Assessing the Impact of Natural Resource Management for Sustaining the Mountain Farming System in Nepal

Kishore Sherchand
Nepal Agricultural Research Council, Khumaltar, Kathmandu, Nepal

Introduction

Agriculture as an art and science has the legacy of human civilization and is necessary for survival. During the course of civilization, other life supporting means such as clothing and shelter followed. Nepal's economy has also been connected with agricultural development. Nepal's share of agriculture commands nearly 39 percent of the Gross Domestic Products (GDP) employing over three-fourths of the active population. Agriculture in Nepal best survives on renewable resources — land, water, air — and those living on them and supporting agriculture. These resources are forest and pasture, livestock, biodiversity, nutrients, and foods and their ecosystems. They survive the interactive relationship in existence often in a symbiotic manner. The traditional agricultural system evolved when there was little or no intervention from the outside to sustain and support the human and animal activities. However, the present state of population growth and modernization gradually tilted towards the imbalance threatening the whole ecosystem. These resources at the same time are renewable and can be sustained if adequate management methods are used. Therefore, wise management of our resources has become the primary concern to sustain agricultural development. Figure 1 shows a typical existing flow of natural resources to sustain the farming system in the hills of Nepal.

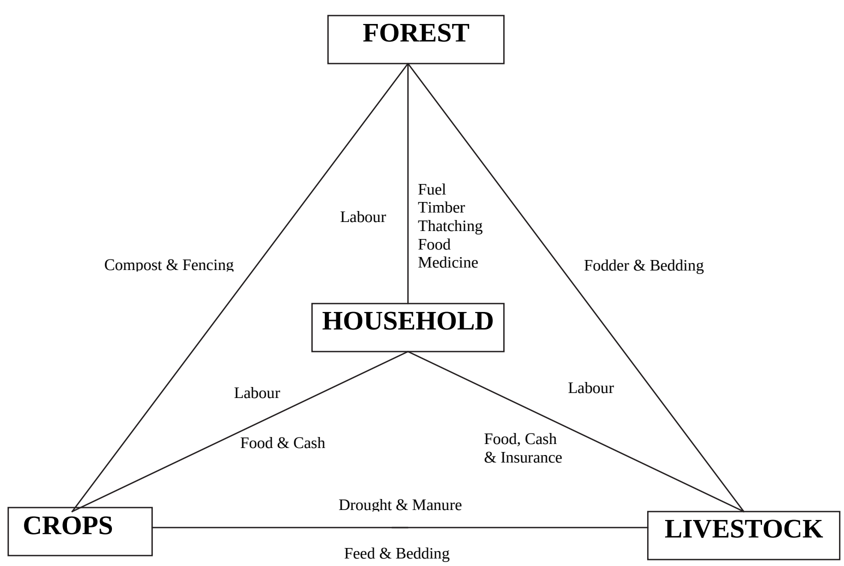

Figure 1. A simple diagram of flow of resources in the hill farming system of Nepal (Pound, et al., 1990)

Degradation Process

The human drive for acquiring more and the resulting inequity among societies has been accelerated by the process of modernization and globalization. Our natural resources are fast approaching being exhausted primarily for three reasons:

- Traditional or indigenous management of natural resource management are not practiced or less practiced or neglected.
- Unchecked population growth is threatening natural resources and is leading to their degradation.
- Globalization further increased the process of mining of various resources.

Land Degradation

Land is vital to agriculture and is embodied as the mother of agriculture. Due to the fragile geological environment of the Himalayan system, the land degradation process is active. Anthropogenic activities have been the primary factor for increasing the degradation process. The rainfall behavior during the monsoon has also increased the process of land degradation due to various water-induced erosion processes. The forest ecosystem has been facing a constant threat from being converted into shrubs then to agricultural land and other purposes. During the last 30 years, the forest of Nepal has declined 13.8 percent — from about 42 percent in 1978/79 to 29 percent in 1994/95 — of the total land use (Table 1). The loss of forest was estimated to be 1.3 percent in the Terai and 2.3 percent in the hills annually. In 1985, estimated soil losses from different land categories could be 5 tons per hectare (t/ha) to 200 t/ha (UNEP, 2001) shown in Table 2. It was estimated that annual loss of 5 t/ha of soil would lose about 75 kilograms (kg) carbon, 3.8 kg nitrogen (N), 10 kg potassium (K) and 5 kg phosphorus (MOPE, 2001). Similarly, the Ministry of Population and Environment (MOPE) estimates that there were about 10,000 ha of land under the process of desertification in parts of Nepal. The losses have not been reversed in a sustained way resulting in increased degradation, which might gradually be converted into marginal lands not suitable for farming.

Table 1. Percent of changes in land use and land cover in Nepal between 1978/79 and 1994/95.

