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*Pradeep M. Tulachan*

# Mountain Agriculture in the Hindu Kush–Himalaya

## A Regional Comparative Analysis





*In order to better understand the state of mountain agriculture, this article analyzes trends for 3 integral components of mountain farming systems—production of foodgrain crops, horticultural and cash crops, and livestock—using time series data published by national governments in 5 Hindu Kush-Himalayan (HKH) countries. Results show that, although the area under foodgrain crops has not increased, their yields have not declined as much as is often perceived. In some cases, crop productivity has increased. This evidently implies that mountain farmers are maintaining productivity of foodgrain crops for food security reasons. Results also suggest increasing trends in crop diversification toward horticultural and cash crops. Present trends in rapid expansion of areas under these crops indicate the growing importance of horticultural and cash crops in mountain farming systems and the household economy across the Hindu Kush-Himalaya. These trends have positive implications for the future development of mountain agriculture in terms of harnessing mountain niches and comparative advantages. In the livestock sector, there is a general decline in the cattle population across the HKH. Trends indicate the possibility of greater development of smallholder dairies with improved buffaloes in the Himalayan subtropics. The number of stall-fed buffaloes and goats is rising with increased use of external inputs and purchased feed, thus contributing positively to food security and nutrition in mountain households.*

***Keywords:*** *Farming systems; comparative economic analysis; foodgrain; horticulture; livestock; Hindu Kush; Himalaya.*

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## Background

The majority of mountain households in the Hindu Kush–Himalayas (HKH) operate mixed crop–livestock farming systems. Production of foodgrain crops, horticultural and cash crops, and livestock are 3 integral components of mountain farming households. Changes have been taking place over the years with respect to cropland use, land resource allocation, production and productivity of cereal foodgrain crops, horticultural crops, and livestock structure and composition. A better understanding of these changes can have important implications for development of sustainable mountain agriculture.

The International Centre for Integrated Mountain Development (ICIMOD) has long perceived the need for an empirical database on mountain agriculture to identify long-term trends and their implications. According to Jodha et al (1992), efforts to put together an empirical picture of existing conditions in mountain agriculture, changes over time, and the various policies and aspects contributing to long-term sustainability have only recently been initiated. Due to lack of empirically analyzed data, earlier efforts to assess the state of mountain agriculture based on microlevel case studies made in some areas, relating to a particular period of time and covering a negligible part of the vast HKH region, were often not well received. Singh (1992) states that "broad generalizations based on the conclusions drawn from this limited number of micro-level studies in a few areas become tentative unless supported by facts at the macro-level." Following his thorough review and analysis of past work on mountain farming systems at ICIMOD, Rhoades (1997) noted the absence of an empirical database to analyze the state of mountain agriculture, and he recommended creation of a systematic database on mountain agriculture.

