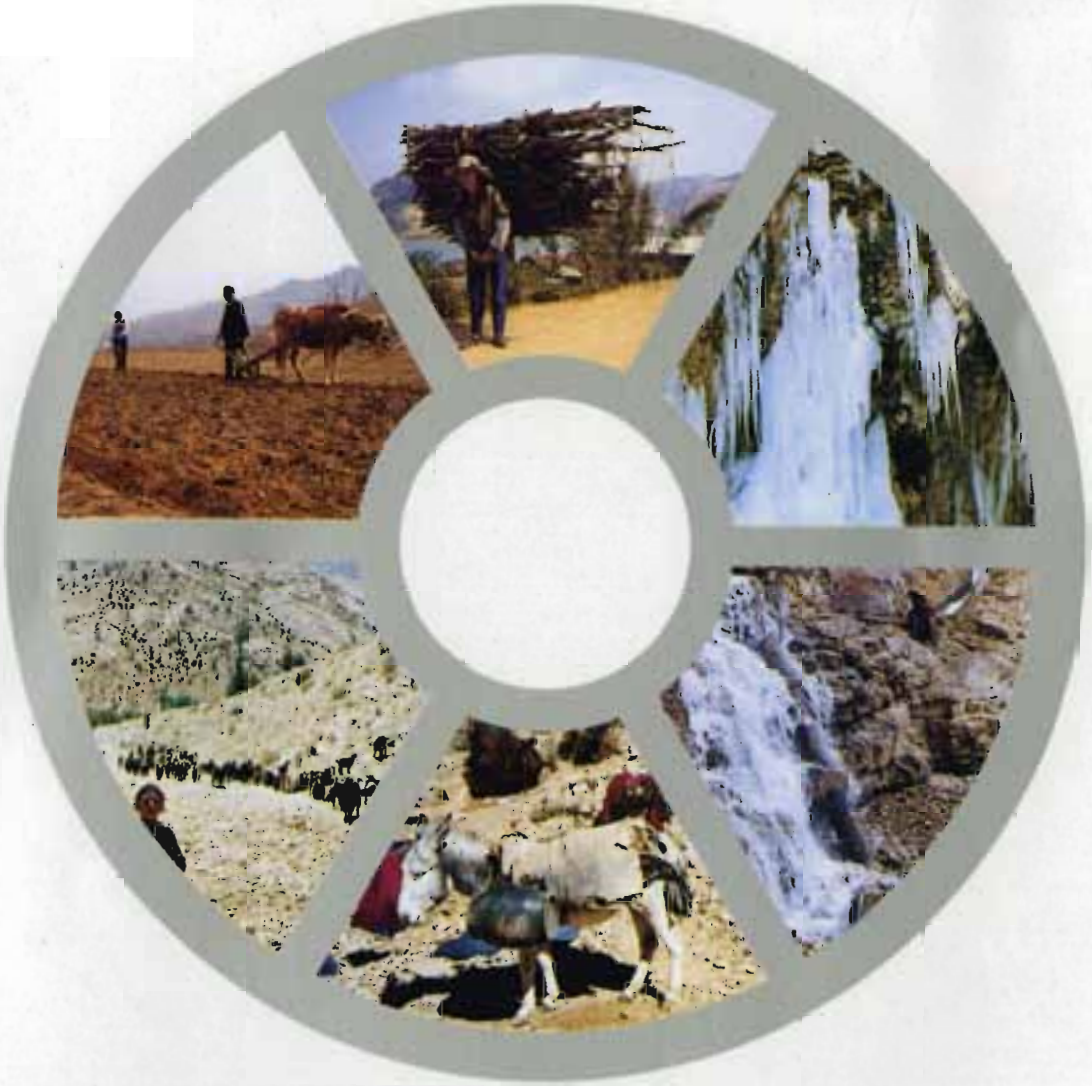
ICIMOD

Appropriate Farm Technologies for Cold and Dry Zones of the Hindu Kush-Himalayas



Editor
Shaheena Hafeez

International Centre for Integrated Mountain Development
Kathmandu, Nepal
1998

Appropriate Farm Technologies for Cold and Dry Zones of the Hindu Kush-Himalayas

Editor
Shaheena Hafeez

International Centre for Integrated Mountain Development
Kathmandu, Nepal

1998

ISBN: 92 9115 838 0

Front Cover Photo

1. A woman farmer carrying fuelwood, China
2. Animal grazing the arid highlands, Pakistan
3. Indigenous agriculture, China
4. Rubber water container invented by Afghan refugees, Pakistan
5. Water seepage in the highlands freezes in winter, Ziarut, Pakistan
6. Water harvesting channel, Ziarut, Pakistan

Back Cover Photo

1. A model of indignenous farm technologies in a village of highland Balochistan
2. Gypsy worker making a broom from dry palm leaves (Balochistan)
3. Rearing poultry at household level, India
4. Afghan woman spinning wool with traditional equipment, Quetta, Pakistan
5. Butter-making with a goatskin churn

Published by
International Centre for Integrated Mountain Development
GPO Box 3226
Kathmandu, Nepal

Typesetting at
ICIMOD Publications' Unit

Appropriate Farm Technologies for Cold and Dry Zones of the Hindu Kush-Himalayas

Editor

Shaheena Hafeez

This collection of farm technologies is a compilation of field work carried out in China, India, and Pakistan. Three experts, namely, Wang Dasheng from CAS, China, P. K. Khosla from Dr. Y. S. Parmar University, India, and A. W. Jasra from PARC, Pakistan, were commissioned to carry out research and documentation of appropriate and indigenous farm technologies in selected sites within their respective countries. The present monograph is a compilation of the studies submitted and these are listed below.

Documentation of Appropriate Farm Technology for Mountain Areas of China by Wang Dasheng, Chinese Academy of Sciences, Beijing, China

Appropriate Indigenous Farm Technologies in Cold Deserts by Khosla, P. K., Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P., India

Appropriate Farm Technologies in Arid and Semi-Arid Mountainous Areas of Pakistan by Jasra, A.W.; Hussain, A.; and Batool, N., PARC, Islamabad; Khan, C. Z. A.; Kasi, M. M. A.; and Mahmood, T., Department of Agriculture, Balochistan; and Ghaffar, C.A., Department of Agriculture, Punjab, Pakistan

Foreword

Documentation and exchange of information on the Hindu Kush-Himalayas is one of the four activities the International Centre for Integrated Mountain Development (ICIMOD) is mandated to do according to its statutes.

Of the 150 million people inhabiting the Hindu Kush-Himalayas and Qinghai Tibetan Plateau, some 80 per cent are engaged in farming; and whereas the farmers of the Central Himalayas have received much attention from governments, NGOs, and donor organizations, those living in cold and dry mountain areas of this region have often been left on the margins of development support.

While it is impressive how local committees in cold and dry mountain areas have responded to their harsh environment by developing technologies for sustaining traditional farming systems, new aspirations have also induced their quest for change. Technologies successful in other agro-ecosystems are often taken on without proper testing. A technology may be revolutionary in terms of increasing sociocultural structures of an area. Therefore, careless dissemination of a technology may harm the credibility of the technology promoter. In addition to describing in detail many of the technologies, a separate chapter was prepared to include women-specific technologies. These technologies are related both to reducing the drudgery of tasks women are often faced with in their daily lives and those that have scope for income generation.

This monograph has been brought together in collaboration with focal institutions in three HKH countries, namely, China, India, and Pakistan. It contains detailed accounts of diversified technologies. I also acknowledge the valuable input given by Dr. Abdul Wahid Jasra, Director, National Aridland Development and Research Institute (NADRI), Islamabad, Pakistan, in compilation of the draft document.

ICIMOD is grateful to Dr. Shaheena Hafeez for her commitment to producing this manual, which we hope will inspire others to test and disseminate these and other technologies that could contribute to improving the livelihoods of the inhabitants of the cold and dry mountain areas of the HKH.

Egbert Pelinck
Director General

Preface

Mountain communities have managed to survive for generations by using local resources as well as indigenous knowledge. Consistently growing socioeconomic pressures compel the traditional farmer to adopt modern technologies in order to improve farm productivity for economic growth. However, the farmer may not be aware that using technologies at random could cause resource degradation. Because of the highly fragile physiognomic features of the mountains in the HKH region, haphazard selection of technologies could increase the risk of degradation. This is largely because the most widely adopted technologies that have a lasting impact on the process of agricultural transformation in the plains may not be so successful when applied to a mountain environment. In order to address this situation, in 1996 ICIMOD began the documentation of appropriate forms of technologies for cold and dry mountain zones of the HKH region. This manuscript is the outcome of the collaborative efforts of ICIMOD and focal institutions in the three regional countries, i.e., the Chinese Academy of Sciences, Beijing, China; Dr. Y.S. Parmar University of Agriculture and Forestry, Solan, Himachal Pradesh (H.P.), India; the National Aridland Development and Research Institute (NADRI), Islamabad, Pakistan; and the Pakistan Agricultural Research Council (PARC), Islamabad, Pakistan.

Chapters One and Two of the book justify the need for appropriate technology in the HKH region, giving comprehensive information on the biophysical and social environment of the areas in which most of the farm technologies are currently applied. Chapters Three to Seven describe relevant farm technologies in various categories in terms of their application. Three kinds of technology are included: modern, indigenous, and a blend of both. Modern technologies have already been tested in one place or another in the HKH region. In some cases, traditional farmers have been highly innovative in developing a useful technology based on their indigenous experience, and this technology is very effective in increasing farm productivity. Some technologies are an integration of modern ideas and indigenous knowledge, i.e., an indigenous technology improved by merging it with any modern innovation or a modern technology modified to suit the local climatic or socioeconomic conditions. These technologies should prove promising not only in most of the dry and cold parts of the HKH region, but also in similar agro-ecological zones all over the world. Thus, one of our recommendations is that an International Conference on Appropriate Farm Technologies should be organized to initiate a worldwide dissemination process.

I greatly acknowledge the support and guidance of Dr. Egbert Pelinck, Director General, ICIMOD, during the whole process of technology documentation. The contributions of Dr. Mahesh Banskota, Deputy Director General, and Dr. Tej Partap, Head, Mountain Farming Systems' Division (MFS), ICIMOD, have been extremely useful in the completion of this work. I sincerely appreciate the contribution of Dr. Abdul

Wahid Jasra, Director, National Aridland Development and Research Institute (NADRI), Islamabad, Pakistan; his technical assistance and professional input in the preparation of the final report were of immense help. His zeal in assisting me cannot be adequately expressed in words. The assistance of Mr. Iftikhar Uddin Sikder, MENRIS, ICIMOD, in providing maps for this publication, is well acknowledged. Mr. Manish Kokh Shrestha has done an excellent job of typing and compiling the document. The publications' staff of the Documentation and Information Service (DITS), ICIMOD, particularly Anita Pandey, Assistant Editor, Asha Kaji Thaku, Cartographer, and Sushil Joshi, Desktop Publisher, were of great assistance to me in preparing the final draft. Finally, I would like to thank Dr. Zafar Altaf, Chairman of the Pakistan Agricultural Research Council (PARC) and current Chairman of the Board of Governors of ICIMOD, for his guidance, technical inputs, and professional assistance, particularly for the Pakistan study.

To the many people who helped me during field travels in the region, my heartfelt gratitude.

Shaheena Hafeez

Abstract

The HKH region is the world's highest mountain region, extending over 3,500km. Appropriate farm technologies of the cold and dry HKH mountain areas of China, India, and Pakistan have been documented in this monograph. Technologies for water conservation are being used for the management of water and the irrigation of staple crops and orchards. There is one innovative technology for the artificial recharge of groundwater, i.e., delay action dams (DADs), that has been documented here. There are a total of 17 technologies for land and soil management. Land management technologies are mostly biological tools that improve land productivity levels under natural conditions, whereas soil-related technologies focus on soil fertility, tillage, and so on for crop production. Most of the technologies to increase productivity focus on fruits and vegetables, with a few concentrating on animal production and farm machinery. The agroenterprise-oriented technologies motivate farmers to transform their traditional subsistence-oriented economies into commercial, income-generating farm economies. Indigenous agro-based technologies are women-specific and focus on gender equity in the male-dominated social structures of the HKH region by strengthening the economic empowerment of women. These technologies include farm produce preservation and commercial processing, beekeeping, mushroom production, palm leaf household products, and other cottage products. Some recommendations for study and dissemination of these technology packages at various levels have been listed. The annexes are valuable and list well-known fruit and vegetable varieties found in the different agro-ecological zones of the HKH region.

Emchi	Indigenous medicinal practice
Faphra	*Fagopopyrum tatricum*
Far or garu	Male off-spring of yak x dzomo
Fir	Male crossbreed of yak x garmo
Garmo	Female off-spring of yak x dzomo
Girmo	Female crossbreed of yak x garmo
Gorich	Winter winds
Gour	A traditional brown sweetener, i.e., a sort of molasses
Kanda	Cultivated fields in the high hills/landholdings far away from settlements
Karez	Underground channelled irrigation system
Karnu	*Carissa caranda*
Katcha	Temporary
Khadis	Handlooms
Kharif	Summer crop season
Khurud	Non-fat dry cheese
Knol khol	Kohlrabi
Kuhl	Channel irrigation
Kuth	*Saussurea costus*
Lafe	Boiled apricot as medicine for animals
Landhai	Air-dried mutton from winter lamb
Lassi	Liquid skimmed milk
Lizo	Wild cherries
Lok	Male offspring of yak x *girmo*
Lokmo	Female offspring of yak x *girmo*
Malik	Tribal chief
Mash, masur, and moong	Lentils and pulses
Methi	*Trigonella foemum-graecum*
Mullah	Muslim saint
Naswar	Chewing tobacco
Nullahs	Streams (perennial or ephemeral)
Nangke	*Ribes orientale*
Pattus, pattis,	Handwoven woollen cloth
Rabi	Winter crop season
Rashtu	*Rhus punjabensis*
Sailaba	Rainfed flooding
Sarson	Mustard
Shangma	A light bluish stone
Thobi	Rugs made from yak hair
Torgmo	Female crossbreed of yak x *lokmo*

Table of Contents

Chapter One
Background & Rationale

A Phenomenon of Change

The sustainable development of the HKH region across eight countries (i.e., Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan) is a challenge assigned to ICIMOD. Over time, the region has witnessed sequences of change in the edaphic, abiotic, and socioeconomic environments. These changes occurred as a consequence of neglect and inappropriate use of mountain resources. If unchecked, this phenomenon could pose a very real danger to the ecological balance of the region, to the extent of irreversible disruption.

In the absence of economic transformation, a scenario of poverty, inequality, and marginality within subsistence-based mountain communities will prevail. Economic development is slow and is not concurrent with the rapidly increasing demographic changes. It is expected that the population in the HKH could double within two to three decades, and this demographic phenomenon may altogether change socioeconomic structures. It would further intensify socioeconomic compulsions that would encourage local inhabitants to overexploit the fragile environment upon which, invariably, their survival depends.

The Compatibility of Mountain Agriculture

Mountain agriculture is a blend of various farming and livestock production systems. These systems were developed over time and were compatible with food security, self-reliance, and a slow rate of change in economic/material demands. Different components of agriculture were successfully integrated, resulting in an important adaptive strategy. Farmers had little urge to intensify their agricultural operations. However, they did adopt various practices to handle the 'mountain specificities' and constraints. These practices were refined through local experience and could be called 'indigenous technologies'. These technologies were low in cost and agriculture-friendly.

Demographic pressures linked with development processes are now questioning the applicability and sustainability of traditional agriculture. Over two-thirds of the people in the HKH region, still dependent on farming, are affected by recent changes. In trying to limit the adverse impact of these changes on their livelihoods, it is possible for them to make the choices given below.

- To intensify agricultural operations and expand the scale of operations

In fact, this is happening in terms of expanding crop cultivation in environmen-

tally sensitive areas and/or increasing the number of animals in herds and flocks, etc. The trend has endangered the biophysical properties of the climax mountain ecosystem.

- To look for off-farm employment or other sources of income generation

Off-farm employment opportunities within the HKH region are limited because public and private sectors are merging. Therefore, some of the job-seeking population is displaced and moves to areas towards the lowlands; their lack of other skills besides farming makes them eligible to work only as poorly paid labourers. Other ways of making a living, such as setting up a small business, are not possible due to lack of resources and training. The social consequences on both sides are rarely pleasant.

- To increase farm income by employing appropriate technologies

Farming communities have managed to survive for generations by using local resources on the basis of their indigenous knowledge. A consistently changing economic and environmental situation proposes a modification of conventional practices of agrarian societies in the HKH region to keep pace with the process. A technological breakthrough could help to sustain these mountain farming systems.

Farmers do recognise their problems. The solutions, and also the problems, are certainly linked to their indigenous capabilities and limited technical skills. This does not mean that indigenous knowledge is not capable of addressing the new era challenges. Simultaneously, many modern technological solutions failed in reality because they were never compatible with local culture and knowledge. Therefore, while development interventions should be based on indigenous knowledge, there should be a process of blending indigenous with exogenous knowledge.

Emphasis on Indigenous Knowledge

Indigenous knowledge cannot be applied indiscriminately, nor is all knowledge always equally useful. However, it does operate within a given socioeconomic and spatial set-up and plays an active role in the culture of a particular community. Integration of indigenous knowledge while developing or selecting a technology would present the technology as one sensitive to the local culture, and this would be an additional advantage for its smooth dissemination at the grass roots' level. It could be promoted as an appropriate, viable, and sustainable technology. An indigenous approach when introducing a new technology could also ensure its cost effectiveness.

Based on the experiences of various international development specialists, Warren and Cashman (1988) have suggested some important projections for incorporating indigenous wisdom in the process of effective technical change for sustainable agriculture and rural development. They stated that dismissing local knowledge would encourage the adoption of practices leading to undesirable effects through the inappropriate use of local resources, besides undermining the delicate balance of the local cultural or natural environment. It would subsequently cause decline in the society's well-being.

It is possible to modify all indigenous knowledge based technologies to make

them appropriate for dissemination. Some technologies can be borrowed in their totality from other cultures. For example, old tyres are commonly used for making water containers and other domestic utensils in Balochistan, Pakistan. These containers are cost-effective, long-lasting, and environmentally friendly. The technology can easily be replicated in other regions. Another such technology is the smoking of orchards using wind direction during the winter in order to protect fruit trees from frost injury.

Most indigenous technologies show considerable scope for improvement. With a little modification, each one could emerge as a highly appropriate means of generating income. For example, the flock owners of Balochistan convert their daily surplus of whey into small dry balls of skimmed milk, locally called *khurud*. It is stored for long periods under ordinary conditions for daily use and is also sold in the market. This primitive technology can be successful in other countries as a means of generating income.The product, a highly nutritious food supplement, can be marketed throughout the world simply by improving the hygiene of the production process, adding various flavours, and by packaging and marketing it in a popular form.

Sustainable development of mountain agriculture requires a well-balanced mix of technological innovations in order for technology to become the main determinant of development (Kaimowitz 1990). It could be based on a continuous flow of new and appropriate technology. A good menu of technologies, i.e., indigenous and modern, offers better choices to local farmers and reinforces competitiveness among technologies. It also motivates the local users to propose improvements or modifications of available technologies to meet different, specific situations.

What Makes a Technology Appropriate

Fresco (1986) defined technology as the means by which inputs are transformed into outputs. A popular agricultural technology in one region may not necessarily be applicable in another region. Many factors such as socioecological paradigms (Gupta 1992) and cultural and political parameters determine its acceptance in a particular place. The technology should address immediate problems and needs of local farmers. It should match the biophysical environment and local sociocultural conditions. Simplicity would be another desirable feature because a complicated technology could discourage the user. It should support, strengthen, and integrate traditional farming systems and overall land-use plans.

The sustainability of an appropriate technology in a particular area would depend very much on its impact. Impact should be measured at the level of the individual farmer as well as at the community level. It could be measured using welfare indicators such as increased farm income, reduced risk, resource conservation, improved livelihood, better security, and overall economic growth (Kaimowitz 1990).

The appropriateness of a technology should preferably take into account the gender issue. The technology should equally benefit all gender segments. Technologies are mostly male-oriented and usually displace the female population. If a technology were to be used exclusively by males, it would be inaccessible to about

50 per cent of the total population. A significant impact on overall welfare in an agrarian society can be made possible when both men and women have equal access to farming technologies. It is recommended that women should be considered 'preferred clients' when preparing a menu of farm technologies.

ICIMOD – A Technology Promoter

Sustainable use of mountain resources demands ecosystem-friendly technologies. Dissemination of this kind of technology could change the socioeconomic scenario of mountain communities besides conserving resources. Many farmers have now realised that adopting such technologies could increase field productivity. However, a majority of farmers do not have access to information about potential farming technologies due to inadequate documentation and dissemination of the relevant materials by the public institutions concerned.

Potential technologies could be indigenous, new, or a blend of both. An indigenous technology from one region could be used successfully as a new technology in another part of the world. Over time, certain improvements could strengthen significantly the role of different technologies for economic and agricultural growth.

A case in point is that of seabuckthorn, a 'magic' plant growing in Russia, China, and most parts of other HKH regional countries. Seabuckthorn is now being promoted as a highly successful, new technology all over the world based on the success of Chinese seabuckthorn models. It is believed that many other indigenous technologies in different HKH zones are not being documented. If information on these technologies was documented and disseminated, they could be replicated in other countries. Similarly, some modern technologies with their origin in scientific research could be adopted 'intact' or with certain modifications. Information on their usefulness and application under specific circumstances could attract farmers of other similar eco-zones to replicate the techniques with anticipated profitability.

Realising that most farmers do not have ready access to such information, ICIMOD is committed to promoting appropriate technologies as per its Regional Collaborative Programmes (I & II). This requires the pooling of all kinds of potentially useful technologies by a central information bank. Each technology must be accurately described in order to facilitate dissemination. For this purpose, the Mountain Farming Systems' Division (MFS) of ICIMOD has accepted the special task of promoting an appropriate farm technology package. This package aims to improve the productivity of small mountain farms without degrading the resource base, and at the same time, integrates gender concerns into mountain agricultural development. The technology package would equip the national and regional extension services to carry out their activities with maximum efficacy.

In this context, the MFS mobilised various institutions from countries in the HKH and organized a meeting of experts in Kathmandu in 1996. One of the specific objectives of this meeting was to develop a methodology for documenting appropriate farm technologies and dissemination approaches in different agro-ecological zones of the HKH region.

Methodology

This information was collected with the collaboration of focal institutions in China

(CAS, Beijing), India (Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, HP) and Pakistan (NADRI, PARC, Islamabad). The technologies were documented in various parts of the HKH countries during 1996-1997.

In each country, field surveys were conducted by a specially coached multidisciplinary team. Participatory Rural Appraisal (PRA) tools were used for the documentation of appropriate farm technologies. During field surveys, farmers were interviewed with the help of semi-structured questionnaires, in group discussions, and when travelling on survey transects using the guidelines of the officials of the concerned public departments. Government departments and non-government organizations (NGOs), if any, were consulted to help document technologies and to obtain supportive secondary information about the area.

The following technical approaches were considered while documenting the technologies.

- The resource base management and development technologies which focussed on:

  natural resource technologies of a physical nature, used mainly for management, development, and conservation of land and water resources and

  farm resource technologies that increase farm productivity of crops, horticulture, livestock, etc.

- Agroenterprise-oriented technologies included household processing, storage, marketing, and income generation.

- Gender-specific technologies involving those that might significantly reinforce the role of women in a particular ecosystem.

Objectives

The specific objectives of this work were as follow:

- building a pool of potential technological options and identifying successful appropriate farm technologies for sustainable mountain farming systems in the HKH region;

- disseminating the most promising technologies on a pilot basis and subsequently promoting the most effective options on a large scale; and

- assessing specifically appropriate technologies for rural women to strengthen their economic position.

Chapter Two
Cold & Dry Environment of the HKH Region

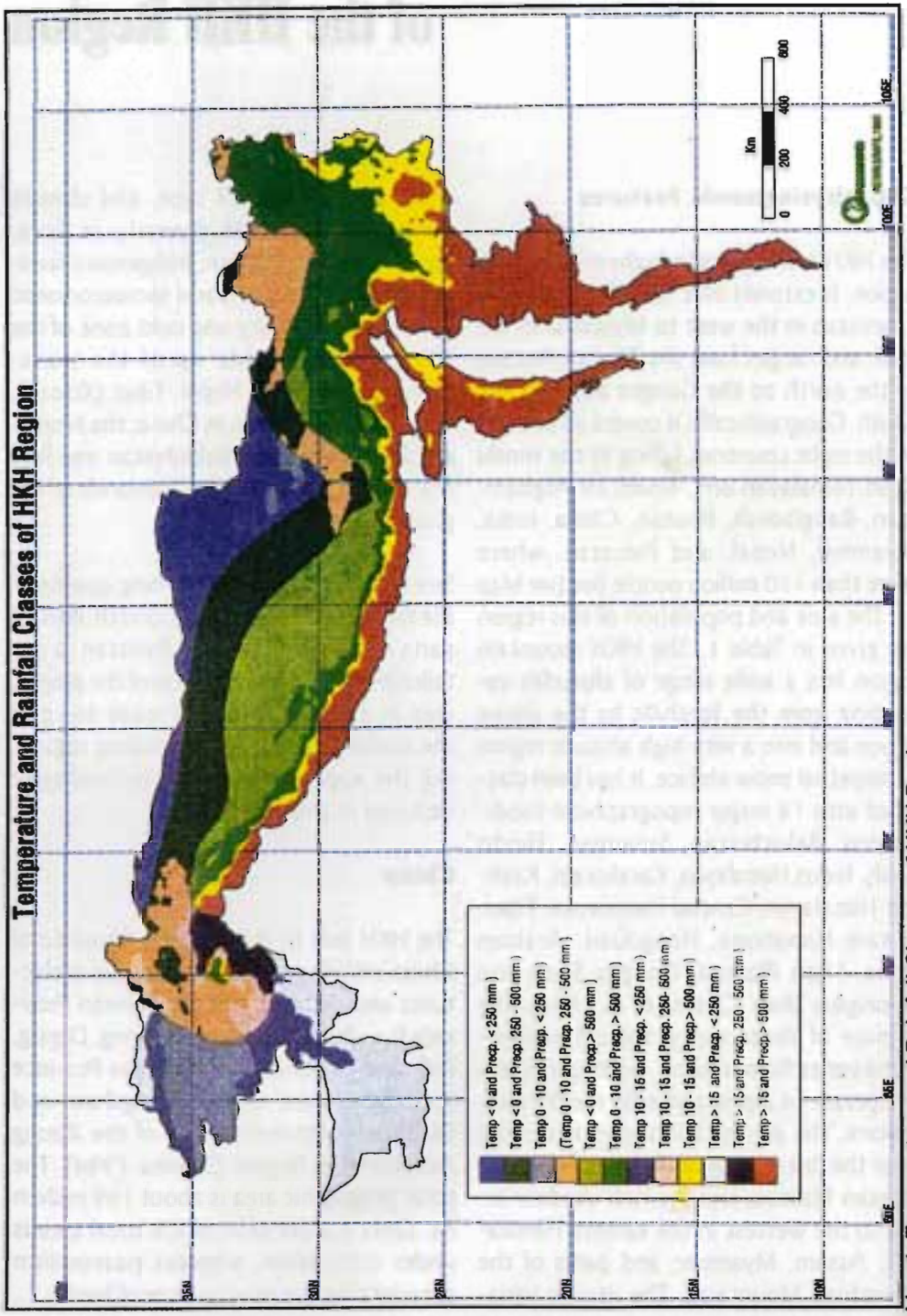
Geo-physiognomic Features

The HKH is the world's highest mountain region. It extends over 3,500km, from Afghanistan in the west to Myanmar in the east, and ranges from the Tibetan Plateau in the north to the Ganges Basin in the south. Geographically, it covers all or parts of the eight countries falling in the Hindu Kush-Himalayan belt, which are Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan, where more than 120 million people live (*see* Map 1). The area and population of this region are given in Table 1. The HKH mountain region has a wide range of altitudes extending from the foothills to the alpine region and into a very high altitude region of perpetual snow and ice. It has been classified into 14 major topographical subdivisions: Balochistan, Sulaiman, Hindu Kush, Indus Himalayas, Karakoram, Kashmir Himalayas, Central Himalayas, Tibet, Assam Himalayas, Hengduan, Arakom Yoma, Shan Plateau, Gongga Shan and Yulongxue Shan (Chalise et al. 1994). The climate of these topographical subdivisions varies from tropical, subtropical, and temperate to alpine and cold tundra conditions. The precipitation extremes range from the driest west of the Himalayas, the Tibetan Plateau, and the rain shadow areas to the wettest in the eastern Himalayas, Assam, Myanmar, and parts of the Hengduan Mountains. The drastic variations in altitude, soil type, and climate determine the great diversity in flora, fauna, land-use pattern, indigenous farming systems, cultures, and socioeconomic dimensions. The dry and cold zone of the HKH region is made up of the trans-Himalayan areas of Nepal, Tibet (*Xizang*), and Western Sichuan in China; the Northern Areas, Northern Balochistan and Rod Kohi in Pakistan; and the highlands of Afghanistan.

Since the work of documenting appropriate farm technologies was undertaken in parts of China, India, and Pakistan, a detailed biophysical description of the project area in each country was made to give the reader a better understanding regarding the applicability of all technologies included in this manuscript.

China

The HKH belt in the People's Republic of China includes all of Tibet, various prefectures and districts of both Yunnan Province (i.e., Baoshan, Lijian, Nujiang, Diging, Dali, and Chuxiong) and Sichuan Province (i.e., Yann, Aba, Ganzi, Liangshan, and Dukou). It also includes all of the *Xizang* Autonomous Region (Sharma 1994). The total geographic area is about 169 million ha. Only 1.2 per cent of the total area is under cultivation, whereas pastoralism accounts for the principal use of land (i.e.,



Map 1: Temperature and Rainfall Classes of HKH Region

Table 1: Area and Population of the Hindu Kush-Himalayas

Country	Inclusions	Area (sq. km.)	Approximate Population '91 (in millions)	Density of Population (per sq. km.)
Afghanistan	25 of the 30 provinces	390,475	13.8	35
Bangladesh	Chittagong Hill Tracts	13,181	1.0	78
Bhutan	Entire territory	46,500	1.2	26
China	All of Tibet and parts of Yunnan and Sichuan Provinces	1,647,725	19.6	12
India	All of 8 and part of 3 northern states	482,920	35.0	73
Myanmar	States of Kachin, Chin, and Shan	280,862	5.6	20
Nepal	Entire territory	147,181	18.5	126
Pakistan	NWFP, FATA, Northern Areas and 12 of the 16 districts of Balochistan	404,195	22.7	56
TOTAL		**3,413,039**	**117.4**	**34**

53.4% as pasture areas). About 69.7 million head of different classes of livestock provide the socioeconomic activity in this part of the HKH region (Chalise et al. 1994). In both Yunnan and Sichuan Provinces, the Hengduan mountains dominate the HKH belt (see Table 2). Tables 3 and 4 respectively contain information on the distri-

Table 2: Distribution of Major Mountain Systems in China

Name	Location	Orientation	Length (km)	Average Height (m)	Main mountain	Elevation (m)
Himalaya Mtns.	South Asia/ Tibet border	NW-SE	2450	6000	Mt. Qomolangma	8848.13
Gandise Mtns.	Southwest Tibet	NW-SE	600	5000-6000	Mt. Kangrengboqing	6711
Karakorum Mtns.	Xinjing and Tibet	NW-SE	400	6000	Mt. Qogir	8611
Tanggula Mtns.	Qinghai and Tibet	NW-SE	700	6000	Mt. Geladandong	6621
Hengduan Mtns.	Western Sichuan and Yunnan, and eastern Tibet	NS	1000	2000-6000	Mt. Gongga	7590
Kunlun Mtns	Among Xinjing, Tibet and Qinghai	WE	2500	5000-7000	Mt. Muzitage	7723
Bayanhar Mtns.	Qinghai	NW-SE		5000-6000	Mt.Bayanhar	5267
Tianshan Mtns.	Central Xinjing	WE	2500	3000-5000	Mt. Tuomuler	7435
Altay Mtns.	Northern Xinjing	NW-SE	2000	1000-3500	Mt. Youyi	4374
Qinling Mtns.	Between Gangsu and Qinghai	NW-SE	1000	4000	Mt. Shuleman	6346
Yinshan Mtns.	Central Inner Mongolia	WE	1200	2000	Mt. Huerbashenge	2364
Helan Mtns.	Ningxia -Inner Mongolia border	NS	330	2000-2500		-
Greater Hinggan Mtns.	Heilongjiang and Inner Mongolia	NE-WS	1200	1000-1400	Mt. Huangangliang	2029
Lesser Hinggan Mtns.	Northern Heilongjiang	WE	-	600-1000	-	-
Changbai Mtns.	Heilongjiang, Jilin and Liaoning	NE-WS	-	500-1000	Mt. Baitou	2749
Taihang Mtns.	Shai, Henan, Hebei	NE-WS	400	1500-2000	Mt. Xiaowutashan	2882
Qinling Mtns.	Qinghai, Gansu, Shaanxi and Henan	WE	1000	2000-3000	Mt. Taibaishan	3767
Wuyi Mtns.	Between Jianxi and Fujian	NE-WS		1000-1500	Mt. Huanggang	2158
Nanling Mtns.	Hunan, Jiangxi, Guangdong and Guangxi	WE	1000	1000	Mt. Maoershan	2141
Taiwan Mtns.	Taiwan	NS	-	-	Mt. Yushan	3997

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

Table 3: **Distribution of Major Plateaux in China**

Name	Area (10^4 km^2)	Elevation (m)	Location	Distribution	Characteristics
Tibetan Plateau	249.6	3000-5000	Surrounded by Qilianshan, Alkin Hengduanshan and Himalaya Mountains	Qinghai Tibet, West Sichuan, Southwest Gansu	Highest in topography, plenty of snowy mountains with icebergs
Inner Mongolian Plateau	100	1000-1500	West to Greater Hinggan Mountains, north to Qilianshan Mountains, the Great Wall and east to Tianshan Mountains	Inner Mongolia, North Hebei, North Ningxia and Gansu	Wind erosion, undulating landform
Loess Plateau	40	800-2000	West to Taihang Mountains, west to Wuqisoling. North to Qinling , south to the Great Wall	Shannxi, Gansu, Ningxia, Shanxi, Inner Mongolia, QingHai, Henan	Porous soil, severe soil erosion and water loss, complicated landform
Yungui Plateau	55	1000-2000	South to Sichuan Basin, east to Hengduan Mountains, west to Xuefengshan Mountains	Guizhou, East Yunnan, Northwest Guangxi. Boundaries of Sichuan, Hunan, and Hubei	Rugged landform, widely distributed landform

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

Table 4: **Distribution of the Main Hills in China**

Name	Distribution	Location
Liaodong Hills	Southeast Liaoning	Surrounded by sea except on one side that is adjacent to Changbaishan Mountain
Liaoxi Hills	Western Liaoning	General term for the low hills south of the Laoha River in Liaoning Province, its main hills are Shongiing, Nuluerhu, and Yiwulu
Shandong Hills	Central & eastern Shangdong	Two parts: to the west are the Vault Hills in Central Shandong, to the east are the Jiaodong Hills (also called the Laoshan Hills)
Huaiyin Hills	Henan, Hubei and Anhui	Henan-Hubei border, the watershed of the Yangzi River and the Huaihe River in Central Anhui. It extends from Tongbeishan Mountain eastward to Hongze Lake, including Dabieshan Huoshan Mountains etc.
Minzhe Hills	Fujian, Zhejiang and Northeast Guangdong	General term for the low hills in Fujian, Zhejiang, northern and eastern Guangdong, including Tianmu, Wuyi, Xianxia, Kuocang, Yandang and Daiyun Mountains
Jiangnan Hills	Hunan, Jiangxii, southern Anhui and southern Jiangsu	General term for the hills south of Yangzi River, north of the Nanling Mountains, west of Wuyishan and Tianmushan Mountains, east to the Guizhou Plateau. The area can be divided thus: (1)West Hunan Hills, including Wuyishan and Xuefengshan Mountains etc. (2) Central Hunan Hills, including Henshan Mountain (3) West Jiangxi Hills, including Munishan and Luoxisoshan Mountains (4) East Jiangxi Hills, including Huaiyushan and Yushan Mountains (5) South Anhui Hills, including Huangshan and Jiuhuashan Mountains (6) Ningzhen Hills, including Ningzhen and Maoshan Mountains
Guangdong, Guangxi Hills	Guangdong and Guangxi	General term for the low hills in Guangdong and Guangxi, including Dayaoshan, Shiwaodashan, Gouloushan, Yunkaidashan, Luofushan and Linhuashan Mountains etc.

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

bution of major plateaux and the distribution of major hills in China.

