inputs from outside the farm due to mountain characteristics, this strategy of backward and forward linkages will be an equally important and viable option even for the future in order to strengthen the capability of the system to sustain itself.

Group Efforts

Any activity undertaken on a communal basis to achieve or fulfill a well-defined objective comes under this strategy of group efforts. The essence of the strategy is that it increases the individual capacity to absorb shock arising from natural calamities, e.g., sharing of foodgrain/livestock during drought, flood, etc. Exchange of labour during peak season and the sharing of farm implements are other examples of group efforts (Table 6.1) that enable one to perform many beneficial activities. This strategy in the past enhanced the sustainability of the system. However this option is now overstrained, primarily due to public intervention.

Let's take the example of the nationalisation of the forest resource base in Nepal which took place in the 1950s. This policy completely disregarded the positive attributes made by the community management system which had greatly enhanced sustainable production and the use of all common property resources (e.g., land, water, etc). The ultimate consequences are deforestation and overgrazing, resulting in serious depletion of the natural resource base and threatening the whole mountain community. The recent change in the policy to safeguard the rights of the community on the forest resource base for its conservation and development is the outcome of full realisation of the disregard of the group effort strategy. Thus, some positive outcomes have already surfaced in all three study areas. Degraded forests in Naubise and Dhuskun and alpine pastureland and meadows in Yelung are now being improved through community management practices and are responsible for the protection, conservation, and utilisation of the produce (e.g., fodder, fuelwood, compost materials). Only two years back, a management committee for alpine

pastureland was formed in Yelung. This five member committee, consisting of local people, with the addition of one technical advisor who is from the cheese factory owned by the Dairy Development Corporation, is stressing the implementation of controlled grazing of animals in rotation rather than haphazardly.

Similarly, the degraded forests in Naubise have been reforested and afforested and the people are allowed only 2 out of 50 ha of forest for free/regulated animal grazing. The rest of the forest is completely controlled and the people are allowed only to'cut and carry' green fodder, compost, and bedding materials. Similar situations prevail in the other areas too.

Remarks. This traditional resource management practice must be strengthened in order to make mountain farming systems sustainable even in the future, be it in the field of forests/pasturelands or water. The recent trend of reinstalling farmer-managed irrigation schemes and water mills for grinding cereals are the outcome of the revitalisation of this group effort strategy. The *ghatta* or water mills, which were operated individually, are also now run on a community management basis. More and more *ghatta* (from five it has increased to nine) are being installed by farmer groups. The practicality and usefulness of this strategy still do exist and will be applicable even in the future.

Risk Hedging

Any activity undertaken on an individual or group/community basis with the aim of protecting it from any risk is termed as risk hedging. The main objective of this strategy is to maximise benefit (e.g., in value or volume of produces) while minimising risk.

One of the basic features of traditional farm management practices is to undertake activities associated with a minimum level of risk. Farmers have always, for instance, preferred local cultivars because of this attribute (e.g., there will be a small reduction in crop yields even during odd periods, viz., drought, hailstorm, insects and disease infection). Use of more seeds is again to hedge the risk arising from moisture stress. Preference for small ruminants over large ones is also guided by this strategy. This is particularly so in the case of small, marginal landholders who cannot take the high risk associated with having large animals, the loss/death of which could mean disaster to them. Investment in large ruminants could be equivalent to the value of the total assets a marginal or a landless farmer may hold (Table 6.1). For some more details see Annex 8.

Biomass Production and Use

This strategy refers to an activity or enterprise, that, when undertaken, helps to increase biomass (e.g., fodder or other vegetation for compost, bedding materials) production.