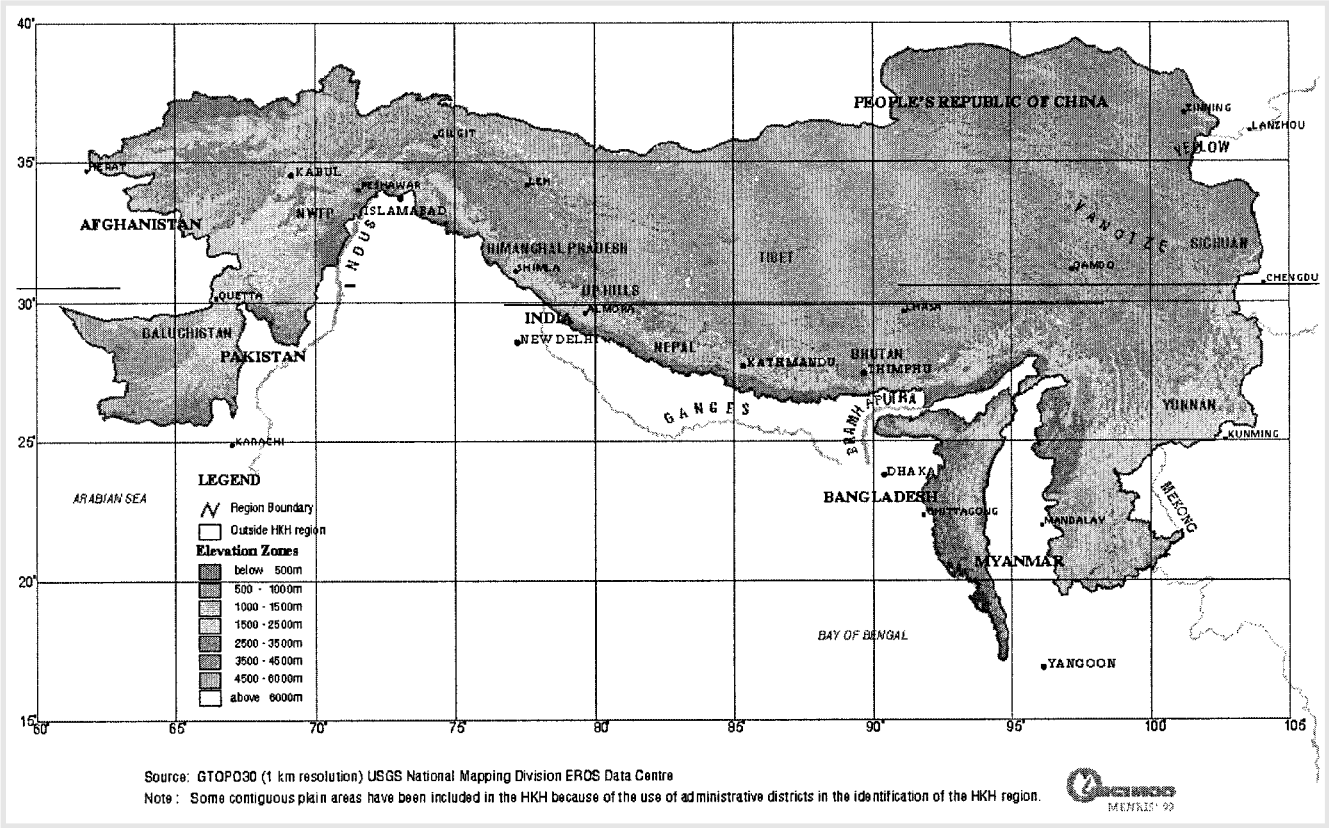
Given this background, ICIMOD initiated an attempt to create a systematic agricultural systems database in 1997, focusing on biophysical and socioeconomic data. Data sources included national government statistics, project reports, consultant reports, case studies, and gray literature. For this purpose, a user-friendly computer framework was designed for systematic storing and easy retrieval of information. This file is called Mountain Agricultural Systems and Societies Information File (MASSIF).

The present article is based on data from this information file and shows how these data can be used in analysis of problems, issues, and trends in the HKH. Its purpose is to examine general trends in mountain agriculture in terms of cropland use changes, changes in crop production and productivity, and changes in livestock population and composition in the HKH over the past 10–15 years. It covers selective provinces, states, and regions in 5 HKH countries (Bhutan, China, India, Nepal, and Pakistan). Analysis provides an interregional perspective on mountain agriculture/farming systems across the HKH and their implications.

## Methodology

The study involved careful review and analysis of data and information from secondary sources. Data from different time periods over the past 10–15 years were obtained from government agricultural statistics for selected mountainous provinces, states, and regions in

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Source: GTOPO30 (1 km resolution) USGS National Mapping Division EROS Data Centre
Note : Some contiguous plain areas have been included in the HKH because of the use of administrative districts in the identification of the HKH region.

**FIGURE 1** The Hindu Kush–Himalaya region: provinces, states, and regions selected for the study. (Map courtesy of ICIMOD)

5 HKH countries. The time series data and data sources are computerized in MASSIF at ICIMOD and can be made available upon request. Study areas as shown in Figure 1 include Baluchistan and the North-West Frontier Province (NWFP) in Pakistan; Himachal Pradesh and UP Hills in India; Tibet, Yunnan, and Sichuan in China; and high- and mid-mountain regions in Nepal. Bhutan is taken into account as a whole. Time series data are analyzed using the econometric tool below (Equations 1 and 2) to estimate annual growth rates for cereal foodgrain crops as well as horticultural and cash crops. For livestock data and wherever time series data were not available, simple analysis is carried out in terms of percentage changes between the beginning and end of a time period.

Annual growth rate is calculated by using semilog transformation:

$$y + ab^t \text{ and } \quad b = 1 + g, \tag{1}$$

where $y$ = production = area = yield; $t$ = year; $g$ = annual growth rate.

The estimating equation is

$$1\ ny = 1\ na + t\ 1\ nb \text{ or } \quad y\sim = a\sim + b\sim, \tag{2}$$

where $y\sim$ = log $y$, a~ = log $a$, $b\sim$ = log $b$. Regression yield estimates of $a\sim$ and $b\sim$ are $b\sim$ = antilog $b\sim\sim$^ and $g\sim = b\sim\sim - 1$.