Geo-ecological Conditions of the Hengduan Mountains

Zheng et al. (1993) have described the geo-ecological conditions of the Hengduan Mountains that fall in the HKH zone in China. The area was divided into three zones. On the northern side of the Himalayas is the agro-pastoral zone. On the southern side of the Himalayas and the southern section of the Hengduan Mountains is the agro-forest zone. The middle and northern sections of the Hengduan Mountains constitute the agro-forest-pasture zone.

The Hengduan Mountains comprise a series of high mountain ridges sandwiched between deep river gorges. The topography is interlaced and separated by mountains, plateaux, valleys, and basins in distinct relief.

The climate of the Himalayas and the Hengduan Mountains is characterised by a monsoon pattern with alternate wet and dry seasons. Winter lasts from November to April and precipitation rarely occurs. Summer extends from May and features heavy monsoon rainfall in most areas of the Hengduan Mountains. The annual precipitation varies between 500mm and 900mm. The mean temperature of the southern aspect of the Hengduan Mountains during the coldest months would be less than 18°C.

Zheng et al. (1993) also divided this area into four physio-geographical zones based on thermal-moisture regions and three-dimensional differentiations.

i) *The tropical and subtropical montane monsoon region with a humid climate*

This region extends over northwest Yunnan and western Sichuan, where elevation is below 2,500m above sea level (masl), the mean temperature of the warmest months varies from 18 to 25°C, and average temperatures during the coldest month fall between 2 and 16°C. The mean annual precipitation varies from 800 to 3,000mm. Popular fruit trees and cash crops are bananas, oranges, grapes, tea, and sugarcane at lower altitudes; while the temperate fruit trees and vegetables such as apples, pears, peaches, tomatoes, and pepper grow at higher elevations.

ii) *The temperate plateau region with humid and sub-humid climates*

This consists mainly of a series of high mountain ridges and comprises the central and northern parts of the Hengduan Mountains. The warmest mean temperature varies from 12 to 18°C at altitudes of from 2,500 to 4,000m. Annual rainfall totals from 400 to 1,000mm. This zone is rich in forest resources, medicinal plants, and mushroom production. Temperate fruit trees such as apples, pears, peaches, and walnuts grow well.

iii) *The plateau temperate semi-arid climate zone*

This is in south Xinang at altitudes of from 3,500 to 4,500m, where mean temperatures during the warm season fluctuate between 10 and 16°C, and average temperatures in the cool season remain within the 0 to 10°C range. Annual precipitation decreases from 500 in the east to 200mm in the west. Temperate fruit trees grow at

altitudes of less than 4,000m and the climate is suitable for potato production and for other vegetables.

iv) *The plateau temperate arid climate zone*

This covers the Nagri region and is composed of the upper reaches of the Indus River, and the broad valley of Banglong Lake where altitudes range from 3,800 to 4,500m. It is warm in summer and mean temperatures are between 10 and 14°C. Winters are severe, however, with a -10 to -14°C mean temperature range in the coldest month. Annual precipitation is less than 50mm. A large portion of the region is used for grazing small ruminants.

Basic Eco-environmental Characteristics of the Tibetan Plateau

Tibet, in the southwest of China, is composed of extremely high mountains and great plateaux. Its average elevation is between 4,000 and 5,000m. The Himalayas, Qandine, Karakoram, and Tanggula are famous mountain systems in the Tibetan region.

The Tibetan Autonomous Region (TAR) constitutes the main part of the Qinghai-Tibetan Plateau. The total area of TAR is 1.2 million sq. km. with an average elevation of 4,000m (Qinye 1997). The Himalayan Mountains from the southern side have a big influence on the climate of TAR. There are a series of high mountains and highlands characterised by wide valleys and basins. The higher altitude causes relatively low temperatures and cold weather. The mean annual temperature is below 0°C in the middle of the plateau and is below 10°C in July in most parts (Qinye 1997).

Qinye (1997) discussed the climate and land-use patterns of TAR. There may be several different climatic zones, ranging from tropical low mountain areas to cold temperate highlands. The Himalayas serve as a barrier between north and south. In the warm season, flora and fauna are mostly distributed on the southern aspect. The southeast of TAR shows vertical zonation of forests, however, alpine meadows, steppe, and desert cover the central plateau. The horizontal changes may be seen from southwest to northwest in a sequence of forest-meadow-steppe-desert. The population density is very low at 4/km^2.

Livestock grazing is the major land use of the Tibetan plateau. There are more than 64 million ha of natural pastures of different kinds. The forage productivity of the pastureland is relatively low at 1,300kg/ha on a fresh weight basis. Forests make up 10 per cent of the total area. Only 0.22 million ha are cultivated (i.e., only 0.3% of the total area). Qinye (1997) divided the plateau into six land-use classes.

- High mountain valley agriculture and livestock region in eastern Tibet
- High mountain deep valley forestry, agriculture, and livestock region of the southern Tibet border area
- High mountain wide valley agriculture and livestock in central Tibet
- Plateau lake basin husbandry and agriculture region in southern Tibet
- Plateau lake basin livestock region in northern Tibet
- Initialised region in the northern Tibetan plateau.

Barley and wheat occupy more than 90 per cent of the cultivated land and aver-

age yield is seldom higher than 2,800kg/ha.

India

The project area of cold deserts in India covered about 15,000 sq. km. and extended over the Leh and Kargil districts of Jammu and Kashmir (J&K), districts of Lahaul and Spiti, and parts of Chamba and Kinnaur in Himachal Pradesh. These deserts are characterised by sub-zero winter temperatures (i.e., -20 to -40°C), a maximum day temperature of 40°C in summer and large diurnal variability in the ambient temperature. The annual precipitation is generally less than 30cm and is mostly received in the form of snow. Soils are shallow with little water holding capacity. High velocity winds blow for 12 to 18 hours per day. These distinct environmental characteristics have been supporting the succession of shrubby vegetation and C_3 plants over several stages. The deserts are ecologically varied and biologically diverse. Their biophysical conditions will be described separately.

Cold Desert of Jammu and Kashmir (J&K)

The cold deserts of J&K are restricted to the Ladakh area and are located between latitude 32 to 36° North and longitude 76 to 79° East. This zone lies in the high altitude range of the northwestern Himalayas. It covers Leh and Kargil districts in the east and borders with Gilgit and adjacent areas in the northwest. It has an area of about 0.067 million sq. km. The topography is rugged with rocky terrain and rough mountainous peaks reaching 4,000 to 5,500 masl. There are also sandy deserts, valleys, and a few fresh water bodies. This region comprises one-third of the total area of J&K. The valleys are relatively long, wide, and open. Six rivers (the Indus, Syele, Zanskar, Nubra, Laru, and Drass) traverse the area.

The climate of Ladakh is temperate, arctic, and extremely dry and cold. Temperatures fall below -30°C. Drass, a small valley in the Ladakh area, is considered the second coldest place in the world. The region is mostly snow clamped and cut off from all other parts of the country for seven months of the year – from November to May. One of the most important characteristics of the area is an optimum thermal regime with stable weather – to which increased crop production can be attributed.

The flora and fauna of Ladakh are unique. Natural vegetation is mostly herbaceous and common plant species include *Juniperous wallichiana*, *J. communis*, *Caragana* spp, *Artemisia* spp, and *Betula utilis*. In addition, artificial forests, mostly made up of poplar, willow, and seabuckthorn, are found along the riverbanks, rivulets, and *nullah*(s). The main wildlife species include the snow leopard, ibex, blue sheep, wild ass, marmot, Tibetan wolf, and gazelle. There are nine varieties of birds, including the snow cock, partridge, and magpie. Large numbers of migrating birds also dwell on the lakes and rivers.

Social Environment

Although influenced by other parts of India and Tibet, the people of Ladakh have succeeded in developing their own distinct culture. They are simple and they follow the old cultural values. Their own script dates back to the seventh century A.D. Local people are fond of song and dance. Drama forms an important part of *Ladakhi*

culture. Losar (i.e., the New Year celebration in the Buddhist calendar) is one of the most important events of the year. *Ladakhi* is the main dialect in the Leh Valley, however, in Kargil both Urdu and *Ladakhi* are spoken. Buddhist priests, called *Lama*(s), are the authority on traditional medicine, which is based on indigenous herbs and shrubs, and the medicinal literature is written in *Ladakhi*. This indigenous medicinal practice is called *emchi*. People in rural areas are engaged in the collection of minor forest products of medicinal value. Some of the important products are *Physochloina praoalta* (Langtang), *Ephedra* spp (*sapat*), and *Podophyllum* spp (*modi*).

The economy is mainly agro-pastoral. However, indigenous cottage industry is fairly well developed. Wood carving and woollen and *pashmina* shawls are popular with tourists. Tourism has great potential because of the unique terrain and rich cultural heritage. Leh is linked by air with Chandigarh, Delhi, and Jammu and has road links with Manali and Srinagar.

Farming Practices

The total cropland area in Ladakh is 1,060,000 ha, with a cropping intensity of 106 per cent. The net irrigated area is 97 per cent. The sole means of irrigation is by canal. Wells and tanks are yet to be used in the irrigation system of the region. Though the area has rich water resources, these are inaccessible. Groundwater is mostly saline and as such its use for irrigation purposes is negligible. The highest concentration of operational holdings is in the category of marginal farms (<1.0 ha) which account for more than 55 per cent of the total operational holdings. Small farms (i.e., 1-2 ha) and medium farms (i.e., 2-5ha.) constitute only 20 per cent of the total holdings. The average holding size is 1.54ha.

The region has essentially only a single cropping season, in the summer, this is called *kharif*, and extends from March/April to October. The cropping season varies at different altitudes, which may be up to two months in zones above 4,000 masl, three months in areas between 3,000-4,000 masl, and five months in locations below 3,000 masl elevation. This weather regime is optimum for growing a number of crops. Millet is grown on 50 per cent of the total cropped area. Wheat is the next most important cereal with 22 per cent of the total cropped area. Other crops grown in order of priority are fodder crops, barley, and pulses. Among the fodder crops, *alfalfa* is most popular due to its better adaptability to moisture stress conditions. The area under maize and rice is negligible.

Fruits and vegetables are the only commercial crops. Due to higher returns, farmers have recently introduced a fast-developing horticulture industry. Every year additional land is used for this activity. Apples, raisin grapes, and apricots are the main fruit crops in this zone, it is also known for its production of *pashmina* goats, yaks, donkeys, and double-humped camels.

The agroclimatic conditions within this zone vary greatly depending upon the altitude, soil, and climate. Hence, the cropping patterns and seasons also differ. During the winter months, different belts remain cut off because the high passes are blocked by snow. Specific farming situations have been identified as per the altitude.

- Upper Belt (3,500-5,000 masl)

This belt includes the sub-snow lines and highland meadows. Changthang, Khardung, and Diggar in Leh district, as well as Zanskar and Drass in the district of Kargil are inside this belt. Early maturing varieties of barley can be grown under irrigated conditions here. Rearing of goats, sheep, and yak is an equally important activity. Pastoral farming takes place in Changthang sub-division. Here, nomadic people rear the special breed of Pashmina goats and Changthangi sheep. In this belt, crop maturity is delayed and sometimes the crop is damaged by frost or hailstorms. The highland pastures and chunks of wasteland are also used for grazing. There are no systematic grazing patterns, and this has resulted in deterioration of the pastures.

This belt, being the highest inhabited part of the region, experiences low temperatures and a short summer. For the most part, no perennial forage crop is raised and the local pea variety is cultivated and hay preserved to feed animals in the winter.

- Central Belt (3,000-3,500masl)

This belt includes Leh and its surroundings, Nubra Valley and a small part of Kargil district. The majority of the land is under cultivation. It is a mono-cropped belt in which barley and wheat are the main cereal crops. Mustard, peas, and lathyrus are also cultivated on a small scale.

Among the fruit crops, apples and apricots are cultivated in limited amounts. This is the belt where most vegetables are being cultivated on an extensive scale. This is probably due to the benefit of being centrally located and near to marketing terminals. The area has great potential for vegetable seed production. *Alfalfa* (Lucerne) is the major fodder crop. This crop is preserved as hay to stall-feed animals during the prolonged winter. Wheat and barley residues also have a lot of fodder value. Crop rotation is not common. Animal rearing is a subsidiary activity.

- Lower Belt (3,000 masl)

This zone is made up of the double-cropped area of Saspol to Dhahanu and Turtuk in Leh district; and Batalik, Gargarthang, and most parts of Kargil district. This area is considered to be a fruit growing belt. It is famous for the production of sun-dried apricots. Apricots and apples are the main fruit crops, along with walnuts, peaches, and plums. In some of the lowermost pockets, grapes are also cultivated. Common crop rotation patterns are barley-millet or turnip-wheat-fallow. Animal production is an essential secondary profession of the farming community.

Although small landholdings are a distinct overall feature of Ladakh, the size of the holdings are the smallest in this belt. This zone has a climatic condition that is suitable for extensive cultivation of vegetables. Conventional methods for preserving fruits are unhygienic and have little market value. Farmers need education and training which can enable them to adopt modern post-harvest technology.

Cold Deserts of Himachal Pradesh

The 'Cold Deserts' in H.P. are restricted to the districts of Lahaul and Spiti, parts of Kinnaur (on the Sumdo side), and Pir Panjal in Chamba. These areas have very difficult terrain with ice fields, perpetual snow-covered peaks, and a hostile climate. The

Great Himalayan range with a mean elevation of 5,500 masl extends from the Kunzam range to the Baralacha and Pin-Parvati ranges, separating the Chamba-Beas basin from the Sutlej-Spiti basin around Pooh. The Great Himalayan range is pierced by the Sutlej at Kalpa. The Zanskar range, beyond the Great Himalayan range, extends from Kinnaur, bordering China,and separates Spiti from Kinnaur and Tibet. The Zanskar range is pierced by the Sutlej at Shipki-la. The cold deserts in HP cover 35 per cent of its total geographical area.

The districts of Lahaul and Spiti are situated in the west of the greater Himalayan range between latitudes 30° 21' and 30° 50' 57" North, and longitudes 75°46' 29" and 78° 41' 34" East. Lahaul and Spiti districts are composed of two different valleys, e.g., Lahaul and Spiti. The Lahaul Valley is narrow, steep, and studded with green patches of poplar, willow, and conifer. The Spiti Valley is rugged, with broad sand dunes,high peaks, and an average height of 6,600 masl.

The Pir Panjal ranges possess perpetual snow cover with steep, rocky, and gorgeous slopes. The Lahaul Valley is home to two very fast flowing rivers, the Chandra and the Bhaga, which converge at Tindi to form the Chandra Bhaga (Chenab). The Chandra Bhaga then flows down to Jammu and Kashmir through the Pir Panjal ranges. In the Spiti Valley, the Spiti is the main river, flowing through the entire length of the valley, and swallows numerous rivulets and rivers (the Pin, Lingti, Gumto and Parechu) on its way. It then converges with the Sutlej flowing through Kinnaur. The cold desert area in Kinnaur district falls adjacent to the eastern part of Spiti (Sumdo). The Sumdo area in Kinnaur comprises a broad, sandy valley surrounded by high mountain peaks.

The geology is made up of gneiss and schistose rocks, slates, quartzite, phyllite, sandstone, (batal) slate, dolomite, shale, limestone (takche) and fossiliferrous limestone. Calcareous shale with rich fossils are found in Lipak, Hunsa and Spiti. Fossils such as *Ammonites*, *Tenaculites*, and *Orthis* (Paleozoic and Mesozoic) are found in complete sequence from the Pre-Cambrian Quarternary.

In a broad sense, the climate can be categorised into spring, autumn, summer, and winter seasons. Natural springs and rivers become frozen in winter. The Lahaul Valley and Pir Panjal ranges experience heavy snowfall throughout the winter, while Spiti has very little precipitation during the winter. This lowers the mercury level to -40°C, although a temperature of -20°C is normally observed. Summers are associated with strong winds (40 to 60km^{-1}) causing dust storms. Relatively high diurnal temperature variations are observed in the summer season.

The natural vegetation cover of the entire area is fairly sparse. However, the Lahaul Valley and Pir Panjal areas still possess some forests on alluvial deposits. In the Spiti and Sumdo area, the number of old trees can be counted on the fingers. The overall vegetation consists of a few tree species, namely, junipers, *Betula utilis*, poplars, and willows. Common shrub species are *Hippophae*, *Myricaria*, *Ephedra*, *Artemisia*, *Rosa*, *Astragalus*, *Caragana*, and *Salix*. Herbaceous elements commonly found are *Thymas*, *Medicago*, *Trifolium*, *Anemone*, *Potentila*, *Epilobium*, *Verbena*, *Allium*, *Aconite*, *Delphenium*, *Aquilegia*, *Primula*, *Geranium*, *Polygonum*, and *Can-*

nabis. The distribution of these species depends upon the altitude, direction, and availability of soil moisture. The fauna are unique with palaeoarctic affinities and Tibetan birds and animals such as the ibex, bharal, brown bear, Tibetan wolf, nayan, marmot, snow leopard, lynx, weasel, vole, snow cock, snow partridge, *chukor*, chough, and raven. Two sanctuaries, namely, Pin Valley National Park in Spiti and the Sechu Tuan Nala in Chamba, have been established in the cold deserts.

Social Overview

The inhabitants of Lahaul, Spiti, and the Sumdo area of Kinnaur are overwhelmingly Buddhist. The 11th Century BC monasteries at Gumrang, Sissoo, Udaipur, Tabo, and Kee are still in good repair. However, in the Pir Panjal area, Hinduism is practised. In Lahaul Valley, the people have their own dialect, whereas in the Spiti and Sumdo area, the language is closer to the Tibetan dialect. The entire population can be categorised as *Swangla*(s) and *Lahaual*(s) in Lahaul, *Bodh*(s) in Spiti and Kinnaur, and Hindus in the Pir Panjal area.

Agriculture and animal husbandry are the main occupations. The area is well known for its disease-free seed potato with the highest yield in the world. *Lahaula*(s) are comparatively open and highly educated. The rise in literacy has abolished the polyandry system from Lahaul, whereas it still prevails in Spiti to some extent. In the Pir Panjal area, livelihoods mainly depend on the agropastoral system.

The traditional medicine system, mostly of Tibetan origin and based on local flora, can be effective in curing both common as well as chronic diseases and disorders. The weaving of indigenous fibre and wool fibre is quite a common practice, especially in winter. Handmade shoes of fibre from *Cannabis* and local leather are comfortable and warm. Woollen garments are made from local wool/hair (sheep, goat, yak). During the summer, the inhabitants collect precious stones and minor forest products of medicinal value in order to earn extra income.

Due to poor communication facilities, tourism prospects are restricted. However, the Lahaul Valley and Pir Panjal ranges offer some very good trekking routes and sites. The Spiti Valley has been opened to foreigners.

General Farm Practices

Farming practices in the cold deserts of HP are discussed separately to facilitate better understanding of local agro-ecosystems.

- Lahaul Valley

The age-old cropping pattern meets the agroclimatic and socioeconomic needs for sustainability of the village ecosystem. Only one ploughing (i.e., pre-sowing) season is the general practice. The fields are ploughed in September before the onset of snowfall in November-December. As soon as the snow melts, the upper surface is stirred up with a rake or hoe for sowing seed. Whenever snow is heavy, there is plenty of moisture for seeds to grow, otherwise fields are irrigated by water channels. Sowing is completed in May or at the latest by early June. Sowing would necessarily be followed by irrigation after every fortnight and sometimes earlier, depending upon the availability of irrigation water. Barley, wheat, buckwheat, peas, and mustard are the most important crops. Barley is the most important staple food crop of the people. Buckwheat

is sown in succession to barley and is grown only on lower ranges. Peas and seed potatoes are grown all over the valley and have changed the tribal economy into a market economy. This process of economic transformation was introduced with the use of *kuth*, which is exported not only to other districts of the state and to other states in India but also outside the country. In May, *kuth* seed is broadcast along with barley. Thereafter, the young *kuth* plants, three months old, are properly spaced and manured. *Cheena* and tobacco are among the additional crops grown in this area. Mustard is grown on a smaller scale at lower elevations for its oil. *Bhang* and a few other vegetables are grown near homesteads. Popular vegetables are radishes, turnip, carrots, French beans, beetroots, cabbages, cauliflowers, and tomatoes. Soybeans are also grown. Crab apples, small in size and poor in taste, are common. Small pears grown here are juicy and delicious. Apricots grow mostly in the wild. They are small and possess a long shelf life. Oil is extracted from the kernels and used for cooking.

A few wild fruit plants include *nangke*, a thornless shrub of 1.2 to 1.5m which bears a red berry-type fruit. Another thornless shrub found here is called *rashtu*. This is almost of the same size as *nangke* and bears a round, black berry. There is yet another thorny shrub, which bears sour, red berries. *Lizo* and *rizo* varieties of wild cherry are also found. Alpine strawberries, small but tasty, and gooseberry bushes having fruits a little larger than grapes, are also found.

Various ceremonies are observed concerning cultivation. Ploughing operations start on an auspicious date fixed by a *Lama* skilled in astrology. When the seed has been sown, the fields are likewise blessed; the *Lama*(s) are led to the fields in a procession to the accompaniment of the local orchestra. Prayers are held and the proceedings terminate with a small feast. To ensure that every seed that has germinated will produce corn ears, yet another ceremony is held in which the fields of sprouting corn are dotted with small sticks of juniper.

- Spiti Valley

Traditional farming is still a common practice throughout the entire Spiti Valley. The main crops are naked barley, common barley, wheat, and potatoes. With the dissemination of new technology by various extension agencies, cash crops such as off-season peas and hops are becoming popular and remunerative. However, lack of transportation facilities is still a main constraint to their cultivation. Sowing operations remain traditional. The area under cultivation is dependent upon assured irrigation. Indigenous ploughing is a common feature, although with the aid of subsidies, threshing operations are carried out mechanically. Farming conditions in the valley are entirely different from other parts of the state. Farmers have to struggle to make a living out of their small holdings on which nothing can be grown without irrigation. The area has witnessed a gradual shift in cropping patterns during the past two decades, from the growing of field crops to the cultivation of high-value cash-crops. At present, more than 50 per cent of the cultivated land is under cash crops such as off-season peas and seed potatoes.

Continuous flooding of individual fields is a common feature in the valley. The water supply and maintenance of the *kuhl* is managed by the community, and water availability is scheduled on a rotational basis depending on the size of the land-

holding. Generally, every farmer gets his turn once a week. The source of irrigation water is generally local *nullah*(s). Maintenance of the irrigation *kuhl* is carried out by the irrigation department. Due to the short growing season and cool climate of the region, monocropping is prevalent throughout the valley. The cereal crops, potatoes and peas are sown in April and are harvested in September-October. The yield is low as technology packages in terms of quality seed and fertilizer application are rarely used.

- Bharmaur Valley

The Bharmaur area is mountainous. The fields are usually of small size and are arranged in terraces, the lower border of each being formed by a rough wall providing terraces upon terraces to make the field more level for ploughing. The people of Bharmaur are agrarian. The net area sown is 2.01 per cent of the total geographical area. The practice of double cropping is limited. There are two crop seasons, namely, *kharif* and *rabi*. The *kharif* sowing season is between the months of April and June and the harvesting is completed by late August to early October. The *rabi* crop is sown during the months of October and November and is reaped in May and June. Because of variations in altitude and temperature, harvesting operations have a wide time gap. These variations have determined different patterns such as monocropping, double cropping, and sometimes biannual cropping.

Food grains occupy 19.1 per cent of the gross cropped area. The principal cereals grown in the valleys are wheat, barley, and maize. Besides these, important locally grown cereals are *phullan*, *seul*, *korda*, *bhares*, *kanni*, and *chanat*. Wheat, barly, mustard, linseed (grown on a small scale), and lentils are the main *rabi* crops. Vegetable crops, such as cabbages, cauliflowers, peas, onions, turnips, carrots, and radish are also grown in limited amounts. Maize, rice, *mash*, *moong*, *seul*, *phullan* and *bhare* varieties of lentils are the main *kharif* crops. Cash crops such potatoes, tobacco, and chillies, and vegetables, such as beans, pumpkin, *brinjal*, lady fingers, etc., are cultivated to a small extent. During *kharif*, maize and rice are the predominant crops, while wheat and barly are important cereals of the *rabi* season.

A rudimentary form of green manuring is practised in paddy cultivation by using the leaves of wild bushes such as *basuti* and *kaimal* in fields before sowing. The practice of growing paddy mixed with *dhaincha* is also adopted, in fields where the paddy crop is broadcast. For this purpose, about 10 to 15kg of *dhaincha* seeds are mixed with every ton of paddy seed. During inter-culture, about a month after sowing, the *dhaincha* plants are uprooted and trampled into the soil in order to serve as green manure. The practice results in an increase in the yield of paddy by one to one and half tons per acre.

Men, women, and children work together in the fields all over the valley. Agricultural operations carried out by men are tilling, sowing, and harvesting. Women play an important role in weeding, harvesting and threshing operations. Children also render considerable assistance in threshing and storage.

The edible nut of *Pinus gerardiana*, locally called *chilgoza* and the hazelnut (called *thangi)* growing under wild conditions are the specialities of the Pangi sub- *tehsil*. Walnut grows wild and is cultivated in fields and in grazing areas throughout the Pangi and Bharmaur sub-*tehsil*(s) and in

many parts of the Churah, Chamba and Bhattiyat *tehsil*(s). Certain parts of the Chamba, and Churah *tehsil*(s)abound with mango trees. These lower regions are climatically suitable for all kinds of subtropical fruit. Gooseberry, strawberry, blackberry, redberry, rhubarb, bramble, and raspberry, all growing in the wild, are found in various parts and at different altitudes. The wild apricot is also harvested and dried. Oil is extracted from the kernels of some fruits, such as walnuts and apricots, and is used for burning in lamps, as well as being eaten as food.

According to a 1982 livestock census, the sheep and goat population constitutes the most significant category of animals, numbering 1,38,365 and forming 87.4 per cent of the total livestock population. Pastoralism is one of the main activities of the area. The steep gorges provide grazing facilities throughout the summer months. A migratory tribe called the *Gaddi* is unique to the area. *Gaddi*(s) own large flocks of sheep and goats and continuously migrate from alpine pasture to foothills and vice versa.

Household cottage industries, such as weaving and spinning, contribute to the economy of the area. Cloth is spun on indigenous home looms called *khadi*(s) in order to fulfill domestic needs. Among the main items made in cottage spinning are *pattus*, *pattis*, and *chadars*. These goods are sold at fairs and when the population migrates to the plains.

- Pangi Valley

The Pangi Valley is surrounded by high mountain ranges. The area is situated in the alpine pastoral zone, which remains under snow for about five to six months annually. Maize, wheat, barley, and potatoes are the staple foods. Wheat is mixed with certain edible grasses and roots before it is consumed. Lentils, such as *mash*, *masur*, and *moong*, are more commonly used. Generally, farmers are sedentary rather than migratory, except in the case of the inhabitants of the higher altitude Sural, Hudan and Saichu *nullah*(s), sub-villages from which the populations migrate to the adjoing areas of Chamba and Churah *tehsil* during the winter months. Agriculture is a way of life rather than a commercial proposition for the people here. The net area sown in the Pangi *tehsil* is one per cent of the total geographic area. The practice of double cropping is very limited. Food crops occupy 99.8 per cent of the total cropped area. The principal cereals grown in the valley are wheat, barley (including a special variety of barley which is used for wine preparation) and maize. The average holding size in this valley is very small, and this can be attributed mainly to the hilly terrain and partly to sub-divisions, a result of the prevailing laws of inheritance.

The people of Pangi Valley are not seasonal migrants in the pastoral sphere of their economy, as is the case in Bharmaur. Migratory herdsmen from outside the Pangi *tehsil* derive much advantage from the summer pastures in this area. The main breed of cattle is the *Choor* (male) and *Choori* (female), which is a crossbreed of the yak and hill cow. The crossbred animals are superior to ordinary local breeds of cattle, both in draught power and milk yield. Sheep and goats are also reared for meat and fibre. The contribution of the bovine population to the economy of the area in terms of milk and milk products, animal manure and animal power used on farms, and for transport cannot be over estimated.

The residents of this tribal area undertake weaving and spinning on indigenous *khadi*(s) as a subsidiary occupation in order to cater to their domestic needs. Among the main items manufactured are *pattoos*, *patties*, *chadars*, and *thobis* (matting).These are generally made for household consumption and most of the raw materials used are available locally. Blacksmiths, carpenters, and tailors are the only village artisans, although in certain places, oilmen, tinsmiths,brasssmiths, and goldsmiths are found. Each artisan caters to the needs of a group of villages. In most cases, the customary payment is made in kind, depending upon the size of a family and the number of implements supplied, or the nature of services rendered.

- Kinnaur

Generally, very little land out of the total geographical area is suitable and available for cultivation of crops in the hills. However, as there is limited scope for other economic activities, such as industry, commerce and trade etc, agriculture is the mainstay of the people.

Farmers take advantage of the *kharif* as a full cropping season. Millet and other grains, including *ogla*, *faphra cheena*, *cholai*, *kangni*, and *bathu* (chenopodium), are the main crops of this season. In winter, the entire area remains under snow. Only wheat, barley, and peas are grown in the *rabi* season, the remaining *rabi* crops in the whole of Kinnaur are grown in the *kharif*. However, in upper Kinnaur, there is only one cropping season and all *rabi* crops are sown in summer. Only one crop is grown in a year and people have to depend upon imported wheat. Wheat and barley are grown in the summer season in fields on high hills owned by farmers. These fields are locally called *kanda*.

Fruit growing occupies an important place in local farming. The dry and cold climatic conditions are ideally suited for the cultivation of fruit such as apples, almonds, apricots, grapes, prunes, and nuts. A limited area is also under *chilgoza* forest. A shift in the cropping patterns, from traditional agriculture to the raising of horticultural and cash crops is taking place.

Vegetables grown include cabbages, peas, turnips, tomatoes, cauliflowers, lady fingers, brinjals, and spinach. Other non-food crops include condiments and spices, such as *zeera* (cummin), and saffron; and drugs and narcotics such as hops, *kuth (Saussurea lappa)*, chicory, *karoo* (horse chestnut), and *patish*. The climate is most suited for the production of temperate vegetable crops such as tomatoes, cabbages, carrots, turnip, and beans. Vegetables, such as tomatoes, turnips, and so on, are dried in the sun and used during the winter months when no other vegetable is available. Fruits, such as grapes, apricot/*chuli*, prunes, apple rings, and pear rings, are dried and consumed during the winter months. The quality of these dried fruits and vegetables is poor due to traditional preservation techniques.

Pakistan

The HKH belt in Pakistan may be divided into two parts, namely, the western mountains and the northern mountains. The documentation of technologies was undertaken in the western mountains, in the northern uplands of Balochistan Province and in the mountains of Sulaiman Rod Kohi. Hence, only the salient features of these two zones of the western mountains are described in this chapter.

Uplands of Balochistan

Balochistan Province may be divided into the northern uplands and the southern

zone. It lies as far south as latitude 25° to 30'N of the Arabian Sea and towards the north it borders Afghanistan at a latitude of 32° 00'N. In the west, it shares the border with Iran and its eastern border coincides with three other provinces (i.e., Rod Kohi region). The area of the northern uplands is approximately 132,000 sq. km. The weather data for the highlands of Balochistan are given in Table 5.

Agriculture is the predominant activity in Balochistan, contributing to over 50 per cent of the province's gross domestic product. About 67 per cent of the labour force of the province are engaged in agriculture.

Balochistan comprises some 40 per cent of Pakistan's area, but due to its arid climate and poor water resources, it has the smallest irrigated area of all four provinces. Whilst grain production is possible on rainfed and flood (*sailaba*) irrigated land, yields are not only low but are also uncertain. High-value agricultural production is only possible on perennially irrigated land and water sources for such irrigation are very limited, comprising occasional perennial streams, *karez*, and groundwater development through tubewells and dug wells. The irrigation water from each of these sources is extremely limited and hence needs to be used as efficiently as possible. This is even more important where groundwater resources are concerned as it is rapidly decreasing.

Balochistan, although having a smaller area of irrigated agriculture than other provinces, produces some high-value crops. This is due to the topography and climate. High elevation valleys (over 1,500m) in northern Balochistan are one of the few areas in the region capable of producing deciduous fruits such as apples, pears, plums, peaches, and grapes, all of which command a high price. Medium elevation valleys to the south and west of the above (1,000 to 1,500m) are capable of producing vegetables in different seasons to those in much of the rest of the country and therefore command a premium price. It is only the lower elevation areas in the plains to the south and east of the province which directly compete with the main, irrigated areas in the Pun-

Table 5: Weather Data of Upland Balochistan (1994)

	Quetta		Zhob		Barkhan	
Months	Temp* (°C)	Precipitation (mm)	Temp* (°C)	Precipitation (mm)	Temp* (°C)	Precipitation (mm)
January	11.4	48.4	N.A.	16.0	17.3	2.3
February	12.1	35.2	12.5	35.0	17.2	56.8
March	20.3	26.6	22.9	59.0	25.7	9.4
April	24.2	4.6	15.1	52.0	27.5	30.9
May	31.4	29.0	33.0	0.8	35.8	7.0
June	36.3	Trace	37.5	54.0	38.5	17.8
July	35.9	64.0	34.6	95.0	33.3	229.1
August	35.8	22.0	35.0	3.3	33.0	96.7
September	28.3	62.0	30.8	58.0	31.1	135.5
October	24.1	Trace	26.9	0.0	28.8	2.3
November	21.8	0.0	24.0	3.0	25.0	2.1
December	13.5	13.0	16.2	16.0	18.3	11.7
Annual	24.7	304.0	-	392.1	27.6	601.6

Source: GOB 1996

* Mean monthly maximum or mean daily maximum

jab and Sindh, since both grow similar types of tropical and subtropical fruit, vegetable, and grain crops. Even in the lower elevation areas, however, some crops such as coconuts, dates, and pineapples are grown which are capable of providing a higher than average return.

In the northern uplands, pastoralism with its associated raiding and caravan trading remained the mainstay of the economy until recently. An irrigated fruit and vegetable culture is now taking over as the main source of income. Nomadic pastoralism is widespread. Land utilisation statistics of cultivable areas under *rabi* crops, and areas under *kharif* crops in eight districts in the highlands of Balochistan are indicated in Tables 6, 7, and 8 respectively.

Table 6: District-wise Cultivable Area in the Northern Uplands of Balochistan

District	Cultivable area (ha.)
Quetta	29,400
Pishin	115,900
Zhob	44,900
Loralai	133,700
Kohlu	30,100

(FAO 1983)

Table 7: Land Utilisation Statistics of Upland Balochistan (Area in hectares)

District	Geographical area	Reported area	Current fallow	Net sown	Sown more than once	Cultivable waste	Forest	Not available for cultivation
Quetta	265,287	139,825	26,997	12,712	100	39,175	39,088	21,853
Pishin	1,111,159	265,470	47,287	51,707	150	11,261	73,065	82,150
Loralai	1,907,140	377,750	106,275	42,971	150	75,598	64,589	88,317
Musa Khail	*	*	8,477	5,957	-	*	*	*
Barkhan	*	*	18,861	16,859	-	*	*	*
Zhob	1,651,787	60,930	9,776	13,904	50	13,387	13,010	10,853
Killa Saifullah	1,061,098	69,728	13,228	20,814	200	8,148	20,302	7,236
Ziarat	95,362	65,976	8,674	3,391	30	76	51,335	2,500
Kohlu	761,025	50,000	17,080	8,971	20	1,512	-	22,437
Dera Bugti	1,015,952	61,014	11,413	7,766	-	1,835	-	40,000

Source: GOB 1996

* Rabi crops include wheat, barley, oilseeds, cummin, pulses, vegetables, fodder.

Table 8: Scale of Cultivation in Upland of Balochistan Area (ha)

District	*Rabi* crops*			*Kharif* crops**			Fruits***
	Irrigated	Un-irrigated	Total	Irrigated	Un-irrigated	Total	
Quetta	3,806	554	4,360	8,332	20	8,352	5,696
Pishin	15,535	10,420	25,955	25,195	557	25,752	15,924
Zhob	1,335	1,595	2,930	10,639	335	10,974	9,715
Loralai	11,300	10,400	21,700	19,131	2,140	21,271	14,073
Musa Khail	720	1,100	1,820	2,685	1,452	4,137	161
Barkhan	4,920	6,700	11,620	2,272	2,967	5,239	1,523
Killa Saifullah	6,265	2,220	8,485	11,659	670	12,329	5,284
Ziarat	-	-	-	3,391	-	3,391	3,369
Kohlu	1,635	4,506	6,141	1,873	957	2,830	810
Dera Bugti	2,235	4,352	6,587	178	1,001	1,179	14

* Rabi crops include wheat, barley, oilseeds, cummin, pulses, vegetables, fodder.