Land use	1978/79 (%)	1985/86 (%)	1994/95 (%)	Percent of Change (1978/79 – 1994/95)
Agriculture				
a. Cultivated	16.5	20.0	20.2	3.7
b. Non-cultivated	10.3	6.5	6.7	-3.5
Pasture	11.9	11.9	12.0	0.1
Forest	42.8	37.7	29.0	-13.8
Shrub		4.7	10.6	
Others	18.5	19.3	21.5	3.0
Total	100.0	100.0	100.0	

Table 2. Estimates of soil erosion. Source: UNEP, 2001 adopted from CBS, 1998.

Land use	Soil erosion rate (t/ha/year)
Well managed forest land	5 – 10
Well managed paddy terraces	5 – 10
Well managed maize terraces	5 – 15
Poorly managed slopping terraces	20 – 100
Degraded range lands	40 – 200

Land degradation can also be explained in terms of nutrient exhaustion due to increased consumption by crops. The carrying capacity of the land to support agriculture has become more and more vulnerable. Joshy (1997) reported that every year 1.8 million tons of nutrients are taken up by crops and the nutrient replenishment by fertilizer amendments makes only 0.3 million tons (16 percent) thus creating a negative balance. Another study done by the Department of Agriculture (2000) indicated that out of 9,827 samples, 48.2 percent, 64 percent, and 35 percent samples were low in carbon, N, and K, respectively. It was further noted that the chemical fertilizers added to the soil were only the major nutrients such as nitrogen, phosphorus, and potash. Micronutrients such as zinc (Zn), boron (B), and molybdenum (Mo) are becoming more deficient, and the symptoms are more and more visible in sensitive crops like fruits and vegetables.

Water Degradation

Water quality is related to chemicals in the water used in agriculture, which can otherwise pollute water affecting human and animal health. Modern agriculture has advocated the use of these chemicals to improve productivity. The use of chemicals in agriculture is reported to be increasing in Nepal (Table 3). Chemicals are used as either fertilizers or pesticides. Nitrogen fertilizer can create nitrate pollution through leaching as well as surface run-off and can be harmful to drinking water causing “blue baby” disorder in humans and also, if in excess, to plant growth. Another important nutrient source is phosphorus which can build up in ponds and water reserves to create eutrophication, which creates unwanted growth of aquatic plants that can damage the environment and be harmful to human drinking supplies and fish cultivation. Additionally, chemicals used and produced in industries can also be potentially toxic to the plants and human and animal health. Industrial pollutants of heavy metals like mercury, cadmium, and lead, which get washed away into the soil can become toxic to the plants. Sulfur emissions from industries, which develop into acid rain, can also be harmful to the forest as well as agriculture. Similarly, studies indicate that arsenic-rich ground water systems cause arsenic-related diseases when consumed by humans. Moreover, arsenic intake through the food chain, particularly from rice grown with arsenic-contaminated irrigated water, would be alarming to the people of Nepal (Duxbury and Zavala, 2005). Water degradation can also be mapped when the source of irrigation water comes from lime- rich rock belts. A typical example can be cited from the water of the Seti River in the Pokhara Valley, which contains a high amount of free calcium carbonate. Using highly alkaline water that’s not suitable for crop cultivation can cause a cementing (binding) property in the plant root zone when irrigated thus restricting the root and shoot growth.

Table 3. Estimates of the use of chemicals.

Year	Pesticides imported/ sold* (a.i. tons)	Pesticide used in agriculture* (a.i. tons)	Fertilizer consumption** ('000 tons)	Nutrient consumption** ('000 tons)
1997	56.17	-	242.41	133.25
1998	77.86	77.86	307.07	169.66
1999	108.43	98.65	378.42	209.98
2000	196.07	176.00	430.47	239.10
2001	146.16	156.43	140.77***	78.18***
2002	177.59	141.88	174.38***	90.87***
2003	176.38	183.66	157.1***	87.5***

*Plant Protection Directorate 2003.
** includes both the official and cross border flow (ANZDEC, 2002).
*** includes only the official figure (A-BPSD, 2004).

The increased application of modern pesticides has also been the source of water pollution and once in the drinking water, there are harmful effects to human and animal health. The consumption of pesticides in accessible areas was found to be over 142 grams per hectare (g/ha) (Plant Protection Directorate, 2003). The use of pesticides is still not to that of a damaging level as in other countries, but the increased trend is alarming in areas where the cultivation of commercial crops has gained significant coverage (Table 3). Crops such as vegetables, fruits, tea, sugarcane, and other commercial crops have been the major commodities that use pesticides.

Air Degradation

Air degradation is also closely linked with the modern developmental process conducted by anthropogenic activities. It is also the process resulting in the climate change and global warming that are not widely discussed in public forums in Nepal. It is the ever-increasing concentration of greenhouse gases (GHGs) such as CO_2, methane, N_2O, SO_x, and hydroflurocarbons made by human activities in which some are beneficial and some are harmful. However, all are contributing to global warming resulting in shifting plant and animal habitats, species destruction, and even threatening the survival of the agriculture system.