## Discussion of results

The results of empirical analysis of mountain agricultural data from selected mountainous provinces, states, and regions in 5 HKH countries are discussed below. Discussion focuses on the findings of a time series data analysis for foodgrain crops, horticultural and cash crops, and livestock.

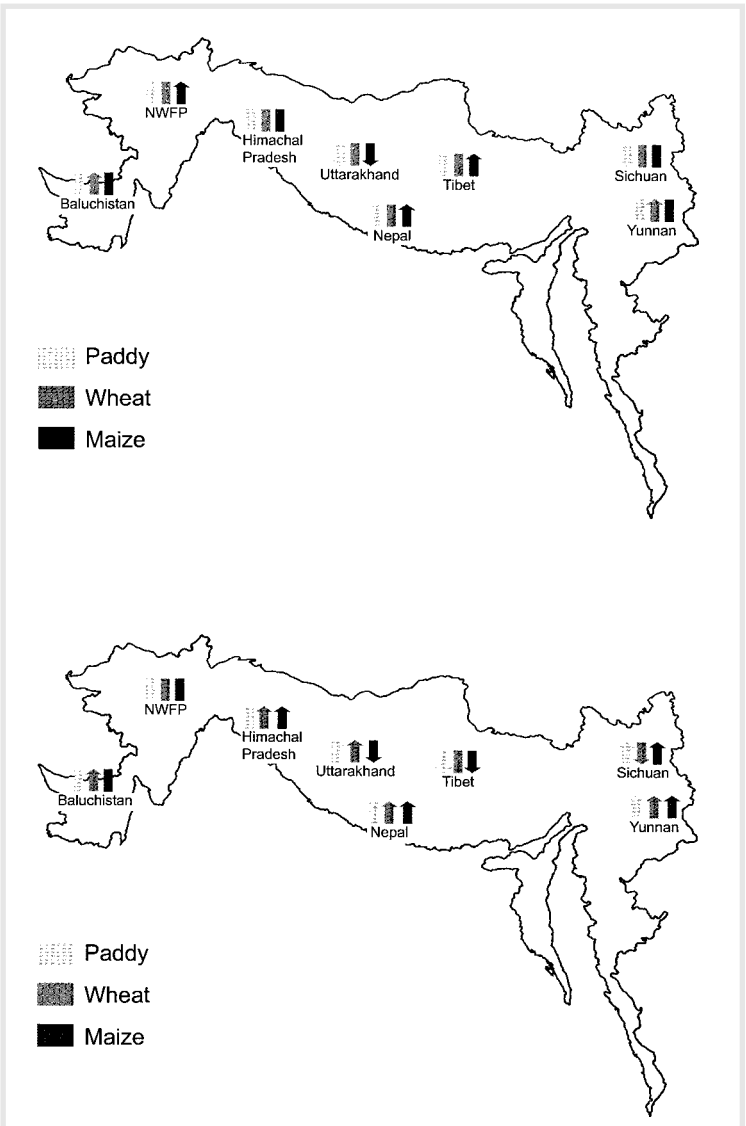
### Trends in production of cereal foodgrain crops

Results of analysis show that the area under foodgrain crops has not increased, but crop yields have remained relatively stable and, for some crops and in some regions, crop productivity has increased (Table 1; Figure 2). In Pakistan, for example, analysis of data for major foodgrain crops between 1975–1976 and 1993–1994 in Baluchistan shows that, while the area under wheat increased significantly at an annual rate of 2.1%, the area under paddy and maize remained stagnant. Wheat yields also increased significantly at a rate of 2%, but yields of paddy and maize remained more or less stagnant. On the other hand, the area under maize in the NWFP grew at a rate of 1.4% per annum, but productivity remained stagnant.