** Kharif crops include sorghum, millet, maize, oilseeds, lentils, onion, potato, other vegetables, tobacco, fodder, sugarcane, cotton etc.

*** All fruits are also included in Kharif crops. The main fruit crops are apple, almond, apricot, grape, peach, plum, pear, pomegranate, cherry and pistachio.

Sociocultural Indicators

Balochistan province had an excessively high annual population growth rate of seven per cent between 1972 and 1981. The enumerated and projected population for Balochistan is indicated in Table 9.

Table 9: Human Population in Balochistan

Year	Population (million)
1951	1.2
1961	1.4
1972	2.4
1981	4.3
1990	7.1
2000	10.7
2010	14.6

The literacy rates of 12.5 per cent for men and three per cent for women are far below the low national average of 31 per cent and 13 per cent, respectively. The majority of the population is Muslim (95.5%). Almost two per cent are Christians and 1.6 per cent Hindus.

The average rural population density of 12 inhabitants per sq. km. (1981) makes Balochistan by far the most thinly populated province of Pakistan (*see* Table 10). Among the socio-linguistic groups, the *Balochi* predominate in the Marri-Bugti and Kohlu areas. The *Sardary* (i.e., tribal) system is particularly strong in this region.

Table 10: Human Population Density in Upland Balochistan ('000)

District	1951	1961	1972	1981
Quetta	109 (41)*	142 (54)*	253 (95)*	380 (143)*
Pishin	104 (9)	125 (11)	249 (22)	374 (34)
Loralai	97 (5)	111 (6)	187 (10)	391 (21)
Zhob	65 (2)	88 (3)	172 (6)	360 (13)
Kohlu	66 (4)	61 (3)	108 (6)	178 (10)

Source: GOB 1996

* Persons per square kilometre

In other districts (Zhob, Loralai, Ziarat, Pishin, and Quetta), *Pathan*(s) are the largest socio-linguistic group. The *Pathan*(s) contrast sharply with the *Baloch*. The *Malik*(s) are the chief tribal representatives, while the strongest moral and social power is centred in the religious leadership of the *Mullah*(s) (Saints).

Table 11: Altitude of District Head Quarters in Upland Balochistan

District headquarters	Metres above sea level
Quetta	1,676
Pishin	1,572
Loralai	1,433
Barkhan	1,067
Killa Saifullah	1,550
Ziarat	2,454
Kohlu	1,219
Dera Bugti	450

GOB 1996

Biophysical Environment

Components of the biophysical environment of each district will be described separately.

- Quetta district

Quetta district lies along longitude 66°-53' to 67°-05' E and latitude 29°-55' to 30°-05' N. Quetta Valley is surrounded by the Murdar, Daghari, and Dhik mountain series on the east with Chiltan and Kumbela mountain ranges on the west. The elevation of these ranges is from about 2,100 to 3,300 masl.

This district is classified as 'subtropical continental highland' characterised by cold snowy winters, cool summers, and frequent fog. It has a dry climate with a

mean annual rainfall of about 200mm, occurring mostly in winter. North and northwest winds, known as *'gorich'*, blow from October to February. Precipitation includes rainfall as well as snowfall. There are usually one to two episodes of snowfall in a year which take place between November and March. Precipitation in the area varies greatly from year to year.

Quetta district consists of a series of flat inter-montane basins surrounded by the Toba-Kakar Mountains. These basins have extensive alluvial and colluvial fans with broad aprons fanning out from the base of the mountains. Physiographically, there is shallow, stony, and steep land, gravelly fans and aprons; piedmont plains; piedmont basins; and loess plains.

The total population stands at 676,941 persons (GOB 1997a). Population density in Quetta district is 144 persons per kilometre, compared to Pakistan's average density of 106 persons per km^2. The urban population in the district is 75 per cent. The average household size is 7.7 persons.

Most of the area has a great potential for irrigated agriculture, nearly 64 per cent of the area is free from physical and chemical limitations and requires only slight to moderate ameliorative measures. The remaining 36 per cent of the area suffers from excessive slopes and may be used for grazing or forest purposes.

Agriculture that is rainfed, or irrigated using traditional practices such as *karez* and springs, is usual in this area. With the supply of electricity and mechanisation, use of tubewells has become a recent practice. The main crops cultivated here are vegetables, fruit (apples, grapes, and apricots) wheat, melons, etc. The actual annual cropped area is generally about 30-50 per cent of the cultivated area.

The existing agricultural land is classified into three different land tenure systems namely 'owner occupier', 'occupancy' (tenant), and 'tenant' at will. Crops are cultivated under rainfed conditions by flooding the fields. This practice is common for wheat production, however irrigation for fruit and vegetables is carried out using well water.

Use of inputs is minimal. Less than 25 per cent of wheat producers use limited amounts of fertilizer and almost no pesticides. For cash crops, such as potatoes, onions, other vegetables, and apples, almost all producers apply fertilizers and pesticides.

Draught animals, mostly camels, or tractors are used for land preparation. Household labour is generally used for farm activity, however, one-fourth of wheat growers hire labourers for harvesting and threshing.

- Farmers grow the following crops. The major summer crops (*kharif*) are sorghum (fodder and grain), maize (fodder and grain), and vegetables such as onions and potatoes, as well as melons.
- The winter crops (*rabi*) are wheat, cummin, vegetables, and *alfalfa* as fodder.

Most of the existing irrigation facilities, except *karez*, are constructed and owned by individual farmers. Most of the *karez* systems have now been abandoned because the water table has gone down, or they are in a state of collapse because of the intrusion of flood water. Most irriga-

tion facilities include open/tubewells, pumps, farm ponds, irrigation channels, and pipelines. Tubewells are used increasingly for irrigation or rural water supplies. Various provincial government agencies facilitate tubewell installations on farmers' requests wherever it is technically feasible. Normally, the turbine or submersible pumps for tubewells, and centrifugal pumps for open wells, are operated by electricity or diesel. Usually a 5cm to 12.5cm dia pump is installed and its discharge is 2 litres to 15 litres/second, enough to irrigate 2 ha to 12 ha of vegetables or fruit trees. Pumped water is usually stored in a farm pond through a pipe leading from the well.

Delay action dams (DADs) have been constructed to recharge the groundwater table and to minimise the flood peak discharge.

- Pishin district

Pishin district was created in 1972. It is bounded in the east by Qilla Saifullah and Ziarat and in the south by Quetta district. The total population is 311,227. The reported area of the district is 210,500 ha, out of which 90,700 ha are cultivated and 119,800 ha are available for grazing livestock (Iqbal et al. 1981).

The general physiographic characteristics of the district are mountainous. Its northern half is covered by *toba* plateau. The hill ranges are uniform in character and consist of long central ridges where frequent spurs descend. These spurs may vary in elevation from between 1,500 and 3,300m (GOB 1997b).

Pishin district is extremely cold during the winter, while summer is pleasant. Rainfall is between 200-250mm annually. In summer very little rain occurs. Rainfall and snow usually occur from January to March. Sometimes winter rains continue throughout April.

Crop and livestock production are the two main agricultural operations. Crop cultivation is generally rainfed; however, in some parts irrigated agriculture prevails with the help of the *karez* system. Irrigation is also supplemented by tubewells for growing a wide range of fruits (mainly apples, apricots, and grapes) and varieties of chewing tobacco. The chewing tobacco industry is developing rapidly in this district and tobacco production is emerging as a principal cash crop for local farmers. The main sources of irrigation are the *karez* system, open surface wells, tubewells, and delay action dams.

Pishin is well connected by road with other principal cities of Balochistan. Early varieties of apricot and grapes, better market access, and higher market prices early in the season makes orchard production a highly profitable proposition for the local growers. Since the district is near the biggest civic centre of the province (Quetta), vegetable production is also quite common.

Wheat is considered less profitable compared to fruit, vegetables, tobacco, etc under irrigation. It also competes with highly popular fruit and vegetable crops in the annual crop calendar, as it is harvested in late May or in early June. Wheat growing is further limited by the lack of water for irrigation during the months of October and November, due to low water levels in the *karez* and because of very little summer rain.

Land tenure is a legal relationship between the landlord and the cultivator for the dis-

tribution of farm produce and the sharing of farm costs. There are three main types of tenure system: owner, owner-cum-tenant, and tenant.

Most of the rural labour force are engaged in raising animals. Sheep and goat breeding is common. These small ruminants are not only more appropriate physiologically to withstand the harsh climatic stresses of the region, but they are also the only means of utilising the vegetation of depleted rangelands in far-flung areas. Cattle are used for draught, meat, and milk purposes. Due to the shortage of fodder and grazing lands, in some villages each family owns a few donkeys and camels that provide help in agricultural operations.

- Ziarat district

Ziarat district lies at latitude 30°-28' in the north, longitude 67°-37' in the east, and at an altitude of 1,700 to 3,000m.

The annual precipitation ranges between 200mm to 400mm. The wettest months are July and August, although significant amounts of precipitation also occur from December to March, much of this falling as snow. The climate is characterised by moderate winds, low humidity, cold winters, and cold summers. Hailstorms are a common crop hazard, otherwise the area has an ideal climate for the production of high quality fruit.

Soils are generally shallow and gravelly. The standard practice is to transport soil by digging silt from the nearest dams or delay action dams and from other muddy areas. The silt is transported in trucks or tractor trolleys and is spread 0.9 to 1.2m deep over the newly terraced fields prior to the planting of young fruit trees. These soils are non-saline and rich in the nutrients required for the kinds of crops grown in the area.

Existing farm operations are geared towards orchard raising. The main fruit trees include apples, apricots, almonds, cherries, plums and peaches. The orchards are irrigated by *karez* and dug wells scattered throughout the district.

In addition, intercropping of tomatoes, potatoes, summer vegetables, onions, and *alfalfa* is common. The fodder production is inadequate for livestock. Winter feed shortages pose a severe constraint to livestock production. *Alfalfa*, maize, and leaves are the main source of fodder for livestock. Small flock owners buy dry leaves from the orchards to graze the animals on. Because of this, sheep are preferred over goats because sheep cause less damage to the tree shoots.

Establishing a young orchard is an arduous task because it requires heavy inputs and involves negative cash flow, at least for the first four to five years until trees reach the fruit stage. Hence, it is common practice to intercrop the young orchards with *alfalfa* for four to five years to improve soil fertility levels.

Apples are the most important fruit. However, there is a good premium for the early crop of cherries in the Quetta and Karachi markets. Sometimes, the premium price may be doubled due to good quality and taste. Young saplings are usually planted after two years in the nursery. Most planting is completed before the end of February and the middle of March. Local nurseries for apples and cherries meet the local demand. Tree spacing is generally adopted, as recommended by the Department of Agriculture. The most popular practice is to plant apple saplings eight to

nine metres apart, while the distance for apricot and cherry trees is about six to eight metres. Farmyard manure is mixed with soil when planting a sapling in the field. Fertilizers are never used at this stage because these are believed to burn the roots of a new plant.

All agricultural products (i.e., apples, apricots, cherries, plums, tomatoes, potatoes, and onions) are transported to various markets of the Punjab, namely, Multan, Faisalabad, Lahore, Rawalpindi, and occasionally to Quetta and Karachi.

Trucks are the means of transportation, with each truck carrying 450 to 500 crates of apples containing 15 to 18kg per crate. Tomatoes are packed in small crates with (approximately) a net weight of 15kg. Onions and potatoes are dispatched in gunny bags containing approximately 100kg and are transported to the Quetta market. Cherries are marketed in 5kg crates to Quetta, to the Pakistan International Airlines (PIA) freight terminal, then onward to Karachi airport and finally by truck to the main fruit markets in Karachi.

Juniper forest makes the beauty of Ziarat Valley and provides firewood. Ziarat possesses one of the most rare forest types in the world, the arid Juniper, *Juniperus excelsa*. The state Juniper forest of Ziarat stretches over an area of 50,000 ha. The tree is extremely slow growing, reaching a height of 1 to 1.5m and a diameter of 2.5cm in approximately 60 years. Many trees having a girth of 1.5m and over 20m tall are 2,000 years old.

Other vegetation in the Juniper forest is as follows.

Trees: *Fraxinus xanthoxyloides* and *Pistacia khinjak*

Shrub: *Artemisia maritima, Caragna ambigua, Prunus eburnea, Ephedra nubrodenis, Sophora alopecuroides* etc.

Grasses: *Pennisetum orientale, Stipa pennanta, Dicanthium annulatum, Chrysopogon montanus, Cymbopogon jawarencusa* etc.

- Loralai District

The district of Loralai consists of two *tehsil*(s) (Loralai and Dukki), and two sub-*tehsil*(s) (Mikhtar and Sanjavi). The physiographic delineation of Loralai district is given in Table 12.

Table 12: Physiographic Regions in Loralai District

Land form	Area (km²)	% of total area
Mountain 2,000m	3,659	19
Upland 2,000m	2,965	16
Piedmont	10,979	58
Flood plain	1,468	7

Source: FAO 1983

The climate of Loralai is a typical semi-arid one. The average daily temperature falls below zero during winter and summer temperatures peak at 40°C for three to four months. It receives winter precipitation although a predominantly summer rainfall regime prevails as one approaches the Takht-i-Sulaiman mountains on the eastern border. The magnitude of annual precipitation is from 250 to 350mm, increasing to 450mm towards the eastern border.

Soils associated with the mountains are largely lithosols, since much of the parent material is high in calcium carbonate. The soils of extensive basins and floodplains are strongly influenced by localised cultivation and fallow practices. The soils are

generally low in both nitrogen and carbon and have a wide textural range.

Crop production in this area is a mix of rainfed, flood, and perennial irrigation systems, with most settlements benefitting from springs and *karez*. Fruit growing is an important way of earning money. Orchards, mainly apples at higher altitudes and almonds at lower elevations, are common in Loralai district. These orchards are being irrigated from the *karez*, springs, and tubewells. Vegetables, wheat, and fodder are grown as intercrops.

Although almonds dominate the area of established orchards, apples are the most important fruit in recent plantations. This shift in production is occurring throughout the district, despite the fact that the climate is generally better suited to almonds, apricots, and pomegranates. Peaches are grown as a minor crop, while there are small patches of cherries and plums.

Young saplings are usually transplanted into the field after two years in the nursery. Most planting is done in late December and January. Nurseries of all fruits are found in the area. The quality of stock in local nurseries and new nurseries is generally poorer than those coming from Ziarat and Quetta. Tree spacing is quite variable and standard layouts are rarely observed. The popular range of spacing for apples is between 6.25 and 9.5m, while the distance for stone fruits is 5.5 to 8 metres apart.

Young apple orchards dominate the area as farmers replace almond trees with apple trees. The current practice is to cut down the almond tree and leave it for two years until the roots have grubbed out, then it is replaced by an apple sapling.

Pruning trees is a very common practice in Loralai. The better-pruned trees show more inward growth and early on display upward growing limbs.

Tomatoes, chillies, cauliflowers, onions, and potatoes are the most common vegetables. Tomatoes and chillies are grown as bushy crops and are not usually supported by stacks. Most farmers get vegetable seeds from Loralai or Quetta. Progressive farmers grow their own seedlings in a nursery for transplanting. Cotton is also grown at high altitudes in Sanghari-Dukki. A small area is used for lentils such as *moong* and *mash*.

The majority of farmers still use a substantial amount of farmyard manure. They never use chemical fertilizer in stone fruit orchards as they believe that it causes excessive growth of the plant. However, a small number of farmers regularly use chemical fertilizers for vegetable production.

Farmers are very conscious of insect pests and other plant diseases. Almond scale is a problem that causes heavy losses and is seldom under control. There was an orchard in which approximately 200 almond trees were affected by almond scale and the farmer was unaware of the chemicals that could to be used to control the pest.

In recent years, farmers have started spraying their orchards. In apple orchards, farmers are aware of the danger of the codling moth, green aphid, and hairy caterpillar and now have control over these insects.

While visiting different farms, it was observed that most farmers were using untreated seeds in their nurseries. Consequently, in one of the farms, the chilli crop was completely damaged and the farmer

was unaware of the disease. During an interview, it was found that the seeds for the nursery were untreated.

There is no tenancy system in the area. The ownership of land is common and the owner takes much interest in establishing orchards. Tractors are common throughout the district. Any farmer can easily hire a tractor on an hourly basis. Tractors and bulldozers are used for land preparation. Bullocks are still used by small farmers. The beds and ridges for vegetables are usually made manually.

- Zhob District

Zhob district is dominated by the Toba Kakar Mountains that run through the central and northern part of the region. A large portion of the district is mountainous. The most extensive floodplain is formed by the Zhob River.

Climatic fluctuations are caused by a gradual increase in precipitation from west to east (i.e., 200to 400mm annually). The eastern part of Zhob has two precipitation periods, one lasting from January until March and the other in July and August. The district experiences latitudinal temperature variations between valleys and slopes. There is a marked temperature gradient from north to south.

In general, soils are high in calcareous material and there is little turn over of organic matter. In mountainous regions, soils are largely composed of weathered parent material with no profile differentiation. The soils of piedmont slopes are strongly affected by periodic erosion and deposition. The floodplains have shown a high degree of disturbance, both from natural and human processes. These soils tend to be formed from alluvial deposits and finely textured loess material. Soils in the *Pinus gerardania* zone along the northern border of the district are very severely eroded.

Cultivation, mainly in the *kharif* season, is irrigated. Fruit production is the main source of income during *kharif*. Apples are predominant in the orchards, followed by almonds and apricots. Other important fruits are grapes, pomegranates, peaches, and plums. Maize and onions are the main crop cultivated. Maize is cultivated under rainfed conditions in about half of the area where it is grown. Some farmers grow tobacco and potatoes exclusively by irrigation. Wheat is the most important *rabi* crop and is grown under both irrigated and *barani* conditions. Barley is also grown along with wheat. Some vegetables and fodder (alfalfa) are grown in irrigated fields.

Blue pine (*Pinus wallichiana*) and *chilghoza* pine (*P. gerardiana*) are found along the northern border. The blue pine is found at the highest altitudes and has survived only on extremely steep, inaccessible slopes. The *chilghoza* pines are harvested extensively for timber, fuelwood, and resin. The edible nuts are collected each year. The largest area of Zhob, in the eastern and central parts, consists of scattered parkland made up of trees, with a lower stratum of herbs and shrubs. *Acacia modesta*, *Pistachia* spp, *Olea ferruginea*, etc occur most frequently in the upper vegetal stratum.

- Kohlu District

Approximately 38 per cent of the district is made up of mountains and uplands, with only three per cent as floodplains.

The southern part (i.e., 60%) of the district is arid, and precipitation is below

200mm. However, towards the north there is a marked increase in precipitation due to the summer southeast monsoon.

Dryland farming during the *rabi* season is the general practice. Wheat is the main crop. Vegetables and fodder are grown under irrigated conditions. Fruit production is less in the Kohlu area. During *kharif*, millet and sorghum are grown as fodder crops. Farmers grow onions, potatoes, melons, garlic, and other vegetables wherever irrigation water is available. Tubewells, wells and *karez* are the main source of irrigation.

Rod Kohi Region

The Sulaiman Rod Kohi Region covers the Sulaiman Mountains and piedmont plains comprising D.G. Khan, the Rajanpur districts of Punjab, D.I. Khan, Tank of the NWFP, and parts of Barkhan, Dera Bugti, and Kohlu districts of Balochistan Province. The area is mostly level, with a gentle slope towards the east. The Sulaiman mountain range extends from north to south along the western side of the piedmont plains. It lies between latitudes 29°-15' and 32° N and longitudes 67°-30' and 71° E.

The region extends over an area of 42,000 sq. km. It is one of the least developed areas in the country but is endowed with ample natural resources. If used and managed properly, it has tremendous potential for increasing food, fodder, fuel, and fibre production. Since land and water are the basic components of agricultural production, their proper use is a prerequisite for achieving sustainable production. The factors that directly influence land use are of a physical, biological, social, and economic nature. A clear perception, knowledge, and evaluation of all the dynamic forces affecting the agro-system is *sine qua non* for ensuring sustainable management of resources. Salient features of the region are given in Table 13.

The climate of this zone is greatly influenced by elevation. Five bioclimatic zones

Table 13: Salient Features of Sulaiman Rod Kohi Region

Extent	42,000 Km² (D.G. Khan, Rajanpur, D.I. Khan, Tank and parts of Barkhan, Dera Bugti and Kohlu districts)
Altitude	250-2,500m
Population	4.0 million
Climate	Arid to semi-arid sub-tropical
Linguistic groups	Siraiki, Pushto
Soils	Deep, loamy through clayey, locally gypsic salinity
Tenure system	State, privately owned large and small holdings
Economic indicators	Livestock production, date-palm and subsistence cropping
Plant indicators	*Prosopis cineraria, Tamarix aphylla, Haloxylon* spp
Wildlife	Chinkara, bustards, sand grouse
Development issues	Flash floods Inadequacy of potable water Soil erosion Deforestation/loss of biodiversity
Development options	Management of Rod Kohi irrigation Soil and water conservation Promotion of fruits and vegetables Management of rangelands and livestock production Agroforestry and dryland farming Wildlife conservation and propagation of medicinal plants

Source: Muhammad 1996

can be distinguished, i.e., (i) mountains (1,000 to 2,500m), (ii) piedmont plains, (iii) desert ranges, (iv) irrigated plains, and (v) riverain areas.

The climate is arid and semi-arid subtropical. Because of low humidity, continental location, and dearth of vegetation, both diurnal and seasonal temperatures are extreme. Beginning in May and lasting until August, the area often experiences a mean maximum temperature of more than 39°C. Winters are cold, but temperatures rarely fall below 5°C.

Mean annual precipitation varies from 180mm in the south to about 305mm towards the north. As expected, most of the rain is likely to fall in the form of several brief, but conventional, summer showers, except for in northern parts where it is more evenly distributed throughout the year. Average monthly rainfall is never sufficient to meet the atmospheric demand or potential evapotranspiration. Periodic rainfall trends are given below.

December to March: Weather during this period is affected by frequent and rapidly moving western disturbances or frontal systems. The mean number of rainy days can be put at one or two in January and two or three per month from February through March. Thunderstorms are also frequent in the month of March.

April to June: This is a season of increasing temperatures, strong surface winds, dust storms, and thunderstorms. Western disturbances continue to move at high altitudes. The mean number of rainy days ranges from one to two per month from April throughout June.

July to September (Monsoon): Active western disturbance and the associated monsoon control the weather during this period. The mean number of rainy days per month stands at three, from July until September.

October to November: During this period, the weather is good. Occasional light rain is caused by movement of a frontal system from the west.

Climatic characteristics of the region recorded at various locations are given in Table 14.

Soil Resources

Soils of the piedmont plains are alluvium, formed of material from the Sulaiman mountain rocks. The main rocks are sandstone, shale, and limestone. Soils are generally very deep, well-drained, homogenised to a depth of more than 90cm with a weak structure. These are predominantly silty loam and fine-silty loam, although locally, clayey and sandy soils also occur and are moderately to highly calcareous. The lime content of the soil ranges from 17 to 43 per cent and is uniformly distributed in the profile. However, in some older soils, lime has concentrated in the form of nodules. These nodules are few and are scattered throughout the profile. The high lime content makes soils hard when dry but soft and friable when moist. These have rapid to slow permeability as well as poor to high water-holding capacity. Soils are generally deficient in organic matter, nitrogen, and available phosphorus as well as micro-nutrients such as iron and manganese.

Locally saline-sodic soils are also found. These soils are characterised by hygroscopic and gypsic salinity and are self-reclaimable if ample quantity of sweet water is available. Most of the soils in the

Table 14: General Climatic Characteristics of the Sulaiman Rod Kohi Region

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
D.G. Khan													
PM	9	9	11	10	9	11	38	34	11	2	2	6	151
P50	2	2	3	3	2	3	21	17	3	0	0	1	135
P70	0	0	0	0	0	0	7	5	0	0	0	0	86
RPAR	0.30	0.30	0.30	0.30	0.30	0.30	0.70	0.60	0.30	0.10	0.10	0.10	2.90
TEMP	12	15	20	26	30	34	33	32	31	26	19	14	24
ETP	67	81	135	186	241	270	253	237	216	166	103	70	2,029
MAI	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.04
D.I. Khan													
P95	0	0	0	0	0	0	8	1	0	0	0	0	114
P75	1	3	6	1	0	0	28	8	0	0	0	0	178
P50	5	10	18	7	2	2	53	24	4	0	0	1	234
P5	58	60	112	99	48	58	170	125	74	21	17	41	418
PM	14	17	32	23	10	12	66	38	16	4	3	8	246
TEMP	12	15	20	26	30	34	33	32	31	26	19	14	24
ETP	69	85	127	161	208	257	221	200	186	140	76	62	1,791
MAI	0.01	0.04	0.04	0.01	0.00	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.10

Source: Muhammad 1996

PM : Precipitation/month
P95 : Precipitation at 95% probability
P75 : Precipitation at 75% probability
P50 : Precipitation at 50% probability
P5 : Precipitation at 5% probability

RPAR : Relative photosynthetically active radiation
TEMP : Temperature °C
ETP : Evapotranspiration (mm)
MAI : Mean aridity index

piedmont plains are dry and barren. Locally, where flood water impounds, a few scattered shrubs of *Capparis*, *Suaeda*, *Salsola*, and *Haloxylon* and moderate cover of *Panicum* and *Sporobolus* grasses are found.

Cropping Patterns

Crop production in the Rod Kohi area is unique and traditionally occurs at the subsistence level. The Rod Kohi area is a floodplain that has a long planting season, starting from February and continuing until August for spring and summer crops and from October to December for winter crops. The main crops grown during the *rabi* season are wheat and barley, while millet sorghum, and *mung* beans make up the summer crops. Crop rotation is traditional. The main crop rotations tested in this area are given in Table 15.

Table 15: Crop Rotations in Rod Kohi Area

i)	Wheat	Sorghum	Fallow
ii)	Wheat	Fallow	Wheat
iii)	Gram	Melon	Gram
iv)	Barley	Millet/ Sorghum	Fallow
v)	Melon/ Sorghum	Fallow	Melon/ Sorghum
vi)	Barley	Fallow	Barley

Source: Muhammad 1996

Cropping Intensity

Cropping intensity in summer, as well as in winter, is very low. Overall, annual cropping intensity is not more than 80 per cent, i.e., 30 per cent in summer and 50 per cent in winter. Wheat accounts for 40 per cent of the cultivated area and is the main crop in winter. Sorghum/pearl millet, with a 25 per cent share of the cultivated area, has second position. Because of their food and feed value cereals are the

most important crop and occupy more than 60 per cent of the area. Musk melon and oilseeds are cash crops. Gram is planted in piedmont sandy areas.

Livestock Production Systems

Livestock production is the main land use in the Sulaiman Mountain and Rod Kohi areas. It is a traditional system based upon rangeland grazing in the hills and integrated with crop farming in the plains, depending on the availability of runoff water. The livestock component of this farming system is managed in such a way as to provide much of the subsistence needs of a farm family during a year. The area is used for grazing camels, sheep, goats, and cattle. These animals are owned by nomads as well as the local population.

There is a shortage of fodder, resulting in problems when breeding sheep. The breeding season occurs in autumn when sheep are in poor health, causing oestrus failure, the loss of fertile ova, and high mortality of lambs. Mineral deficiency is common. Sheep in particular are susceptible to internal parasites and most of them suffer from worms and externally from mites. Common livestock diseases are foot and mouth, sheep pox, pleuro-pneumonia, enterotoxaemia, and black quarter.

Most farmers rear sheep for lambing, milk, and wool, and these provide an income to most families. Damani sheep involve a smaller capital outlay and only seasonal work. They can easily be milked by hand and the milk is converted into yoghurt and cheese. The lactating sheep have well-developed udders and long teats. Milk production of two to three litres per day has been recorded.

Chapter Three
Technologies for Water Conservation and Development

In HKH mountain agriculture, proper water harvesting, good management, and appropriate development are of great importance. Proper water harvesting not only increases crop production in areas with insufficient precipitation, but also controls soil erosion and recharges aquifers tapped for irrigation. Water harvesting is considered a resource-improving technique when used in combination with other modern technologies (Reijntjes et al. 1992). Changes in land use, particularly change of vegetal cover, affect turn-off and infiltration rates. Excessive overflow of water may cause severe soil erosion. Thus, water flowing through mountain terrain, particularly needs to be managed well in order to to avoid harming the resource base. Inappropriate development is like over-pumping groundwater, as is the case in many low rainfall regions where the practice is endangering sustainable agricultural production. In fact, a balance is required between the recharging groundwater reserves and the outflow by pumping or other means. The effective recharging of groundwater reserves requires parallel development and improvement in watershed areas through re-vegetation schemes and water conservation activities (Reijntjes et al. 1992).

Water conservation in the HKH belt has not yet received sufficient attention. Global climatic changes could redistribute or reduce water supplies and intensify storms, this may add to the challenge of managing a sustainable water supply (Ahmed 1996). Ahmed (1996) concluded that actual per capita water availability in the HKH region would be much less due to steep slopes and rugged terrain, and his predictions about per capita water availability indicated a declining trend (see Table 16).

Table 16: Population, Annual Renewable Fresh Water Availability and Per Capita Availability in the HKH Region

Country	Annual renewable fresh water available billion m³	Population (millions)			Per capita availability (m³)		
		1960	1990	2025	1960	1990	2025
Afghanistan	50.0	10.8	16.6	45.8	4,630	3,012	1,092
Bangladesh	2,357.0	51.4	113.7	223.3	45,856	20,730	10,555
Bhutan	95.0	0.9	1.5	3.4	105,556	63,333	27,941
China	2,799.5	657.5	1,153.5	1,539.8	4,258	2,427	1,818
India	2,085.0	442.3	846.2	1,393.9	4,714	2,464	1,496
Iran	118.0	21.6	58.3	144.6	5,463	2,024	816
Myanmar	1,082.0	21.7	41.8	75.6	49,862	25,885	14,312
Nepal	170.0	9.4	19.6	40.1	18,085	8,673	4,239
Pakistan	168.0	50.0	118.1	259.6	9,360	3,963	1,803

Source: Ahmed 1996

Although the water development process in the HKH region is not rapid, water conservation and development is a high priority for local people, mainly in the context of agricultural development. The governments concerned are now realising this fact and are focussing on water resource rehabilitation and management using modern knowledge. This chapter will describe several promising water-related technologies as documented in various agro-ecological zones of the HKH region. Most of these technologies are being used for managing water and irrigation for crop and orchard production. Since irrigation reduces the risk of biological failure due to drought, local farmers have traditionally designed small-scale irrigation systems. The area under irrigation is increasing day by day, as the public sector promotes various modern irrigation technologies as described in this chapter.

Kuhl Irrigation

Significance

The origin of this technology lies in the cold deserts west of the Indian Himalayas where underground saline water cannot be used for irrigated cultivation. This technology is also commonly used in the highlands of Balochistan (Pakistan), although with some minor modifications. A *kuhl* is in fact a small water channel that is built along the hill gradient for maintaining the proper gravity flow of water. The majority of the hamlets lie on the plateaux either side of the main river, and cultivated fields are found either on naturally levelled plateaux on the banks of the rivers/torrents, or on hillside terraces. The physiographic features of the terrain restrict irrigation from rivers as they flow between steep banks. In temperate areas of cold deserts, crop cultivation without irrigation is not possible because precipitation occurs mostly in the form of snow. People have taken advantage of the glacial water to perform a collective operation for effective distribution, ensuring the supply of this scarce resource. A specialised water management technology has thus been developed which is adapted to a particular topography.

Plate 1: Kuhl Irrigation in the Indian Himalayas

Components

Kuhl(s) (i.e., irrigation channels) are diverted from river tributaries/perennial torrents to a natural gradient so that the level of water is higher than that of cultivated fields. In some cases, spring water is collected in small reservoirs scattered at intervals on high uplands and is drawn down to fields whenever required through *kuhl*(s). A *kuhl* is diverted from any nearest tributary and is constructed to flow towards fields on safe sides of the terrain to avoid any danger of its being damaged by avalanches or falling rocks. Usually a spade is used for making these channels. The whole community plays an important role in the construction of the main irrigation channels as well as in the equitable distribution of water. Channels are dug in the ground to regulate the flow of water. Wherever digging is difficult or has to pass through a village track route, underground channels covered with slates are constructed. Sometimes, in this situation, wooden channels are also constructed. The wooden channels are prepared by making a deep groove in a tree trunk. Main channels are long and considerable labour is required for their annual maintenance and repair. Usually the community works together for this purpose.

Minor channels linked to the main channel irrigate all fields. Fields are generally divided into small compartments by using earthen bunds (embankments) to allow water to stand in the field for a longer time for maximum water retention. Hence the need for a second irrigation arises only after three weeks, otherwise a crop may require another irrigation within two weeks. The process of irrigating a field is begun by flooding the nearest compartment, followed by the next, and so on. For the second irrigation episode, these compartments are irrigated in reverse order, with the last compartment being flooded first, followed by the second to last, and so on. This management of water in a particular field by apportioning it to various compartments regulates proper water flow across the whole field. The reverse order of irrigating a field is used simply because irrigation is closed in that last compartment and a minor channel existed there to serve it.

Participatory management is employed for the distribution of water. The whole community is divided on the basis of the total number of farming families. Each family is assigned one full day to irrigate its fields turn-wise. For example, in the case of a total number of 20 farm families in a village, the turn of each one would come after every 20 days. However, two adjoining families may share water from each other's turn for half a day on a mutual basis, and as an internal arrangement. This arrangement allows both families to irrigate their fields after a gap of 10 days rather than 20 days. The turn of a family begins at 20:00 or 22:00h on a particular day. That day, almost all the family members are engaged in managing and distributing water in the fields.

Farmers ensure optimum irrigation to the desired soil depth by inserting a spade into the soil. If its blade is completely inserted into the soil, the field is considered properly irrigated. In a few locations, the irrigated soil is thrown upside down. If it splits into pieces, it is taken as a sign of a well-irrigated field.

Farmers have developed irrigation schedules matching the phenological stages of the cultivated crop (i.e., germination, vegetative, bloom, seed set, and harvest).

Spang Grass for Controlling Seepage Losses

Significance

Since water is transported through earthen channels, it results in huge conveyance and application losses due to seepage. The irrigation efficiency is between 50 to 60 per cent. This seepage loss is not retrievable as the water level is too deep (Ahmed 1996). Similar losses occur in the case of water stored in dug-out ponds.

Components

Spang grass is called *Pang* in Ladakh, where it grows profusely. Local people use this grass as an inner lining for water courses and ponds in order to prevent percolation losses. Spang grass has special non-permeable properties similar to that of a polythene sheet or cement lining. Farmers claim that its use in water retention gives far superior results than both polythene and cement. Its mysterious chemistry requires detailed analysis.

Karez Irrigation

Significance

A *karez* is an underground, channelled irrigation system, an ancient technology that has played a historical role in the agricultural development of Balochistan, Pakistan. The history of the *karez* goes back thousands of years to when construction of *karez* systems was a hazardous and extremely specialised job. Amazingly, *karez* systems still exist in Balochistan. For centuries, these have been a perennial source of water for agricultural practices. Being a communal effort, water distribution rights and schedules are well settled as in the canal command areas of the Sindh and Punjab provinces of the country.

With the influx of modern technology such as tubewells, the role of the *karez* system is now gradually diminishing. However, this is still an important source of irrigation in the uplands of Balochistan.

Components

A *karez* is an underground water channel system. Lined mother wells are dug in the foothills at certain distances apart to intercept the water table high up in an alluvial fan, then water is lead to the valley floor under gravity. These mother wells are

Plate 2: Karez Irrigation System in Balochistan, Pakistan

The maintenance of karez systems is becoming very expensive. This ancient technology is being ignored because of the low rechargable capacity of underground water and the high influx of tubewells in the region. An awareness campaign may save this historical technology from becoming extinct.

connected underground through tunnels. A series of mother wells take water to cultivable lands. Sometimes, a *karez* may take perennial water flow as far as 40km.

Water is rotated from distributor to distributor and within sections of a distributor. In recent developments, concrete versions of flow dividers can be seen.

Sailaba Farming

Significance

Sailaba indicates moisture conservation through flooding fields during the rainy season. *Sailaba* farming is extensive in most parts of Balochistan, Pakistan, particularly in the highlands. During the rainy season, flood water is harvested in catchments for crop production. This technology is extremely important in the kind of region where aridity prevails and mountain terrain accelerates water runoff. Most runoff is harvested for cultivation.

Components

Sailaba farming involves diversion of runoff or flood water to terraced catchments for moisture conservation. These catchments are later cultivated, generally with a mixture of crops. Farmers construct relatively level terraces, where land slope may vary between one and five per cent. The terraces usually cover a large part of the valley and are flanked by hills on either side. Each terrace will have an embankment at the sloping end to harvest water. The height of the embankment varies from one to 2.5m, and the width at the top is one metre across; the lower slopes have a gradient between 2 and 2.5:1, unless the slopes are stone pitched, in which case they are vertical. Tractors and bullocks are used to make these embankments.