Among the GHGs, carbon dioxide can lead to an increase in biomass production of several agricultural crops, particularly C3 species, but at the same time can increase the atmospheric temperature. According to the World Meteorological Organization (WMO)/ United Nations Environment Programme (UNEP) Intergovernmental Panel on Climate Change (IPCC) predictions, the global temperature could increase from 1.5 to 4.5 ^{0}C by the end of the 21st century. This increase in temperature will likely cause biomass destruction or unbalancing the source-sink relationship.

Our model-based studies have shown that the C4 plant species are more affected by the climate change process due to the temperature rise (DHM and MOPE, 2004). The other GHGs that could be potentially harmful to human and animal health and to plant species are methane, nitrous oxides, and hydroflurocarbons that also cause damage to the ozone layer. Similarly, the contamination of air due to the industrial sulfur emissions causing acid rain might impact biomass destruction. Furthermore, the climate change process has become a contributing factor in causing extreme events like floods, droughts, and cold waves detrimental to agriculture. One can only imagine what the consequences would be for natural eco-systems and on the socio-economic well-being of human societies. At this stage, Nepal is certainly not a contributor to the global warming but suffers from its consequences. The more temperature-sensitive highland livestock, such as yaks and mountain goats, will likely have their habitat threatened due to global warming. However, due to the modernization process there have been changes in the livestock-based socio-economic activities of local peoples and this will impair the associated economic prosperity, but has not yet been well studied.

The national study conducted by DHM and MOPE (2004) indicated that the total methane emission for 1994 from domestic livestock enteric fermentation was estimated to be about 528 Gg (61 percent of the total) as shown in Figure 2. Non-diary cattle contribute 280 Gg or 53 percent of the total emission from livestock enteric fermentation while buffalos contribute 32 percent. Secondly, the total methane emission from paddy fields in 1994 was estimated to be 306 Gg or about 35 percent of the total methane emission from the agricultural sector. Irrigated rice is the major source of methane emission in rice cultivation. The rice area under different water regimes is given in Table 4. Thirdly, emissions from domestic livestock manure management are estimated to be 34 Gg (4 percent of the total). Dairy cattle contribute 15 Gg (44 percent of the total); non-dairy cattle 26 percent, buffalo 21 percent, and swine 1 percent.

Nitrous oxide emissions are primarily due to the use of fertilizers, which include synthetic nitrogen fertilizers, synthetic multi-nutrient fertilizers, and organic fertilizers. Total nitrous oxide emissions from agricultural soil management system in Nepal are about 27 Gg. Included among the various processes are the indirect nitrous oxide emission from grazing animals, pasture and paddock (41 percent), direct from agriculture fields (31 percent), and indirect from atmospheric deposition NO_x and leaching of NH_3 (28 percent) (Figure 3; DHM and MOPE, 2004).

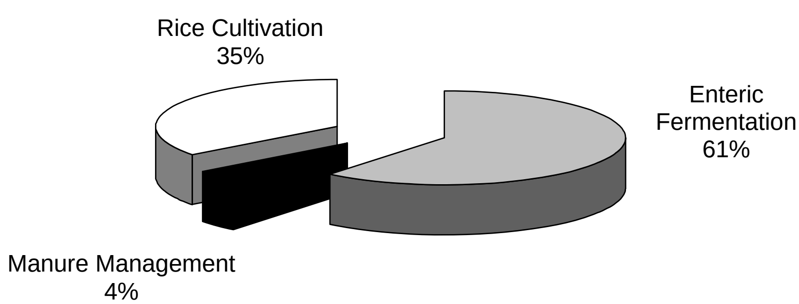

Figure 2. Methane emission from different agricultural activities for 1994.
Source: DHM and MOPE, 2004

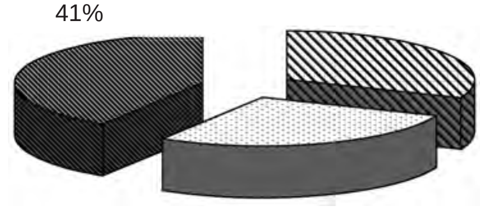

Figure 3. N_2O emission from agricultural management in 1994. Source: DHM and MOPE, 2004.

Table 4. Area and percentage under different irrigation regimes.

Water management regime	Harvested area (m^2 x 10^{-9})	Percent of total area
Irrigated continuously flooded	3.1474	24
Rainfed flood prone	1.0947	8
Rainfed drought prone	9.0316	68

Source: DHM and MOPE, 2004.

Biological Diversity Degradation

In the past century, the reduction of biological diversity had been the course for the developed countries that were able to obtain the maximum genetic gain for commercial venture but by decreasing their own resources. The modern farming system focused on the exploitation of hybrid technology, a strong business sector in agriculture. They then searched in the developing world where the value of genetic diversity was little recognized or little exploited. A few countries like China, India, Brazil, and Mexico voiced their strong protest to make necessary provisions in international forums to protect rights of genetic resources at the area of origin and benefited by sharing with the local and indigenous people.