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**TABLE 1** Trends (annual growth rates in %) in cropland and productivity of foodgrain crops in the Hindu Kush–Himalayas.

| Province/state/region | Growth rate in cropland | | | Productivity growth rate | | | Period |
|---|---|---|---|---|---|---|---|
| | Paddy | Wheat | Maize | Paddy | Wheat | Maize | |
| **China** | | | | | | | |
| **Sichuan** | –0.14 | 0.33 | 0.12 | 1.49 | –0.04 | 1.52 | 1983–97 |
| **Tibet** | 0.38 | 0.54 | 1.62 | –1.91 | 0.17 | –1.30 | 1983–97 |
| **Yunnan** | –0.58 | 1.36 | 0.04 | 1.93 | 2.37 | 1.81 | 1983–97 |
| **India** | | | | | | | |
| **Himachal P** | –0.38 | 0.17 | 0.19 | 0.53 | 2.10 | 1.32 | 1981–91 |
| **UP Hills** | –0.13 | 0.01 | –0.94 | 1.48 | 2.35 | –0.26 | 1980–93 |
| **Nepal** | | | | | | | |
| **Hills** | 0.36 | 0.55 | 1.06 | 0.68 | 1.03 | 1.12 | 1985–94 |
| **Mountains** | 0.74 | 0.85 | 1.11 | 0.19 | 1.77 | 0.41 | 1985–94 |
| **Pakistan** | | | | | | | |
| **Baluchistan** | 0.6 | 2.1 | 0.6 | 0.5 | 2.0 | 1.0 | 1975–93 |
| **NWFP** | 0.1 | 0.4 | 1.4 | 0.1 | 0.8 | 0.5 | 1975–93 |




In India, the area under paddy has declined in Himachal Pradesh and the UP Hills. Interestingly, although the areas under wheat and maize in Himachal Pradesh (HP) are stagnant, their yields have grown by 2.10 and 1.13%, respectively, per annum, but the paddy yield is stagnant. In the UP Hills, productivity of both paddy and wheat has increased considerably, although the area under foodgrain crops has declined. In the mountains and hills of Nepal between 1985–1986 and 1994–1995, analysis showed that annual growth rates in area, production, and yields of paddy are below 1% each, indicating stagnation. However, maize production in the mountains and hills increased at an annual rate of 1.52 and 2.17%, respectively. Similarly, wheat production increased by 2.62 and 1.58%, respectively, per annum.

In the mountainous provinces of Sichuan and Yunnan in China, the area under rice either stagnated or declined slightly between 1983 and 1997. During the same period, however, the yield increased significantly, at rates of 1.49 and 1.93%, respectively, per annum in Sichuan and Yunnan. Similarly, the area under corn stagnated, but yields increased considerably in both provinces between 1983 and 1997. As for wheat, both area and productivity increased significantly in Yunnan. In Tibet, the areas under rice and corn increased considerably while the area under wheat remained stagnant.

### Trends in production of horticultural crops and cash crops

Empirical analysis of the trend data presents significant increases in the area under horticultural crops across the HKH region (Table 2; Figure 3). As for cash crops,

**FIGURE 2** (a) Trends in cropland allocation for foodgrain crops in the HKH. (b) Trends in productivity for foodgrain crops.



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| Province/state/region | Growth rate in cropland | | | | Productivity growth rate | | | | Period |
|---|---|---|---|---|---|---|---|---|---|
| | Apple | Citrus | Tomato | Vegetables | Apple | Citrus | Tomato | Vegetables | |
| **China** | | | | | | | | | |
| **Sichuan** | 1.40 | 1.25 | — | — | 1.17 | 2.46 | — | — | 1985–97 |
| **Tibet** | 1.11 | — | — | — | –2.0 | — | — | — | 1984–97 |
| **Yunnan** | 4.93 | 4.36 | — | — | –0.57 | 0.94 | — | — | 1983–97 |
| **India** | | | | | | | | | |
| **Himachal Pradesh** | 1.6 | 3.4 | — | 2.5 | 0.4 | –2.3 | — | — | 1981–92 |
| **Nepal** | | | | | | | | | |
| **Hills and mountains** | 2.83 | 2.39 | — | — | 0.45 | 0.31 | — | — | 1993–97 |
| **Pakistan** | | | | | | | | | |
| **Baluchistan** | 4.87 | 4.45 | 3.59 | 2.96 | 0.88 | 2.60 | 0.61 | 0.23 | 1981–94 |
| **NWFP** | 2.37 | 0.76 | 3.23 | 1.88 | –0.23 | 0.08 | 0.29 | 0.49 | 1981–94 |

**TABLE 2** Trends (annual growth rates in %) in cropland and productivity of fruit and vegetables in the Hindu Kush–Himalayas.

potatoes made significant gains in production area. In Baluchistan, for instance, the areas under apples, citrus, and apricots grew at significant annual rates between 1981 and 1994, but growth in productivity was less than 1%. The area under vegetable crops increased by 2.96% per annum, but the yield stagnated between 1981 and 1994. The area under tomatoes increased considerably, averaging growth rates of over 3.5% per year, but the yield has remained more or less stagnant.