Farmers have adopted various operational measures under this strategy. Some land, particularly in Yelung was abandoned, not only because of uneconomical cultivation in terms of low yields of foodgrain but also to allow the vegetation to regenerate which could be used as fodder/bedding materials. Use of more maize seeds is also guided by this strategy so that increased green fodder enhances the productivity of animals, otherwise the emphasis on the usage of high stalk: grain ratio crops would never have been appreciated. Perhaps the strategy of biomass production and use which is associated with traditional farming practices is one of the most important elements in the sustainability of a system. Some operational measures adopted by the farmers under this strategy are presented in Annex 8.

Remarks. This strategy can also be appreciated in the context of mountain characteristics, such as inaccessibility and fragility, since the compost materials and manure are the only sources for fertilizing land and the vegetative cover improves the fragile environment. Therefore, their option is still feasible

and will be effective even in the future for sustainable development of mountain agriculture, particularly in the remote and inaccessible areas.

Diversification

Diversification of farming relates to the practice of growing various kinds of cereal, fruit, and vegetable crops and maintaining different types of animals on the farm.

The Government is giving new impetus to diversifying crop husbandry in agricultural development. This policy has helped farmers in Naubise to diversify their farm activities by cultivating not only new varieties of cereal crops but also fruits and vegetables, thereby rising above the subsistence level of production; some of the farmers are making gross incomes of hundreds of thousands of rupees from such diversifications particularly from vegetable farming on a commercial scale on about a hectare of land. Multiple cropping and crop - livestock integrated farming are also examples of farm diversification.

Remarks. Mountain regions, as such, are typified by diversity in terms of their topography, altitude, slope, and aspect, resulting in a large variation in microclimates which ultimately provides the opportunities for undertaking diverse activities in order to exploit the 'niche' of the mountains. This implies that there is comparative advantage in exploiting this diversity. Therefore, the strategy of diversification should be given invariable impetus even in public interventions in future because diversity will prevail forever and so will the variation in microclimates in the mountains.

The Sustainability Implications of Mountain Agriculture

Attempts have been made to assess mountain agriculture in the context of its sustainability/ unsustainability by studying three different types of mountain farming system. As discussed earlier, they are crop-dominated, horticultural crop-dominated, and livestock-dominated farming systems located in Dhuskun, Naubise, and Yelung respectively (Table 2.1). To this effect, both the positive (+) and negative (-) changes in resource characteristics, production flow, and the utilisation/management of farming systems which have been conceptually considered as the three most important elements/components of a sustainability matrix (Chapter 2), were recorded and documented based on extensive and comprehensive discussions with farmers, local leaders, key informants, and the study team's observations. Some of the changes are easily perceivable while others are in disguised forms.

These over time positive/negative changes, considered as indicators of sustainability/unsustainability of mountain farming systems, are shown in Tables 6.2, 6.3, and 6.4. Here readers are cautioned that any positive or negative change that relates to the sustainability or unsustainability of a farming system are, in general, location-specific. These over time changes refer to the changes that have taken place during the last thirty years or so.

Basically, these changes are the outcome of the strategies adopted by farmers while responding to the endogenous and exogenous factors of a mountain farming system (Fig. 1), keeping in mind the mountain characteristics as they are perceived. The positive changes can be considered to occur when convergence between the attributes of strategies and mountain specificities takes place and vice-versa.