At the Earth Summit, the first of these formal commitments was the signing of the Convention on Biological Diversity (CBD). The genetic exploitation and reduction in the areas of origin began increasing. In the face of globalization and the development process, there is starting to be a reduction of biodiversity in Nepal also. Many of the original Nepalese rice varieties are vanishing and completely out of the reach from our farmers. Many aromatic local rice varieties are on the verge of extinction. Wheat varieties have been completely replaced by the imported modern varieties in the name of progress. Pure local maize cultivars are difficult to find even in the remotest areas due to the competition between the local and introduced cultivars. Many local potato cultivars are difficult to name and can only be recalled by elderly people. Most of these cultivars are now found only in the gene or seed bank thorough “ex-situ” conservation. We even failed to utilize them in our breeding efforts by recognizing their valuable attributes. Almost 26 livestock species are said to be on the verge of extinction or listed as endangered.

Nepal is a signatory to the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES); there are at least 129 species of plants and animal species in Nepal listed in the various categories of CITES Appendices (Table 5). Similarly, the International Union for Conservation of Nature **(**IUCN) lists at least 120 plants and animal species in different threatened categories (Table 5).

Table 5. Threatened plant and animal species of Nepal.

Species	CITES				IUCN red list							
	I	II	III	Total	Ex	E	V	R	I	K	T	Total
V. Plants	1	8	6	15	1	12	11	22	2	5	7	60
Mammals	29	7	22	58		8	10		4	5	1	28
Birds	16	9	15	40		6	6	4	3	3		22
Reptiles	7	4	2	13		1	2	1	4			8
Amphibians		1		1								
Insects		2		2			1	1				2
Totals	53	31	45	129	1	27	30	28	13	13	8	120

Source: MoFSC 2002; Joshi, et al., 2003.

Productivity Degradation

Agriculture has survived the legacy of various historical processes and continues to produce more and more. On the global scale, it is claimed that food production has been successful in meeting the growing population of the world. In the case of Nepal also, some statistics show a trend of productivity gain in most of the crops but at what cost? The green revolution added a few kilograms of grain yields per hectare but at what cost? Modern agriculture added more amounts of fertilizer to get more outputs but at what cost? We added more amounts of pesticides not thinking of what its environmental consequences would result in but at what cost? We ignored the eco-system balance between all living entities. We kept on ignoring these issues to the detriment of our future generations. We tried to move away from nature to obtain short-term benefits at the cost of a sustainable developmental paradigm.

Several studies also support the fact that there has been a gradual decline of productive capacity of our soils (Sherchand, 2004; A-BPSD, 2004; and Sherchand, 2001). In some cases, the soil and nutrient exhaustion is so acute that many crops are not thriving for the lack of balanced use of fertilizers. The productivity degradation can also be mapped by showing the existing gap between what we have and what it ought to be; between what it is and what its potential would be. The model evaluation figures out that those yield gaps are not showing signs of significant improvement (Table 6).

Table 6. Yield Gaps (t/ha) between potential, attainable, and national of Nepal.

Crop	Potential*	Attainable**	National***
Rice	10.0	7.0	2.68
Maize (OPV)	7.0	5.0	1.88
Wheat	6.0	4.0	2.01

Source: *Sherchand, 2004; ** National rice, maize and wheat programs; and *** A-BPSD, 2004.

Classical experimental evidence derived from long-term rice-wheat production shows that the nutrient depletion from our agriculture system doesn't support the sustainability of our cropping system. Figure 4 shows that the rice yield continued to decline from 5 t/ha to 1 t/ha when soils are not replenished adequately and some other macro- and micro-nutrients were exhausted affecting the productive capacity of our soils (Regmi, et al., 2004).

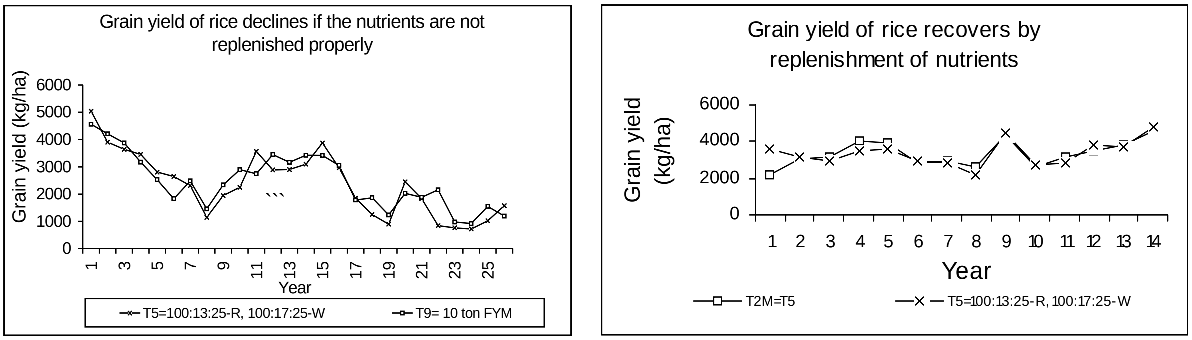

Figure 4. Yield declines over years if nutrients are not properly replenished (Regmi, et al., 2004).