In the NWFP, areas under apples and apricots grew by 2.37 and 2.36%, respectively, per annum, but productivity declined between 1981 and 1994. Although the area under vegetables grew by 1.88%, productivity declined. Similarly, as for tomatoes, the area increased significantly by 3.2% per annum, but the yield declined by 0.29%. In Himachal Pradesh, the area under citrus increased between 1981 and 1992 at an annual rate of 3.4%. Similarly, the area under apples grew by 1.6% per annum. Nevertheless, citrus yields declined by 2.3% per annum and the apple yield remained virtually stagnant. Although the area under vegetable crops increased by 2.5% per annum, productivity more or less stagnated.

In Nepal, considerable expansion took place between 1987 and 1997 in the area under horticultural crops; increases in both area and production were over 20 and 40% for fruits and vegetables, respectively. While the area under apples increased by 2.83% per annum, the area under citrus grew by 2.39% per annum between 1993 and 1997. However, yields of these fruit crops remained stagnant.

Among the mountainous provinces of China, Yunnan had the highest growth rate of the area under apples, at 4.93% per annum between 1983 and 1997;

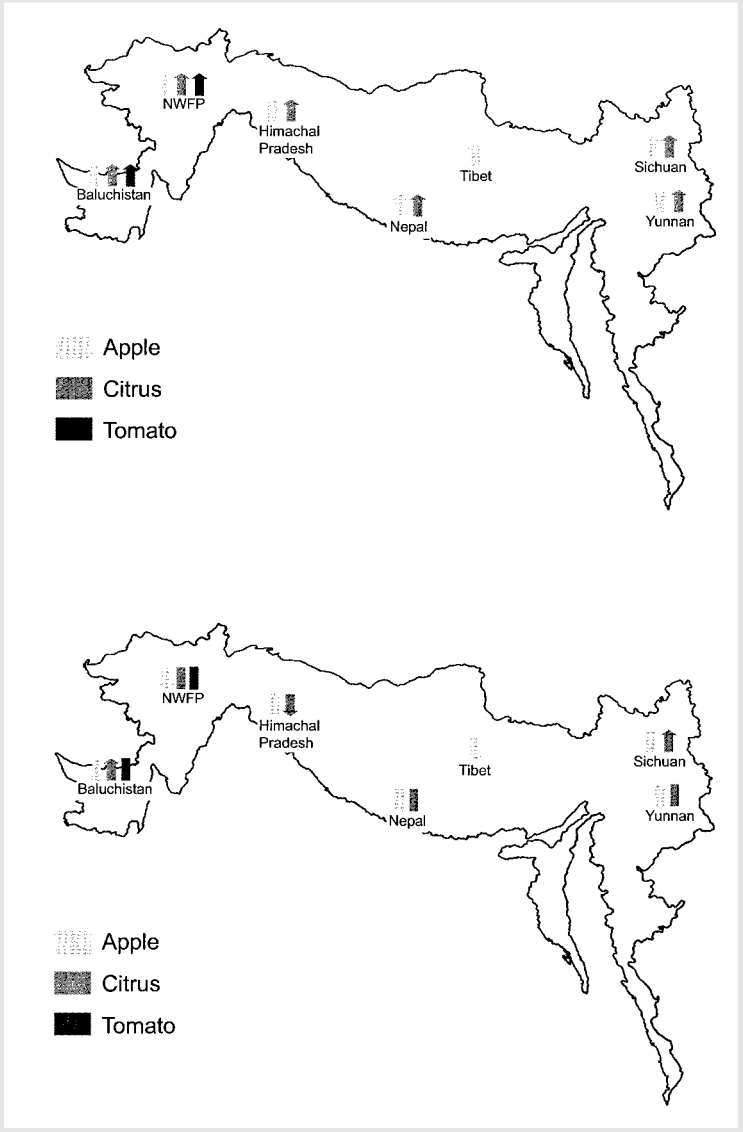



**FIGURE 3** (a) Trends in cropland allocation for fruit and vegetables in the HKH. (b) Trends in productivity for fruit and vegetables.