Flood-water channels run along a tier of terraces and bring runoff from the surrounding hills; individual terraced fields are

Plate 3: ***Sailaba Field in Balochistan***

Sailaba water harvesting is a practical method of controlling soil erosion and the movement of sediment, in addition to aiding crop cultivation. The same technology may be used effectively for conserving water on ranges and for increasing forage production by improving species' cover.

flooded sequentially. Two different systems are used to control the water movement from terrace to terrace. In the first, a stone-pitched spillway, about 2m long and 0.3 to 0.5m deep, is built at the lower left or right hand corner of the field. In the second system, flood water flows into the field from the top corner adjacent to the water supply channel. The down-stream embankment is slightly elevated for this purpose.

Pond Water

Significance

The scarcity of irrigation water is a critical constraint to improved farm productivity. A standard sized water pond is an integral component of a farm's infrastructure throughout Balochistan – for the following reasons.

- Underground water is very deep and low discharge by tubewells (wherever applicable) causes very slow and inefficient water conveyance. It may take hours to irrigate one hectare of land. The pond is used for quicker irrigation and to avoid conveyance losses.
- Irregular power supply may shut down the tubewell for many days or at any time and causes problems during peak hours. Farmers keep their ponds filled round the clock, using them as and when the need arises.
- Farmers may sell this water to neighbours for irrigation and other purposes, charging the buyer on an hourly discharge basis.
- Farmers plant timber and forage trees all around the pond to meet their domestic needs.
- It improves the underground water table.

*Plate 4: **The Water Pond is an Integral Part of the Agricultural Farm***

These water ponds are potential sites to be used for fresh water fish production and offer great scope for high returns from meagre inputs.

Components

An earthen pond measuring roughly 25m x 30m is dug at any suitable elevated site in the farm area. It is normally constructed close to the tubewell. The pond is about 1m to 1.5m deep, although the depth may vary. Tubewell water is first collected in this pond to regularise the irrigation.

Persian Wheel

Significance

Underground water is quite deep down in most parts of the highlands. Deep wells are historically used for obtaining underground water for all purposes. The Persian wheel is a very old technology used for pulling water out of wells, mainly for irrigation. This method is in popular use in the uplands of Balochistan and in the Rod Kohi area where modern equipment, such as tubewells, is not feasible due to institutional or socioeconomic constraints.

Components

The Persian wheel is driven by a cow, bullock, or camel. The animal drives it through a wooden rod 4.5 to 6m long. The components of the Persian wheel are as follow.

- A wooden rod, 4.5 to 6m in length, with one end connected to a small iron wheel and the other end drawn by the animal.
- Two other iron wheels of different sizes, with teeth in between the wooden rod and the Persian wheel itself (only operating within the well) to pull out water. The Persian wheel is

Plate 5: ***A Persian Wheel Being Operated by a Bullock***

The role of Persian wheel technology is diminishing due to the popularity of modern tubewells among farmers. However, tubewells will not be sustainable in an arid ecosystem where the recharge rate of underground water reservoirs is very slow. Farmers will continue to depend on the Persian wheel for exploiting underground water, probably with slightly modified, more efficient equipment.

equipped with an iron necklace containing about 100 to 120 steel pots. The capacity of each pot is two to three litres and is attached to the necklace at a distance of about one ft. The length of the necklace and the total number of pots attached to it depend on the depth of the water level in the well. Approximately eight to10 pots are always within the water table.

- An animal drives the Persian wheel through a long wooden rod and an other two wheels. The Persian wheel moves the necklace within the well in an oval cycle. Water is collected in a steel channel in the centre of the Persian wheel. This steel channel takes water to the main collection site.

Trickle Irrigation

Significance

In Balochistan, irrigation methods currently followed by common farmers include the controlled flood irrigation technique on either wide border strips or basins. It is a very simple, cheap method, requiring little maintenance, yet it is also very inefficient and wastes almost 50 per cent of the precious water during conveyance from the source and by leaching from the field. Modern irrigation systems have been introduced among the more progressive farmers to control water losses and to improve the efficiency of water usage.

Components

Trickle irrigation is most commonly micro-irrigation and involves dripping water on to the soil at very low rates (4 to 24 litres/h). It is commonly used in orchards and for vine crops, it is adaptable to any farmable slope, and is applicable to a variety of soil textures.

A typical drip irrigation system is listed below.

Water source: A supply of water with adequate pressure is essential. Tubewells fitted with centrifugal electric pumps, which can pump water directly to the sys-

*Plate 6: **Trickle Irrigation System at a Government Farm***

tem with a minimum pressure of 30 Psi at the well outlet, are the most appropriate.

Control head: The control head consists of valves to regulate discharge and pressure in the entire system. A 200 litre pressurised vessel with an inlet and outlet is used to inject soluble nutrients into irrigation water with a 140 mesh screen filter to clean water from any debris and undissolved nutrients, and it includes gauges to indicate the correct pressure of the system.

Main line: Usually a locally manufactured 7.5cm dia PVC pipe (class D) that connects different sub-mains and is laid at a depth of 90cm below the ground to protect it from any damage from mechanical activities on the farm.

The sub-main: This supplies water to the laterals on one or both sides. A locally manufactured 3.75cm PVC pipe, six bars' rating, is laid at 60cm below the ground and receives water from the main line through a separate gate valve on a galvanised iron risen assembly.

The laterals: These supply water to the emitters. Usually a locally manufactured 13mm ID low-density polyethylene pipe of 1.5mm wall thickness is used. This pipe is rated at a working pressure of four bars and it is laid on the ground's surface to receive water from the sub-main via a 3.75 x 1.25 x 3.75cm MPT PVC reducing T,and a polypropylene male adapter of 13mm x 1.25cm MPT. Each lateral has a stopper flushing facility at the end.

The emitters: These are the beast of the system from which water drips at a constant low discharge from the lateral to the atmosphere. The recommended emitter is a turbo that is self cleaning, pressure compensating, self piercing, has a single outlet, and is capable of delivering a 4gph discharge at a minimum pressure of 15 Psi.

For orchard trees, the recommended drip irrigation system designs are of two types:

- drip continuous 'on the line system' and
- drip loop 'around the tree system'.

Drip Continuous 'on the line system': Recommended for newly-established plantations. Especially suitable for grapevines that are to be trained on trellises, with the aim of eventually having a continuous strip of irrigation along the row using equally spaced emitters on the lateral line that runs along the row of plants. Usually, each plant receives two emitters at plantation time, placed 0.6m apart for sandy loam to loamy sand soils and 0.8m apart for sandy clay loam to clay loam soils where the tree trunk is in the middle.

Two years later, as the plant grows, another set of two emitters are put in place, one on each side of the existing emitters at the same distance of 0.6 to 0.8m apart. Four years after plantation, emitters are added on the lateral pipe as needed, so that the distance between any two emitters always remains 0.6 to 0.8m, thus ensuring a continuous wet strip along the whole length of a row.

Drip Loop 'around the tree system': Recommended for medium-sized trees planted at moderate distances along the row (not more than 4.5m). The layout of the loop around a tree with enough equally spaced emitters should ensure that the root volume receives sufficient water. The duration of each episode of irrigation

should be carefully timed to ensure that enough water is delivered to the root volume, while wetting patterns of each emitter on the loop should partially overlap. Emitters are placed around the loop 0.6m apart for sandy loam to loamy sand soils and 0.8m apart for sandy clay loam to clay loam soils where the trunk of a tree is in the centre of the loop.

Advantages

- Due to the slow rate of water application, the extent of penetration increases in problem soils.
- Water savings are made due to the application of water around the root zone, especially when trees are young.
- Frequent light water applications can maintain soil water within a narrow range, usually closer to soil field capacity, and this enhances growth and increases yields.
- Because irrigated areas are limited, weed growth is reduced.
- This system permits nutrient induction (fertigation) to the plant root zone in automatic and accurately controlled quantities.
- It allows much easier, more efficient, and economic control of weeds and pests.
- Could be used successfully on fields with great slopes where traditional surface irrigation cannot be applied.
- There is a highly efficienct water application, i.e., 90 per cent.

Disadvantages

- It is a costly system and unaffordable for small landholders.
- Most growers are reluctant to plant orchards on all of their land, and they also practice intercropping until trees start fruiting. This intercropping of certain vegetables and melons gives growers a good cash return until their orchards start bearing fruit, but it is a key constraint in the adoption of this system.
- Drip irrigation results in the accumulation of tons of salt at the outer edges of wet soil, especially in areas of low rainfall.
- The emitters are susceptible to blockage.

Bubbler Irrigation

Significance

This may be defined as 'localised flood irrigation' in which each plant receives its water individually and the water is confined only to its root zone volume. This is a suitable alternative for irrigating large widely-spaced trees which have always been irrigated by flood methods such as basin irrigation.

Components

The basic components of the system are as follow.

Water source: This should be a tubewell pumping directly into the network, if enough water is supplied to meet the high discharge of the bubblers, and a pressure

*Plate 7: **Alpha Irrigation System in Balochistan***

The popularity of this technology among farmers depends largely on its cost effectiveness. Local manufacture of equipment using indigenous materials will substantially reduce costs.

of at least three bars (45 Psi) is attainable at the well outlet before the systems' control head unit. If the above two requirements are not fulfilled, storage is necessary to collect water from the source, and a booster pump is needed to deliver water under the required pressure.

Control head: Connected either directly to the tubewell or alternatively to the booster pump, the control head consists of valves and gauges to regulate discharge and to indicate pressure. A fertilizer tank is not needed because solid fertilizers and manures can easily be spread in a basin around the tree trunk. Since the control head has a large opening outlet, a filtration component is unnecessary.

Main line: A locally manufactured 10cm UPVC pipe (class D) is used to connect different sub-mains and is laid at a depth of at least three feet below the ground.

The sub-main: Usually a locally manufactured 7.5cm UPVC pipe, 10-bar rating is laid at 0.9m below the ground. It receives water from the main line through a separate gate valve on a galvanised iron seizer assembly and supplies the laterals on one or both sides.

The laterals: A locally manufactured 2.5cm to 0.6cm UPVC pipe, six-bar rating, is laid at 0.4m below the ground and is 0.8m away from the tree trunk. These receive water from the sub-main via a 7.5 x 3 x 7.5cm all-socket PVC-reducing (T, and supply water to the risers, on which the bubbler heads are placed. Each lateral is fitted witha PVC end top and cap above the ground for flushing purposes.

The risers: The risers are 1.25cm SCH 80 UPVC pipe sections, 0.6m in length, male threaded both ends, that extend 15cm above the ground, receiving water from the laterals via a 3 x 1.25 x 3 cm MPT PVC-

reducing T and have the bubbler head screwed in place on one of the ends.

The bubbler heads: These are system heads from which water is discharged in a fully circular umbrella pattern to the basin around the tree. The recommended bubbler is a pressure compensating circle, with a 1.25cm threaded female inlet.

Advantages

- Because the flow of water is under pressure in closed pipes, water conveyance efficiency from source to plant is 100 per cent.
- Since all pipes are completely buried below the ground, except the riser extending 15cm above the surface, mechanical activities on the farm are not disturbed.
- The time of irrigation is less than for other systems; thus reducing the cost of power for the system's operation.
- It permits manual spreading of fertilizers and farmyard manure on soil inside the basin around the tree.
- Due to the large outlets, the bubbler can expel solid particles of a comparatively large size, especially under higher operating pressure: thus, the bubbler outlets are not easily blocked.

The water application efficiency is high for this system - about 85 per cent almost twice the efficiency of surface irrigation methods.

Disadvantages

- The initial cost of the system is very high and thus unaffordable for small farmers.
- A high discharge rate and high pressure at the water source are the basic requirements of this system.
- If the basic requirements are not met with direct pumping from a tubewell then a field reservoir and booster pump combination are needed, adding to the total cost of the system.

Sprinkler Irrigation

Significance

Sprinkler irrigation can be used on most soils and for almost all crops except rice and jute. It is not suitable for very fine textured (heavy clay) soil where infiltration rates are less than 4mm/hr. It is well suited to sandy soils and small streams. Shallow soils and soil involving intensive land preparation can be irrigated efficiently. Land with steep slopes can be irrigated safely.

Components

In this method, water is sprayed into the air and is allowed to fall on the surface of the ground, in a manner somewhat resembling rainfall. The spray is developed by a flow of water under pressure through small orifices or nozzles.

The required pressure is usually obtained by pumping using a careful selection of nozzle sizes, operating pressures, and sprinkler spacing.

Plate 8: ***Sprinkler Irrigation is Best on Sandy Soils***

Although these modern irrigation systems are expensive, their use is necessary to stop the overexploitation of underground water resources where recharge is minimised by decreasing vegetal cover.

Advantages

- Careful application of soluble fertilizers, herbicides, and fungicides is possible (and economical) by adding them to irrigation water.
- The system is very useful for protecting crops against frost and high temperatures.
- Labour costs are less than for other methods.
- More land is available for cropping.
- Irrigation does not interfere with farm machinery.
- This method is popular in regions of water scarcity and uneven topography.

Disadvantages

- It is not useful in windy areas.
- Ripening fruit must be protected from spray.
- A stable water supply is required.
- Water must be clean and free of debris, sand, and a large amount of dissolved salts.
- It requires a high initial investment compared to surface irrigation methods.
- Power requirements are usually high since sprinklers operate at a pressure of 5N/cm² to 900N/cm².

Delay Action Dams (DADs)

Significance

Tillage operations in Balochistan, depend largely on irrigation using groundwater by tubewell, *karez* irrigation, and flood irrigation by spreading the flood water from

Plate 9: ***DADs May Be Effective for Artificial Recharge with Good Management of Vegetal Cover in Watershed Areas***

The silting up phenomenon can be checked by proper grazing management and by constructing artificial plant communities in catchment areas. DADs have the potential to be exploited for fresh water fish production

hill torrents. In recent years, excessive groundwater exploitation by tubewells for irrigation, corresponding with rapid expansion of orchards, has caused considerable lowering of the groundwater table.

Simultaneously, a mismanagement of watershed areas followed by a sharp decline in vegetal cover is accelerating runoff with diminished natural groundwater recharge. Realising the hazard of complete exhaustion of underground water resources within a few decades, the government decided to induce artificial recharge by constructing delay action dams.

Components

The irrigation and power department of the province has promoted artificial recharge of groundwater by means of the construction of delay action dams (DADs). At present, about 110 DADs are completed or are under construction. Furthermore, 500 more DADs have been proposed. Some technical difficulties in construction and operation/maintenance of the completed DADs have been reported.

The Delay Action Dam recharges the groundwater using flood water. A DAD is constructed just within the hills where a river or creek with its flood water enters any gravelly fan. Using modern technology to construct a huge embankment, a large reservoir is created. This reservoir is located on river alluvium in transition to a fan. The stored water is supposed to infiltrate and percolate to the groundwater. Unfortunately, DADs are silting up rapidly so that the stored water tends to become finite, with water evaporating rather than infiltrating.

Chapter Four
Technologies for Land and Soil Management

Introduction

Without conservation measures and land management planning on extremely fragile terrain, as in the HKH region, the threat of land degradation and loss of fertile soil will exacerbate. Based on land-use patterns, land resources are generally classified into natural resources and farm resources. Conservation and development of both classes should evolve together for a sustainable mountain environment. Since both are inter-related, any negative impact on the health of one class is quickly reflected in the other. While planning for a long term, profitable mountain farming system, the parallel development of adjoining natural resources has to be taken into account.

Soil is the primary resource base for both classes of land. Loss of valuable soil due to wind and water erosion and depletion of soil fertility are emerging as the primary constraints to sustainable land use within the mountain ecosystem. HKH soils require scientifically based, site-specific soil and land management practices because of their shallowness (i.e., <20cm deep) with extensive colluvial slopes. Nizami (1996) described the characteristics of HKH soils. The soils have a well humidified, dark colour. The amount of organic matter is generally one to two per cent. The soil's organic matter content and thickness are generally greater on cooler and wetter aspects. HKH soils are mostly gravelly, coarse to moderately coarse in texture, and susceptible to erosion. The severity of erosion is linked with the gradient of the slope and vegetal cover at a particular location. Soils are calcareous, the content ranging from weak to strong, and the reaction to alkaline – with a pH range of 7.0 to 8.4 – is neutral.

The changing socioeconomic scenario of the HKH region is causing disturbances on rangelands and watershed areas, along with a rapid deterioration of chemical and physical properties and a declining fertility status of most soils. Thus, technologies included in this chapter will deal with natural resource rehabilitation, conservation, and improvement, as well as land preparation and means of improving the soil fertility of farm resources.

Range Improvement Using the Three Strata Model

Significance

The Three Strata Model (TSM) counts as a range improvement technology. It involves the rehabilitation and management of degraded ranges, as well as the improvement of relatively sustainable grazing areas, by

Plate 10: ***The Three Strata Model for Range Improvement has Multiple Benefits***

Simply by incorporating a desirable shrub component into a range vegetation structure, the same range area can withstand stocking rates many times higher than usual.

constructing and harvesting the vegetal structure in a sequence of strata (i.e., grasses and forbes, shrubs and trees). TSM ensures increased and sustainable forage supplies to livestock, mainly during lean periods, and persistent supplies of firewood for domestic use. TSM creates a more pleasing environment, as some strata will remain green all year round.

Components

Many considerations must be taken into account when constructing a stratified plant community with multiple benefits on rangelands. These include biological, ecological, and cultural uses as well as socioeconomic factors. Plant species, which complement each other and are of multiple use, are extremely desirable. For example, mixing leguminous herbs with grasses in the lowest stratum would not only improve the nutritive quality of forage for animals, but would also increase yields due to improved soil fertility by legumes. Similarly, the inclusion of leguminous, non-leguminous and palatable shrubs in the middle stratum, and trees in the upper stratum, would improve the micro-climate for lower strata species that would result in their greater diversity, richness, and pronounced socioeconomic benefits. Thus, one of the crucial points for range re-seeding operations is the selection of proper species. For most of the HKH arid tract, the species to be seeded must be drought resistant, palatable, and salt tolerant. Among the grasses, *Lasiurus sindicus*, *Cenchrus ciliaris*, etc are recommended for this type of tract. Re-seeding by conventional means is likely to fail in low rainfall areas. Therefore, seeding of grasses coupled with water-harvesting techniques, such as spreading, pitting, contour trenching, and furrowing, is needed for the success of seeding operations.

From the existing native vegetation, it is evident that shrubs are capable of with-

standing the harshness of the arid climate as well as heavy grazing pressure. Shrubs provide good forage during winter when grasses disappear or dry up. Shrubs usually contain more protein than grasses. Certain trees and shrubs possess morphological and physiological elasticity in relation to drought. Fodder shrubs and trees possess a definite potential for resolving climatic, biological, social, and economic constraints encountered in arid and semi-arid areas. The following trees and shrubs are recommended for planting in the HKH belt, along with the above-mentioned grasses.

Acacia nilotica, A. modesta, A. tortilis, Prosopis cineraria, Tecoma undulata, Zizyphus mauritiana, Z. nummularia, Atriplex nummularia, A. polycarpa, A. canescens, Opuntia indica, and Tamarix aphylla.

Seabuckthorn - A Magic Plant for Dry Mountains

Significance

Seabuckthorn (*Hippophae* spp) is a deciduous shrub, widely distributed throughout the temperate zones of Asia and Europe, and the subtropical zones of Asia at high altitudes. It is commonly found throughout the countries of the HKH region. It has a highly developed root system, which is excellent for holding soils on a fragile slope. In seabuckthorn planted areas, loss of topsoil caused by seasonal monsoons can decrease to less than 30 per cent, and it is possible to hold more than 80 per cent of water in the ground. Seabuckthorn has the ability to take root even in poor soils, because it can fix nitrogen directly from air through the nodules in its roots. A natural seabuckthorn forest can yield 750 to 1,500kg of berries per hectare. Its fruit is a rich source of vitamins. Oil from the pulp and seeds is valued for its medicinal properties. It supplies palatable forage to all classes of livestock during most of the year.

Components

Seabuckthorn is described as the most appropriate multipurpose biological option for mountain areas. Its fruit can be used for making more than 100 products such as soft/hard/powdered drinks, jams, sweets, cosmetics, and medicines. Despite the scientifically proven potential of seabuckthorn for manufacturing several high-value products for human consumption, its harvesting is constrained by the lack of appropriate technologies and facilities for processing. China and several central Asian states used it effectively in industries related to food and medicine.

Use in the food industry: At present, many factories are producing seabuckthorn food, beverages, and other products such as jam, jelly, juices, and syrup. Along with traditional foods, some new ones such as condensed juice, mixed juice, seabuckthorn carrot jam, candied fruit, seabuckthorn cheese, seabuckthorn butter, tea, and health protection drinks are also being produced.

Use in the medicinal industry: About ten varieties of seabuckthorn drugs have been developed and are available in the form of liquids, powders, plaster, pastes, pills, liniments, aerosols, etc. These drugs are used for treating burns, gastric ulcers, chilblains, scales, oral mucosities, rectal mucosities, cervical erosion, radiation damage, skin ulcers caused by malnutrition, and other damage relating to the

*Plate 11: **Seabuckthorn in Mastung Area of Chitral, Pakistan***

Seabuckthorn is a 'magic' plant species and may be the best option when establishing a Three Strata Model for range improvement in arid mountain regions.

skin. The most important pharmacological function of seabuckthorn oil is in diminishing inflammation, disinfecting bacteria, relieving pain, and promoting regeneration of tissue.

Use in the cosmetic industry: Many kinds of seabuckthorn cosmetics have been developed and tested in hospitals. It is proved that seabuckthorn beauty cream has positive therapeutic effects on melanosis, skin wrinkles, keratoderma, keratosis, senile plaque, xeroderma, facial-acne, recurrent dermatitis, chemical corrosion and inchthyosis, as well as freckles. Other seabuckthorn extracts can improve metabolism and retard skin maturation. In China, it has been found that seabuckthorn products can cure 16 tropical diseases.

The use of leaves and residues: The leaves of seabuckthorn contain many nutrients and bioactive substances. Leaves and fruit residue used as supplementary food can promote growth of animals and poultry. There are no toxic or carcinogenic side effects.

Use as a food additive: The pigments of seabuckthorn are widely used as a food additive. Seabuckthorn yellow consists of flavours, carotene, and vitamin E. Its physio-chemical properties, such as appearance, solubility, colour value, heat and light stability, and effect of pH and metabolic ions, make it a very useful food additive.

Role in maintaining ecological balance: It has been observed that a number of wildlife species depend on seabuckthorn stems, leaves, flowers, roots, fruit, and seed. In the Loess Plateau of China, 51 bird species are entirely dependent and 80 bird species are relatively dependent on seabuckthorn for their food. In winter, the importance of seabuckthorn increases as it is almost the only food available for birds. Seabuckthorn provides long-term benefits in terms of maintaining the ecological equilibrium and improving the environment.

Use as fuelwood forest: In the HKH region, plant biomass is the most important source of energy. Seabuckthorn has proved to be a popular green energy plant because of its quality biomass. The calorific value of dry seabuckthorn wood is 4,785.5 calories per kg. It is a good source of firewood. In a six-year old seabuckthorn forest, each hectare can produce 18 tons of firewood, equal to nearly 12.6 tons of standard coal.

Fourwing Saltbush - A Forage Shrub for Arid Highlands

Significance

This technology has been tested successfully in the arid highlands of Balochistan, Pakistan.

Fourwing saltbush can be established in cold and arid zones of the HKH region by using the proper techniques for soil moisture conservation. The most valuable characteristics of this plant include its tolerance for extreme drought, cold, and high quality browsing facility, especially during the autumn and winter months. This shrub is a perennial halophyte which continues to produce green leaves and twigs round the year. Fourwing saltbush is an excellent seed producer, with the seeds maturing from October to December. The seeds dry on the plant, thus allowing some flexibility in harvesting.

It can also be used as fuelwood in addition to forage for livestock. About 0.5 to 1.0kg of dry wood per plant can be obtained after an initial two years of plant growth and then each year. Fourwing saltbush can be promoted as a sustainable source of fuelwood and can help reduce the uprooting of local shrubs from already denuded rangelands.

Components

Atriplex canescens, commonly known as fourwing saltbush, is an evergreen shrub with dense foliage, 1.8 to 2.7m high. It

Plate 12: ***Sheep Grazing Fourwing Saltbush in Cold and Dry Mountains***

Fourwing saltbush is an exotic forage technology. By establishing forage banks on marginal lands, the ranges can be de-stocked for improvement and rehabilitation purposes.

bears male and female flowers on separate plants. The flowering period is from July to August. Fourwing saltbush has an extensive root system and is adapted to a wide range of soils and climates. It thrives in areas with a mean annual precipitation of 250mm. Below 200 to 250mm, additional water from runoff, irrigation, or the presence of a water table is mandatory for good production. Fourwing saltbush shows good adaptation to cold environments, withstanding temperatures as low as -20°C. On the other hand, it can survive at 35°C during hot dry periods in arid climates. It does better on shallower, silty soils, for example, soils having shallow lime crusts, etc. Fourwing saltbush has a good tolerance for saline conditions.

Normally, the seeds do not germinate under natural rainfed conditions, so direct seeding is not recommended. The best way to grow this plant is in the nursery. Germination takes place in about seven to 10 days in spring, summer, and early autumn. Seedlings are transplanted at four to five months of age in the winter rainfall season. However, planting can be carried out throughout the year if irrigation is available. Under rainfed conditions, it is recommended that the first watering should take place at the time of planting to help the plants establish their roots deep in the soil.

Fourwing saltbush can be planted in holes (0.5m deep and 0.5m wide) to collect and store rain water. It can also be planted in ripped lines. For raising forage reserves, a 2 x 2m plant-to-plant distance is recommended that may be changed according to the type of plantation. Plants should be protected from grazing until they are about 18 months old and have woody stems and a well-developed root system. Plants can be grazed during winter without reducing the vigour of the shrub. However, heavy use in late summer or autumn could be detrimental to the plants. Sheep and goats would require an adaptation period of 10 to 15 days for grazing and then the farmer should increase their herbage intake over time. An average biomass of 1,200 - 1,600kg dry matter could be obtained per hectare, which is sufficient for six sheep to graze the area for three months.

Fourwing saltbush can withstand moderate to heavy grazing pressure and responds vigorously by re-sprouting the next spring. Plants become woody and less palatable if not grazed or pruned after two years of growth. Therefore, periodic grazing or pruning is required to keep plants highly productive and palatable. The quality of feed improves significantly after pruning, particularly the protein and carotene content of leaves. In addition, access for animals to graze the plant efficiently is also improved after periodic grazing and cutting.

Fourwing saltbush generally possesses a low energy value due to the high mineral content. The energy value is enough to supply the maintenance needs of sheep if they consume 1.2 to 1.5kg of dry matter (DM) per day. An important quality of this species is its high protein content, which can be as high as 15 to 20 per cent. The digestibility of dry matter and organic matter could be 60 and 50 per cent, respectively. The digestibility of nitrogen ranges from 50-55 per cent.

Kallar Grass for Biological Reclamation of Saline and Waterlogged Areas

Significance

Kallar grass (*Leptochloa fusca*) for biological reclamation of saline and waterlogged

Plate 13: ***Kallar Grass is a Biological Reclamation Tool of Waterlogged Areas Where Soils are Saline- Sodic and Supplies of Irrigation Water are Saline.***

Growing this species is a viable way to make optimum use of soil and water resources. On saline or sodic soils, this grass may be grown with good quality or sweet irrigation water and used to improve the properties of the soil.

areas is widely distributed in salt-affected areas of Australia, India, Pakistan, the USA, and other tropical arid and semi-arid regions of the world. It is easily propagated through seed, stem cuttings, or root stumps and exhibits excellent growth under saline, sodic, and flooded soil conditions. Kallar grass is amongst the few plant species that are well adapted to both waterlogged and saline conditions.

Components

Kallar grass is grown on salt-affected and waterlogged soils with peak yields during the rainy monsoon season. The stump planting requires regular flooding for good growth and survival. This vegetation can evaporate large quantities of groundwater. An added advantage of kallar grass under waterlogged conditions is that it reduces the salinity of groundwater and provides a better environment for other plants. The high tolerance of kallar grass to being waterlogged is obviously related to its ability to efficiently transport oxygen through its aerial parts to aerate the root system via internal air channels (parenchyma) in the same manner as rice and other wetland species. Similar to many other monocot species, this species is capable of producing numerous adventitious roots that emerge from the base of each node on the shoot when in water or wet soils.

The species does not grow without excessive salts and vanishes when salts are removed. This is an advantage because the grass cannot become a weed in non-saline and improved soils. Soils on which kallar grass is grown may improve sufficiently to support the growth of other field crops. Many farmers in Pakistan have reclaimed their salt-affected wastelands by growing kallar grass for three to five years continuously, until less salt tolerant and even sensitive plants could be cultivated. Farmers are now making a good living by

raising buffaloes, cattle, goats, and sheep on this reclaimed land. A large number of small farmers are now adopting this practice, thus reducing rural to urban migration.

Shoot foliage can increase organic matter, humus, and soil mulching; decrease surface evaporation; and improve physical properties of the soil. Thus, with the passage of time, this process of amelioration can improve problem soils.

Mesquite for Stabilising Desert and Degraded Areas

Significance

Mesquite wood is hard and heavy with a specific gravity of 0.70 or higher, is excellent for firewood, and makes superior charcoal. Because of its high calorific value, the wood has been called 'wood anthracite'. It burns slowly and evenly and holds heat well. The tree is also valued for shade, timber, and forage. Pods are eaten by livestock and can be ground into flour for human consumption. It is planted where other more valuable forest species cannot be grown (Table 17).

Stabilisation models for sand dunes using mesquite have been developed successfully in Balochistan, Pakistan. Mesquite seeds were raised in polythene bags filled with coastal sand and irrigated with good quality water. Six-month to one-year-old seedlings were planted in coastal sandy belts, spaced 2m apart. These were irrigated without any chemical amendment with sub-soil brackish water obtained from nearby wells. It is important to mention that during this work no chemical fertilizer, plant protection measures, mulching, or wind barriers were used.

Components

Mesquite (*Prosopis juliflora*) is a thorny semi-deciduous, large-crowned, and deep-

Plate 14: ***Mesquite Growing in a Sandy Area***

Prosopis juliflora inherits a strong defence mechanism which protects it from grazing and eventually lets it become a vigorous invader, with minor care and management, on abandoned soils.

Table 17: Beneficial Effects/Potential Uses of Prosopis Propagation in the Arid and Semi-Arid Areas of the HKH Region

Soil fertility	Environmental	Socioeconomic	Food/feed	Other products
Agroforestry systems	Improved C-sinks in the soil	Employment creation	Improved pasture	Charcoal
Control of soil erosion	Increased methane oxidation in soil	Diversification of food	Forage for ruminants	Gasification, electricity generation
Sand dune stabilisation	Sequestration of C in wood	Famine security (animal, humans)	Feed for domestic animals	Construction timber
Desalination	Alternative fuel (renewable resource; reduced use of fossil fuels)	Fuelwood for household use		Fencing materials
Prevention of salination		Cash flow	Supplements for meat/milk production from grass/crop etc. residues	Wood for furniture
N_2-fixation	Water runoff and quality improvement	Shade for humans and animals		Honey/hive products
Recycling of nutrients	Improvement of the micro-climate			Pharmaceutical products
Improvements in physical, chemical and micro-biological properties of the soils	Preservation of wildlife			Oil Gum (pods & bark)
	Landscape beautification (n.b. recreational areas to promote tourism)			Sugars
				Non-starch carbo-hydrates
	Hedging			Sweeteners
				Fibre source (food processing)
				Polyphenol resins (from heartwood)

Source: Muhammad 1996

rooted tree, which may grow up to 10m or more depending on the kind of site on which it grows. It was introduced into Pakistan in the early 1950s, mainly to stabilise dunes and for fuelwood. The tree grows on a variety of soils, but does especially well on sandy soils and can grow on rocky terrain, provided its roots do not face competition.

Mesquite has great potential for reclaiming desert and degraded lands. However, the following operations are a prerequisite for successful mesquite plantations:

- selection of genetically sound mother trees on inherently fertile soils;
- seed collection, cleaning, sorting, classification, and storage;
- nursery operations, maintenance, and transportation; and
- planting of trees with post planting care schemes.

Using rain-water harvesting techniques, mesquite has been planted successfully

on arid lands. Among rain-water harvesting treatments (sand dune slopes) mud and wheat straw plaster yielded maximum rain water. But in areas where sub-soil water is available and can be lifted with small diesel operated pumps, it is easier, and the outcome more successful, if the sand dune slopes are planted with different kinds of plants.

Medicinal Plants

Significance

Because of varying agro-ecological conditions, the HKH region is rich in medicinal flora growing under natural conditions. Farmers collect medicinal plants for their ethno-pharmaceutical uses and market the product for income generation. Proper propagation of important medicinal plant species would not only improve the ecological balance of natural resources but would fetch handsome prices in the market. Farmers may be encouraged to undertake unconventional cultivation of selected annual and perennial herbs as high-value cash crops.

Components

The *Ephedra* species grows widely on most rangelands of the HKH region. In fact, multi-national pharmaceutical companies have been producing the famous brand 'Ephedrine' from it. These companies are producing many other medicines from naturally growing plant species of this region. Because of the many socioeconomic factors and the ignorance of local inhabitants, the raw materials have been going to these factories at a nominal price, or free of cost. A list of important medicinal plants suitable to the region are given in Tables 18 and 19.

Plate 15: ***Ephedra Grows Widely in Cold and Dry Mountains***

The lack of awareness among local people, coupled with the overexploitation of medicinal plants (particularly the Ephedra species) by pharmaceutical firms, has endangered the highly valuable plant diversity. The cultivation of medicinal plants along scientific lines may change the economic scenario for local farmers.

Table 18.:Medicinal Plants Collected by Farmers in India

No	Drug Plants with high market demand	No	Drug Plants with moderate market demand
1	*Aconitum chasmanthum* (Bikh)	1	*Pistacia integerrima*, Stewart (Kakar singhi)
2	*Aconithum heterophyllum* ,Wall. (Patis)	2	*Bergenia ligulata* Wall. Engl. (Pashan bedh)
3	*Aconitum violaceum*, Jacq. (Mitha patish)	3	*Punica granatum* (Desi anar)
4	*Berberis aristana*, *Berberis asiatica* and (Kemal or Rasaunt plant), *Berberis lycium*	4	*Terminalia belerica* Roxb. (Behera)
5	*Podophyllum hexandrum*, Royle. (Ban kakri)	5	*Terminalia chebula* Retz. (Harrey)
6	*Viola serpens*, Wall. (Banafsha)	6	*Centella asiatica* Linn. (Urban brahmi booti)
7	*Veleriana wallichii* DC. (Banafsha)	7	*Angelica glauca* Edgew (Cobra)
8	*Jurinea macrocephala* Benth. (Dhup)	8	*Taraxacum officinale* Wigg. (Dudhali)
9	*Saussusrea costus* C.B. Clarke (Kuth)	9	*Rhododendron campanulatum* Don. (Kashmiri Patha)
10	*Gentiana kurro*, Royle. (Kaur or Karu)	10	*Gymnema sylvestre*, R. Br. (Gurmar)
11	*Swertia chirayita* Buch. (Chirayata)	11	*Swertia angustifolia* Buch.
12	*Atropa acuminata* Royale ex Lindley (Indian Belladonna jharka)	12	*Onosma bracteatum* Wall. (Rattanjor or Ratta)
13	*Picrorhiza kruuoa*, Roule ex Benth. (Kutki)	13	*Withania somnifera* (Dunal)
14	*Salvia moorcroftiana* Wall. (Thuth)	14	*Thymus serphyllum* Linn. (Ban ajawan)
15	*Ephedra gerardiana* Wall. (Somlata)	15	*Cinnamomum tamala* Fr. Nees (Tejpat)
16	*Ephedra intermedia* Schr. and Mey	16	*Embilica officianlis* Gaertn (Amala)
17	*Colchicum luteum* Baker (Hirantutiaja or Suanjan-a-tallah)	17	*Mallotus philippinensis* Muell (Kasmal)
18	*Artemisia maritima* Linn. (Santonin plant)	18	*Orchis latifolia* Linn. (Salam panja)
		19	*Asparagus filicinus* Wall. (Satawar)
		20	*Dioscorea deltoidea* Wall. (Kniss)
		21	*Acorus calamus* Linn. (Bach)
		22	*Terminalia chabula* Retz. (Marcy)
		23	*Withania somnifera* Dunal (Ashigndha)
		24	*Polygonatum multiflorum* Allioni
		25	*Polygonatum verticillatum* Allioni (Salam misri)

Source: Khosla 1997

Jojoba Cultivation in Tropical Aridlands

Significance

Jojoba tolerates extremely high temperatures. During summer, daily shade readings of from 35° to 48°C are common in its natural habitat. However, temperatures above 38°C appear to be of no advantage to the crop and may actually decrease its productivity because such temperatures cause stomata to close, thereby stopping vegetative growth. Jojoba is an exotic species and is successfully being grown in sandy deserts. It also has tremendous potential in arid mountainous regions.