Social and Cultural Degradation

The institutions of social and cultural assets have remained as the custodian of natural resources and their management. Those institutions evolved through the legacy of preserving indigenous and traditional ecological knowledge systems to integrate them into the rural economy. Those institutions served as the key players, regulating when needed, and continuing to meet the local needs. They knew better than any other entities when to integrate land, water, forest, grassland, and livestock supporting the agriculture system.

In parts of the country, the locally adopted electoral systems (the local administrative institution) have played the central role in the decision-making process in natural resource management. The indigenous systems still play customary roles, although the state-owned local institutions are in place. They hold the respect of communal philosophy based on the social and cultural values and deserve a deciding role in managing natural resources. It is ironic that those state-run institutions are kept in the shadows of the indigenous institutions. Those indigenous authorities are respectfully elected from the people whereas, the state-controlled institutions are politically flawed and do not recognize just, moral, and ethical values. However, in the domination of state local administration, those traditional institutions started gradually breaking away.

The forest, soil, and water management, for instance, were more efficient in the hands of those indigenous and customary institutions. When the forest was nationalized in the early 1960s, the local people were simply ignored. The forest resources underwent a rapid degradation process in the hand of government authorities. Later the government was forced to introduce a community and participatory forest-management system, derived from indigenous forest management. In this sense, the community-based farming system has a legacy as opposed to the modern institutions particularly in the more mountainous areas. The gradual shift from family to corporate-based farming systems has been the characteristic of the modern development process and can be a detriment to social and cultural cohesions.

Livestock

Livestock contributes currently 31 percent of the Agricultural GDP and the Nepalese Agriculture Perspective Plan (APP) envisages increasing this to 45 percent with an accelerated growth rate from 2.9 to 6.1 percent at the end of the planned period. Nearly 12 percent of the total land area (147181 km2) is available for livestock grazing in the country (A-BPSD 2001). The livestock development plan however is based on the parallel growth of the crop sector, market demand, lifestyle change, and private sector investment.

The country has experienced an unbalanced pressure on the grazing lands due to the increased number of unproductive livestock population. A strong imbalance exists between livestock population and grazing land. The alpine region, which has 63.8 percent grazing land, has only 13.4 percent of the livestock population. The sub-tropical belt, which has 34.4 percent of the livestock, has 22.5 percent grazing land (Table 7); but the sub-temperate region has 42.2 percent if the livestock but only 13.7 percent of the grazing land. The balance should come either from crop residues, concentrates or forest resources. The crop residues do not meet the requirement, and it is mostly limited to commercial stall-feeding. This in turn puts pressure on the forest. This would again force the farmers to exploit more forest and upset carbon sequestration. And the current stocking density is exceeding the carrying capacity except in the alpine region (Table 8). The grazing of livestock has exerted intense pressure in the mid-hills and the open grasslands.

Table 7. Livestock and grazing land distribution by ecological region. Source: A-BPSD 2001.

Ecological Region	Livestock Percent	Grazing Land Percent
Sub-tropical	34.38	22.5
Semi-temperate	52.22	13.7
Alpine	13.40	63.8
Total	100.00	100.00

Table 8. Stocking density by rangeland. Source: Third Livestock Development Project 2002.

Range land type	Carrying Capacity LU/ha	Stocking Density LU/ha
Mid-Hills	0.31	4.08
Steppe grasslands	0.01	0.19
Open grasslands	0.54	7.07
Alpine meadows	1.42	0.64

Climate

The monsoon is the most dominant climatic event in Nepal, which has a direct relationship with the rice production system. The productivity of rice directly depends on the monsoon both spatially as well as temporally. Nearly two-thirds of the total land is rain-fed or partially irrigated. Thus agriculture is largely determined by the weather conditions. The production of rice, for instance, increased more than expected in 2000, which was largely attributed to favorable weather conditions. On the other hand, the 2002 monsoon created a high uncertainty with nearly 40,000 ha of rice under water due to floods in the eastern areas of Terai, and 20,000 ha under drought in the western Terai. The variability of the onset of the monsoon in the central part of Nepal which determines the rice planting is given in Figure 5.