Table 6.2: Over Time Changes as Indicators Leading to Unsustainability/Sustainability of Mountain Agriculture (Crop - dominated Farming System in Dhuskun)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of changes
I. RESOURCE BASE	- Increased literacy rate	(+)	- Increased distance to parcel	(-)
	- Abandonment of land due to landslides	(-)	- Increased fragmentation of land	(-)
	- Abandonment of land due to low fertility	(-)		
	- Decreased area under forest pastureland	(-)	- Reduced size of parcel	(-)
	- Emergence of stones/rocks on cultivated land	(-)		
	- Increased size of farm through conversion of arable land	(-)		
	- Increased size of farm through conversion of marginal land	(-)		
	- Decreased size of livestock holding, without adequate qualitative change	(-)		
	- Reduced diversity of natural vegetation, e.g., disappearance of fodder trees sp. from forests, grasses from pastureland, etc.	(-)		
II. PRODUCTION FLOW	- Declined level of cereal crop yields	(-)	- Increased collecting time of fodder, fuelwood, timber, from public or common land	(-)
	- Declined level of crop by-products	(-)		
	- Reduced quantity of compost, manure application rate per unit of cropped area	(-)		
	- Decreased level of fodder, biomass supply from private land	(-)	- Increased time allocation for water fetching	(-)
	- Decreased level of fodder, biomass supply from public land	(-)	- Reduced level of nutrition supply to human population	(-)
	- Declining trend of livestock productivity	(-)	- Increased intensity of foodgrain supply from outside the farm	(-)
			- Increased income from off-farm activities	(+)
			- Increased rate of out-migration, e.g., seasonal	(-)
III. UTILISATION/ MANAGEMENT PRACTICE	- Forest and other common property resources are under community's control (e.g., fencing forbidden) in order to improve the resource base	(+)	- Increased intensity of crop by-product use (e.g., maize cobs after threshing, wheat and barley straws, etc.) as firewood	(-)
	- Emergence of increased level of stall-feeding practice	(+)	- Utilisation of *'banmara'* plants as roofing materials for cowsheds due to shortage of *khar* - traditional plant material for roofing.	(-)
	- Increased expenses in other domestic unproductive activities from the income derived from agriculture and off-farm activities	(-)		
	- Increased cropping intensity	(+)		

Note: Negative sign of change (-) = Leading to unsustainability
Positive sign of change (+) = Leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g. resource base, production flow, and utilisation/management practices).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place during last twenty/thirty years or so.

Table 6.3: Over Time Changes as Indicators Leading to Unsustainability/Sustainability of Mountain Agriculture (Horticultural Crop-dominated Farming System in Naubise)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of changes
I. RESOURCE BASE	i. Increased rate of literacy	(+)	i. Increased fragmentation of land	(-)
	ii. Increased level of stream or river bed	(-)	ii. Reduced size of parcel of land	(-)
	iii. Nearby forest and grazing land converted into cropland	(-)	iii. Increased distance to a parcel of land	(-)
	iv. Grazing land (in Jiwanpur) was completely converted into fruit and vegetable farms	(-)		
	v. Increased size of farm through the conversion of marginal land	(-)		
	vi. Cattle replaced by buffalo keeping	(+)		
	vii. Decreased size of livestock holding with qualitative change in herd structure	(+)		
	viii. Increased area under vegetable cultivation	(+)		
	ix. Increasing trend of fodder fuelwood tree plantation on private land	(+)		
	x. Reduced volume of water in *'kuwa'*(well)	(-)		
	xi. Accumulation of assets due to increased income from vegetable farming (e.g., purchasing of land; *'khar'* roofing materials replaced by tin, buying more buffaloes while replacing cattle etc.)	(+)		
II. PRODUCTION FLOW	i. Increased level of cereal crop yields	(+)	i. Increased collecting time for fuelwood from common land	(-)
	ii. Increased level of vegetable production	(+)	ii. Decreased time allocation in water fetching due to increase in rate of piped water supply	(+)
	iii. Increased quantity of crop by-products (e.g., straws)	(+)	iii. Increased level of nutrition for human population	(+)
	iv. Increased level of fodder/fuelwood supply from private land	(+)	iv. Increased level of off-farm income	(+)
	v. Decreased quantity of fodder and other biomass supply from public or common land	(-)		
	vi. Reduced level of compost and manure application rate per unit of land	(-)		
	vii. Augmented intensity of chemical fertilizer application rate	(+)/(-)		
	viii. Increased intensity of disease and pest infection	(-)		
III. UTILISATION/ MANAGEMENT PRACTICE	i. Nearby small patches of forests are under control by the comunity to improve the degraded resources	(+)	i. Emerging trend of renewing improved seeds	(+)
	ii. Increased cropping intensity	(+)		
	iii. Increased intensity of stall-feeding practices	(+)		
	iv. Increased intensity of water utilisation practice (e.g., winter irrigation for vegetable farming is the present trend)	(+)		
	v. Emergence of use of agro-chemicals for storing grains	(+)		
	vi. Emergence of practising improved methods of compost making (10% of the total household is practising the method)	(+)		