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**TABLE 3** Trends (percentage of change between beginning and end of time period) in livestock population and composition in the Hindu Kush–Himalayas.

| Province/state/region | Change in livestock population (in %) | | | | Change in herd composition (in %) | | | | Period |
|---|---|---|---|---|---|---|---|---|---|
| | Cattle | Buffaloes | Sheep | Goats | Cattle | Buffaloes | Sheep | Goats | |
| **Bhutan** | –23.0 | — | 21.26 | 108.83 | 9.97 | — | –1.09 | 9.52 | 1986–96 |
| **China** | | | | | | | | | |
| **Sichuan** | 20.62 | 4.40 | 6.97 | 81.02 | –3.74 | –2.80 | –3.04 | 9.58 | 1986–97 |
| **Tibet** | 2.19 | — | 2.28 | 8 | –0.34 | — | –0.70 | 1.05 | 1986–97 |
| **Yunnan** | 9.58 | 17.34 | –25.6 | 13.77 | 0.36 | 1.16 | –3.06 | 1.54 | 1986–97 |
| **India** | | | | | | | | | |
| **Himachal Pradesh** | –1.06 | 13.64 | –8.15 | 5.25 | –0.71 | 1.62 | –1.91 | 1.00 | 1982–92 |
| **UP Hills** | –5.2 | 15.1 | –9.1 | 7.1 | –3.0 | 2.5 | –1.0 | 1.4 | 1978–88 |
| **Nepal** | | | | | | | | | |
| **Hills** | 3.17 | 0.58 | –9.59 | 2.87 | 0.89 | 0 | –1.70 | 0.80 | 1988–96 |
| **Mountains** | 5.77 | 8.30 | –2.53 | 9.37 | –0.51 | 0.21 | –9.59 | 2.87 | 1988–96 |
| **Pakistan** | | | | | | | | | |
| **Baluchistan** | 81 | 133 | 185 | 87 | 1.26 | 0.002 | 10.50 | –9.24 | 1984–94 |
| **NWFP** | 9.5 | 68 | –39 | –10 | 5.16 | 5.29 | –10 | –0.45 | 1976–86 |

production also increased at an annual rate of 4.36%. In both Sichuan and Tibet, the annual growth rate of the area under apples was above 1%. Yunnan also had the highest growth rate for the area under oranges, at 4.65% per annum. The area under oranges grew by 1.25% per annum in Sichuan. Sichuan had the highest growth rate for the area under pears, at 2.56% per annum. Among cash crops, the area under tobacco grew considerably in both Sichuan and Yunnan, with annual growth rates of 2.26 and 5.30%, respectively.

In Bhutan, analysis of data between 1986 and 1995 indicates that the area under apples increased considerably, by 32.87%, while the increase in the area under oranges was comparatively small. The largest gain within that time period was in the area under vegetables—an increase by a factor of over 7. As for cash crops, the area under ginger and potatoes increased by more than 100%.

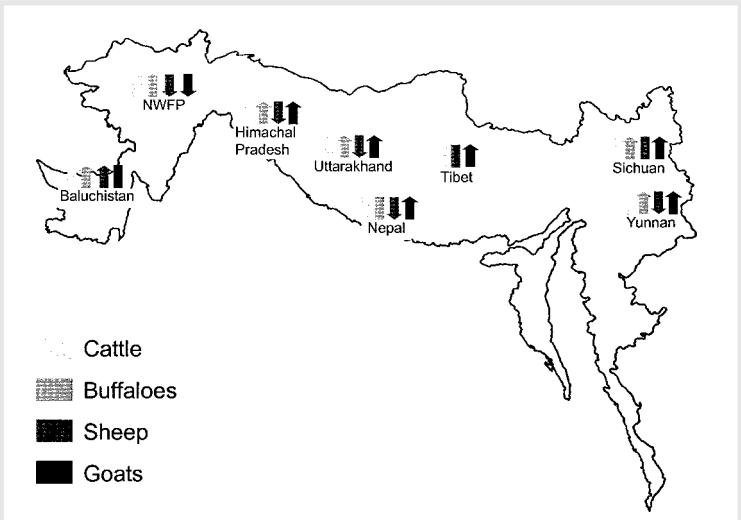



**FIGURE 4** Trends in livestock populations in the HKH.

### Trends in livestock population and composition

Analysis of livestock data shows that there is a trend toward decline in cattle and sheep populations across the HKH. On the other hand, buffalo and goat populations are showing a tendency to increase (Table 3; Figure 4). In Baluchistan, the increase in the buffalo population between 1984 and 1994 was much larger than for cattle. This also applies to the NWFP between 1976 and 1986.

Analysis of livestock data between 1978 and 1988 in the Central Himalayan region (UP Hills) and between 1982 and 1992 in the Western Himalayas (Himachal Pradesh) shows that, while the cattle population declined, the buffalo population increased significantly. Among small ruminants, the sheep population declined considerably, and it is interesting to observe a significant increase in the goat population. Accordingly, in terms of herd composition, the share of cattle and sheep declined and that of buffaloes and goats increased.