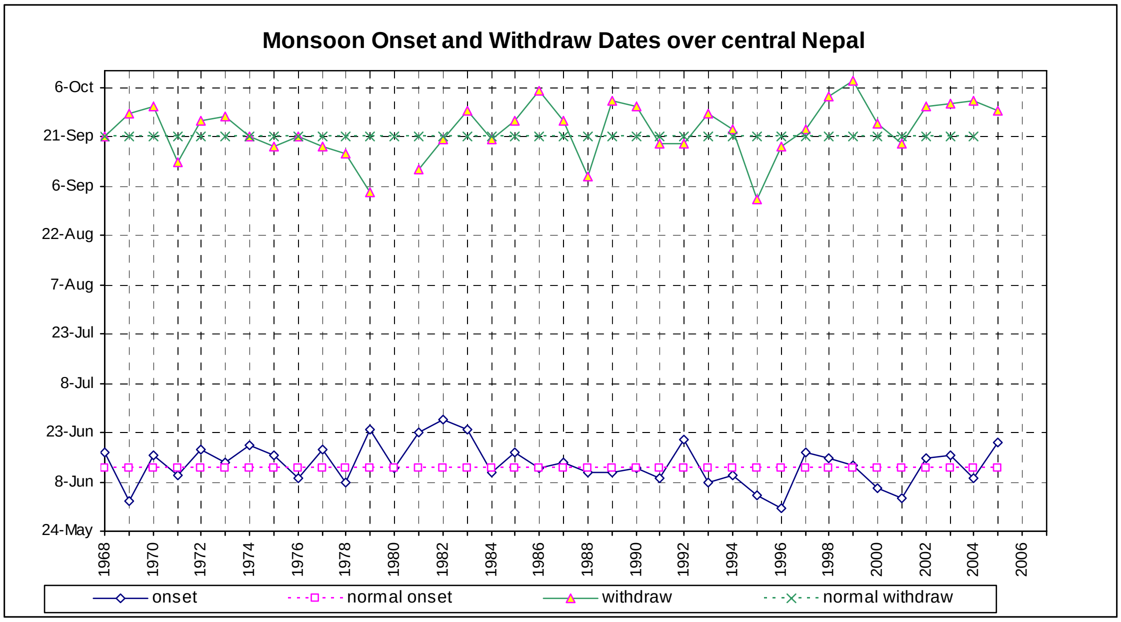

Figure 5. On-set of monsoon variability. Source: DHM, 2005.

The erratic climatic behavior commonly known now as cold wave is being experienced in the country causing damage to human and animal lives and winter crops. In the 1997/98 winter, the Indo-Gangetic plain including part of Terai experienced severe overcast skies. The temperature dropped to a minimum level and winter crops especially potato, oilseeds, pulses, tomato, onion, etc., were affected. The potato yield dropped by at least 28 percent, mustard (*Brassica campestris* var. toria) by 37 percent, sarson (*Brassica campestris* var. sarson) by 11 percent, rayo (*Brassica juncea*) by 30 percent, lentils by 38 percent, and chickpeas by 38 percent (Table 9). The severe market shortage caused the price hike of these crops to reach very high levels. This prompted the farmers to change the cropping pattern the following year.

Managing the Resources

The peoples' concern in managing our own natural resources is considered vital. However, the problem pivots on how to retain the balance between consumption and conservation. It is ironic that the much discussed Nepalese APP has failed to address natural resources management and land use policy in the broader context. Resource exploitation has been the prime commercial objective in reviewing or protecting the fragile mountain ecosystem. The proportional relationship among land, water, forests, and their supporting and dependent entities is kept silent in the name of commercial exploitation.

There are differences in how Nepalese farmers manage to recycle farm resources compared to how farmers in developed countries manage them. We use a crop-residue-livestock system and give back to the land in a cyclic manner. This works so long as the livestock population remains as a stable fixture of the farm household economy. On the other hand, in the commercial agriculture of developed countries, farmers recycle by leaving a major portion of crop stubble and residues in the field and allowing them to decompose before the next crop season. Regretfully, our scientists and development workers fail to teach this and provide a balanced use of nutrient sources to our stressed farmers. The farmers are even more stressed and unable to bear the risks due to the compounding effects of social, cultural, and economic taboos.

Table 9. Impact of cold wave on winter crop yields estimated in the Terai of Nepal, 1997/98.

Year	Potato (t/ha)	Mustard (kg/ha)	Sarson (kg/ha)	Rayo (kg/ha)	Lentil (kg/ha)	Chickpea (kg/ha)
1987/88				960	539	1320
1988/89		703	563	728		
1989/90	25.54		503	844	819	709
1990/91	19.72	570			912	
1991/92	22.28	949				
1992/93	17.36					
1993/94	22.13	712	785	601		1044
1994/95	23.76	718	524	548		
1995/96	17.21	760	636	565		
1996/97	22.63	815	803	887	959	922
Mean	21.33	747	569	733	807	999
1997/98	15.39	474	505	513	504	619
% Reduction	27.8	36.5	11.2	30.0	37.6	38.0

Source: Sherchand, 2001.