Note: Negative sign of change (-) = leading to unsustainability. Positive sign of change (+) = leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g., resource base, production flow, and utilisation/management practice).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place over the last twenty/thirty years or so.

Table 6.4 Over Time Changes as Indicators Leading To Unsustainability/Sustainability of Mountain Agriculture (Livestock-dominated Farming System in Yelung)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of Changes
I. RESOURCE BASE	i. Increased literacy rate	(+)	i. Increased fragmentation of land	(-)
	ii. Increased trend of encroachment of forest pastureland for food production by converting them into cultivated land	(-)	ii. Reduced size of parcel of land	(-)
			iii. Increased distance to a parcel of land	(-)
	iii. Decreased trend of area under pastureland/meadows for grazing	(-)		
	iv. Reduced level of genetic diversity (e.g., some nutritious grasses in the pastureland are disappearing)	(-)		
	v. Abandonment of land due to low fertility, though on small and limited scale	(-)		
	vi. Decreased size of livestock holding without adequate qualitative change	(-)		
	vii. Decreased level of water in the streams of Yelung	(-)		
	viii. Emergence of sporadic over-grazing	(-)		
	ix. Change in herd structure by discarding goat together with *chauri* flock (perhaps it is an indicator of reduced level of biodiversity)	(-)		
II. PRODUCTION FLOW	i. Declining trend of crop yields	(-)	i. Increased collecting time for compost, fodder, and other biomass from forest/ pastureland	(-)
	ii. Fodder tree supply from common land slightly reduced	(-)		
	iii. Emergence of declining trend of compost and other biomass supply from common land	(-)	ii. Emergence of shifting labour use from livestock farming to foodgrain production	(-)
	iv. Increased demand for labour in foodgrain production without much increase	(-)	iii. Increased incomes from sideline activities	(+)
	v. No chemical fertilizer application	(+)		
	vi. Extensive use of local cultivars, even among the farmers who are practising improved cultivation to safeguard local resource-centred production patterns	(+)	iv. Increased foodgrain supply from outside (e.g., NFC, Jiri)	(-)
	vii. Exploiting local resources through quarrying	(+)		
	viii. Increasing (slightly) supply of milk from *chauri* due to DDC policy	(+)		
III. UTILISATION/ MANAGEMENT PRACTICE	i. Emergence of alpine pastureland/meadows under community management system	(+)	i. Still the majority of farmers (66%) harvest only the top portion (with grains) of the wheat stem while leaving the lower part for animal grazing	(+)
	ii. Increased use of water mills *('ghatta')* for grinding cereals releasing labour req. during peak period	(+)		
	iii. goats with *chauri* replaced by sole *chauri* keeping and thus reduced level of biodiversity	(-)	ii. Application of agro-chemicals (e.g., pesticides)	(+)
	iv. Open and haphazard grazing practice on pasturelands	(-)	iii. Increased rate of women's involvement in the decision-making process, particularly in *chauri* farming	(+)
	v. Compost making with pits during rainy season and without pits during winter season	(+)		

Note: Negative sign of change (-) = leading to unsustainability. Positive sign of change (+) = leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g. resource base, production flow, and utilisation/management practice).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place over the last twenty/thirty years or so.