Components

Jojoba (*Simmondsia chinensis*) is a woody shrub or small tree, multi-stemmed, and varying in height from 2 to 2.5m. It produces fruits after three to four years after plantation and is in full swing by nine to 10 years. Male and female plants are separate. Maximum production per unit area can be harvested if a male to female plant ratio is maintained at 1:8. These shrubs have a lifetime of over 100 years. The tap root of mature plants can be 15 to 25m below the soil, with substantial parallel lateral and secondary roots, which give jojoba the ability to draw moisture from a considerable vol-

Table 19: Important Medicinal Plants in the Western Mountains of Pakistan

Scientific Name	Local Name	Habitat/ Occurrence	Potential Uses
Acacia nilotica	Kikar	Plains	Used for diarrhoea, coughs, dysentery, diabetes, throat and chest complaints.
Alhaji maurorum	Jawasa	All habitats	Plant is a laxative, diuretic, expectorant, used as an aperient, and a blood purifier.
Calligonum polygonoides	Phog	Plains	Boiled roots in combination with catechu are used as a gargle for sore throats.
Capparis decidua	Karir	All habitats	Bark is laxative, diaphoretic, anthelminitic, acrid, used in asthma, cough, inflammation, boils and swelling.
Cenchrus biflorus	Lidder	Plains	The decoction of fruit is considered pectoral and a diuretic.
Crotolaria burhia	Sis, meimi	Plains	The plant is sold by medicinal herb vendors and is reputed to have cooling properties.
Cymbopogon jawarancusa	Khavi	Plains, hills	Plant contains essential oil (1%). Grass grown in Hazara contains 90% of d-piperitone and that from Sindh contains 44% Ketone.
Cynodon dactylon	Khabbal	Plains, hills	Plant is laxative, hamostatic haemostatic, demulcent, astringent, used in epilepsy, dysentery and opthalmia.
Desmostachya bipinnata	Dab	Plains	Gum is a stimulant and diuretic, used in dysentery and menorrhoea.
Euphorbia spp	Thor	Plains, hills	Used for snake bites, scorpion stings , is purgative, expectorant, also used in erruptions.
Indigofera oblongifolia	Jhil	All habitats	Purgative, used for rheumatic joints, has antisyphilitic and antiphelogistic properties.
Kochia indica	Bui	Fallow lands	Plant is a cardiac stimulant used in cases of weak and irregular heartbeat.
Peganum hermala	Harmal	Deserts	Seeds and fruits contain four alkaloids: harmine, hormaline, harmaline and pegamine.
Phoenix dactylifera	Khajoor	Deserts	Demulcent, nutrient, aphrodisiac, expectorant, laxative, used in cough, asthma, chest complaints and fever.
Prosopis cineraria	Jand	Deserts	Used for pregnant women, also for rheumatism, scorpion stings and to remove hairs from the skin.
Rhazya stricta	Senhwar	Plains, hills	Used as tonic, for skin erruptions, boils, sore throat, low fever etc.
Saccharum bengalense	Sarkanda	Flood, plains	Diuretic, demulcent, refrigerant, aphrodisiac and used for blood troubles and urinary complaints.
Salsola baryosma	Lani	Saline soils	Plant is used as a vermifuge and ash is applied to itches.
Salvadora oleoides	Wan	Desert	Purgative, to cure cough, aphrodisiac, vesicant and rheumatism.
Suaeda fruiticosa	Lana	Saline soils	Leaves are emetic, used as poultice in ophthalmia.
Tamarix aphylla	Frash	Plains	Galls are astringent, tonic and aphrodisiac used against eczema and other skin diseases.
Tribulus terrestris	Bhakara	All habitats	Plant is cooling, diuretic, tonic, aphrodisiac and aperient, used for mictorition, urinary disorders, impotence, cough and for kidney stones.
Withania coagulans	Paneer	Plains	Coagulant, alterative, sedative, emetic, diuretic and anodyne, used in chronic fever complaints, dyspepsia, intestinal affections and colic.
Zizyphus mauritiana	Ber	Plains, foot-hills	Used in diarrhoea, for purification of blood, digestion, wounds and ulcers.
Zizyphus nummularia	Mallah	Dry areas	Leaves are applied externally on boils and scabies. Fruit is astringent, cooling and used for bilious afflictions

Source: Muhammad 1996

ume of soil. This, combined with sclerophyllous leaves, which are rather hard, stiff, and remain on the plant year round, enables the plant to grow in arid regions.

The biggest and most vigorous jojoba plants are found on sloping, well-drained soils with silt and clay in the lower horizon. In cultivated stands, some plants are successful on sandy soils, others on silt-loam.

Plate 16: ***Jojoba is an unconventional high value resource for marginal lands***

The liquid wax, which is a clear, golden colour (known as liquid gold), is commercially called Jojoba oil and has a wide range of uses, including specialised lubricants, cosmetics, pharmaceuticals, and so on.

Jojoba oil can be used in alcohol and acid derivatives for the preparation of disinfectants, surfactants, driers, emulsifiers, resins, plasticisers, protective coatings, fibres, corrosion inhibitors, and in bases for creams and ointments. It can also be used in preparing hydrogenated waxes (solids), which in turn are used in polishing wax, protective coating for fruits and in smokeless candles. Additionally, jojoba foliage makes excellent browsing feed for deer, cattle, sheep, and goats.

Raising *Salicornia Halophyte* with Saline Water

Significance

Salicornia bigelovii, commonly called 'samphire', can be grown with sea water to a tolerance limit of 50,000 ppm without blighting. Non-potable well water can also serve as an irrigation supply source for *Salicornia*. *Salicornia* has also been grown successfully using labour-intensive techniques such flood irrigation, which means that it could also benefit farmers and consumers in low income countries.

A pilot farm of 150 hectares was planted in Saudi Arabia to raise it on a larger scale. The crop was harvested in September, 1994, and has been a success. The target at Ras al-Zawr is 4,500ha consisting of 90 pivot irrigation circles, each 800m across. Sea water is directly pulled in from the Gulf and is sprayed on the crop. One hundred tons of *Salicornia* crop were previously baled as forage for dairy herds, and the farmers are exploring the possibility of exporting the crunchy green tips to France as samphire salad ingredients. But the real value of the project lies in the oilseed which is now being processed. Suitable areas for *Salicornia* crop are places with saline groundwater. It has been successfully introduced in Balochistan, Pakistan.

Plate 17: ***Salicornia seeds produce high quality oil***

Salicornia crops have been grown successfully in the United Arab Emirates, Egypt, and Kuwait.

Components

Salicornia grows naturally along the sea coasts. Its seed has been developed selectively since the early 1980s at a test farm in Mexico's Sonora state, on the edge of the Gulf of California. It is an annual, succulent plant that is a member of the halophyte (literally 'salt plant') family. It has jointed, succulent stems and no leaves. These are common adaptations to a salty environment, since the stem helps the plant keep fresh water within the tissues.

Salicornia is known for its oilseed as well as its straw. It produces as much seed per hectare as soybeans and more than sunflowers. It is a high quality crop with 30 per cent oil of its total weight compared to 17 to 20 per cent of soybean and 30 per cent protein. The oilseed is low in salt. The oil is extracted by conventional milling procedures. Although edible for humans, the oil can also be used in animal diets. The seed meal left after pressing out most of the oil contains 33 to 43 per cent of crude protein, depending upon the purity of the seed and how much oil is left behind after pressing. The meal contains saponin, which interferes with its use in poultry diets, but it can be substituted for cottonseed meal or other protein sources in ruminant diets at 10 per cent inclusion. Using the method of hexane extraction of the oil results in a meal with approximately five per cent residual oil, but other pressing methods yield meals with 10 per cent or greater oil contents. *Salicornia* oil also contains 72 per cent linoleic acid - a healthy polyunsaturated fat - levels are close to these found in safflower oil, and more than twice that of oil from soybeans. The *Salicornia* meal has been used with success as a poultry feed additive. Salicornia oil might also be used to produce pharmaceutical products and cosmetics.

Protection Spurs

Significance

Flash floods during the rainy season erode large amounts of precious soil mainly be-

Plate 18: ***Protection spurs in the highlands***

The effectiveness of these spurs could be increased considerably by planting soil-binding plant species along the spur, which is rarely seen in Balochistan.

cause of the uneven mountainous features of this region. Most of the time, flood waters take away agricultural fields, resulting in immense destruction. Farmers have begun to protect their fields, by constructing protection spurs.

Protection spurs are seen throughout Balochistan, Pakistan, and their role in protecting land from water erosion is great.

Components

A protection spur is a 0.9m wide and about 1.5m high wall of stones constructed on either side of a stream or any natural flood water channel. Traditionally, farmers used to protect their fields from flood damage by erecting tree trunks as wooden poles at a given distance and in a certain angle along their fields to protect against flood water. The gaps between the wooden poles were filled in with heavy stones. Farmers were able to protect their fields as well as divert flood water in a certain direction.

Scarcity of forest wood and awareness of modern knowledge have changed the raw material used in making protection spurs. Stones, roughly rectangular in shape, are put together to make a wall along a field and a wire net holds them together as a wall against flood water. These are used widely along hill torrent banks to control expansion of their basins.

Donga Soil Trap

Significance

Physiographically, the HKH belt is made up of high and low mountains and gravelly fans and terraces. Much of the surface of dry and cold mountain and hill slopes is comprised of bare rock and is without soil cover. Various patches contain shallow or very shallow, largely calcareous, gravelly, and stony loam soils. Soils of gravelly fans and terraces are shallow to moderately deep, heavily calcareous, with a lime content of about 30 per cent in stone or powdery form in the sub-

Plate 19: ***Donga soil trap in the western mountains, Balochistan***

Such soil traps increase infiltration, promote nutrient rich highly fertile sediment, and prevent widening of gullies and seasonal stream basins. Donga(s) slow down the velocity of runoff water, hence, prevent damage to adjoining land.

soil with a low water holding capacity. This phenomenon is peculiar to most of the western HKH zone. Desert varnished stones and coarse gravel, having thick lime coatings on their under parts, limit the use of these soils. Lack of good deep soil is an inherited and a major physiographic constraint of crop and orchard production. Traditional farmers developed this technology to collect eroded soil from flood water to construct agricultural fields and mainly for establishing orchards.

Components

A *donga* is in fact a dug-out pond measuring roughly 6 to 16m along the side of a seasonal tributary stream for trapping soil. It is always close to an agricultural field where soil is transported. A dyke keeps out the flood water from the *donga*. However, the pond is filled up by flood waters through a small inlet in the dike, which permits only muddy water to enter and prevents rocky materials from getting in. The water is stored there for two to three months.

Once the water dries up, it leaves behind fertile soil in the bottom of the *donga*, which is collected and taken to the fields to establish orchards. Some time later, a *donga* may become a field and a new *donga* is built next to it. Slowly and gradually, the wide bed of a stream is converted into fertile agricultural fields. The large scale apple orchards seen today in the Urak area of the Quetta Valley, Balochistan, are there just because of the *donga* technology used by local farmers over the past few decades.

Construction of Agricultural Fields by Transporting Soils

Significance

This technology is being used widely in the Balochistan province of Pakistan where agricultural activities (particularly orchard

Plate 20: ***Field being constructed by transporting soils***

The transported soils may be invariably deficient both in organic matter content or certain nutrients. Some farmers did complain about certain problems – apparently of nutrient deficiency. Soil samples from this kind of field should be analysed for a nutrient profile so that any nutrient deficiencies can be corrected.

production) are largely linked to the practice. Lack of good and deep soil is the main constraint to the development of farm agronomy in this region. Native soils contain a lot of rock matter, which restricts the growing of crops and orchards. Since the invention of this technology, the cultivable area has been increasing gradually in the region. Until now, more than 90 per cent of orchards have been established by constructing new fields on agriculturally unproductive areas by using sediment soils brought from other places.

Components

A selected piece of land is levelled and an embankment is constructed all around it while levelling. Sediment, or any good soil, is collected mainly from delay action dams, riparian zones, check dams, etc and is transported to this piece of land. Tractor trolleys are a popular means of transport and are rented for the job. A layer of one metre thick fertile soil is laid over the levelled piece of land. Finally, the orchard is established.

This technology is labour intensive and requires a lot of cash investment. Farmers undertake this activity gradually and with lots of patience. Sometimes, a farmer does not have sufficient resources. Initially, he will prepare a site for this purpose. A selected piece of land is bulldozed or levelled by tractor blade. Heavy stones are picked up and used for constructing an embankment around it. The farmer will lay out the tree plantation and will import a number of soil loads equal to the total number of saplings to be planted (i.e., one soil load for one tree). Each trolley is unloaded as per the plantation layout. This method provides enough deep soil to each sapling to grow vigorously, meanwhile, the rest of the field is filled gradually by transporting more soil. Sometimes it may take years to construct a field fully.

Plate 21: ***Salinity control channels in the highlands of Balochistan***

Farmers need education about proper use of already scarce water resources.

Salinity-controlling Channels

Significance

The origin of this technology also lies in Balochistan, Pakistan, where agricultural fields are mostly terraced and are constructed by transporting soil from other places. Excessive irrigation of orchards and other cultivated fields is a general tendency among local farmers, as they believe that it improves productivity. They continue to flood their fields even if it is not required. The persistency of this practice has been causing salinity problems in most fields due to the saline water or soils. Local farmers have overcome this problem by constructing salinity-controlling channels along their terraced fields.

Components

Each terraced field is sloped to a certain degree. A salinity-controlling channel is actually a drain built on the sloping side. This drain is 0.6 to 1m deep, is about 0.6m wide, and runs parallel to the terraced field. Each drain is linked to a main drainage channel. Salts that have leached from the soil along with excessive water are collected in the first step channel and are taken to the main drainage channel.

Belcha Soil Tillage

Significance

In Balochistan, land holdings are small and terraced. The farm economy is heavily dependent upon orchard production. Farmers use small row to row and plant to plant distances in orchards to increase plant density per unit of cultivated land. This narrow plantation poses problems for tilling during intercropping. Farmers cannot undertake ploughing by tractors or traditional animal driven ploughs. Tillage is carried out manually using a tool called a *belcha*.

Components

A *belcha* is in fact a modified spade. It has multiple uses and can be used efficiently for many other field operations such as constructing and cleaning water channels,

crop residues, domestic residues, animal excreta, etc) and for improving overall soil fertility (Reijntjes 1992).

Farmers of the HKH, in general, and of Balochistan in particular, are marginalised, resource poor, and lack access to chemical fertilizers. Most farmers depend heavily upon compost as an indigenous fertilizer for improving the soil nutrient status.

Components

Composting is in fact the break down of organic wastes by micro-organisms and soil fauna, in order to prepare the material called 'compost' (Reijntjes 1992). This organic fertilizer also increases the resistance of plants to pests and various diseases.

Composting is normally done in heaps, however, local farmers have adopted a very simple method of preparing organic fertilizer. A dug-out about one metre deep, measuring roughly 4.5x9m, is constructed for this purpose. All kinds of home wastes, animal dung, ash, fallen leaves from the orchard, etc are dumped into it. Once filled, it is covered with a layer of soil. Sufficient water is added to it to moisten the material, and it is left to decompose for a few months or sometimes for a year. The farmers do not add any mineral such as rock dust, rock phosphate, or urea, thus compost quality is relatively poor. Later the compost is taken to the field as compost fertilizer. The same practice is repeated annually.

An improved version of preparing enriched compost could be popularised among the farmers. The procedure is as follows.

Construct a pit measuring 3x2x1m. Line it with a polythene sheet. Add a 30cm thick layer of organic waste and moisten it with water containing five per cent rock phosphate and two per cent urea fertilizer. Two such layers of organic waste should be laid above it in the pit. For aeration, PVC pipes could be inserted into the pit. Cover it with a 10cm thick layer of soil. After one month, turn over the organic waste and cover it again. The compost will be ready for use in three months.

Organic Manure

Significance

The organic manure content of a soil improves the sustainability of farming by promoting the nutrient index and soil life. The farmers of the Indian HKH region use manure to the fullest advantage for mountain farming. Manure is used extensively in wheat, paddy, millet, and maize fields. Local people are apprehensive about the use of chemical fertilizers as they believe that these fertilizers cause soil compaction which hinders other farming operations. In some areas, kitchen ash and manure are mixed together and are used for kitchen gardening and for improving the size of potatoes.

Component

Cows, sheep, goats, and donkeys are the main sources of manure. In some areas, human excreta and poultry manure are also collected. Traditional practices of collecting manure vary from area to area. Farmers of Lahaul and Spiti use an innovative means for collecting the excreta of small ruminants (i.e., sheep and goats). When flocks are taken out for grazing, each animal has a small bag covering the anal parts tied to it and faeces are collected in it. The faeces are later used to fertilize the extremely sandy, low fertility soils.

Plate 24: ***Organic manure is popularly used as cooking fuel***

In the Spiti Valley, manure is applied to the fields only once a year (i.e., September and October) after the crop harvest. This practice has traditionally been developed because of the monocropping pattern. Manure is broadcast over the entire field and is followed by ploughing for thorough mixing.

Human excreta, called *chaksa*, is considered to be the richest manure and is collected in a special dry latrine pit. Local people also crush the bones of dead animals and mix in the power, which adds phosphorus and calcium. Cattle dung is also collected, particularly during winter, from sheds and kept open in heaps for further decomposition until the next summer. The leaves and grasses used as bedding for animals get soaked with faeces and urine and are also collected periodically as manure. Some farmers believe that excessive use of sheep and goat manure is harmful to crops. Ass dung, though not preferred, is also used.

Organic manuring is the principal mode of improving soil fertility. Local inhabitants take every measure to arrange as much manure as possible for their fields. For this purpose, local pastoral tribes, such as the *Gaddi*, are paid for the animal excreta of their flocks. Thus, *Gaddi* grazers will camp with their flocks in particular fields.

Indigenous Land-use Systems

Significance

The indigenous knowledge of a community in a particular region is derived from the local people's farming experience and is handed down from previous generations to present generations. It entails many insights, perceptions, and intuitions, relating to local environment (Reijntjes et al 1992). The indigenous land-use systems in the Indian Himalayan region take into account ecological, social, and religious factors. Because availability of cultivable land is determined by fertility status and moisture regimes, fields are dispersed at different altitudinal zones. Land consolidation has occurred in such a manner that each family gets its share of the upper, middle, and lower reaches of the slopes.

Plate 25: ***A typical view of indigenous land use in the mountains***

Religious sanctity is also attached to traditional land distribution patterns.

Components

Land holdings have been consolidated to facilitate an intensive land-use system that yields maximum benefits to meet social and cultural needs. There are monastic lands (belonging to a monastery) and private lands. Both involve different types of tenancies in accordance with local social norms and extend opportunities for intensive land use by employing collective labour. Management of cultivated lands and grazing lands is undertaken as per the agro-climate, altitude, and terrain.

Cultivated land holdings are relatively small in size and are generally distributed at three altitudinal (i.e., lower, middle, and upper). Some of these are close to a settlement and others are far away from it and are isolated. These are called *kanda*. The permanent settlements are mostly located in the middle zone. A farmer usually makes a small, low-cost house at the *kanda* for periodic and secondary use. This is called *dogary*. The *dogary* is used temporarily during cultivation and harvest at the *kanda* and is also used for grain and hay storage. Cultivation at lower elevations takes place earlier due to the warmer climate. Sowing is mostly completed by mid April at lower elevations near the river banks and is followed by sowing in the middle zone. Sowing is, however, delayed for at least one month at upper altitudes.

Farmers move up and down from the centre for farming. During cultivation seasons, they leave their houses early in the morning and return by evening and carry a cooked meal with them. Sometimes they need to spend nights at the *kanda*(s) in order to complete the heavy work. In this situation they would take along provisions for a certain number of days.

Field boundaries are separated by erecting stone and mud walls, constructed mostly by women. Seabuckthorn and other thorny bushes are commonly used to keep animals out and earmark land ownership. Ploughing is generally carried out by *dzo*(s) and sometimes by horses on sandy soils.

However, all kinds of animals are put to work for draught purposes and for quicker completion of the job during a short growing season.

Major crops (i.e., barley and wheat) are harvested by uprooting them along with the roots. For this purpose, the soil is softened a day earlier by light irrigation. The person harvesting beats large handfuls of uprooted plants against his/her legs to shake off most of the soil from the plant roots. The harvested plants are then tied together in bundles which are piled upon a roof in such a skilled way that the ears of the lower row are covered and protected from birds by the roots of upper stacks.

The objective of leaving very little plant material in the soil indicates the farmers' strategy of maximising their dry hay storage for livestock during the winter. It may also help to prevent soil-borne diseases.

This region contains extensive grazing lands. Some are near settlements (i.e., villages) and others may be on high mountain ranges. The high mountain ranges are only accessible to sheep and goats in summer. Cattle graze in pastures close to villages along with small ruminants. The remote pastures are watched by hired shepherds who stay there with the flocks for several months during summer. *Dzo*(s) and yak, being very hardy, are allowed to reach the highest altitudes near glaciers for foraging.

Village grazing resources vary in size and also in number (i.e., one to four pieces). They are called *doksa*. This resource can be distributed over three altitudinal zones. A *doksa* near a settlement and the lower zones will have permanent housing for animals (i.e., yards and pens) with stone walls and roofs, while others will have circular stonewalls for temporary shelter.

The *doska*(s) are compatible with local ecological conditions and serve as buffer zones for grazing in early spring and late autumn when upper grazing lands are snow-covered. Rotational grazing is a common practice for sequential recovery of vegetation. Appropriate stocking rates are indigenously observed and livestock distribution and movement is controlled using an innovative manner of grazing management (i.e., the animal urge for mineral consumption).

Since winter is long (i.e., at least six months) and grazing areas are covered by snow, the peculiar climatic conditions necessitate sufficient dry fodder storage for animals. Farmers follow certain land-use schemes for growing grasses, meadow weeds, and other nutritious herbs. Steeper mountain slopes and ridges are protected for this purpose as hay fields. Hay fields are harvested and the harvest is sun dried. Hay is stored for winter use.

Indigenous Land Preparation Practices

Significance

Local farmers in the HKH belt have developed various indigenous tillage practices through a process of informal research and development. These are compatible with the local agro-ecology, are local resource-based, and suggest advantages for their practical application on a given terrain.

Components

Fields are ploughed in a sword-like curved pattern to ensure proper land tillage at all corners. This pattern is successful in checking sudden runoff. Sloping lands are

Plate 26: ***Indigenous land preparation practice in China***

ploughed, following a bottom to top approach to avoid the soil losses that would occur otherwise.

The tillage tool is an indigenous plough with two extra flat pieces of wood attached to both sides of its iron blade. This plough is always preferred over the one available in the market, probably because of its two-fold function of saving labour and stabilising loose sandy stratum in one action.

The tillage operation is followed by the levelling of the field by using a *maddin* behind an animal. A *maddin* is a plain wooden plank. A heavy stone is put on the *maddin* to create a good levelling force. Sometimes, a person will also sit on it to increase pressure. Levelling of the ploughed field helps moisture conservation.

Cultivation practices are generally limited to plain and flat pieces of land to help reduce soil erosion. Fallow fields are irrigated in autumn to protect the surface layer of soil against heavy wind, which is a common feature of these cold deserts. The wet surface gets frozen during winter thus protecting it from being blown away. This practice also facilitates easy tillage operations during the next spring.

Chapter Five
Productivity Increasing Technologies

Introduction

The inhabitants of the HKH region inherit strong livestock traditions along with subsistence level crop cultivation. While maintaining this socioeconomic profile over centuries, the traditional approaches have undergone a process of transformation. Better communication with the rest of the world, and easy access to neighbouring commercial markets have motivated the tradition bound dwellers to shift to high-value farm operations. Although the shift is slow and gradual, mainly due to poor resources, it is nevertheless visible. The cropping approach is now based on cash crop farming and inter-systemic linkages, new forms of activities, and increased flow of inputs from science and technology (Partap 1996). Due to physiographic constraints, and fragmentation of permanent land holdings within the family, scope for expanding cultivation on a larger scale used to be limited. Finally, the number of marginal and small farmers is increasing throughout the HKH region. Incidentally, the situation has challenged small farmers to integrate scarce resources to such an extent that farm productivity is optimum (Partap 1996).

There is evidence that fruit and vegetable production is emerging as the most significant means of cash generation, although still heavily integrated with livestock production. New technological choices such as off-season vegetable and fruit production, cultivation, the harvesting of medicinal plants, floriculture, and improved varieties of major crops have encouraged the small mountain farmer to accept the challenge and work with the changing socioeconomic scenario.

This chapter contains various technologies for improving the productivity of the orchard, for growing vegetables and other cash crops, and for better animal husbandry. This technology package also includes successful indigenous practices, which may be blended with modern innovations to make them culturally and environmentally friendly within a particular farming zone. Some options also focus on farm mechanisation, necessary for farming in particular agro-ecological conditions.

Katcha Orchards

Significance

The apple orchard is the most successful and popular proposition for a mountain farmer in Balochistan, subject to water availability. However, a new apple orchard takes a minimum of five to seven years to generate cash flow. Meanwhile, it involves considerable investment to become established and to reach the fruiting stage.

Plate 27: ***Prune, Plum etc Planted among Apple Trees***

Katcha trees have changed the economic scenario for orchard growers. This technology has emerged as a popular one among local farmers, especially since it generates early income during the interim period before a permanent orchard reaches optimum yield, and afterwards provides the option of inter-cropping.

Farmers lack resources and their farm revenues must be supplemented by some other source of income to support their poor economy in the meantime.

Katcha means 'temporary'. This orchard technology has given relief to local apple growers. Fast growing *katcha* fruit trees start bearing fruit within two to three years providing a means of income generation at the farm. Due to their shorter lifespan, they complete their growth cycle within half a decade, at the time a permanent orchard (i.e., mostly of apples) reaches peak production.

Components

A *katcha* orchard is temporarily established for a maximum period of 6 to 8 years. Apples, apricots and almonds are considered permanent orchard trees because their productive lifespan is longer. The permanent orchard tree takes no less than five to seven years to yield the desired level of productivity. Meanwhile, the temporary (*katcha*) fruit trees are planted among the permanent trees.

For this purpose, parallel rows of rapidly growing *katcha* fruit trees (i.e., mostly peaches and plums) are established in between permanent tree rows. This practice demands a slight increase in the distance, plant to plant (i.e., 10 x 10m), between the permanent trees. The *katcha* trees start producing fruit during the second or third year of plantation and are uprooted after six to eight years when permanent orchards reach the stage of optimum yield. Their removal follows inter-cropping of alfalfa and other vegetable crops by farmers. Farmers may make money by selling the wood of uprooted trees or they may use it for domestic needs.

Plate 28: ***Modern Pruning Techniques Help Improve Orchard Productivity***

In Balochistan, orchard producers apply rarely used modern pruning techniques, consequently, many taller trees are seen. The productivity per tree can easily be increased manifold by training farmers in modern pruning techniques.

Pruning Techniques

Significance

The pruning of apple fruit trees is the foremost indigenous practice for the maintenance of tree vigour and productivity. Low yields and poor fruit quality may be attributed to poor light penetration in the tree canopy. Alternate bearing, poor fruit set, high insect-pest and disease incidence, and poor fruit colour are also due to uncontrolled tree growth.

Components

Orchards are pruned manually, with the following basic rules being adhered to while pruning to enhance yields.

Rule 1

- Limb orientation influences fruiting. Vertical or upright vigorous growth habits do not induce lateral branching so that there is no flower bud formation and consequently no fruit will be formed on such branches of a tree.
- Limbs at a 30 to 45 degree angle develop not only laterals but some spurs that lead to early flower bud formation.
- Limbs below horizontal orientation develop water shoots and less fruit of poor quality.

Rule 2

- Unpruned limbs do not develop proper laterals and spurs. The lower part of the limbs also remain barren.
- Severe pruning results in heavy regrowth that does not favour bud formation.

Rule 3

- Intensity of light spectrum, essential for fruit bud formation, decreases sharply after it intercepts the tree periphery. Any inner part receiving less than 30 per cent sunshine cannot develop flower buds.

Rule 4

- The best time for bending branches is when growth is about to cease, i.e. in early August for cooler regions and in the first half of September for relatively less cold areas.

Smoking of Orchards

Significance

During winter, when temperatures go down to well below freezing (i.e. -12°C), orchards are highly prone to frost and severe chill injuries that may cause high mortality in trees. Irrigation for saving trees is not possible owing to the very low temperatures. If farmers do not take appropriate measures to protect trees from severe cold, it may devastate their orchards. Damage is particularly heavy when trees are at the flowering and sprouting stage. Smoking of orchards has emerged as an orchard saving technology in the highlands of Balochistan. It is the cheapest and easiest way of saving trees from frost injury.

Components

During the coldest nights, when there is the danger of damage by frost or by severe, chilling, windy weather, local farmers create smoke by burning bags, leaves, debris etc. in their orchards. Smoke is set in the direction of the wind so that it reaches all around the orchard. The smoke warms up the micro-climate and eventually the trees are protected. This technology has been widely adopted by local farmers.

Orchard Bathing

Significance

Due to low rainfall and a dry climate, the apple orchards are exposed to dust and

Plate 29: ***Smoking of Orchards Protects Fruit Trees from Frost Injury***

Plate 30: ***Orchard Bathing Saves Fruit Trees from Dust and Pests in the Absence of Rainfall***

pest infestation. The deposition of dust on apple fruit results in low production and fruit of inferior quality, which ultimately reduces farm income. Apple orchards are given a 'bath' to overcome this problem. Farmers believe that, in this way, the colour of fruit is also improved and it fetches a better market price.

Components

Rain is the main way in which orchards are washed (particularly apple trees). Rainbaths eliminate losses by dust and pests during fall and winter. Whenever rain is delayed, farmers use an indigenous and local method of orchard bathing. Using a long rubber pipe, along with a powerful spray nozzle, for washing trees, the farmer connects the pipe to a water source, i.e., a water tank or water channel. A mobile water tank behind a tractor is becoming a popular method of supplying water for orchard bathing. A spray nozzle operates through the tractor. Water is showered on to the trees using a long pipe or by moving the water tank closer to the trees. This technology is in common use nowadays, mainly to prevent loss due to pests and to allow farmers to market quality produce.

Wire Nets for Vines

Significance

Grape production is common in northern Balochistan. Traditionally, vines were grown on trees, ridges, etc. Wire net technology allows more space for the vines to grow with a relatively high density per unit of land which improves grape yields. Unlike traditional methods of grape production, farmers are able to inter-crop berseem, lucerne, etc with grapevines, which further increases farm income.

Traditional grape production methods have two main disadvantages:

- heavy losses throug predators such as birds and animals, and

Plate 31: ***Grape Production under Wire Nets***

Wire nets are gaining popularity with farmers for growing grape vines. However, because the bunches of grapes are always in the shade, they have the greenish appearance of having been prematurely harvested. The market agent grades the produce as low quality and prices it accordingly. Research work is required to eliminate the myth that grapes grown in this way are of inferior quality.

- a laborious and difficult harvest of produce.

This technology has been developed mainly to overcome these two problems in addition to the other benefits it confers.

Components

Vines are grown in fields by following a row to row and plant to plant layout. Overhead wire nets are installed all over the field with the support of wooden or iron poles. Initially, young vines are directed towards the wire net to grow freely. Usually, they attain a height of about 1.5 to 2.5m above the ground. Farmers do follow plant to plant and row to row distancing (i.e., 3 x 3m and 3 x 3m) and it is always sufficiently wide enough to allow inter-cropping, mostly of fodder crops such as *alfalfa*. Bunches of grapes hanging under the cover of wire nets and mother vines are protected from birds. They remain clean and protected from other pests. This method allows quick and easy harvesting while walking between the rows under the net.

Trellis Grape Production

Significance

Traditional grape production on ridges causes heavy losses in terms of low grape yield. Additionally, the traditional system is labour-intensive, particularly in the beginning. It also relies on heavy water supplies and eventually incurs higher water losses.

The Department of Agriculture, Balochistan, has successfully introduced

*Plate 32: **Trellis Grape Production System***

The Trellis System has potential for improving grape yields. Organized and wide-scale extension efforts are required to introduce it amongst grape producers.

an improved grape production technology during the past decade called the Trellis System of grape production. It replaces the traditional production of grapes on ridges. It improves grape yields substantially by preventing field losses, and the produce is uniform. This technology has been cleverly combined with trickle irrigation. This combination of two modern technologies has encouraged farmers to open more areas for grape vines previously never suited to this purpose.

Components

In a selected field, angle irons (poles) are erected according to a field layout. A standard layout is followed, i.e., having a 6m distance between poles and a row to row distance of about 4.5m. An angle iron approximately 1.5m long with a 0.9m T-arm on one end is used for this purpose. Each pole is erected in such a way that it is 0.3m inside the ground with the T-arm about 1.2m above the ground. Each pole in the row is connected to the next by trellises. The T-arm of each angle iron possesses 0.3m spaced holes, and these allow the stretching of parallel metallic wires of a certain gauge from one end of the row to the other while connecting all T-arms of the pole with each other.

Vines are planted along the row, 2.5m apart. Young vines are trained to climb on trellises. This allows the vines to grow above the ground and prevents many diseases. It also facilitates a quick and easy harvest.

Indigenous Greenhouse Conditions for Grapevines

Significance

Farmers of Nubra Valley in the western Himalayas of Indian territory grow grapes under severe, cold desert conditions by

Plate 33: ***Indigenous Greenhouse in Ladakh Area***

creating a warmer micro-climate. The localised greenhouse conditions have made it possible for local farmers to undertake grape cultivation.

Components

Warmer niches are located for grape cultivation. Vines are grown in pits by regulating the temperature of the basins. Pits are filled with locally available crushed stone, bricks, grass, hay, and soil. This warms up the micro-climate of the basin, which is otherwise cool due to the sandy soil. The vines are also covered with warm clothes, gunny bags, or wooden baskets for protection against the cold during the first one to two years.

Modern Nursery Techniques

Significance

Non-availability of true variety saplings for direct plantation is a critical constraint in mountainous areas. The root stocks of different fruit species such as apples, cherries, etc are imported by spending foreign exchange. This root stock is later used for propagating certain varieties using budding and grafting techniques. Budding is commonly used in Balochistan, however, it takes longer (two years) to develop a true variety plant than when by using grafting technique, in which case it takes only one year. Both these techniques are an important means of renovating old and unproductive orchards. They are also useful for changing the variety of trees in the orchard, a need brought about by the following factors.

- A decrease in market demand for certain varieties and loss of commercial value.
- Top working has a significant dwarfing effect.
- Varieties planted earlier may not cross-pollinate properly.

Hot bed technology is a revolution in nursery techniques. It may eliminate all root stock imports and subsequent budding or grafting procedures. This technique pro-

vides directly true variety saplings for field plantation. In this way, it cuts one to two years off the growing time of the vines for the benefit of farmer or nursery grower, thereby reducing expenses considerably.

Components

To carry out top working of trees and to propagate the germplasm, the following three options are available.

- Grafting
- Budding
- Hot bed sapling production

Grafting

Grafting is done with dormant scion wood with two buds in April to May, when the bark of a top-worked tree separates easily from the wood. Scion woods for grafting must be collected in the dormant season and kept dormant in cold storage in plastic bags until use. The best time to head back trees is February to March.

A good scion wood must have the following properties.

- Must have shown one year's growth of 0.3 to 0.6m during the previous season.
- Should be as thick as a lead pencil.
- Must have large, visible buds.
- Should be free of injury, infection, and remain absolutely dormant.

There are two types of grafting, that is cleft grafting and bark grafting.

Cleft grafting: This is the most commonly used method. It is important to consider the following while carrying out cleft grafting.

- The best branches to graft are below six inches and should be upright or sloped, at an angle of not less than 45°.
- The scions and stocks must be inserted carefully and tightly.
- A strip of plastic tape should be tied around the stock and left for about three months, after this time it must be cut but not removed.
- All cut surfaces should be sealed with grafting wax, asphalt paint, or non-toxic oil paint.

Bark grafting: Bark grafting is easier to carry out than cleft grafting. It gives good results in the case of stone fruits and pears. The disadvantage is that the graft is sensitive to wind damage.

Budding

Budding must be carried out in late summer or early fall, using bud-sticks. It is commonly used for top working of peaches, plums, cherries, and apples. The following rules should be followed while carrying out budding.

- Head back stock trees, as described earlier under the section on grafting.
- During summer time, select 3 to 5 new shoots for autumn budding.
- One-year old shoots are ready in autumn for T-budding.