Analysis of livestock data in Nepal shows that the most noticeable change in the hills is a significant

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increase in the buffalo and goat populations between 1988–1989 and 1996–1997. Percentages of buffaloes and goats increased, while those of cattle and sheep declined. The most noticeable change in the mountains/hills is a considerable decline in the sheep population.

In the mountainous provinces of China, analysis of livestock data between 1986 and 1997 shows that the goat population increased more than the cattle, buffalo, and sheep populations. Although the sheep population increased slightly in Sichuan and Tibet, it decreased significantly in Yunnan.

Analysis of livestock data in Bhutan between 1986 and 1996 shows that the cattle population declined by 9.97%. On the other hand, the goat population increased considerably, by 9.52% over the same 10-year period.

## Possible reasons for trends in mountain agriculture

The major observation is that, although the area under foodgrain crops has not increased, yields have not declined, as is often perceived. Productivity has actually increased for some foodgrain crops, leading to increased foodgrain production in a few mountain areas over the past 10–15 years. The reasons for this could be (1) government policies relatively favorable to production of foodgrains in an attempt to ensure food security—for example, subsidies for fertilizers are common across the HKH region; (2) most of the fertile valley lands with irrigation are under foodgrain crops; (3) development of road infrastructures could be contributing to timely supply of modern inputs, such as fertilizers, improved seeds, and pesticides.

The area under horticultural crops such as fruits and vegetables has increased significantly over the past several years, indicating the importance of horticultural crops in farming systems and the household economy in the HKH. The main reasons for rapid expansion of areas under horticultural crops seem to be (1) cash-earning opportunities for mountain households (because of increasing accessibility through improved road and transport networks, farmers have easy access to major consumption centers, both in highland towns/cities and lowland towns/cities) and (2) increased income among urban dwellers (there has been an increase in demand for fruits and vegetables, with demand for these commodities being income elastic).

Despite their value for income generation, the productivity of horticultural crops has either stagnated or declined. This decline in yields could be linked to use of marginal lands and other factors such as poor orchard management. In Himachal Pradesh, for example, more than 80% of fruit farming occurs on marginal and sloping lands (Verma and Partap 1992). Furthermore, use of low-yield heterogeneous varieties, poor fruit setting, and fruit drops are common in apple-growing areas of the HKH region. In some production pockets, biennial/irregular bearing, poor pollination, heavy rains at fruit maturity, and moisture stress during summer are common problems that result in low, erratic, and poor-quality fruit production (JMA 1995; Jindal 1996).

In the livestock sector, there is a general trend toward declining cattle populations in the Indian Himalayas, Nepal hills/mountains, and Bhutan. This could be mainly due to decreasing feed resources and a decline in open grazing areas. On the other hand, there is a growing trend toward stall-fed buffaloes in the Himalayan subtropics of India, Nepal, and Pakistan because of their multiple uses, mainly for milk and meat production. On the whole, the sheep population has been in decline (except in Baluchistan) and the goat population has been on the increase across the HKH. The decline in the sheep population could be the result of limited open grazing lands and restrictions on open grazing imposed by communities. In mountainous areas of China, for example, a case study discovered that grassland available per sheep unit decreased from approximately 9 *mu* (15 *mu* = 1 ha) in 1976 to approximately 6 *mu* in 1986 (Yanhua et al 1992). Goats can be stall-fed and do not need grazing, especially in the high-pressure Himalayan subtropics in areas with mixed crops and livestock farming systems. Furthermore, goats have been an important source of cash income in the Himalayan subtropics. The overall implication of these trends is that the importance of buffaloes and goats has increased in the livestock economy, with important consequences for the generation of household cash income.

## Implications for development of mountain agriculture

Empirical analysis shows that production of cereal foodgrain crops in the HKH has not declined as much as is often perceived. In fact, production has increased in some cases due to increased productivity. With government policies favoring support of development and improvement of road infrastructures in mountain areas, there is a prospect for increasing foodgrain production. Production increases can be mainly due to improved access to modern inputs such as quality seeds, fertilizer, and irrigation, resulting from favorable government policies. Nonetheless, there seems little prospect for expansion of the area under foodgrains, and per capita food availability may decline due to population increases.