The Crop-dominated Farming System at Dhuskun

Based on the widespread negative changes, the crop-dominated farming system study area appears to be the most critical area. The production flow (extraction rate) has been seriously affected, because the crop yields and biomass supply from the land are declining critically, and also because the resource base (endowment) itself has been gravely damaged and requires a considerably long time period to regenerate even if effective measures are taken immediately to relieve the pressure on land. Unlike the Yelung site, there is no land (e.g., marginal, forest grazing land) left for further cultivation. In addition, the cropping intensity is also the highest (172 %) in the area and this indicates the limited scope for further intensification of agricultural production. In some areas, stones/rocks have begun to surface on cultivated land since the supply of compost materials from both private and public land and manure from livestock have been greatly reduced compared to twenty or thirty years ago. Because of this seriously depleted condition of natural resources, the limited available area under forest is strictly forbidden for use. It is now under the control of the Government. Unlike in the Naubise area, the fodder supply from private land is very low and has resulted in a reduced size of livestock holding and thereby a decreased level of manure; an essential for crop production. To compensate, there is an emerging trend of chemical fertilizer application (33 kg /household). But on the supply side, fertilizer has always remained problematic. Moreover, the effectiveness of the fertilizer will be encouraging only when irrigation facilities with improved seeds are available and these too are lacking in the area.

During the field survey, some farmers had also reported that the average application rate of compost and farm-yard manure had increased because of the increase in stall-feeding practices. However, the majority of farmers were of the view that, owing to multiple factors (e.g., decreased quantity and quality of forest/pastureland, reduced size of livestock holding and increased cropping pattern), the average application rate of organic manure per unit of cropped area had decreased by 30 per cent over a time period of about three decades or so.

People have expressed their concern about the likely reduction in off-farm income due to the completion of the Bahrabise portion of the Arniko highway which has been generated substantial employment opportunity since the last few years. Another major source of income is from business. Therefore, the contribution of off-farm income to the total cash income is the highest (95 %), although the total amount is the lowest in this area compared to other study areas (Annex 4, Table 2).

Apparently, it appears that ethno-engineering seems to be in a more developed form in the Dhuskun area where stable terrace farming is very prominent. Some farmers have also cultivated land in different locations at varying altitudes (1,000 m to 3,000 m), giving an indication of the diverse nature of the farming system*. This also indicates the presence of intensive cultivation in the area, however it is with a low intensity of inputs. The average FYM/compost application rate per unit of cropped area, for instance, is the lowest (only 2.8 MT/ha) in Dhuskun whereas the figures for Naubise and Yelung are 4.0 MT and 4.7 MT respectively (Annex 3, Table 5). The resource base, particularly cultivated land, forests and pastureland, seems to be exhausted in this area and is evident from the fact that farmers have begun to use the *'banmara'* plant, which is considered to be of a very low quality, as roofing material and there is a severe scarcity of the traditional roofing material called *'khar'*. Hence, the technological and institutional measures have had several side effects that have adversely affected the sustainability of mountain agriculture (N.S. Jodha and S. Shrestha 1990).

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* One farmer (Mr. Dal Bahadur Basnet, Dhuskun) was found to have four plots; one (0.15 ha) at an altitude of 1,370m with paddy as the main crop because of low land, second (0.04 ha upland) with maize crops at 1,820m where nobody resides, a third plot (0.35 ha upland) with wheat crops at an elevation of 1,880m, and the fourth and last plot (0.25 ha upland) with maize crops at 2, 120m.

Tables 5.1, 5.2, and 5.3 also depict the weakest backward and forward linkages among different components of the farming system in this area. The crop-dominated farming system appears to be the most unsustainable among these three farming systems.

The Livestock - dominated Farming System at Yelung

The situation in the Yelung area is not an encouraging one either. Two elements, particularly of the sustainability matrix (e.g., production flow and resource base), have been affected by their degradation. Not only because of the declining trend of crop yields, but also as a result of population growth, the per capita foodgrain available is believed to have decreased. Therefore, more than one-third of the total foodgrain supply now comes from outside the farm, although there is no strong evidence to support this because of lack of data. However, it is believed that people in the area are now depending more and more on Nepal Food Corporation's supply of grains. At the same time, the rate of seasonal migration is also increasing.