The natural water resources are still abundantly available and mostly untapped. Nepal, except in a few areas, has an annual average rainfall of 1,450 millimeters (mm) which is considered theoretically enough for growing major crops. Yet, an uneven distribution of rainfall and its erratic behavior is compounded by global climate change causing flooding on one hand and drought on the other. This surely demands a careful management of water resources. Rain-fed agriculture still dominates the production capacity of the land. According to the Nepalese Irrigation Department, about 40 percent of the total land has irrigation structures but year- round irrigation is still rather distant. To acquire sound irrigation systems or to avert the process of water scarcity, four options could be considered: expansion of surface irrigation; exploitation of ground water; rainwater harvest; and the improvement of water use efficiency though proper on-farm water management. The new and emerging on-farm water management has sent an encouraging message to the benefit of agriculture which would complement the efforts of our water-structure engineers.

There are at least 132,000 biogas plants in Nepal, which have a potential of producing 760,000 tons of slurry annually. This could be used to manure 76,000 ha of cropland. The nutrient content of slurry has been proven to be qualitatively better and yielding by an average of 10-15 percent more than the normal farmyard manure (Karki, 2002). However, the use of slurry in farm production has not gained momentum for its lack of proper knowledge among the farmers.

Nepal also houses a large number of unproductive domestic animals, which are also responsible for emitting methane gas without offering much to the national economy. The methane emission in Nepal is estimated to be 100 grams per kilogram of milk production compared to less than 25 grams in the developed countries (Stem, et al., 1995). Those unproductive animals should be gradually curtailed to reduce the environmental risks.

Indigenous and Local Ways of Resource Management

The legacy of natural resource management in agriculture continues with prevailing farming systems. The performance of natural resource management that uses the local resources became more prominent in the mountains and hills through various institutions linked by a notion of "commons," which are owned by the local community as a whole. The resources ranging from land, water, forest, pasture, even labor and capital are the key constituents that remain under the functionaries of local institutions. A few noteworthy examples include the following: terracing and bunding, rain water harvesting for rice transplanting, protection from erosion, rotational grazing, rotational irrigation, ridge planting of fodder trees and their nutrition, evaluation of land quality, seasonal herding of highland animals, compost making, and use of local plant species to reduce the attack of pests. Similarly, rotational farming, particularly in the eastern Himalaya and the hills of Nepal, is often left unrecognized by state authorities since it is believed to be unsustainable farming, yet it has the strong legacy among indigenous people. However, there is now an increased sense of revitalization of its importance in sustaining the natural resource management through the built-in community cohesion (IAITPTF, 2002, and Kerkhoff, 2004).

Gill (1993) who fears the damage of ignoring the indigenous systems has suggested that it be seen as having both strengths and weaknesses since it has evolved and lived for generations in sustaining their livelihoods. To keep the rural economy going forward, indigenous people use their own human and social capital, labor, and draft animal management through an exchange popularly known by "*perma*," which has become highly recognized. Furthermore, in order to fulfill their own basic needs, the Nepalese exchanged grains and services, which later developed into a mode of financial capital formation. This sort of capital formation is popularly known as "*dhikuri*" and has spread not only in the rural but also in the urban economy. There has also been the debatable notion that rural people in Nepal have evolved the theory of "tragedy of commons," which assumes that common ownership always facilitates the degradation of resources. On the contrary, few ecological and social scientists have contradicted this as opposed to the commercial exploitation and the view that the corporate institution matters more than the common ownership which causes degradation (Fisher, 1992).

Emerging Technologies

Emerging resource conservation technologies developed by our scientists in Nepal and elsewhere have been tested in research centers and are in the stage of being validated in farmers' fields through a participatory extension approach. Among the noteworthy technologies are zero tillage in wheat and other crops, surface seeding in wheat, and bed planting in rice and wheat. These technologies have proven to be cost-effective and efficient in the use of scarcely available water and for carbon sequestration; they also cause minimum water and wind erosion damage, etc. Currently, rice and wheat area under zero or reduced tillage exceed 2.5 million ha in South Asia, and claims are being made that it's reducing costs by 40 percent and water usage by 30-60 percent. Bed planting also covers about 1,000 ha in India and Pakistan but significantly less in Nepal. Surface seeding of wheat in high-moisture lowlands has proven to be allowing timely planting of wheat and compensating the loss of wheat yield. All of these technologies have the additional advantage of saving time as compared to conventional methods, which becomes important under tight cropping practices. Table 10 shows the comparative advantages of these newer technologies over the traditional practices.

Table 10. Advantages of frontier technologies in crop production.

Technology	Area in Nepal (ha)	Crop	Cost saving %	Water saving %	Time saving %
Surface seeding		Wheat	100	60-100	80
Zero tillage	50	wheat, lentil	40	30-60	80
Bed planting	10	Wheat	0	30-60	10
Two-wheeled tractor rotator	early stage	wheat, rice lentil, mustard	30-40	10-20	40
Two-wheeled tractor reduced till drill	early stage	wheat, rice lentil, mustard	60	20-30	70

Source: NARC and Justice, 2004.