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Results of data analysis also suggest that there have been increasing trends in crop diversification toward horticultural and cash crops. Therefore, better prospects do exist for development of niche-based horticultural crops in the HKH. As mountains have the potential for small-scale, specialized farming activities with high payoffs, proper harnessing of niche-based farming can boost food security through direct use of products or trade in high-value products (Jodha 1992, 1995). Present trends in rapid expansion of horticultural crops have positive implications for the future development of mountain agriculture in terms of harnessing mountain niches and comparative advantages, that is, advantages with positive ecological and economic effects. This could also lead to putting more fertile irrigated lands (lands currently used for cereal foodgrain production) under high-value cash (HVC) crops such as fruits, vegetables, and medicinal plants that are more profitable and sensitive to market demand.

Case studies on agricultural transformation of mountain areas show how farming of HVC crops has increased food security and employment, thus improving living conditions for mountain people (Partap 1995; Sharma 1996; Sharma 1997; Sharma and Sharma 1997; Tulachan 1997; Badhani 1998). They also show that accessibility, wider market networks, and strong R&D institutions are critical to the commercialization of subsistence agriculture in mountains through development of HVC crops.

Development and further diversification of HVC crops in mountain agriculture will also increase trade between highlands (mountains) and lowlands (plains), with highland farmers specializing in HVC crops such as fruits, vegetables, flowers, and medicinal plants and lowland farmers specializing in cereal crops. Thus, developing an effective exchange mechanism enables improvements in trade in favor of hills and mountains.

However, there has been a trend toward declining productivity of HVC crops, raising concerns about their long-term sustainability. In this context, Jodha (1991, 1995) points out that reckless exploitation of mountain niches can result in their elimination. A study of niche-based farming of horticultural crops in the Nepalese mountains shows both spatial and temporal dimensions of sustainability: High economic benefits induce a spatial dimension, with a particular crop spreading rapidly. Nevertheless, the temporal dimension of niche-based farming is manifested by subsequent soil nutrient losses and diseases (Tulachan et al 1998). Furthermore, increasing use of pesticides on horticultural crops has been reported. Due to small farm size, there have been increasing trends toward agricultural intensification and multiple cropping, with excessive use of chemical fertilizers and pesticides in commercial production areas. This has raised concerns about environmental pollution, for example, groundwater pollution and related health hazards, and about equity with respect to main beneficiaries and gender issues. Thus, along with development of HVC crops, many second-generation issues are emerging.

According to Rhoades (1997), "perhaps, more importantly, the 'second generation' problems of ecological and social issues need to be understood prior to wholesale promotion of high-value cash crops. Impacts on equity of class, gender, and ethnicity, in particular, need to be further explored." Thus, the key challenge to HKH policy makers, planners, researchers, and field workers is how to address these emerging environmental and socioeconomic issues in order to sustain production of HVC crops on a long-term basis.

Trends in the livestock sector indicate that, in the future, there is a possibility of greater development of smallholder dairies with improved buffaloes in the high-pressure Himalayan subtropics where mixed crop–livestock farming systems are present. The number of stall-fed buffaloes and goats is growing, with increased use of external inputs and purchased feed. This will put less pressure on common property resources such as forests and community lands, leading to positive impacts on the environment. Also, farming of buffaloes and goats will contribute positively to food security and nutrition of mountain households.

## Data limitations and opportunities for further studies

This article is based on official government figures, which are the only authentic and authorized data available, and its findings illustrate broad trends and patterns in mountain agriculture across the HKH. Although each national government has well-established administrative/organizational set-ups to collect agricultural data, many mountain areas pose data collection problems due to rugged and inaccessible terrain. Human factors, miscommunication, sampling errors, etc, pose still greater challenges for quality data collection. Thus, it is imperative to make judicious interpretations of findings based on government data in reference to specific areas and situations.

Moreover, data at the province and state level tend to camouflage specific trends and patterns in mountain agriculture at district/county levels. Thus, the implications of this article for individual districts/counties should be regarded with caution. The smaller the area investigated, the greater the probability that errors in data collection will be minimized and contextual representation improved. Therefore, future efforts should be made to analyze agricultural trends using time series data at the district level or, if possible, at lower levels, which can reveal variations between districts within a

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state/province. Such analysis at a smaller scale provides a better understanding of mountain agriculture, and findings can have specific implications for different districts. Thus, there are numerous opportunities for ICIMOD to collect and analyze agricultural data at the district level across the HKH in order to provide a better understanding of variations in trends or transitions taking place in mountain agriculture across the HKH.

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## FURTHER READING

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