Due to degradation of the forest resource base there is some reduction in biomass supply per unit of cropped area. This is also because of the increase over time in area under cultivated land, due to conversion of forest/pastureland into arable land. However, farmers have not used chemical fertilizers yet to compensate for this. Farmers are of the opinion that fertilizer application destroys the land quality in the long run. It may also be true that perhaps the opportunity cost for compost and FYM application is lower than that of fertilizer use. Moreover, chemical fertilizers are not easily available due to the remoteness.

Despite the fact that the interval between two "*Bukma* Systems" (Annex 9) has been shortened three to five years from the earlier six to seven years, the shifting cultivation method is still in widespread practice. The practice of extensive cultivation may also be the indication of not only the deteriorated condition of the farming system in the area, although it has been realised that the resource base itself is also under strain because the area under forest and alpine pastureland is steadily decreasing. Over time, the genetic biodiversity has reduced because of the fact that some nutritious grasses and fodder tree species are slowly disappearing. Goat keeping with *chauri* farming is vanishing. Biodiversity, which is an important element in the sustainability of mountain farming systems is dwindling and can ultimately lead to unsustainability. Some negative changes have also been noted in terms of water resources; the water mills *('ghatta')* used to be run almost throughout the year in the past, they now run for only 8-10 months. The present open and haphazard grazing practice on the alpine pasturelands and meadows will only lead to deterioration of the resource base, which has already begun. This is also because of public interventions after the resource base, was nationalised. However, the farmers have now begun to manage the pasturelands and meadows under a community management system which is a sign of the sustainability of the system.

Hitherto, the farming system is based on local resources and this is an indication of sustainability, particularly in remote areas like Yelung. The natural resource base (e.g., cultivated land, forest, and pastureland) is not so much degraded as it is in the Dhuskun area. However, some negative changes have been taking place and are leading to unsustainability unless public policies and programmes that are compatible to mountain characteristics are introduced as interventions.

Horticultural Crop-dominated Farming System

The farming system in Naubise has dramatically changed from a cereal crop to a horticultural crop-based system over the last few years. Fruit and vegetable farming is becoming increasingly popular in the area and is bringing several positive changes to the system, for example, an increased level of nutrition of the

people and accumulation of assets (buying more land for cultivation, purchasing improved animals). This is happening due to an increased level of major crop yields and fruit and vegetable production.

Despite the fact that forestry is one of the vital components of the general model of a farming system- it has collapsed to a large extent and the horticultural crop-dominated farming system has appeared as the most promising system among the three studied systems.

If the dependency on forests is the highest in Yelung then it is the lowest in Naubise. Almost all biomass required for crop production and livestock-keeping comes from private land (e.g., homestead, cultivated land). This has enabled farmers to practice stall-feeding to a large extent. The situation has, in fact, brought about some positive changes even in the herd structure. Farmers have begun to replace cattle by buffaloes which are productive animals. Due to the increased level of fodder production, the intensity of stall-feeding is very high. Even the fuelwood supply from the farm is now very substantial.

Similarly, some changes in production flow and utilisation/management practices have been noted. The increased application rate of chemical fertilizers and the increased use of agro-chemicals for storing grains are encouraging. This is the reason (external input supply) why intensive cultivation practices (e.g., multiple cropping) are becoming more and more feasible.

Keeping in mind the population pressure, intensive cultivation is considered necessary. But this option is debatable, particularly in mountain areas, due to its associated side effects. Nevertheless, this practice appears to be feasible for Naubise even for the future, as the supply side of inputs (e.g., improved seeds, fertilizers, agro-chemicals, and existing infrastructure of institutions and support services) appears to be guaranteed or sustainable, and because Naubise is not only accessible but also exposed to new agricultural technologies. Moreover, the largest and the greatest market (Kathmandu Valley) in Nepal is just about 30 km away from the study area.