The Global Voice

In the process of globalization, competitiveness prevails as the deciding factor. Competitiveness causes exploitation and the selling of user’s rights related to the intellectual properties. In such situations, some are winners and some are losers leading to the uneven distribution of wealth and resources. Social and cultural values and mutual respect are not recognized but rather invites overexploitation leading to exhaustion. On one hand, this offers an opening to trade our resources in the international markets, but on the other, it will likely eliminate the rights of our farmers and the indigenous peoples who had been conserving these resources and associated knowledge. This is why it is particularly important to maintain biodiversity, which the farming and indigenous communities have been doing through the centuries.

The provision of intellectual property rights at the cost of the traditional community does not seem to be in conformity with the people’s aspirations. Although the international conventions like the Convention for Biological Diversity (CBD) has provision for the recognition of indigenous knowledge, ownership, and benefit sharing, and even offers an alternate way of defining the “*sui generis*” system, and subsequently the FAO’s “farmers right;” we have yet to see something worked out by the state for meeting the people’s perspectives in Nepal. This is still a dream due to the lack of legal provision and necessary ground work at the national and local levels. Furthermore, the provisions made in the Kyoto Protocol for Clean Development Mechanisms (CDM) that could be achieved through afforestation and reforestation, do not really seem to be in conformity with the CBD to protect the biological diversity and benefit sharing (Sherchand, 2002).

Competition on the one hand provides an occasion to use more chemical based inputs, but on the other, there is also a need to produce environmentally healthy foods. Globalization and economic prosperity have become a major force in determining which type of food society needs. In due course, the market-induced commercial agriculture has been gradually taking shape, often undermining the subsistence or nature-based agricultural system. Commercial agriculture promotes the use of chemicals to boost more production. Similarly, the genetically modified seeds have provoked the environment with an unfriendly production system ignoring the human and natural survival relationship. Despite all of this, there has also been an increased demand in natural-based products such as chemical-free fruits, vegetables, orthodox tea and coffee, and honey, etc. But the success and expansion of these products have not been as wide as their production, consumption, and marketing; and they depend on the consumers' choice in consonance with their economic status and awareness. At the growing level of import-export demand, Nepal has to face the non-tariff barriers in agriculture such as technical, sanitary, and phyto-sanitary in pursuance of the global trade regimes. To promote and comply with the international trade-related treaties, the state should be prepared to put the regulatory mechanisms in place, promote public awareness, and promote technical and institutional support.

Natural farming in the present context of environmental management in agriculture has been a rising voice in urban and more elite sectors of the society. Many innovative ideas are emerging such as permaculture, effective microorganism (EM) technology, vermiculture, organic or natural farming, ecological farming, and model bio-villages, etc. Those technologies have their own constraints and are confined to a limited area but could not become widespread, regardless of our discussion of the benefits. Definitely, these technologies could pave a pathway among the small-scale but more innovative farmers.

Population and Food Provision

Food security can perhaps be more appropriately defined in terms of food provision in the context of the globalization process, or the access to and availability of food. This demands not only adequate production but also the improved economic gain to buy food. Ironically, for a country like Nepal, the greatest challenge is managing the provision of food and population. According to a medium-population growth rate, Nepal's population will likely double in the next 30-35 years; if food demand remained at a modest level that would mean about 15 million tons. The current food production level is almost in balance with the needs of the population. However, the food needs of the population will not be met if there is some natural, economic, or political crisis. If this remains the national picture, Nepal will ultimately become a food importing country. Table 11 clearly indicates that there have been either decreased or stagnant trends of food production in response to the increased population growth. As a result, highland-to-lowland and rural-to-urban migration for off-farm economic activities have become a compelling factor. Furthermore, it is increasingly evident that the younger generation is moving out of or not going into farming as a profession, leaving the aged, women, and children as a major source of farm employment.

Table 11. Population and per capita production (kg) of foods.

Year	Population (million)	Rice	Maize	Wheat	Potato	Oilseeds	Pulses	Total
1961	9.41	224	90	15	n.a.	n.a.	n.a.	328
1971	11.56	203	66	19	25	4.9	n.a.	318
1981	15.02	170	50	35	21	5.3	8.8	291
1991	18.49	174	65	42	40	4.8	8.4	334
2001	23.15	180	65	54	64	5.8	10.8	338

Source: ASD, 1990 & A-BPSD, 2004.

The complementarities and renewed relationships between agriculture, forest, and livestock managed by the farmers should not be allowed to turn into a desperate situation. A healthy agriculture system demands to be revitalized and relationships reasserted. There should be a win-win situation between conserving resources and boosting agriculture production. This should therefore remain the case for sustainable agriculture development.

Author E-mail Contact: ksherchand@yahoo.com

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