Great care must be taken of the grafts in the first few years, mainly for the following reasons.

- The new fast-growing shoots are sensitive to breakage by wind, as well as damage by insects and fungal disease.
- So that a good, strong branch structure of the new top is developed.

During the summer time, inspect the grafts weekly and carry out the following operations.

- Tighten them when they reach 15 to 20 cm in thickness to prevent wind damage.
- Pay careful attention to plant protection measures.
- Carry out summer pruning, pinching, and bending of new secondary shoots, to form a proper tree branch system.

Hot bed sapling production

This is an innovation for producing true variety saplings or root stock in a very short duration to meet the demand of large scale orchard plantations. The main constraint with this technology is that it requires a stable source of electricity round the clock. Other requirements include a suitable room for controlling climate, a small specified electricity transformer, and specified electrical heating elements.

A small sandy bed (15cm depth) or a series of sandy beds (each measuring roughly 1 to 2m) are constructed in a room.

Electrical elements are used to maintain the sub-surface temperature of the sandy bed within a range of 20 to 24°C by placing them under the surface according to a layout. These elements are connected with an electricity supply through a transformer.

A standard bed measuring 1m to 2m may contain about 6,000 cuttings to produce saplings. One end of the cutting is treated with a solution of Indwell Butyric Acid (IBA) and is placed vertically into the bed. The moisture of the bed is maintained at field capacity, and the humidity of the room should be at 80 per cent.

Root initiation takes place within four to six weeks. Afterwards, the cutting is transplanted into a nursery tunnel or open soil beds.

Commercialised Wild Orchards

Significance

Low-producing orchards of wild fruit trees such as apricots, walnuts, crab apples, almonds, *behmi* (wild apricot), and grapes are a common sight in Ladakh and other areas of the western Indian Himalayas. Wild plantations are being converted into commercial orchards using modern nursery techniques and improved varieties, as introduced by Parmer University. Eventually, the Kinnaur apple emerged as the most prized crop, fetching maximum prices in the market due to its high quality and delayed marketing season. Apricots, walnuts, and almonds cultivation is also becoming a valuable commercial enterprise.

Components

Modern grafting techniques are being used extensively to convert wild orchards into a highly productive commercial enterprise.

Plate 34: ***Hotbed Technology is Feasible for Commercial and Community Level Multiplication of Root Stocks and True Variety Saplings of Orchard Plants***

Wild walnut trees are grafted with improved high-yielding varieties producing thin-shelled dry fruit.

Simultaneously, the improvement of wild apricot plants by introducing modern varieties is progressing quickly in different valleys. Scions of sweet fruit varieties are grafted on to wild apricot plants. Local people are now skilled enough to insert half lamina along with petiole into a peeled part of the wild stock. The union is tied with bark. Preferably, two- to three-year old scions are used. The whole procedure involves cutting bark at a bud point of a selected plant with slow rotary movements, in such a manner that a cylindrical bark cap is peeled off from the top of the stem. After grafting with a scion, this bark cap is placed back over the top and is sufficiently tightened, so that the union of the scion's petiole with the stock is strengthened. The use of the peeled off bark cap signifies the local wisdom for ensuring enough moisture reaches the grafted union. The half lamina is used as a check against any possible damage to the union due to wind.

Fresh-growing trunks and young plants are wrapped with gunny bags or covered by a tin sheet to protect them from browsing goats.

Off-season Vegetable Production

Significance

Vegetable production in cold mountain deserts has traditionally been limited to the domestic scene. In recent years, development of infrastructure resulting from the tourism industry, etc has created more demand and better marketing opportunities for locally produced vegetables. Vegetable production promises a consistent cash flow during most of the year. Finally, the cropping pattern in cold deserts has undergone a tremendous change with the introduction of off-season vegetable crops;

Plate 35: ***Off-season Vegetable Production Can Increase the Income of a Mountain Farmer Substantially***

women are heavily involved in the local sale of produce.

Components

Vegetable cultivation, particularly, has a great potential for improving income generation in the cold deserts of Ladakh and Himachal Pradesh. In the Ladakh area, cabbages, cauliflowers, turnip, *knolkhal* (Brassica), Chinese radishes, carrots, spinach, *methi*, coriander, and potatoes are being grown successfully. In addition to local sales, these vegetables are marketed in neighbouring lowland areas as off-season vegetables and fetch good prices. Cauliflowers are especially produced as an off-season vegetable during July through to the end of September.

Ladakhi farmers follow an indigenous root-spreading technique for increasing vegetable production. A wooden implement called a '*tokhre*' is used for this purpose. They use *tokhre*(s) for digging soil around vegetable plants to redirect roots towards the surface of the soil. The objective is to enable the plant to obtain maximum nutrients from the fertile topsoil. The wooden structure protects roots from any mechanical damage and is also used for weeding.

Peas, seed potatoes, cauliflowers, cabbages, turnip, and coriander are important vegetables grown in Himachal Pradesh. Seed potatoes and peas cover most of the cropped area in Lahaul. Government subsidies and incentives have a positive impact on adapting vegetable cultivation to produce cash crops.

The cold desert areas are designated disease-free zones. The cold climate is very suitable for vegetable seed production. Cabbage and cauliflower seed production is known as a successful economic enterprise in this region. Seed potato cultivation for one of the biggest success stories for modern technology. The Lahaul Potato Growers Cooperative Society has emerged as a leader in the history of co-operative movements in India. The millet and coarse grain-based farming system has changed to extensive seed potato cultivation. This

region has witnessed the highest yield level in the world. Peas are also making their mark, even in zones where the seed potato dominates. Four harvests are completed in order to enter the markets of the plains selling off-season vegetables. Farmers normally receive three to four times more than normal market prices from businessmen who visit and contact the farmers directly.

Indigenous Farm Resource Management

Significance

Cold deserts face formidable challenges in terms of their remoteness, the fragility of their resources, and their inhospitable climates. The inhabitants have explored the interactions of biotic and abiotic components of their local ecosystem to an impressive degree. Farming methods are based on the indigenous knowledge and practices of the people of the region. Cropping patterns have been adjusted as per their food needs, availability of resources, sloping terrain, and altitudinal zonation of land holdings. Their farming practices and resource management are synonymous with traditional knowledge and maintain a delicate balance between sociocultural ethos and specific qualities of the region. Indigenous knowledge remains extremely valuable in terms of its wider applicability, adoption, and uniqueness.

Components

Crop production

Some of the indigenous farm management practices that prevail in the cold deserts of Ladakh and HP are discussed here in relevance to the sustainable use of farm resources.

In the absence of a modern solar calendar for the region, Ladakhi farmers have developed their own astrological system encompassing solar observation, astrological dogma, and traditional wisdom of observing the previous seasons. Agro-meteorological forecasts are made in order to predict the advent of snowfall, winds, storms, solar radiation, and pests. A special cairn is built on the eastern side of a field and the field is ploughed along the skyline ridge. During spring, once the northerly progression of the sunrise reaches this point, it is taken as a favourable omen for cultivating various crops, with a high probability of suitable weather.

Annual crop rotation in some areas makes optimum use of local agro-climatic conditions. In Pattan Valley, the farmers take advantage of a slightly lower elevation and relatively longer summer to grow two crops in one season. Since fields are covered until the end of April, farmers spread soil over snow in fields to catalyse snow melt. This practice enables them to start land preparation and sowing of the barley crop in March and early April. Barley is harvested in July and is immediately followed by the sowing of buckwheat. Buckwheat is harvested by the end of September. *Kuth* is preferably sown in November prior to any snowfall, since a longer period of seed stratification is essential for good germination. The *kuth* crop is harvested after mid-August. In any climatic zone, the order of crop rotation follows crop maturity seasons. The most prevalent sequence is wheat, barley, peas, and buckwheat. However, barley-peas-wheat is also a common rotation. Mixed cropping is also a common practice for maintaining soil fertility and as security against single crop failure. The cultivation of maize in combination with millet, beans, and lentils is a general mixed cropping pattern.

In some locations, crop rotation is governed by soil fertility. For example, since a barley crop requires heavy doses of organic manure for a good yield, the farmer will thoroughly manure one third of the land holding, depending upon the quantity of available manure, and grow barley in the first year. This part of the field is then used for growing buckwheat during the next year, with no additional input of manure. Wheat is grown in the third year. Meanwhile, another one-third of the landholding is prepared for a similar crop rotation. Under irrigated conditions, wheat alternates with paddy. Mono cropping is generally practised under rainfall conditions. Wheat or barley rotates with maize and/or lentils. The local crop rotation practices also take into consideration the control of any soil-borne or crop-residue carrying diseases and pests.

Local germplasms of major crops are highly acclimatised to the peculiar harsh, dry, and cold climates as well as the short growing period. The conservation and propagation of local germplasm receives high priority from local farmers.

Local germplasm is conserved year after year. Table 20 indicates the traditional germplasms Ladakh. Some studies conducted by Sher-e-Kashmir University of Agricultural Sciences and Technology and the Research Station at Leh have indicated higher yields of some of the local varieties compared to the recommended modern varieties from the adjoining plains.

The common practice is to collect seed from selected stands that are showing vigour, disease resistance, and higher productivity for the future. After every three to four years, the seed source is changed without diluting selection criterion. It extends a natural check against inbreeding and low productivity.

Farmers have developed simple and unique methods for different farm operations to increase productivity. A stone called *shangma*, light bluish in colour, is used for seed control. A small heap of soil is piled up in the middle of a fallow field in the month of December. Pieces of soluble *shangma* stone are spread over it. Mild irrigation or rainfall creates a thin layer of it all over the field.

It successfully inhibits plant growth in the field for from 10 to 15 days. The practice

Table 20: Traditional Germplasm in Ladakh

Crops	Variety of crops (Phonetic)	Transliteration	Meaning
Barley	Ne-nak	-	Black barley
	(Ladd, nak-nas)		Heavy barley
	Yang-ma	Gyong-ma	Early ripening
	Yang-kar	Eyeing-dkar	White wealth
	Sermo	-	Yellow mother
	Tug-zur	Drug-zur	Six cornered
Wheat	To-chen	Gro-chen	Big wheat
	To-chen	Gro-chund	Small wheat
Peas	Sren-mar	Sran-mar	-
Alfalfa	Buck-suk	-	-
Lucerne	(Lad-Lol)	-	-
Mustard	Nyus-Kara	Yungs-dkar	-
Buckwheat	Ta-wo	Bro-wo	-

Plate 36: ***A Chinese Woman Broadcasting Seed***

may be shifted according to the cultivation schedule.

Coriander seeds are hammered with leather shoes, which improves germination – probably because the hard testa of the seed is broken during this process of mild mechanical stratification.

Monastic traditions are employed for improving barley yields. Whenever the barley yield goes down and most seeds are empty, farmers will spread sand sanctified by the Lamas all over the fields. This seems to be a soil management practice that improves the porosity of soils when the inner layers become compact due to continuous barley cultivation. Somehow the practice has been linked to religious faith.

Unloading 20 to 25kg of manure after every seven steps taken by a woman ensures soil fertility and uniform distribution of organic manure. Later, the remainder is scattered all over the field. It has been observed that this method gives optimum manure distribution over a particular area.

Crop sowing is mostly undertaken by young girls who broadcast the seed. Girls are trained during childhood to pick up uniform handfuls of seed. One handful is broadcasted in three to four equal lots. The quantity of each lot is determined by whether the ploughing will be narrow or wide. Proper seed rate and uniform spacing is verified by random placing of the palm in the field from which a handful of soil is gathered. Each time, a handful should contain seven seeds. It coincides roughly with the recommended seed rates.

Strings of yak hair are used to check grain loss by birds from mature crops. These strings are used for shooting or harassing birds visiting fields by catapulting small stones from a distance.

Animals, particularly *dzo*(s), are trained to thresh the harvest by trampling. A large circle of packed earth (i.e., about 10m in diameter) forms the threshing floor. The animals are tied in line to a central pole. *Dzo*(s), once stirred, will revolve continuously for hours without any fatigue. There is often a combination of animals (as many

as twelve) with *dzo*(s) in the inner circle. A container is used for collecting animal dung during the operation to prevent any spoilage of the grain by excreta.

Special wooden houses away from residential units are constructed for grain storage. Sufficient care is taken to check the entry of rodents. Well- ventilated conventional stores ensure grain storage for considerably long periods in case of drought or famine.

Farming communities have developed different kinds of socioculturally bonded community organizations to carry out routine farm operations on a sustainable basis. These organizations also come forward to handle the situation in case of any calamity. Some of these organizations are described below.

In most villages, a village mate is annually selected from certain families and his special job is to make all kinds of community related announcements, such as the necessity of repairing the *kuhl*(s) and water tanks, as well as any special events, ceremonies, and so on. This man walks through the streets and shouts out the message. A token amount of money is collected and paid to him.

Animal production

Indigenous practices such as breeding, health care, and feeding to improve the productivity of native livestock are discussed below (Table 21).

Although sheep and goats are pastoral wealth, *dzo/dzomo*, yak/*demo*, and donkeys are choice animals in most areas, due to the physiograghic features of the region, and serve as the main source of draught power. Sometimes, even sheep and goats are used for transporting goods to difficult and inaccessible terrain. The cows, *dzo* and *demo*, are prinicpal milk producers for domestic consumption. Animal production is an important component of farming due to the vast amount of pastureland in the alpine zone (Table 22).

Table 21: Local Groups Sharing Responsibilities of Livestock Breeding

Organisation	Objective
Faspoon	A group of 7 to 8 families who look after indoor work in case of death
Langgsthay	Families sharing bullocks for draught purposes
Ra-rays	Collective grazing
Beyas	Group of farmers who carry out various cultivation operations together
Srang-Pa	Informer of a community

Farmers have a well-organized system for branding their animals for identification. Each family will assign a 'V' or 'U' or any shaped sign to its animals. The sign is iron branded on the outer side of the ears of the animals.

Local cattle breeds are genetically poor and, therefore, poor milch breeds. Crossbreeding of cattle with yaks is considered

Table 22: Cross Breeding of Livestock

Cross	Off spring	
	Female	Male
yak x cow	*dzomo*	*dzo*
yak x *dzomo*	*Garmo*	far or *garu* (sterile)
yak x *garmo*	*girmo*	*fir* (sterile)
yak x *girmo*	*Lokmo*	*lok* (sterile)
yak x *lokmo*	*Torgmo*	
yak x *torgmo*	*dimo*	yak

especially important to produce a strong and superior crossbreed of males called *chura*. The *chura* is small and has a heavy, thick hair coat all over the body. It is a very strong draft animal for the cold region, but it will not procreate. Selected yak bulls are maintained for crossbreeding with cows for this purpose. Breeding of cows and yaks, followed by reciprocal crosses, is an age-old practice enabling farmers to produce suitable hybrids for milk and draught power.

The animal calving/ lambing/ kidding schedule is synchronised with the warmer season in order to obtain a higher survival rate and to offer good quality forage to lactating females and growing young. The birth of farm animals takes place mostly in April and May. It is controlled either by isolating males from females during breeding seasons or by covering the male genitalia. Males of small ruminants may also be castrated.

Health management and indigenous veterinary care are very important in these areas to prevent mortality losses. Veterinary measures are quite effective for treating various animal diseases. For most problems of indisposition in cattle, the fruit of wild apricots boiled with water (called *lafe*) is given to the animal to eat. For any serious problem, a small cut in the outer portion of the animal's ear is made for the exudation of blood. In the case of dysentery, a red-hot iron is brought near the nose of an animal, this is claimed to be the most effective treatment. Most of the animal paralysis cases are treated by physiotherapy of the forehead with a warm stone, locally called *chaggar*. Common local veterinary treatments include the following.

- Long grasses found in fields are boiled and fed to animals suffering from stomach problems.
- A bottle of *sarson* (mustard) oil is fed to an animal with stomach problems.
- The bark of the *beli* tree is wrapped over the injured portion of the animal for a speedy recovery.
- The problem of falling wool in sheep is overcome by massaging in a mixture of sulphur and *sarson* oil.
- *Khurdu* disease (insect attack on sheeps' feet) is cured by wrapping the crushed leaves of the *karnu* tree on infested feet after washing with lukewarm water.
- A hot soup of *zeera* (cummin) and garlic is fed to animals suffering from simple temperatures and colds.
- Garlands of fresh garlic are hung on the necks of cows with stomach problems for effective treatment.
- Human saliva is collected after spitting it on the arm of any person and is then put into the suffering animal's eyes. This is the most effective treatment for sores affecting the eyes.
- *Jawanlari* grass, after burning with black cloth and mixing with oil, is fed to cows suffering from dysentery. This grass is dried and stored for the winter months.
- The sanctified soil of a termitorium is thrown over a cow suffering from stomach pain. The cap of any person is then beaten against the body of the

cow. A special person usually sanctifies the soil before throwing it. If such a person is not available in the village, an expert is invited from another village.

- Yaks and *dzo*(s) are prevented from drinking water after heavy work by tying their mouths. Farmers believe that allowing the yak or *dzo* to drink after intense labour leads to the formation of tumours in the neck region.
- During the lush, green, summer grazing season, animals returning from pastures are allowed restricted watering during the first twenty-four hours. They believe that the stronger urge of the animal for salt results in heavy water intake resulting in stomach inflation and subsequent death, particularly in the yak.

Special feeding practices are adopted to obtain quality produce. A native shrub, called *capsion*, is fed to sheep to increase wool production. Similarly, *pashmina* goats are grazed in deep gorges and severely cold *nallah*(s) in the upper reaches of mountains near glacial points, this is thought to give good quality mohair with longer staple length.

Dry hay is stored in open fields during September and October for the winter. It is piled up about 20 to 25cm high over a circular base made of stones. The stone base is first layered with thorny bushes. The grass bundles are then arranged over the bushes so that the top forms an ellipsoidal shape. The top is covered with rugs made from yak hair called *thobi*, followed by a layer of green, thorny bushes along with wheat straw. Finally, heavy wood logs or stones are put in place to keep it pressed down.

Common Vetch - An Important Forage Legume for Dry Mountains

Significance

Vetches originated in the Mediterranean region. Common vetch is an important plant grown throughout the world. It is used extensively as a cover crop in orchards and citrus groves for erosion control, soil improvement, green manuring, livestock forage, and wildlife food and shelter. Common vetch is a rainfed winter forage crop. Excepting for sandy soil, common vetch can be grown on all types of soil, even on depleted soil which is usually not suitable for cereal crops. It produces a reasonable bulk of forage in the cool season in the tropics, which is a time of forage deficit. It can be used as cut forage, grazed, or preserved as hay or silage.

Components

There are almost 150 vetch species reported from all over the world. *Vicia sativa* or common vetch is a semi-viny, herbaceous annual legume which grows erect in the early stages but lodges later due to a heavy mass of tendrils. Leaves are pinnately compound, with the petiole less than one cm long and hairy. Leaflets are small, entire or dentate at the apex, linear or oblong, petiolated, and are usually numerous. Flowers are crimson, purplish violet, and, rarely, white. The pods contain six to 12 seeds and shatter readily on reaching maturity. Common vetch has been found suitable for cultivation in the highlands of Balochistan, in the Sulaiman Mountains, and in the Karakoram ranges.

Common vetch does not require intensive land preparation. Two to three ploughings after harvesting the summer crop are suf-

Plate 37: ***Common Vetch in the Highlands of Balochistan***

Common vetch should be introduced into the cropping calendar of the highlands as a winter fodder crop to mitigate the nutritional stress faced by livestock, as winter is the most critical feed scarcity period.

ficient. It can be grown using the ordinary *rabi* seed drill. The line to line distance should be 30 cm and the sowing depth 5 to 8cm. An optimum seed rate of 80kg/ha gives a plant density of 120 to 150 seeds/ m^2. The best sowing season is from mid-October to mid-November. Common vetch can be intercropped with grasses, especially oats, for improvement of yield and quality. Being a legume, it can fix atmospheric nitrogen, so urea is not applied. A free living soil organism, *Rhizobium*, infects the root hair and causes formation of root nodules in the host plant, and these become sites of nitrogen fixation. *Rhizobium leguminosarum* is the vetch rhizobium and can be obtained from nodules on the roots of *Lathyrus*, *Pisum*, *Lens*, and *Vicia*. This symbiotically fixed nitrogen is not only sufficient for plant growth but also adds 80 to 100kg N per ha to the soil annually.

Maximum yield from common vetch is obtained at the stage when 50 per cent of the plant is in flower. Forage quality depletes rapidly soon after the pod filling stage. A fresh yield of 30 to 40 tons and a dry matter (DM) yield of five to eight tons/ ha can be obtained, if conditions are favourable.

Vetch contains 36 per cent crude protein in the early stages and up to 26 per cent in the flowering stage. The crude fibre content is 24.3 per cent, ash 22.3 per cent, ether extract 2.8 per cent, nitrogen free extract 38.8 per cent, calcium 0.49 per cent, and phosphorous 0.61 per cent. Digestibility is 81 per cent for crude protein and 53 per cent for crude fibre. Hence, vetch makes good quality forage compared to grasses. However, the seeds cannot be fed to farm animals as they contain poisonous glycosides such as vicine.

The surplus forage can be converted into hay and silage so that it can be used during lean periods.

Urea Molasses Blocks

Significance

Small ruminants in the HKH region often face feed shortages, especially at the end of the dry season and in winter. Many animals have to survive on poor quality range plants and cereal straws, especially wheat straw. Due to the high lignin contents of these feeds, feed intake and digestibility are low. Animals often lose weight and deaths may occur from starvation. Giving supplementary feed in the form of a solid block containing molasses, urea, and other nutrients can prevent this.

Liquid molasses cannot be transported easily to rural areas and they are difficult to use in rations, being very sticky, whereas molasses in block form are easier to transport and use. Nomadic and transhumant livestock producers can carry blocks with them. Feeding molasses in block form to animals is an excellent way of regulating their intake of urea.

Components

A urea molasses block is made up as follows.

i.	molasses	50 %
ii.	urea	10 %
iii.	salt	5 %
iv.	cement (dry)	10 %
v.	wheat/rice bran	25 %

It is also possible to add more minerals to the mixture when deficiencies occur.

The making of blocks should start at the beginning of the dry season, and the blocks will then be ready for use at the end of the dry season.

Hardness of Blocks: This is essential. For large-scale use, a penerterometer is used to measure hardness.

Plate 38: Urea Molasses Block Being Offered to Goats

Nutrient (i.e., energy and protein) deficiencies are prevalent in flocks. They are particularly severe during winter. A successful transfer of this technology to flock owners will boost the overall productivity of small ruminants in the mountains.

Preparation of Ingredients: All ingredients should be weighed before mixing. Molasses should not be diluted with water. Any lumps in the urea and salts should be crushed.

Mixing the Ingredients: The ingredients should be mixed by hand. The following order should be observed when adding ingredients for the best results: (a) molasses, (b) urea, (c) salt, (d) cement, (e) bran.

Half of the salt should be mixed with cement/water to improve the setting of the block. Four litres of water should be mixed with every 10kg of cement. The bran should be added gradually to ensure even distribution in the mixture.

Use of Moulds: For small moulds, buckets with a capacity of 10 litres can be used.

Big moulds can be made from four wooden boards in which slots are placed to form a rectangle. A height of 20cm is recommended. A frame of 2m x 2.5m x 0.2m can hold 1,000 litres (1,200kg) of mixture. A plastic sheet (100 microns thick) is normally placed in the mould before pouring in the mixture. Moulds should not be in direct sunlight.

Removal and Cutting: After 24 hours, the blocks are removed from the moulds. Blocks in buckets are simply turned out and the plastic removed. Marks should be made to assist in cutting a block of the required weight. For example, a mark 25 cm x 30 cm will produce a block of 10 kg if the height of the block is 20 cm. Cutting can be done with a flat spade.

Drying: The cut blocks should be placed in the shade with good ventilation. Drying time may vary according to climate and location.

The following instructions should be observed when feeding blocks to animals.

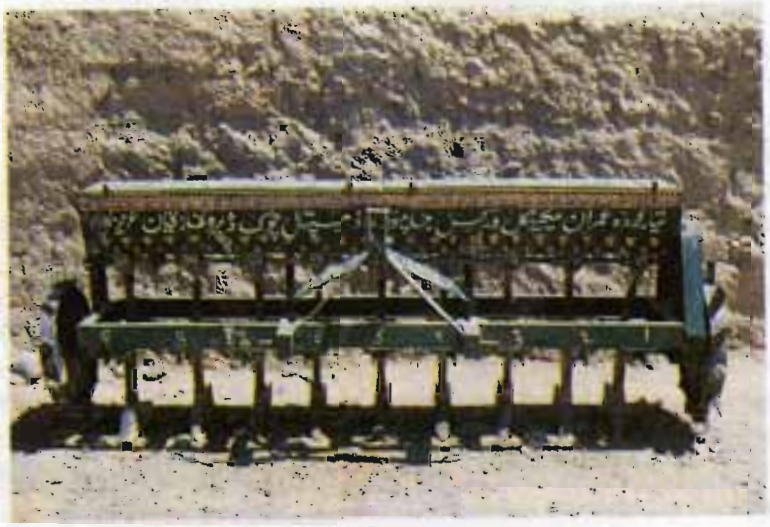
- Blocks should only be used for feeding ruminants, e.g., cattle, buffaloes, camels, sheep, and goats.
- Never feed these blocks to monogastric animals, i.e., horses, donkeys, rabbits, pigs, and chickens.
- Blocks alone must not be fed to animals. Animals must also consume enough dry feed such straw etc.
- Blocks should be given in the evening.
- Do not use blocks during the rainy season.

Modified Sowing Drill

Significance

Use of modern farm machinery has become necessary with the inflow of remunerative returns from growing high-value cash crops. The peculiar biophysical conditions of the HKH region require compatible farm machinery and implements. Unfortunately, most modern implements have been designed for agronomic practices in the plains and are not appropriate for mountain farming. The following sowing drill was invented by an employee of an agricultural research institute at Quetta, Balochistan, who happened to be a local farmer. While using an ordinary tractor-driven sowing drill, he experienced many problems due to the terrain and typical climatic constraints. He travelled to the plants where modern drills are manufactured in the Punjab, Pakistan, and was able to get a modified sowing drill made, one which meets the requirements of local agronomic practices. This drill is being used successfully in the desert area

*Plate 39: **A Prototype Modified Sowing Drill for Drop Sowing in Rainfed Mountains***



Since this drill takes into account the specific climatic, edaphic, and topographic features of arid mountains, it improves yields by achieving maximum germination and uniform stands of seedlings. By considering this machine to be a prototype model, its design can be improved and cheaper and more economical drills for arid mountains can be manufactured by involving private entrepreneurs.

of Balochistan. Neighbouring farmers prefer to use this drill on a rental basis for all their sowing operations.

Components

This drill is a modified tractor-driven sowing drill and differs from the original in the following ways.

- In desert areas where soil is relatively hard and moisture is found deeper in the soil, seeds do not reach down to the desired depth to catch moisture when sown by ordinary drills. Modified drills possess longer tillage blades supported by steel pipes which take seeds deep enough into the soil moisture.
- It works equally well under zero tillage and saves labour and the cost of two ploughings for land preparation.
- It has nine tillage blades, all of them in one line, in contrast to the two lines with alternately placed blades in the original drill.
- The original drill requires an attached land leveller behind it or post-sowing land levelling to conserve moisture. The modified drill does this job by itself because of its design, and thus saves money and labour.
- There are strong iron springs supporting the tillage blades, thus eliminating the danger of any wear and tear.

Olive Cultivation

Significance

Olive oil is considered one of the best edible oils in the world. In most of the Middle Eastern and some European countries,

Plate 40: ***Modern Olive Cultivars Possess Great Potential to be Exploited in Cold and Dry Zones of the HKH Region***

olive cultivation is very commercialised and the farmers' economy is significantly based on olive production. The countries of the HKH region import olive oil mostly for medicinal use, and the oil is very expensive. The agro-climatic conditions of the whole of the HKH belt are very favourable to olive plants. Large-scale stands of wild olive (*Olea cuspidata*) are found throughout all mountainous regions. There is great scope for introducing improved varieties of olives all over the region, which may change the socioeconomic priorities of local farmers.

Components

Seventeen improved cultivars of olive have been introduced in the hills of Uttar Pradesh, India, since 1985. These cultivars are suitable for both oil and pickling. Some of the cultivars, such as Pendolino, Leccino, Coratina, Frantoio, and Cipressino, are already performing well under local conditions on government as well as on private demonstration sites in Dehra Dun and Nainital in India. Large-scale multiplication of improved olive cultivars has been commenced using both cutting and grafting techniques. Saplings raised by grafting are planted in rainfed areas, whereas cuttings are grown under irrigated conditions (Seth 1993).

The successful cultivation of various exotic olive cultivars has taken place at a model government agricultural farm in Loralai, Balochistan, Pakistan.

Tea Cultivation

Significance

Tea, being a species of the *Camellia* genus, is a typical plant of the sub-tropical evergreen broad-leaved forest. It originated in the south-east of Asia. Tea cultivation has had recent success in the Hengduan Mountains and the Himalayas of southern Tibet, originally regarded as an unfavourable area for growing tea. (Zheng et al. 1993). In Pakistan, tea has been suc-

cessfully cultivated on an experimental basis in Mansehra.

Components

The green tea cultivar is Sci No. 21 and for black tea, the cultivars are Shu- Yong No. 3, No. 307, and No. 808. These are cold resistant cultivars. In the Himalayas, tea species were mainly introduced from the Sichuan and Yunnan Provinces, China. Two large-leaf and small-leaf species are now cultivated.

The most suitable temperature for tea plant growth ranges between 20 and 25°C. A temperature above 35°C may cause damage. Similarly, a temperature lower than -15°C will cause most above ground plants to die. The water requirement is at least 888mm annual precipitation. Tea plants grow successfully on well-drained, acidic soils with a pH of from 4.5 to 5.6 (Zheng et al. 1993).

Soil factors in the Himalayan soils are favourable to tea cultivation because the whole soil profile presents an acidic reaction. The plantation may be distributed at elevations between 1,000 and 2,500m on the southern flanks (Zheng et al. 1993).

Floriculture

Significance

Hilly areas are important sources of cut flowers, bulbs, and plants for the lowlands. Cut flowers are marketed in the off-season for income generation. Floriculture is an attractive proposition for HKH farmers and enables them to increase their farm incomes. There is great potential for developing floriculture at the farm level by supplying cut flowers, cut foliage, bulbs,

Plate 41: Commercial Tulip Production in Arid Mountains

tubers, corms, seeds, live flowers, dry flowers, foliage, and perfumes. These are high in value compared to any other horticultural crop (Swarup 1993).

Components

There is great demand from the florists of metropolitan cities for cut flowers. Among the flowers, the orchid is one of the most fascinating, long lasting, and expensive. Important wild orchids of the northeastern Himalayas are *Cymbidium*, *Paphiopedilum*, *Dendrobium*, *Vanda*, *Pleione*, and *Phaleonopsis*. It is not difficult to produce plants and cut flowers of these species. *Gladioli* flowers from Shimla, Nainital, and Srinagar are supplied to florists in the major cities of the plains during the off season (i.e., June to September) at a considerable price. The domestic rose can be grown profitably for essential oil in the

Kashmir Valley and other similar areas of the Himalayas. A private firm in Kochi, near Shamble (H.P.) is producing pot chrysanthemums in polythene houses for marketing during the summer months in major cities. The HKH mountainous region is ideally suited for growing temperate flowers such as the daffodil, narcissus, lily (Easter and Tiger), iris, peony, hyacinth, and tulip. Lavender can grow well on the slopes of Jammu and Kashmir and the highly valuable lavender oil is used in cosmetics (Swarup 1993).

Chapter Six
Agro-Enterprise Oriented Technologies

Introduction

Mountain farming has been stagnant for a long time, with the economy of farming societies revolving around grain and livestock production for subsistence level domestic needs. Any surplus is exchanged for other living necessities. Fewer choices for income generation and inaccessibility to markets have further hindered poverty alleviation in the mountain ecosystem. Various sociocultural restrictions also discourage the development of agro-based cottage industries.Consequently, an effective and viable integration of various farm operations having a commercial perspective could not occur.

Advances in communication, transport, and technology in the modern era enable mountain farmers to exploit the situation in their favour while using native farm resources. Shifts in traditional farming systems are in progress, however, this change is only visible in urbanised niches. Changes in remote areas are taking place more gradually and are less discernible. Successful models of agricultural transportation in the mountains, and the subsequently improved economy and quality of life of traditional farming communities (such as the fruit and vegetable growers in HP, India), are now being acknowledged by others. There are other similarly successful models of cash crop transformation within a very short period of time in the HKH regions of China and Pakistan.

Mountain communities are now very close to accepting the verdict that cultivating cereals for subsistence farming is no longer economically feasible on small and marginal land holdings (Partap 1996). However, it would be rather difficult for them to give up the traditional approach altogether. It will remain a significant part of the transformed system for some time. Because of many socioeconomic reasons, there will be a compromise between the two approaches. Taking all their needs into account, farmers are inclined to opt for technologies that are agroenterprise-oriented. The technologies that would become popular most quickly are those which incorporate the traditional regenerative and resource recycling agricultural practices of mountain farmers (Partap 1996). This chapter describes some successful agro-enterprise oriented technologies which have the potential for significant income generation, simply through by intelligent processing and marketing.

Dry Fruit Processing

Significance

Fruit production continues to be a principal farm activity in the HKH region. Historically, the area lacked good marketing

Plate 42: ***Common Dry Fruits of Dry, Cold Mountains***

Dry fruit processing lacks quality control and good standards of hygiene. Market presentation is poor. If farmers are trained in these aspects, they can significantly improve the product's market value and acceptance.

channels as well as modern cold storage facilities. Human population densities used to be very low and consequently, local consumption was also low. All these factors caused wastage of surplus orchard produce. The wastage of fruit crops possessing a shorter shelf life was significantly higher. Local farmers initially preserved the surplus by drying rapidly perishable fruits in order to store them for longer periods, mainly for domestic consumption. It was this practice that eventually turned into a potential source of farm income. Nowadays, dry fruit processing is becoming a popular activity for the mountain farmer. In most of the large towns and cities, there are special dry fruit markets that attract tourists. With improvements in transportation, communication, and road infrastructure, dry fruits are now transported to other regions where they fetch a good price.

Components

Grapes, apricots, figs, pomegranates, and dates are common sun-dried fruits. To begin with, the local farmer estimates his surplus harvest. He selects a dry, clean, and open site exposed to maximum sunlight during the day. The roof of the house is a favourite place. Apricot and pomegranate seeds are layered on the ground and left there until completely dry. Generally, this takes 40 to 60 days, depending upon weather conditions and the number of sunny days. Finally, the dried fruit is collected and packed for marketing and domestic consumption.

Technology is allowing apricots to be produced commercially in the Ladakh area. A subsidy package that contains superior planting stock of promising varieties and other inputs, such as drying trays, a poly solar drier, ultraviolet film, and a waterproof nylon sheet, are being offered to farmers by the government to help improve quality and gain a better market price.

Grapes are dried in two ways to make raisins.

- Bunches on the vines are tightly covered with cloths to protect them from air and sun. They are harvested after they become dry. The quality of this type of raisins is believed to be good and farmers generally produce these raisins for home consumption.

- For commercial raisin production, bunches of grapes are dipped once into boiling hot water and are later dried in the sun, similar to the way apricots are dried.

Harvested green walnuts are sun dried for a couple of days to start the green shells' peeling process. The walnuts are later stored in wooden boxes with a bedding of wheat or barley straw for 10 to 15 days. Afterwards, the green shell peels off easily and the walnuts are ready for marketing.

Figs are dried in a different way. A fresh fig is pressed flat using an indigenous instrument. It is important to select fruit at a specific stage of maturity to prevent its rupturing while pressing. The individually pressed figs are threaded on to a palm leaf string. The fig 'necklace' is usually half a metre to one metre long and may weigh approximately two kilogrammes. The necklaces are hung in an open yard for drying and are stored or marketed in this shape.

Chilghoza

Significance

Chilghoza is an edible nut collected annually from the Nut Pine (*P. Gerardiana*) which grows at high altitudes (2,500m above sea level) in Afghanistan, Zhob (Pakistan), and Kinnaur, India. These nuts are used as dry fruit, particularly during the winter. *Chilghoza* nuts are sold widely in the dry fruit markets in both the mountains and the plains. It is the most expensive among all dry fruits. Local farmers make a considerable profit from selling *chilghoza* nuts.

Chilghoza production is restricted to very high altitudes where the Nut Pine grows

Plate 43: ***Chilghoza Cones Being Sun Dried at High Altitudes in Zhob, Pakistan***

naturally. Its demand in neighbouring regions has encouraged local dwellers to sell the nuts to supplement their income.