Some negative changes, however, have also taken place over the time period. Forest and grazing land nearby have been converted into cultivated land. Fragmentation of land is increasing and thus the size of land parcels, mainly due to population pressure, has reduced. The volume of water in each *'kuwa'* (small well) has decreased. However, the changes in resource base are generally positive and encouraging (Table 6.3).

Despite the fact that the present farming system in Naubise has deviated from the traditional management practice to a large extent, the farmers are still adopting several strategies that have evolved through traditional practices (see Annex 8). The strategies of backward and forward linkages, risk hedging (e.g., integrated crop and livestock farming), biomass utilisation, diversification (e.g., cereal and horticultural crop production), and group efforts (emergence of forest resource management at community level) have helped bring the farming system to the present encouraging level. These strategies will be feasible, even in the future, to attain a sustainable farming system amidst increasing population pressure, provided that the new technologies and public interventions (e.g., institutional arrangements for resource management; seeking people's maximum involvement in resource management; pricing policy, which at present is favourable to vegetable farming, and provision of necessary agricultural support services) are compatible to mountain resource specificities and characteristics.

Elements Contributing to Unsustainability/Sustainability of Mountain Farming Systems

Elements Causing Unsustainability of a Farming System

The question arises as to what are the elements that contribute to negative and positive changes leading to unsustainability and sustainability of mountain farming systems? Based on the assessment of the three different types of farming system, four elements emerge as having caused unsustainability of the farming system, and they are - (i) high population pressure on land; (ii) inappropriate institutional interventions; (iii) lack of market integration; and (iv) breaking down of farmers' traditional strategies without the support of appropriate technologies and support services.

The population density per hectare of cultivated land is estimated at about 10 persons in Dhuskun (crop-dominated farming system) and seven persons in Naubise (horticultural crop-dominated farming system). Moreover, the quality of land is much lower in the former area compared to the latter. This indicates that there is high population pressure on the land in Dhuskun. This pressure induced farmers to opt for intensive cultivation (e.g., the cropping intensity of 172% is the highest among the three areas) without good market integration. Hence in the absence of necessary chemical fertilizer supplies and other inputs from the market (e.g., Naubise) for supplementing the reduced quantity of compost materials from the forest and manure from livestock, the productivity of land is low in Dhuskun.

Consequently, even stones/rocks have started to emerge on to the surface of cultivated land in some areas. Because of the lack of employment opportunities caused by the rapid increase in population growth, people have no other choice but land cultivation. Therefore, this high man:land ratio is contributing to the unsustainability of the mountain farming system.

The negative impact of inappropriate institutional interventions has already been discussed in earlier chapters; all forest/pasturelands available in the area are in an extremely degraded situation due to the lack of conservation and protection from the time the Government took over control from community ownership of the resources. Similar is the case of the water resource utilisation pattern, particularly in the context of irrigation systems. Farmers themselves used to form groups for constructing and using irrigation channels in the past, but this has stopped since the Government intervened. Similarly, biomass production and use, which is another form of farmer's traditional strategy, have started to break down. Trees on private land - *kharbari* (marginal land)- were also cut fearing that the Government might consider the land to be part of forest land.

As discussed earlier, lack of regular off-farm employment opportunities in Dhuskun, also forced farmers to use their land intensively. Major sources of 'sideline' activities, viz., construction works (road construction is over now), businesses (Nepal-Tibet border), are temporary and the income generated from them fluctuate every season and every year.

Having briefly discussed the elements contributing to the unsustainability of the farming system, it is relevant to note here that the presence of all or parts of the four elements can indicate the severity of the unsustainability. According to our assessment, all of these four major elements prevail in Dhuskun. This is the reason why the crop-dominated farming system appeared to be the most critical or unsustainable system. In the livestock-dominated farming system located in Yelung, elements (i) and (ii) prevail.