Components

Chilghoza nuts are obtained from the naturally growing Nut Pine. Small, oval cones are harvested from the trees. These cones are spread on the ground to dry in the sunshine for a few days. The cones crack naturally during drying, or are cut into four pieces with an axe. Sticks are used to separate *chilghoza* nuts from the dried up fruit cones. On average, 25 to 30 cones yield one kg of *chilghoza* nuts. The *chilghoza* are packed in gunny bags and are marketed roasted or unroasted.

In Ladakh, the community manages the cone harvest. Harvesting dates are fixed, with each family sending two of its members to do the work. One person harvests the cones by lopping branches, while the other collects the cones that fall to the ground. The day's total harvest is divided equally amongst all the farm families.

Domestic Wine

Significance

Domestic wine production is a general feature of each household in Kinnaur, India. During the extremely cold winter, consumption of domestic wine is extensive over the entire expanse of this cold desert region. The quality of domestic wine extracted from grapes is comparable with any imported liquor. The government discourages its large-scale production by issuing special permits to each family for keeping a maximum of 24 bottles in their possession at any one time. There is great scope for developing a cottage industry to produce wine on a commercial scale, taking into account the regulations of the region. The government may encourage domestic wine production by involving any licensed liquor company to purchase any surplus product.

Components

Domestic wine is prepared mainly from grapes; however, wild apricots, pears, apples, wild almonds, etc are also used. Millet serves as the main source of alcohol. Fruits such as apples and pears are cut into pieces before fermenting. Apricots are sun dried on the roof after removing the kernel. The fruit is then put into wooden drums for fermentation. Molasses or *gour* (a brown sweetener derived from sugarcane) are added to the fruit. The drums are tightly covered with a wooden or stone lid until the fermentation process is over. Indigenous wisdom is used for assessing a good ferment. The judgement for determining a complete fermentation is made after removing the lid and is usually based on the following guidelines:

- when larva in the pulp are not alive,
- by the quantity of vapour on the inner side of the lid, and
- when a flame quickly extinguishes above the pulp while inside the drum.

Farmers have standardised the local distillation process. The pulp is put in a metallic pitcher, which is covered with a stone slate with a hole in the centre. This slate is used to avoid any overflow of material during boiling. A metallic pan is kept on the slate, which has also a hole of the same size. The pan has a side pipe through which the condensed alcohol comes out.

This utensil is covered with a larger metallic pan which is cooled during extraction. Two pipes, one inlet and one outlet, open into this pan through which cold water falls on the pan and warm water goes out. This topmost pan is kept on a slight slant. The inlet of water is on the upper side and the outlet is on the lower side. This cools the bottom of the utensil and condenses the alcohol vapours touching its lower surface. The condensed material runs out through the side pipe of the lower utensil from where it is collected in a pot. A rubber pipe is also attached to the metallic side pipe to keep some distance between the collection pot and the distillation plant. Approximately 12 to 13 bottles of alcohol are collected from 40kg of fruit. However, when it is mixed with *gour* (molasses, 5 to 6kg) the yield is 18 to 19 bottles. Fuelwood is used for heating. All joints are made using barley, *faphra*, or wheat paste.

Chewing Tobacco

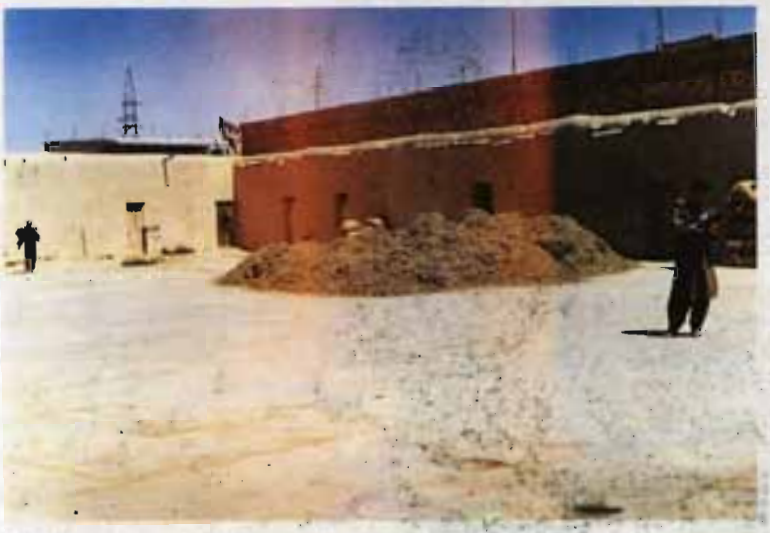
Significance

Chewing tobacco, called *naswar*, is used extensively throughout both Afghanistan and Pakistan. Historically, mankind used tobacco as a drug and it is being raised in fields as a special crop. A large number of small *naswar* producing units are operating locally in both countries, these units purchase raw tobacco from local farmers. Tobacco has emerged as a high-value crop for these farmers.

Components

Naswar is manufactured after tobacco passes through a series of processes. Cut tobacco leaves are sun dried in the field, and are sold to a local manufacturer. Before any processing, the leaves are cleaned and again dried within the factory. The dry

Plate 44: ***A Local Naswar Producing Unit in Balochistan, Pakistan***



The introduction of small, modern, cooperative based tobacco processing units will improve the quality of the tobacco and will reduce processing losses. It will create better marketing opportunities and a healthy competition amongst producers. Multinational cigarette companies may be attracted to the area in order to grow high-yield, high-value tobacco varieties as they are doing in the North West Frontier Province (NWFP) of Pakistan.

leaves are converted into powder by grinding machines. This powder is supplemented by some other premixes of different ingredients. The premixes differ according to the nature of the demand in the various regions of a country. Dry supplemented powder, *naswar*, is marketed in packets of varying sizes.

Gour

Significance

Gour is the traditional brown sweetener found throughout rural areas. During the past couple of decades, the sugar mill industry has been expanding tremendously, and *gour* is gradually being replaced by sugar. However, *gour* will remain the favourite sweetener of rural communities, particularly in the mountains. Its production will continue to be a vigorous activity at the farm level wherever sugarcane grows. Farmers prepare *gour* for domestic use and they earn cash by selling the surplus. Compared to sugar, *gour* is relatively crude in form: however, its handling losses during transportation, marketing, domestic use, etc are very low. Influenced by the irrigated plains, farmers in mountainous Balochistan and Rod Kohi, Pakistan, grow sugarcane, and *gour* is produced at the farm level in the absence of any sugar mill. Nowadays it fetches a better price than sugar in the market. A special kind of *gour*, in which different kinds of nuts are added for winter use, is sold at relatively higher prices as a speciality of the mountains.

Components

An animal operated machine crushes the sugarcane. The juice of the crushed sugarcane is collected from the crushing unit and is transferred to a huge boiling pan. It continues to boil until it reaches a specific point of condensation. The highly concentrated juice is then transferred to

Plate 45: ***Gour Production at the Farm Level***

Gour, being a product free of chemicals, remains a favourite natural sweetener. The process for making gour is labourious, unhygienic and consumes considerable fuel for boiling the raw juice. Modified modern boiler units such as those used in candy factories may be introduced to save wood. The training of farmers in hygienic processing and market presentation is required.

a tray where it is allowed to cool and crystallise. Later, it is converted into small, irregular, oval-shaped pieces of varying size (100 to 200g). After sun drying, it is stored under normal conditions. *Gour* has a long shelf life. It is used for making all kinds of sweets and dishes. It is also used raw.

High-Value Cash Crops

Significance

Unconventional high-value cash crops are now playing an essential role in improving the economy of localised niches. The Lahaul Valley, India, has earned special distinction in this regard. Parallel to modern cash crops, such as seed potatoes and peas, the Government of India has successfully exploited the commercial potential of indigenously growing plant species by introducing their cultivation through R & D packages.

Components

These high-value cash crops include *kuth*, hop, *saffron*, *kalazeera*, etc. *Kuth* has been growing in the Lahaul Valley for the last four to five decades. It is a two-year crop: its roots are exported and fetch a good price. The process of transforming Lahaul's poor economy into a market economy was in fact initiated by *kuth*. *Kuth* farming is regarded as a modern day example of how farmers can take the initiative to domesticate and cultivate the wild gene pool. The farmers' work led to the formation of a cooperative for marketing *kuth* and has earned large dividends besides export-based production.

Hop cultivation is another successful model. It has been introduced all over H.P., India. It has already been introduced for cultivation in the Ladakh area, since the climatic conditions of cold mountainous deserts are very suitable for the cultivation of hops. However, the Lahaul Valley has adopted it as a new agro-enterprise in a spectacular way. As a crop, hops has shown great promise and farmers are reaping large dividends. Two hops processing units have been established for a guaranteed remuneration to the hops' producers. Government patronage has helped in making it a highly profitable agro-enterprise. Four processing units have been installed for drying green matter prior to its marketing. Now, different varieties of hops have been released to promote its cultivation.

Saffron cultivation is currently being tested as a commercial crop in Kinnaur. Saffron flowers produced in the cold, dry mountain climate are considered superior in quality to those produced in humid and sub-humid areas.

Technology for the domestication and commercial production of *kalazeera* has been developed in Kinnaur and Ladakh.

Non-fat Dry Cheese

Significance

Non-fat dry cheese is produced all over the HKH region. The product is fat free and is a highly nutritious, daily food supplement. It can be stored under ordinary conditions for long periods and nowadays is being commercially marketed. In Afghanistan and Pakistan, it is called *khurad*. A pastoral family in mountainous tracts with large flocks of sheep and goats or large herds of cattle cannot consume all the milk produced by lactating females every day, and there is no opportunity for marketing it. The surplus milk is eventually fermented and churned for making butter. The non-

Plate 46: ***Dry Cheese, a Popular Product of Livestock Households***

Dry cheese, with its distinctive taste, is a primitive technology used by almost all types of livestock households. Although dry cheese is a highly nutritious food supplement, the cheese-making process lacks hygiene. Its commercial marketing through the introduction of new food technology techniques (including different flavours, colours, quality packing, etc) and by modern advertising campaigns could generate substantial income for livestock producers.

fat solids of residual milk, called *lassi*, are separated from the water and are dried as small balls for domestic use. The dried milk balls are used for making *curry* and are diluted to make *lassi* a pure, natural drink.

Components

The daily surplus milk is usually fermented into curd overnight. The next day, the curd is shaken vigorously in a soft leather pouch made of goat skin until the butter is separated from the *lassi*. The pouch can accommodate 15 to 20 litres of curd. In some areas, a ceramic pitcher is used and curd is manually churned in a wooden structure on the ground called a *madhani*.

The *lassi* is sieved through a clean muslin cloth by hanging it up for two to five days. The non-fat milk solids are collected from the muslin cloth after the water is completely drained through. These solids are finally converted into small balls of cheese (each ball weighs roughly 50g), which are sun dried. The dry cheese is ready for domestic consumption as well as for the outside market.

Winter Lamb Mutton

Significance

Winter is severe in the highlands. The temperature is below freezing and is coupled with chilling winds. Local inhabitants in remote communities are confined within their homes for about two to four months. Climatic restrictions rarely allow any food supplies from outside. Farmers prepare themselves for this imposed hibernation well ahead of time by storing sufficient quanti-

Plate 47: ***Landhai is Traditionally Prepared from Lamb Mutton***

Landhai mutton is traditionally preserved for domestic needs. It has considerable potential to emerge as high income-generating technology for sheep producers. It is simply a matter of motivating them to produce and market landhai mutton as a speciality winter lamb mutton along commercial lines. They may be trained to shift from the selling of live animals for cash to producing landhai from the surplus flock. By marketing landhai mutton, they will fetch higher returns compared to the prevailing practice. The markets of the plains may also be explored through proper advertisement and presentation.

ties of grain and preserving mutton for their daily consumption while their flocks migrate down to the warmer plains. Winter lamb mutton, called *landhai*, is locally preserved sheep meat which, under normal conditions, can be stored safely during the long winter.

Components

Landhai is made only from sheep meat. Fat and healthy animals are chosen for slaughtering. Wool is plucked from the carcass manually by the frequent application of boiling hot water and the skin remains a part of the carcass. The abdominal cavity is opened with an incision. After removing the stomach and other visceral organs, it is re-stitched. A long, sharp iron rod is passed through the abdominal cavity parallel to the vertebral column. The carcass is rolled on a hot fire for a few minutes to burn away the remaining wool fibres, if any. This is followed by cleaning the carcass with a dilute solution of caustic soda. All the bones are separated from flesh in a skilled manner. The flesh is treated with the desired quantities of salt and the meat is hung in an open and well-ventilated room for 40 to 50 days. Once it is air dried, it is cut into small pieces and stored for use during the winter for making many routine food dishes.

Post-harvest Apple Storage

Significance

This technology originates in mountainous Balochistan, Pakistan, where about 81 per cent of the total apple crop is produced. Cold storage facilities exist in the big cities of other parts of the country, so

Plate 48: ***Post-harvest Apples Stored in a Farmer's Field***

Post-harvest apple storage at field level helps farmers to market their produce with a good margin of profit by using better market intelligence. Additionally, it allows them to harvest the apple crop earlier and to cultivate orchards for other crops

in the absence of any proper storage facility, local farmers invented a conventional apple storage method to check post-harvest losses. It enables them to store the apple produce for 30-60 days. Meanwhile, a farmer observes market fluctuations and he is not compelled to sell his farm produce readily to middle-men. When apples are destined for domestic consumption, this technology also improves the apples' shelf life. It is believed that this storage improves the ripening of the apples during the post-harvest period and gives a good colour to the fruit.

Components

The technology is very simple and cheap. Rice straw and used newspapers are key components. Rice straw is transported from the irrigated plains at very cheap rates.

A safe and levelled corner of the field or house is selected for this storage. The ground is covered with a thick layer of rice straw, which is covered by newspapers. Apples are heaped on it. The total covered ground area and the height of the heap will vary according to the quantity of apples to be stored. Apples are covered with newspapers and, finally, a thick layer of rice straw is applied on top. These will stay there until the apples are packed in crates for the final marketing process.

Post-harvest Grain Storage

Significance

The resource-poor farmer cannot construct proper storage facilities for farm produce, particularly for grains. The farmer needs to store his grains somewhere for long periods to find better market prices as well as during domestic use. This storage technology is used successfully for storing grains under the open sky for long periods and with negligible storage losses. The materials used in storage are called

Plate 49: ***Wheat Grain Stored in Chitai Sacks under the Open Sky***

Palm chitai(s) are multipurpose and are also being used for packing various farm produce for marketing, for example, dates are also marketed in chitai sacks. Chitai packing can successfully replace wooden crates for apples and marketing of other fruit. It could save thousands of trees from being cut down for this purpose.

chitai and are cheap and easily available in the region. Sometimes, the farmer's family will make *chitai* on its own by using palm leaves naturally growing in the area. *Chitai* grain storage is very popular in certain areas of Pakistan, mainly due to its low cost and very low storage losses.

Components

An elevated platform two feet above the ground is constructed under the open sky. It is usually close to residential areas. The platform is erected by placing long, flat pieces of wood on mud pillars that are set at desired distances. The length of this platform may vary according to the number of *chitai* storage sacks to be placed on it. Its width is roughly two metres, however, this may vary with the size of the *chitai* sacks.

Grains are stored in *chitai* sacks. A sack is made by a *chitai* measuring 4 x 1.25m, although its dimensions may vary. The required number of empty sacks is placed on a platform in a row, and they are filled with grains. The opening of each filled sack is closed with another piece of *chitai* and finally the top of the sack is plastered with mud.

Corrugated Fibreboard Cartons

Significance

As farm productivity grows, marketing becomes a very important aspect in order to take farm produce to the non-agricultural sector. Most of the fruits are traditionally marketed in wooden boxes. These boxes are not properly standardised for one or different commodities. With the current timber crisis, high costs, and ecological as well as environmental concerns, a corrugated fibreboard (CFB) carton has been developed to replace wooden cartons. The CFB cartons consume less wood and are comparable in performance. These cartons with paper pulp trays have long

been used for packing and transport of fruits and vegetables in many developed countries (Anand and Grover 1993).

Components

A CFB carton consumes only 30 to 40 per cent of wood used for a wooden box of the same capacity. These cartons can also be made from other agro-wastes such as biomass, bamboo, bagasse, wheat, and rice straw. The corrugated texture helps to minimise the bruising of fruit. The weight of such a carton is only one-fifth of a similar wooden box. The cartons are also punched and ventilated. They can be fabricated and turned out quickly in highly precise and accurate sizes and are recyclable into pulp, unlike wooden boxes which are invariably used as fuel. The CFB cartons used in apple packaging have an inner dimension of 50.8 x 30.8 x 28cm. They are assembled by fitting two standard telescopic pieces of five-ply into each other, thus giving a 10-ply thickness on the sides and a five-ply thickness on the top and bottom of the carton. The fruit is packed in paper pulp-moulded trays with the appropriate sized cavities and the trays are stacked one above the other, carrying 120 pieces of fruit altogether. Each tray is arranged in the opposite direction to the one beneath in order to distribute the weight evenly on the projections of the tray cavities. Details of CFB cartons used for apples, plums, apricots, and almond packaging are given in Table 23. (Anand and Grover 1993).

Table 23: Details of the CFB Carton Used for Apple, Plum, Apricot, and Almond Packaging

Type	Size (cm)	Approx. capacity (kg)
Telescopic CFB carton with 6 trays for apples	50.8 x 30.8 x 28.0	20
Universal CFB carton	45.0 x 30.0 x 27.5	18
Universal *Kullu Dabba*	48.7 x 20.5 x 22.5	10
Universal CFB carton for plums, apricots, and almonds	37.0 x 18.0 x 15.0	5-6

Chapter Seven
Pro-Women Technologies

Introduction

Although most mountain communities in the HKH region have in common their heavy dependence on subsistence agriculture and pastoralism (Sharma 1994), the social environment is largely variable and diversified. The magnitude of diversification is significantly determined by socio religious elements along with bio-climatic factors. Within this diversified social environment, however, men commonly dominate the society. Historically, and in line with sociocultural norms, the human population was segregated on the basis of indoor and outdoor activities. Domestic household activities along with family care were assigned to the female segment, while work which involved outdoor mobility (i.e., cultivation, pastoralism, etc) was taken by the men. As farming operations expanded due to localised socioeconomic compulsions, the dominant segment also put women into outdoor work to meet increased labour demands. Under the influence of male heads of family, women accepted this additional role and could not deny them this support under invisible social barriers, but remained discredited in terms of economic empowerment (Figure 1).

Many publications focus on gender analysis and its equity (Nathan 1995; Zaidi 1996; Syed 1994; Sharma 1997), and several researchers have emphasised the need for appropriate farm technologies that reduce the workload of rural women and increase their income generation capability. Depending upon the individual's approach and his/her perception of gender issues, numerous appropriate technologies have been recommended in this regard (FAO and IIRR 1995; Capistrano et al. 1990; Anonymous 1995; Carr 1991; Prasad and Ram 1990). Figure 1 invites the reader to understand a conceptual process of workload increase with regard to traditional rural women. Most of the suggested woman-related technologies are promising, however, these suggestions require women to undertake outdoor activities in addition to their traditional household jobs. Their involvement as farm labourers with the heavier workload declines very little. It does not necessarily mean that women should not accept any productive role in developing the household economy in addition to their traditional jobs. When discussing this issue it is critical to understand the rebound phenomenon of labour displacement from agricultural fields (*see* Figure 2).

The Rebound Phenomenon

Sooner or later, agricultural fields will be mechanised, as is the case in developed

Figure 1: Conceptual Diagram of Historical Workload Segregation of Human Population in the HKH

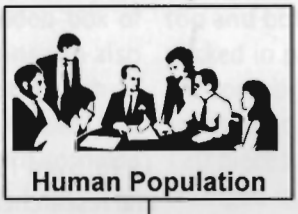


Figure 2: A Conceptual Rebound Phenomenon of Labour Displacement

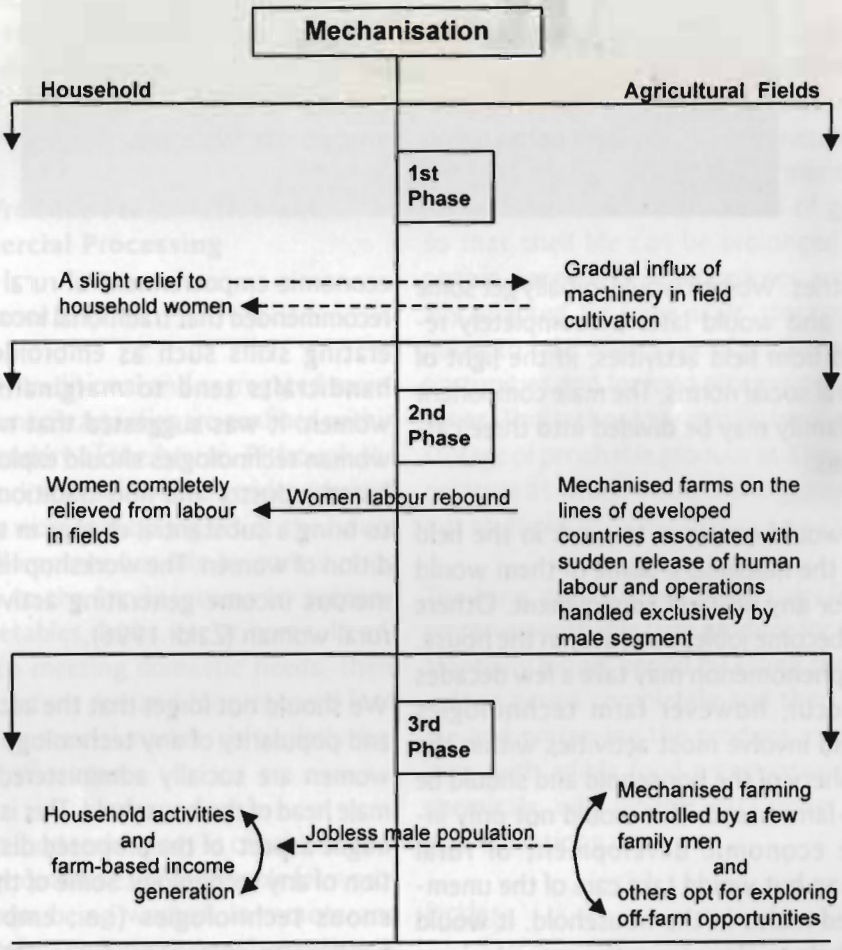


Plate 50: ***A Chinese Woman Threshing Wheat Grains***

countries. Women would initially get some relief and would later be completely relieved from field activities, in the light of general social norms. The male component of a family may be divided into three categories.

Few would continue to work in the field with the machinery. Some of them would opt for any off-farm employment. Others may become jobless and stay in the house. This phenomenon may take a few decades to occur, however farm technologies should involve most activities within the periphery of the household and should be agro-farm based. This would not only induce economic development of rural woman but would take care of the unemployed males in the household. It would also help to slow down the pace of migration of the rural population to metropolitan cities.

The Nature of Pro-Women Technologies

A workshop sponsored United Nations Development Programme (UNDP) on the economic empowerment of rural women recommended that traditional income generating skills such as embroidery and handicrafts tend to marginalise rural women. It was suggested that new pro-woman technologies should explore agro-based industry and non-traditional ideas to bring a substantial change in the condition of women. The workshop listed numerous income-generating activities for rural woman (Zaidi 1996).

We should not forget that the acceptance and popularity of any technology by rural women are socially administered by the male head of the household. This is a highly fragile aspect of the proposed dissemination of any technology. Some of the indigenous technologies (i.e., embroidery, handicrafts, cottage products, etc) will remain popular because of social acceptance – however, these technologies should not be flatly rejected, but rather improved and blended with non-traditional ideas and attractive market presentations. The success of any pro-women technology is largely linked to the parallel motivation and involvement of the family's males with the

technology itself and their involvement throughout the process. All technology promoters might first focus on the male segment for the social acceptance of the new and highly productive role of rural women. Men may realise that they have to share the household's workload while women are working on economic activity out of doors. This would also make most other technologies that involve women in field operations more effective. While selecting pro-women technologies for this chapter, we have attempted to consider most of the implications discussed above.

Farm Produce Preservation and Commercial Processing

Significance

In highly traditional and segregated societies, women's activities are confined within the boundary of the house. Although the daily work schedule of this gender segment is full, a woman working inside the house can still improve her role by contributing directly to the family income by preserving vegetables, fruits, etc at home. In addition to meeting domestic needs, there is a persistent demand for preserved food in the commercial market, particularly during the off season.

Modern food technology is capable of saving huge quantities of perishable farm produce from being wasted. In remote and inaccessible communities where there is no marketing infrastructure, the surplus fruit and vegetables are fed to animals, or their fate is to be thrown in the garbage dump. Marketing constraints strongly influence the annual crop calendar of a farm. Farmers could restrict themselves to growing perishable fruit and vegetable crops on a smaller scale.

The preserved farm produce (i.e., vegetables and fruit) provides highly nutritious food throughout the year and during the off-season. The influx of skilfully preserved food items may be used effectively to control seasonal fluctuations in the market price of various vegetables and fruits.

Components

There are two methods of preserving vegetables and fruits (i.e., short duration and long duration). The short duration food preservation techniques are generally applied in order to prevent the fermentation process and the multiplication of germs, so that shelf life can be prolonged for a certain period. These procedures are usually adapted for large-scale storage purposes to take advantage of marketing opportunities and for food processing in factories. This technology mostly involves the storage of perishable produce at a low temperature at which most of the germs cannot multiply.

The long duration method is applied to preserve perishable farm produce for a substantially longer period by killing the hazardous germs completely and then packing and preserving the produce as a food item with edible food preservatives (i.e., chemicals, oils, vinegar, etc) under hygienic conditions.

Pickles

Pickles can be made from both fruits and vegetables. A single vegetable/fruit or a mixture of them is used as raw materials for pickles. There are two kinds of pickles – oil pickles and vinegar pickles. Cut pickles of choice vegetables and fruits are mixed with the desired spices, salt, and turmeric and kept under sunlight for at least three

days and are later preserved in a sufficient volume of mustard oil or vinegar. The upper level of oil/vinegar should always be about two inches above the raw material content. The spices are added to give a certain taste. Turmeric is an important component of an oil pickle, because it serves as a germicide as well as giving a good colour to a pickle. The processed product is stored in ceramic pots at room temperature. A delicious pickle is ready within from five to seven days and may be stored for years.

A few recipes are as follow.

i. Mango pickle

Ingredients

mangoes	2kg
mustard oil	1kg
green chillies	120g
turmeric powder	4 tblsp
peeled and sliced ginger	125g
peeled garlic flakes	120g
chilli powder	200g
coriander and cumin seeds	6 tblsp
salt	1/2 cup
vinegar	1/2 cup
aniseeds and fenugreek	1/2 cup

Seasoning: Two tblsp *saunf* and mustard seeds (rye) fenugreek (*methi*), two tblsp whole pepper corns.

Cut the mangoes into four pieces. Remove the white seeds then wash and drain. Mix two cups of salt, turmeric powder, coriander, *methi* and aniseed. Keep in a jar for three days. Drain pieces and throw away the water. Dry pieces in sunlight for a few hours.

Heat the oil and cool and then add the masala powder (i.e., all spices). Pour this mixture over the mangoes. Add vinegar. Make a saturated solution of salt in water. Cool and add to mangoes. Oil should stand 5cm above the level of the mangoes.

This pickle can be kept for an indefinite period.

ii. Tender mango pickle

Ingredients

tender green mangoes	1kg
mustard	2 tblsp
chilli powder	4 tblsp
oil	2 tblsp
cummin seed	2 tblsp
sugar or jaggery	1 tblsp

Rinse and dry mangoes. Cut the peeled mangoes into small pieces. Remove white seed. Heat oil, fry cummin and mustard seeds and add the mango pieces. Stir well. Add chilli powder, salt, and cook. Then add a cup of water and cook till the gravy is thick. Stir in sugar or jaggery. Cool and serve.

iii. Tamarind pickle

Ingredients

ripe tamarind	1kg
grated jaggery	500g
fenugreek (*methi*) and aniseeds	2 tblsp
chilli powder and salt to taste	4 tblsp

Remove the brown skin of the tamarind and break it into pieces. Pound together all the spices coarsely, mix them with salt and chilli powder and add to the tamarind. Put one cup of water into the jaggery and prepare a one-thread consistency. Put in tamarind, mix well and cook for ten minutes. Remove from heat and, once cool, put into jars. Sun dry for two days.

Plate 51: ***Pickles, Jams, Chutneys Processed by Women on a Commercial Scale***

Training of this gender segment in food preservation and processing techniques should be high priority for those who disseminate pro-women technologies.

iv. Mixed vegetable pickle

Ingredients

cauliflower	350g
each of potatoes, peas and thin papadies	250g
garlic cloves (peeled)	250g
ginger (sliced)	30g
salt	2 tblsp
vinegar	2cups

Seasoning: 1 tblsp fenugreek (*methi*) seeds, 1 teaspoon mustard, 1/2kg oil.

Rinse and dry the vegetables. Cut vegetables into small pieces. Grind the spices into a fine powder. Heat oil, fry mustard and fenugreek seeds until spattered, then add and fry garlic, ginger and let it simmer. Add the ground spices, fry and stir well until brown. Add cut vegetables and cook for 4 to 5 minutes. Add vinegar, salt and boil until oil separates. Remove from heat, once cool, pour into a clean, dry jar.

Chutneys

i. Tomato chutney

Ingredients

tomatoes	250g
ginger	1 tblsp
raisins	125g
sugar	½ tsp
cumin seeds	½ tsp
garlic juice	1 tblsp
almonds	8
chillies	½ tsp
cardamom (powdered)	100g
vinegar and salt	to taste

Boil water and add tomatoes to the boiling water for peeling. Mash them well. Add onions, ginger, garlic and chillies. Cook by stirring these occasionally until all the ingredients are well mixed and tender. Once the mixture is a little thick, add vinegar and other ingredients. Almonds and raisins should be blanched and sliced before

being added to the tomato mixture. Cool for about 7 to 10 minutes, preserve in a jar. The chutney should be stored in a cool place.

ii. Plum chutney

Ingredients

fresh plums and tamarind	as desired
salt	6 to 8g
red chilli powder	6 to 8g
sugar	1kg
vinegar	4g
cumin seeds, clove, cinnamon, caraway seeds	11g

Wash and clean plums and tamarind. Add water in sufficient volume so that its level is about 5cm above the plums. Add sugar and cook on a slow heat until plums and tamarind turn soft. Put remaining ingredients in a muslin bag and tie it, this is called pith. Put this bag of pith in the plum mixture and cook until thickened. Add salt and cook. Remove the bag of pith and cook until thickened. Add vinegar. Remove heat and pour into hot, sterilised jars.

Jams, Murabba, Jellies and Marmalades

Jams and jellies are mostly prepared by utilising low grade but healthy fruits such as apple, mango, citrus fruits, etc. These are all prepared in a similar way, however, the examples given below have mostly incorporated mango fruit.

i. Green mango jam

Pare and cut green mangoes into pieces. Add enough water to just cover it and cook on a slow heat until mangoes turn soft. Mash and pass through a big hollow sieve and measure the quantity of pulp. If it is one cup, add two cups of sugar and 1/4 tsp citric acid. Mix well and boil the mixture until it reaches a jam consistency. Cool to room temperature, put in a sterilised bottle and cork.

ii. Ripe mango jam

Take fully ripe mangoes. Pare and cut them into pieces. Reduce them to a pulp. Measure the pulp. If it is cup, take one cup of sugar and 1/4 tsp citric acid. Mix well. Boil until the pulp settles in the water clearly. Simmer until a jam consistency is reached. Cool, put in a sterilised bottle and cork.

iii. Raspberry jam

Remove seeds and measure the de-seeded berries. For every one cup of berries, add 3/4 cups of sugar and simmer until it reaches a jam consistency. Cool, put in a sterilised bottle and cork.

iv. Carrot murabba

Ingredients

bright red carrots	250g
sugar	250g
cardamom seeds	1 tblsp
citric acid	1/4 tsp
essence of saffron and silver or gold paper	

Scrape carrots and cut into thick slices length-wise, then pierce all over with a sharp needle. Boil in water until they become almost tender. Drain completely and spread on a cloth to dry for a couple of hours. Prepare a light syrup with sugar and 1/4 litre water. Put in carrots and cook on a slow heat until the syrup turns thick. Stir in essence,cardamoms and citric acid.

Cool and bottle. Mix in pieces of foil. Lasts for two weeks.

v. Mango murabba

Ingredients

rajapuri mangoes	6 large
sugar	1/2 kg
cardamom seeds	2 tblsp
citric acid	1/4 tsp
essence of saffron	
pan-ka-chuna	1 tsp

Mangoes should be firm and not soft. Cut the peeled mangoes into fairly thick slices. Take a large vessel full of water and boil, then cool, and add 1 tsp of *pan-ka-chuna*. Stir it well and soak the mangoes overnight. Next day, drain the mangoes into a colander and let them remain there for a few hours to drain off water.

It is preferable to use a tinned copper or enamel pan for making this murabba. Put sugar in a pan, add four to six cups of water, it should just cover the sugar (do not add too much water) then keep it on the heat, stirring until the sugar is melted. If the syrup is too thick, add a little more water. Strain the syrup through a fine muslin cloth and wash the pan in which the syrup was made. Then pour the syrup into it. Add the well-drained mangoes and put on the heat. Bring it to a fast boil, then lower the heat and let it simmer for about 2 hours, or until the syrup is fairly thick, about the consistency of honey. Then add citric acid. Do not make it very thick or it will be sticky. The colour of the syrup should be a nice, reddish brown. Do not stir mangoes too often. Try to push the mangoes at the side over to the centre when it is ready. Sprinkle the pounded mixture of nutmeg and cardamom. Remove from heat, cover with a clean cloth and leave it overnight. Next day, stir well and bottle. This preserve will remain good for over two years. Vegetarians can add a little milk to the syrup.

vi. Mango marmalade

Ingredients

pulp of huge green mangoes (crossbred variety)	1 cup
white sugar	2 cup

Pare and cut huge green mangoes. For 1 cup of mango pulp, add 2 cups sugar and boil on a slow heat. Keep removing scum that forms while boiling. When it thickens to a marmalade consistency, cool at room temperature, put in a bottle and cork.

vii. Orange marmalade

Ingredients

oranges	1kg
sugar	1kg
lemons	2

Peel oranges and remove pith, the inner skin, etc and take the pulp. Shred half of the total peel and boil it in water and strain. Repeat this three times then add the peel to the pulp and boil with sugar. When it is ready, add lemon juice and cool.

viii. Orange marmalade

Peel and extract the juice of a few oranges. Strain and measure the juice. If it measures two cups, take two cups of sugar and boil both together until a thick syrup is formed. Keep removing the scum that will be formed on the surface. Cool to room temperature and bottle.

Soak orange peel in salt water for two days. Drain and boil in fresh water until the peel becomes tender. Drain and put them in cold water and scrape the white pith from the inside of the peel. Wipe and cut them into thin, short slices. Measure peel and take an equal quantity of sugar and water and boil until a thick syrup is formed. Add the bottled syrup prepared two days earlier and simmer until a marmalade consistency is obtained.

Ketchup and sauces

i. Tomato Ketchup

Ingredients

tomatoes	5kg
ground onions	2g
garlic	60g
cloves	2g
cinnamon	2g
garam masala	6g
red chillies	4g
sugar	500g
salt	60g
vinegar	200mg

Take healthy tomatoes, wash and cut them into small pieces. Boil in water until softened. Strain the mixture through a fine muslin cloth. This tomato syrup must be 5kg. Tie all other ingredients in a muslin cloth and put it in the syrup and boil on low heat. Add one cup of sugar when the syrup is fairly thick. Remove the pith bag of spices and add remaining sugar and vinegar. Cook it for approximately 50 minutes or until the syrup is reasonably thick. Mix in Sodium Benzoate (½ gram) and store in a sterilised jar.

ii. Tomato sauce

Ingredients

tomato pulp	4kg
sugar	1kg
ginger	120g
garlic	120g
salt	4g
vinegar	1ltr
red chilli	120g

Boil the tomato pulp. Strain the mixture through a fine muslin cloth. Add half of the salt and half of the vinegar and boil it for making tomato syrup. Prepare a syrup of the remaining vinegar, sugar, salt and all the other spices by boiling in water. After 15 minutes, mix this syrup with the tomato syrup. Boil it for two hours or until the syrup is fairly thick, strain the syrup through a fine muslin cloth. Store in sterilised bottles stopped with a cork.