The horticultural crop-dominated farming system, which is considered to be sustainable, could be adversely affected by element (i) in the future, if necessary measures are not taken.

Tables 6.2, 6.3, and 6.4 depict that, along with the negative changes in various types of farming system, some positive changes have also taken place. This is particularly so in the case of Naubise where vegetable farming is widespread. Besides horticultural crops, cereal crops and livestock farming have also improved production and management systems. Productivity of land and livestock are increasing and have contributed towards better living standards, despite the fact that the population is on the increase. There are several factors behind these positive factors, however, and the major elements could be considered as -(i) availability and adoption of new agricultural technology; (ii) market integration; and (iii) biomass production and use on the farm. However, it is difficult to list these elements in order of merit. For instance, market integration has played such a vital role in Naubise that it could be the first major element for transformation of agriculture in the area.

In general, it can argued that the stronger the linkages among the three vital components (e.g., crops, livestock, and forestry) of a mountain farming system, the higher the sustainability of the system. Because of various mountain characteristics (e.g., inaccessibility, fragility, marginality, diversity, 'niche', and human adaptations), a closed system and a local resource-centred farming system have better chances of sustainability. However, the Naubise farming system seems to be heading towards one of these mountain farming systems and hence towards sustainability even though the linkage and contribution of one component, i.e. forestry, to the system is nil. Although the cropping intensity (165% at present) is ever increasing, loss of soil nutrients have not been noted. This is because of two factors: firstly, biomass production at farm level, and secondly, market integration. Farmers, have emphasised the cultivation of perennial crops (e.g., fodder, fuelwood tree plantation) on private land which has greatly substituted for the earlier loss of compost. Farmers have also significantly increased the rate of chemical fertilizer application to about 350 kg per hectare of cultivated land or 212 kg per hectare of cropped area. This situation has, in fact, greatly relieved the pressure on forest land. Consequently, the farmers have been able to protect almost all of the available 50 ha of forest land without use. In the initial phase of five or six years of protection, farmers tried to minimise the use of the forest, so that the forest as one of the vital components of the mountain farming system could be properly integrated. This endeavour could bolster the sustainability matrix in the future.

As soon as the Naubise farming system was integrated into the wider market economy of Kathmandu Valley, the farm management practice began to transform from subsistence to commercial farming. Table 5.2 indicates that there is stronger market integration in Naubise compared to Dhuskun (Table 5.1) and Yelung (Table 5.3). Farmers are now planning to go in for both winter and summer vegetable farming; hitherto winter vegetable cultivation after the main crop (e.g., paddy) was the practice. Because of this integration, farmers have already started to replace cattle with buffaloes ; farmers are buying more and more buffaloes with their increased income, derived mainly from the sale of fruit and vegetables. Because there is a very good market for milk in the valley and the area is accessible by road, milk can be marketed to the valley easily.

The availability of improved agricultural technology has played no less an important role in the area. Farmers now grow almost all cereal crops originating from HYVs. The improved method of compost making and the use of agro-chemicals to store grains have further improved the overall situation of the farming system. There are many farmers who are resorting to improved stoves, which has again contributed to the minimisation of fuelwood requirements; fuelwood is a very scarce commodity in the area. Installation of biogas plants has also played a significant role in saving energy originating from the forest and its by-products.

The strategy of biomass production and its use at farm level has also contributed to many positive changes in the area. Farmers apparently appear to have selected and cultivated even improved cereal crops by employing the strategy of backward-forward linkages in Naubise. It has already been recognised that the area enjoys the highest level of new agricultural technologies (in terms of improved crop cultivation and management practices). In addition, the higher level of main crop yields, the yields of crop by-products (e.g., dry fodder, compost, bedding and roofing materials) per hectare of cropped area is also the highest in the Naubise area (2,620 kg) followed by Dhuskun (2,130 kg), and Yelung (1,785 kg).