Squashes and syrups

i. Lemon squash

Ingredients

lemon juice	6 cups
sugar	6 cups
water	12 cups
potassium meta bisulphite	1 tsp

Take lemon juice, sugar and water, and mix until all the sugar is dissolved. Then take one cup of hot water, dissolve one tsp potassium meta bisulphite in it, add it to the juice mixture and stir. Put in an airtight bottle.

ii. Rose syrups

Ingredients

rose petals	1kg
sugar	6kg
water	8kg
sulphuric acid	10 drops

Boil rose petals on low heat until mixed with water. Strain the water through a fine muslin cloth, then pour the sugar into the rose water and put it on the heat. Bring to a fast boil, then lower the heat and let it simmer for about an hour, or until the syrup is fairly thick, about the consistency of honey. Do not make it very thick, as it will be sticky. Mix sulphuric acid and essence and put in an airtight bottle.

Vinegar

Ingredients

grapes	5kg
salt	1/2 kg
water	
ceramic pot	

Clean and wash the grapes. Put salt, water and grapes in the ceramic pot. Close the opening of the pot with a cloth. Keep this ceramic pot in a dark and cool place for 40 days. After 40 days, strain the vinegar through a fine muslin cloth. Put in a bottle.

Mushroom Production

Significance

The history of the mushroom is as old as the history of mankind. In different civilisations, it is used as both food and medicine. In the mountains, wild mushrooms can be found in hilly and plain areas during the spring and mushrooms are used as a daily food. Poor farmers collect wild edible mushrooms during the mushroom season and sell them in the towns and cities. Nomads dry mushrooms under sunlight and store them for their future food needs.

Mushrooms are very high in protein content (i.e., 30%). They are low in starches and lipids and are therefore recommended as the best food for diabetic and heart patients. Commercial mushroom production

*Plate 52: **Commercial Production of Mushrooms on a Farm***

This technology has tremendous potential for income generation. The scope is widened by its role in improving the protein component of the daily domestic diet

is popular in Europe and America. The technology is simple and low cost. Compared to other crops, the mushroom crop is less labour intensive, of short duration, and has the potential for substantial income generation.

A great variety of cheap and farm-based materials (e.g., agricultural wastes and household wastes) can be used successfully as a growing medium for various edible mushrooms. Mushroom growing requires little space and possesses great potential for landless and marginalised households. Mushroom cultivation remains an indoor activity.

Components

There are different kinds of mushroom, however, the mushroom section of the Agriculture Department, Balochistan, recommends the Oyster and Button varieties for mountainous regions.

Mushroom production needs some special treatments such as the preparation of artificial composite, pasteurisation of composite, preparation of beds, and spawning. Indoor mushroom cropping is becoming quite popular. Mushrooms are cultivated on compost in a suitable room. Horse dung is a traditional compost, however, modern research has developed methods to cultivate this crop vigorously on artificial composts of different compositions. The following is the simplest method of preparing artificial compost. Wheat straw is moistened in boiled water for 12 to 18 hours. This helps to kill all the germs in the straw. The straw is then spread over a floor or a plastic sheet to drain the surplus water. Spawn is added to it @ 100g of spawn per kg of dry wheat straw and is thoroughly mixed. The packing of this straw into polythene bags follows (with each bag weighing roughly 1kg to 2kg). These bags are placed on steel or wooden frames within the room. Meanwhile, the room temperature should be maintained at 25 to 28°C for eight to 10 days. Afterwards, the temperature may range between 5 and 18°C. The optimum humidity levels should be 85 to 90 per cent. The room should be well ventilated. Under these conditions, a mushroom harvest may be obtained within four weeks.

Palm Leaf Household Products

Significance

Palms (*Nannorrhops ritchieana*) grow naturally all over northern Balochistan and in most other part of the HKH region. Certain gypsy tribes make their living exclusively by making and selling palm leaf products. Over the years, the gypsies have adopted it as a profession and it is now emerging as an industry. Most of the time, all family members specialise in making palm products – however, women are the key workers. Gypsies usually stay near to towns and cities. The male family members procure palm leaves from major production areas and transport them in truckloads to the places where their families are temporarily based. They are also responsible for marketing the products. Females and children work individually and in groups to make a variety of household products.

Components

Palm leaves are cut and air dried in the fields. Later, the dry leaves are transported to big towns or cities. Gypsy workers use these leaves for making household items such as brooms, baskets, caps, hats, *chitai* (used for the roofs of huts and other do-

Plate 53: ***Women are Key Workers in Making Palm Leaf Household Products***

The making of palm leaf household products is gaining the status of an industry. As a species, the palm is experiencing intense and frequent cutting. The sustainability of this industry is linked to proper conservation measures and future propagation plans, along with good harvest management.

mestic purposes), decorative items, etc. Workers design the products in varied and beautiful colours, which add to their aesthetic attraction. Fresh leaves are used for making shoes.

Cottage Products

Significance

The HKH region experiences severe winters and as such, there is a big demand for wool and woollen products. The small-scale cottage industry has found an important economic opportunity in the area. Most households such as those of the *Gaddi* in HP, India, have installed indigenous handlooms and produce different woollen products. In the Ladakh area, goat and yak hair are especially used for making warm clothing for shepherds.

The majority of the sheep population in these mountains produce carpet type wool. Wool fibres are coarse and the quality is low, which restricts its consumption by the woollen textile mills. The carpet industry is also not locally operative and local wool must travel to major cities for carpet production. The existing marketing intermediaries offer very low prices for wool clippings. Marketing opportunities for goat hair are equally bleak. Farmers prefer to use the hair for domestic needs rather than selling it at a nominal price.

Marketing as well as socioeconomic constraints direct livestock producers to maximise their domestic use of wool and hair. Previously, they used to make wool/hair cottage products for daily usage in the household. In time, the trend changed and farmers now market their cottage products, although they are still being exploited by market elements. Smart and well-informed marketing agents will purchase these products at cheap rates and will sell them to tour-

Plate 54: ***A Hand Loom Used to Make Woollen Cottage Products***

The socioeconomic profile of gender on this aspect may be assessed to make it an income generating activity. Modern spinning and knitting equipment are required to meet this objective. Training programmes in modern designing coupled with intelligent marketing would make a positive difference.

ists as handicraft items with a very high profit margin.

Women are the actual workers who produce these cottage products at home.

Components

Shearing and clipping are generally done by the male members of the family. However, the processing involves women who produce a variety of wool and hair products. These products include grain storage bags, gypsy huts, transportation sacks used on horse and camel backs; ropes made mainly of goat hair; as well as rugs, mats, shawls, blankets, etc made from wool fibre.

Women spin wool/hair using traditional and rustic equipment. They may use traditional dyes to produce different colours and dye mainly wool fibre. Very simple and inherited techniques are used to prepare hand-made products. The whole assembly includes a few wooden poles and ancient knitting equipment (i.e., a handloom) to produce a mat of a certain given length and width. One or more mats are then stitched to make a variety of cottage products.

This process is time consuming and involves many women hours to finish a cottage product.

Afghan refugees in Balochistan have given a new dimension to the local cottage industry. In refugee camps, the Afghan women are producing cottage products to improve their family income. Very interestingly, they use synthetic fibre obtained from used sweaters etc. Imported, used, warm clothing is available in local markets and is a sustainable and relatively cheap source of synthetic fibre for this industry. By producing attractive colours and a beautiful pattern, the Afghan women are successfully creating a market for their cottage products.

Rubber Water Containers

Significance

Water scarcity hinders not only agricultural operations, but equally affects the normal day to day life of the human population in the mountains. The problem is particularly visible in arid and cold tracts. Most of the time, local inhabitants travel long distances to transport water for their daily domestic use and to water animals. Women are mostly responsible for collect-

ing water for domestic use. Traditionally, water is transported on donkeys and camels in most of the western mountains of the HKH region. Goat skins are popularly used for transporting water and for storing water at home.

Rubber water containers (RWC) have emerged as a popular drudgery reducing utensil for women. Water is now mostly transported on animals in these containers of varying sizes and is stored at home. They have completely replaced goat skin containers due to their many advantages. They are seen everywhere in Balochistan.

Components

RWCs are roughly oval, barrel-shaped, with both ends round, and vertically flat. They are available in the market in many sizes (range of capacities). They are made of the used tyres of heavy duty vehicles and are therefore cheap. They are designed in such a way that one can conveniently carry at least two containers on an animal. They are equally convenient for a human to carry on the back. The cost of an RWC ranges from Rs 200 to 250 (i.e., US$5.0 to US$6.25). Farmers can easily use them for more or less five years. They can keep water fresh for many days.

Beekeeping

Significance

The HKH region is a focal point in the origin and evolution of honeybees. Modern intensive agriculture with its diversified cropping patterns and orchards is becoming increasingly popular in the mountain ecosystem. The current agricultural transformation, once linked to apicultural operations, offers much scope for income generation through beekeeping.

Beekeeping also increases production of fruit and vegetables, particularly cross pollinated crops such as apples, pears, plums,

Plate 55: ***Rubber Water Container in Balochistan, Pakistan***

The RWC is environmentally friendly, because it consumes used and old tyres which otherwise are burned, producing a lot of smoke. Other items of domestic and daily use made of used tyres are also now available in the market. They are cheaper than the same type products in metal.

and litchis and seed production for cabbages, cauliflowers, carrots, turnips, radishes, and other vegetables (Azad 1993).

Traditionally, mountain women are rarely involved in beekeeping, perhaps due to ignorance. Beekeeping requires light labour, no permanent infrastructure and exploits orchard flowers beneficially for extra income generation. Apicultural operations can easily be undertaken by women of mountain households without any extra drudgery.

Components

Farm women can be trained successfully within a week in beekeeping operations such as hiving bees, bee swarms, occasional feeding, division of colonies by mass rearing of queens, uniting the colonies, queen introduction, prevention of absconding, swarm control, and honey extraction (Pandey and Pareek 1990). A household can keep as many boxes as can be conveniently managed by its women. An apiary with 10 bee colonies would cost less than US$ 150 as an initial investment in most HKH countries. Peak average production in the second year would annually be 20kg of honey per colony with an additional five kg of beeswax. The initial investment would easily be recovered during the year following the establishment of the bee colonies (Saxena and Dhruvanarayana 1990).

There are four main species of honeybee found in the HKH mountains, i.e., *Apis cerana*, *A. mellifora*, *A. dorsata*, and *A. flora*. *A. mellifera*, a European species, is becoming very popular and is replacing the native species,. *A. Cerana*.

Chapter Eight
Recommendations

In order to alleviate poverty in the HKH region, farmers could be moved away from the subsistence economy by exploiting known abilities and tested technologies to lead this area into a new millennium. Since the social order is ossified with centuries of traditions, it would certainly require major and carefully planned modifications in the overall social system, although not total social disintegration. However, incorporation of modern technologies has already caused extensive damage to social structures in various niches. The sudden damage or unplanned breakage of the social order may not be compatible with the fragility of the mountain ecosystem; this is the most important aspect to be considered during any development plan.

The goal of this publication is promotion of promising farm technologies through a vigorous delivery mechanism in such a way that it is taken up by end users. However, such things are never so simple and the process has several implications other than those mentioned above. This process should pass through a careful planning and evaluation stage at different levels, so that the appropriate technology package is friendly to the physical, socio-cultural, and environmental settings of the region. The following recommendations are made in this regard:

- An international conference on 'appropriate farm technologies' should be organized. The participants may represent all levels, i.e., farmers, extension services, public departments, policy-makers, non-government organizations (NGOs), International Organizations, etc. The objective of this conference should be to assess promising technologies from different dimensions and to remove future constraints and possible implications. The conference may also extend an opportunity to hand over this technology package to all concerned in one stroke.

- The significance of indigenous knowledge cannot be overruled by modern technologies, rather, innovations should be compatible to traditional methods in such a friendly manner that productivity is improved with little or no fragility consequences. Quite a few research findings have recognized many primitive techniques of various regions as appropriate and sustainable and scientists are now becoming more interested in traditional agronomic practices to eliminate the deficiencies from modern agriculture. This transfer of learning should occur rapidly before this wealth of practical knowledge is lost forever (Altieri et al. 1987). More re-

search should be funded for improving existing indigenous technologies by making improvements and by blending them with modern ideas.

The inhabitants of the region have long been marginalised from the mainstream. Although very well equipped with indigenous wisdom of the general balance of the mountain ecosystem, they obviously lack a deeper perception of the delicate and minute linkages between different external and internal elements. Similarly, most outside researchers, with excellent modern knowledge, lack in-depth perception of the fragile ecosystem to develop appropriate technologies or propose improvements in indigenous practices by swiftly incorporating modern knowledge. Training (short as well as long term) of local inhabitants should be undertaken as a new initiative. It may be time consuming but has to be done as quickly as possible. It should focus on economic literacy, agricultural literacy, social awareness, and all other parts of the system.

- The female segment is roughly 50 per cent of the human population. Women are central to agricultural development, but their concerns have been recognised too little. This half of the human populace is particularly marginalised especially (in terms of literacy) in the social framework of the mountain environment. The male-dominated power structure discriminates against women in terms of direct access and control over development resources. An outspoken approach aimed at achieving gender equity may severely injure social and family bonding, which is inevitably desired for sustainability. The sociologist must examine carefully how the peaceful transformation of the social order can be achieved.

The current form of this publication offers a palatable and diversified technological menu which can be used to encourage policy-makers, public managers, NGOs, and international donors to realise the opportunities and potential of agricultural development, heavily linked to poverty alleviation in the HKH region. The dissemination of each technology at the grass roots' level would, however, need further details about the technology in question. It would be desirable to prepare a separate extension kit in local languages for each category (i.e., chapter) of technology with sufficient detail for extension agents operating at the grass roots' level.

Bibliography

Ahmed, S. 1996. 'Issues and Options of Sustainable Water Resource Development in the Hindu Kush-Himalaya [sis] Dry Region'. In *Proceedings of the Regional Workshop on Sustainable Agriculture in Dry and Cold Mountain Areas*. Sept.25-27, 1995. Islamabad, Pakistan: PARC and ICIMOD.

Alam, Z. 1993. 'Development of Horticulture in the Mountain Regions of Pakistan: Progress, Potential and Constraints' In Teaotia, S.S., (ed) *Proceedings of an International Experts' Meeting on Horticultural Development in the Hindu Kush Himalayan Region*. New Delhi, India: Oxford and IBH.

Altieri, M.A., Norgaard, R.B., Hecht, S.B., Farrell, J.G. and Liebman, M., 1987. *Agroecology: The Scientific Basis of Alternative Agriculture*. Westview (Boulder), London: Intermediate Technology Publications.

Anand, J.C. and Grover, O.P., 1993. 'Postharvest Practices as Affecting Marketing of Fruits and Vegetables in Himalaya [sic] Mountains Region in India'. In Teaotia, S.S., (ed) *Proceedings of Horticultural Development in the Hindu Kush-Himalayan Region*. New Delhi, India: Oxford & IBH.

Anonymous. 1995, *Missing Links - Gender Equity in Science and Technology for Development*. Ottawa, Canada: IDRC, London: ITP /New York: UNIFEM.

Azad, K.C. 1993. 'Present Status of Horticulture Development in H.P'. In Teaotia, S.S., (ed) *Proceedings of an International Experts' Meeting on Horticultural Development in the Hindu Kush Himalayan Region*. New Delhi, India: Oxford & IBH.

Capistrano, L.N., Durno, J. and Moeliono, I., 1990. *Resource Book on Sustainable Agriculture for the Uplands*. The Philippines: IIRR.

Carr, M. 1991. *Women and Food Security. The Experience of the SADCC Countries*. London, UK: Intermediate Tech. Publications.

Chalise, S. R., Shengji, P., Bhatta, B., Shah, P.B., and Gurung, J.D., 1994. 'Natural Resources' Management in a Mountain Environment'. In *Proc. International Symp. On Mountain Environment and Development*. Kathmandu, Nepal: ICIMOD.

FAO and IIRR, 1995. *Resource Management for Upland Areas in Southeast Asia*. Farm Field Document 2. Food and Ag-

riculture Organization of the United Nations, Bangkok, Thailand and International Institute of Rural Reconstruction, Silang, Cavite, The Philippines.

Food and Agriculture Organization, 1983. *Balochistan Assistance to Rangeland and Livestock Development Survey*. TCP/PAK/0107, Pakistan: FAO.

Fresco, L. O., 1986. *Cassava and Shifting Cultivation: A Systems' Approach to Agricultural Technology Development*. Amsterdam : Royal Tropical Institute.

Gils, H.V. and Baig. M.S., 1993. *Environmental Profile Balochistan*. Pakistan, ITC (unpublished).

Government of Balochistan, 1993. Outreach and Transfer of Technology in Balochistan' (PAK/89/014), Field Document No. 1, Deciduous Fruit Development Centre. Extension Bulletin. Agriculture and Cooperatives' Department, Quetta , Balochistan: GOB.

Government of Balochistan, 1995. *Balochistan in Figures*. Bureau of Statistics. Quetta: Planning and Development Department, GOB.

Government of Balochistan, 1996. *Agricultural Statistics of Balochistan* — Extension Bulletin. Quetta: Statistics Wing, Agri. Dept, GOB.

Government of Balochistan, 1996. *Feasibility Study on the Irrigation Water Resources Development with Delay Action Dams Project in Balochistan*. Progress Report (1). Quetta: Irrigation and Power Department, GOB.

Government of Balochistan, 1995. *A Practical Guide to Urea Treatment of Straw in Balochistan*. Field Resources' Development Project (PAK/88/050), Quetta: Livestock Department, GOB.

Government of Balochistan, 1987. *Diagnostic Study of Farming Systems in Balochistan*. Quetta: Agricultural Extension and Adaptive Research Project. Agri. and Cooperatives Department.

Government of Balochistan, 1993. *Out reach and Transfer of Fruit Technology in Balochistan*, (PAK/89/014) — Extension Circular No. 3-9. Deciduous Fruit Development Centre. Agriculture and Cooperatives Department, Quetta: GOB.

Government of Balochistan, 1993. *Out reach and Transfer of Fruit Technology in Balochistan*, (PAK/89/014) Extension Leaflet (HT-02). Quetta: Deciduous Fruit Development Centre, Agriculture and Cooperatives Department, GOB.

Government of Balochistan, 1994. *Improved Feeding of Sheep and Goats in Balochistan from Pre-Mating through Lactation*. Field Resources' Development Project (PAK/88/050), Quetta: Livestock Department, GOB.

Government of Balochistan, 1995. *The Manufacture and Use of Molasses Urea Block in Balochistan*. Quetta: Field Resources Development Project (PAK/88/050), Livestock Department, GOB.

Government of Balochistan, 1997. *Quetta - A District Profile*. Quetta, Pakistan: P&D Department

Government of Balochistan, 1997. *Pishin - A District Profile*. Quetta, Pakistan: P&D Department

Gupta, A. K. 1992., 'Farmers' Innovations and Agricultural Technologies'. In Jodha, N.S., Banskota, M. and Partap, T, (eds) *Sustainable Mountain Agriculture*. Kathmandu, Nepal: ICIMOD and New Delhi: IBH Oxford Pvt. Ltd.

Iqbal, M.; Wahid, A. and Rafique, S., 1981. *Sheep and Goats' Production Practices and Potentials in Balochistan, Quetta*. Balochistan: Part-I, Pishin District. AZRI, PARC,

Kaimowitz, D., 1990. *Making the Links - Agricultural Research and Technology Transfer in Developing Countries*. USA: ISNAR and Westview Special Studies in Agriculture and Policy (WSSASP), Westview Press.

Khurana, D.K. and Khosla, P.K., 1993. 'Agroforestry for Rural Needs'. In *Indian Society for Tree Scientists*, Vol-2. Solan-173230, HP, India: ISTS.

Mohammad, N. 1996. *Integrated Management of Sulaiman Rod Kohi Region - An Action Programme*, Islamabad: IRRES, PARC.

Nathan, D. 1995. 'A Gender Framework for Resource Management'. *In Asian Watmanet Newsletter*, #5, Kathmandu, Nepal: (PWMTA) FAO.

Nizami, M.M.I, 1996. 'Sustainable Use of Soil Resources in Dry and Cold Mountains'. In *Proc. of The Regional Workshop on Sustainable Agriculture in Dry and Cold Mountain Area*, Sept. 5 -27, 1995, Pakistan and Nepal: PARC, ICIMOD.

Pandey, R.M. and Pareek, O. P., 1990. 'Horticultural Production Technologies for Farm Women . In Prasad, C. and Ram, S. (eds), *Women in Agriculture Technological Perspective*. India : IFWA and ICAR.

Pandey, R.M. and Teaotia, S. S., 1993. 'Development of Mountain Horticulture in the Indian Himalayas'. In Teaotia, S. S.(ed) *Horticultural Development in the Hindu Kush-Himalayan Region*. Kathmandu, Nepal: ICIMOD.

Partap, T. 1996. 'Overview of the Agricultural Development Processes in the Hindu Kush-Himalayan Region and Sustainability Concerns'. In *Proc. of The Regional Workshop on Sustainable Agriculture in Dry and Cold Mountain Areas*. Sept.25-27, 1995. PARC, Pakistan and Nepal: ICIMOD.

Partap, T., 1993. 'Genetic Resource Issues in Horticultural Development Approaches of the Hindu Kush Himalayan Countries'. In Teaotia, S.S., (ed) *Horticultural Development in the Hindu Kush-Himalayan Region*. Kathmandu, Nepal: ICIMOD.

Prasad, C. and Ram, S. 1990. *Women in Agriculture - Technological Perspective*, New Delhi, India: IFWA, ICAR.

Qinye, Y. 1997. 'On Ecological Characteristics, Utilization and Management of the Tibetan Plateau, China'. In *The J. Chinese Geography*, Vol. 7, No.2.

Reijntjes, C ., Haverkort, B., and Bayer, A. W., 1992. *Farming for the Future - An Introduction to Low-External Input and Sustainable Agriculture*. Netherlands: ILEIA, AB Lensden.

Saxena, P. and Dhruvanaraayana, V. V., 1990. 'Watershed Management: A Boon to Farm Women of the Hills'.

In Prasad, C. and Ram, S. (eds), *Women in Agriculture Technological Perspective*. India: IFWA and ICAR.

Seth, J.N. 1993. 'Horticultural Development in the Uttar Pradesh Hills'. In Teaotia, S.S. (ed) *Horticultural Development in the Hindu Kush-Himalayan Region*. Kathmandu, Nepal: ICIMOD.

Sharma, P. 1994. 'Population and Employment Challenges in the Mountains'. In *Proc. of the International Symp. on Mountain Environment and Development*, Kathmandu, Nepal: ICIMOD.

Sharma, P. and Banskota, M., 1992. 'Population Dynamics and Sustainable Agricultural Development in Mountain Areas'. In Jodha, N.S., Banskota, M. and Partap, T. (eds) *Sustainable Mountain Agriculture*. New Delhi: IBH Oxford Pvt. Ltd.

Sharma, P. N. 1997. *Participatory Process for Integrated Watershed Management*. PWMTA - FARM Field Document No. 7, Kathmandu, Nepal: FAO.

Swarup, V. 1993. 'Potential of Floriculture in the Hindu Kush Mountains'. In Teaotia, S.S., (ed) *Proc... Horticultural Development in the Hindu Kush Himalayan Region*. New Delhi: IBH Oxford Pvt. Ltd.

Syed, F. H. 1994. *Role of Women in National Development*.Rawalpindi, Pakistan: FRIENDS.

Verma, L.R. 1993. 'The Role of Beekeeping in the Developing of Horticulture in the Himalayan Mountains of India'. In Teaotia, S.S. (ed) *Horticultural Development in the Hindu Kush Himalayan Region*. Kathmandu, Nepal: ICIMOD.

Warren, D.M. and Cashman, K., 1988, *Indigenous Knowledge for Sustainable Agriculture and Rural Development*. IIED, Iowa St. Uni. USA: CIKARDTSCP.

Yanhua, L.,Fei, W. and Dafu, Y,. 1992. 'Farmers' Strategies in the Mountain Areas of West Sichuan, China'. In Jodha, N.S., Banskota, M. and Partap, T., (eds) *Sustainable Mountain Agriculture*. Nepal: ICIMOD and New Delhi: IBH Oxford Pvt. Ltd.

Zaidi, Y. 1996. *Economic Empowerment of Rural Women*. Workshop Report, Islamabad, Pakistan: UNDP.

Zhaogu ang, L. and Ning, W. 1992. 'A Local Resource - Centered Approach to Rural Transformation: Agro-based Cottage Industries in Western Sichuan, China'. In Jodha, N.S., Banskota, M. and Partap, T., (eds) *Sustainable Mountain Agriculture*. Kathmandu, Nepal: ICIMOD and New Delhi: IBH Oxford Pvt. Ltd.

Zheng, D., L. Gaosha and J. Hong. 1993. 'Horticultural Development in the Himalayas and the Hengduan Mountains, China'. In Teaotia, S.S. (ed) *Horticultural Development in the Hindu Kush Himalayan Region*. Kathmandu, Nepal: ICIMOD.

Annex 1

Practical Agricultural Techniques in Mountain Regions of China

A. Crop Production

Name of Technique	Sources or Origin	Significance	Components	Impact
Wheat-cotton inter-planting with irrigation through plastic film		Water and plastic film have multiple uses. A new water saving and yield increasing irrigation technique	The inter-planting techniques of wheat and cotton covered with plastic film (applying base manure better, determining the width suitable for water content, piercing plastic and planting the seedling), the techniques of irrigation through the plastic film (speed of water running, suitable length of flow ditch, water discharge of single ditch the quality of irrigation water)	30% less water is needed for wheat and 40% for cotton
Technique of ploughing-free with inter-cropping and inter-planting	A History of Modern Agricultural Sciences and Technology in China	It is useful to take advantage of both temporal and spatial resources and green fertile fields	Planting later-rice between intervals of early-rice, or inter-planting cotton in the wheat field, or inter-cropping wheat with bean rice with beaten, or rice with fertilizer	Increases multiple crop index and multiple cropping area
Crop rotation	A History of Modern Agricultural Sciences and Technology in China	Wipes out weed, reducing insect pests and plant diseases and increasing crop production	Continuously planting rice, millet and hemp is forbidden, planting leguminous crops before planting grain crops	
Three crops in two years	A History of Modern Agricultural Sciences and Technology in China	Increases utilisation rate of land, light, temperature and water resources	In hilly fields, planting wheat at first, then bean, then Chinese sorghum, millet etc	Greatly increases the crop yield
Rice-bean inter-crop	A History of Modern Agricultural Sciences and Technology in China	Increases crop output and maintains soil health	Planting beans before rice harvesting	Raises crop yield and improves land productivity
Wheat-bean inter-cropping	A History of Modern Agricultural Sciences and Technology in China	Increases crop yield and maintains land productivity	Planting broad beans along the side of wheat fields, planting peas with barley etc	Yields more beans and improves land productivity
Rotation system	ZhuHe County Annals	Combines land use and land maintenance	Bean, Chinese sorghum and millet rotation in 3 years	Keeps land productivity sustainable

B: Land Preparation and Soil Fertility

Names of Technique	Sources of Technique	Importance and Significance of Technique	Key Technique	Benefits
Compound fertilizer to match supply and demand of soil nutrients	Chinese Academy of Sciences	Promotes the productivity of the following significantly: rice, wheat, barley, rape, cotton, potatoes, flax, etc	Compounding fertilizer according to soil nutrient supply, nutrient demand and different crop requirements	Increases productivity by 10 to 20 per cent
Conserving soil moisture	A History of Modern Agricultural Sciences and Technology in China	Ploughing deeply to conserve soil moisture, there is no serious harm if there is no rain in slack fields during the summer	Ploughing shallowly to remove stubble, ploughing deeply to store soil moisture, raking and grinding to gain soil moisture	Good yield in case of drought
Ploughing, raking and pressing of water fields	A History of Modern Agricultural Sciences and Technology in China	Soil of water fields for rice cultivation is solid inside but loose outside	Ploughing field in winter, raking shallowly, ploughing field in spring, raking rice stubble smashing soil to pieces after raking	Beneficial to rice growth
Applying bone ashes on rice roots	A Study on Agricultural Sciences and Technology in China	Functions as a cold resistant	When setting in seedlings, dip the roots in bone ash	Gives fertilizing effect to seedlings
Integrated technique of improving saline-alkaline land	A History of Modern Agricultural Science and Technology in China	Saline-alkaline fields are improved and production is increased to normal or high	Plowing high and turning up the soil high, scraping saline and alkaline, spreading strange soil, building mess fields, spreading sand and covering up with grass	Unproductive land converted into highly productive land

C. Moisture Conservation and Irrigation

Names of Technique	Sources of Technique	Importance and Significance of Technique	Key Technique	Benefits
Springs' water in valley flying channels	A Study on Agricultural Sciences and Technology in China	It is helpful in solving the problem of supplying water to the fields in valleys	Storing water in big or small ponds or building small reservoirs to store water in lower reaches, and building bamboo channels when springs are blocked by ridges	Irrigation for higher production
Buckwater weir or dam	A Brief History of Water Conservancy of the Yellow River	Solving the irrigation problem when fields are higher than the water level	Raising water level of the river course	Increases area under irrigated cultivation
Irrigation techniques of drawing water	A Study on Agricultural Sciences and Technology in China	Developing irrigation on sloping fields	Building ponds on slopes and drawing water hidden within mountains into the ponds	Increases irrigated area
Underground irrigation channels	Ten Popular Agricultural Techniques	Land and water conservation	Tile-made tube or under earth stone-channel around mountain	Water losses significantly reduced.

D. Pest Control

Name of Technique	Sources or Origin	Significance	Components	Impact
Biophylaxis prevention and control technique for bean diseases and insect pests	The Comprehensive Prevention and Control of Crop Diseases and Insect Pests	Reduces costs and pesticide pollution	The biotic-control is carried out by natural enemies of soybean pests such as trichograma, batrytis, bacteria etc.	Has notable ecological and economic benefits
Biophylaxis prevention and control technique for cane diseases and insect pests	The Comprehensive Prevention and Control of Crop Diseases and Insect Pests	Reduces costs and pesticide pollution	Controls white sugarcane borer, striped borer, stem borer by trichogramma and fabricius	Has notable ecological and economic benefits
Expunging pests with duck herding	Records of locust expunging, texts of locust control	Controls pests by using natural enemies, low cost, no pollution	Ducks can eat locusts when they are still young, catching locusts by ducks is not as good as catching locust nymphs by ducks, catching nymphs is not as good as digging them, is not as good as rooting them out, and so on	Has notable effects
Ploughing deeply and irrigating in winter to freeze pests to death	Farmers' minds and words	Prevents pests by ploughing technique	Ploughing deeply and irrigating in winter to freeze the pests and their eggs to death	Alleviating harm
Proper rotation of crops to prevent pests	Talk on Agriculture	Taking prevention as a key link in reducing loss	Rice-cotton rotation, rice culture is notably successful in drowning land worm	Effective performance
Applying ash agents for controlling pests	A History of Modern Agricultural Science and Technology in China	Prevents and controls pests with lime, rice straw ash, wood ash and chrysanthemum ash	Lime can heat soil and kill pests, spreading the powder of rice straw ash and lime on the tips of rice and wheat can save them being eaten by locusts; killing locust eggs with lime water can get twice the result with half the effort, controlling wheat moth with chrysanthemum ash	Effective
Controlling and preventing potato diseases and insect pests	Brief investigation of agricultural production in Fujian perfection		Using copper sulphate lime liquid, 0.25kg copper sulphate, 1 kg lime , 1.5 hectolitre of water, mixing them evenly	Effective
Controlling wheat diseases and insect pests	The Comprehensive Prevention and Control of Crop Diseases and Insect Pests	Controls diseases and eliminates pests with natural enemies and no pollution	Preventing and controlling eastern tent caterpillar with *Alaptus westwood*	Parasitic rate of the trichograma to pear core pear's egg is over 95 per cent
660B	Chinese Academy of Sciences	Controls more than 20 kinds of fungal diseases	660B preparation	Prevention and control effect about 75 per cent success rate and field crop output is increased by 8 per cent

E. Animal Production

Name of technique	Sources or origin	Significance	Components	Impact
Poultry hatching	A History of Modern Agricultural Science and Technology in China	It can be applied in border areas	Heat source for artificial hatching: 'to incubate in the hot season by fried chaff or by fried wheat and hatch in hot season by horse urine'. Direct heating 'put duck eggs in the chaff, and smoke them slightly by charcoal fire'	
Cattle and sheep fattening	A History of Modern Agricultural Science and Technology in China	Developing fattening techniques; making use of the superiority of agricultural areas and pastoral areas	Buying old and weak cattle and sheep from pastoral areas in winter when there is a lack of grazing grass and fattening them in agricultural areas using plenty of straw resources	With excellent benefits
The method of giving drugs through the animal's rectum	A History of Modern Agricultural Science and Technology in China	Having good effects on constipation	Making a cake with caster bean, honey and onion and placing it in the animal's anus, the animal's defecation is instantly assured	With excellent benefits
Technique for temporarily suturing the anus	A History of Modern Agricultural Science and Technology in China	Having good effects on prolapsed rectums and avoids muscle and tissue damage	For any cattle suffering from this disease, shower the prolapsed rectum with warm water from a tin bottle, smoking the diseased part with one or two incense burners, making bloated gas and extravasated blood clean. After doing so, wash it with cooled water, decocted from dried Chinese mugwort, then lightly fill the anus with seasame oil and temporarily close it by suturing.	With excellent benefits
Disinfectants for animals	A History of Modern Agricultural Science and Technology in China	Annihilates parasites	Decocting dried Chinese mugwort, gypsum, mirabilite, root of Zhejing figwort and some other Chinese herbal medicines with water and washing the animals when the water is cooled, so as to avoid infections	With excellent benefits

Annex 2

Apple cultivars used in the Hengduan Mountains of China

- American Summer Pearman
- Golden Delicious
- Starking
- Jonathan
- White Winter Pearman
- Rall's
- Huanong No. 1
- Yellow Transparent
- Red Transparent
- McIntosh
- Cravenstein
- Ben Daris

(Zheng et al. 1993)

Annex 3

Traditional Farm Implements and Ethno-Engineering for Self Sustenance in Ladakh

Farm implements have been developed/modified through the experiences of previous generations and emerging socioeconomic and farming challenges.

i) *Khazas*: Structure with nail-like formations on a piece of wood, attached to a long rod; used for the collection of straw
ii) *Nyashing*: A wooden structure used for bullock support
iii) *Okham*: A wooden structure used for assembling wheat grains
iv) *Ongmol*: Broom made from wild grass known as *chipkyang*; localised in Shashoot village; commercial sale of the grass is common
v) *Pankha*: Used for assembling wheat grain; comprised of a long wooden stick/ rod (1 to 1.3m) with a semi-circular structure in front
vi) *Phat*: Gunny bag prepared from goat hair; can carry up to 100 kg
vii) *Staybo*: A small axe
viii) *Shawl*: Local plough
ix) *Taspo*: Wooden basket
x) *Tsagsma*: A sieve (large one)
xi) *Zar*: Structure used for winnowing of farm produce; made from wood with five finger-like elongations at the apex
xii) *Zora*: A small sickle used for cutting grasses/farm produce

Annex 4
Traditional Implements of Himachal Pradesh

Local name	English name	Use	Approximate value (Rs.)	Service life(yrs)
Chagwal	Spade	Carrying earth	13	5
Chutse	-	Chiselling	5	3
Dranti	Scythe	Harvesting the crop	4.25	4
Gainti	Pick axe	*Kuhl* making, harvesting of *kuth* and digging out stones	18	4
Jhabbal	A large iron rod with a sharp end	Digging out big stones	22	10
Jathugza	Sharp blade fitted to a crooked wooden handle	Harvesting the crop	4	3
Kahti	Mattock	For making *kuhl*, embankments	4	2/3
Karji	Axe	Cutting wood	16	3
Khawang-shing	Yoke, or *punjali* similar to the one in the plains	Yoking the bullocks for ploughing	15	3
Ngal	Wooden plough with an iron blade	Ploughing	35	2
Okthan	Same as *kudal*	Clod-crushing and levelling of land	6	2
Surmn	Iron hook attached to a wooden handle	Hoeing and weeding	8	2
Thowa	Hammer	Breaking big clods	6	12

Annex 5

Fruit and Vegetable Varieties in The HKH Region of India

A. Apples

i) Himachal Pradesh

- Delicious group, i.e. Red, Starking (Royal), Golden Delicious, Rich-a-Red
- Others group, i.e., Red June, King of Pippen, Worcester Peerman (early varieties); Red Gold, Granny Smith, Rust Pippen, Winter Delicious (late varieties)

ii) Jammu and Kashmir

- Maharaji - white dotted red
- Delicious group
- American - Apirouge
- Ambri

B. Other Fruits

- Peach - Elberta, July Elberta, J.H. Hale
- Plum - Santarosa, Mariposa, Greengage
- Apricot - Safeda, Kaisi and Ambrosie, Nari
- Cherry - Red and Black Heart
- Almond - Thin shelled, Non Pareil
- Pineapple - Giant Kew, Queen and Mauritius

C. Vegetables

- Brinjal (aubergine, egg plant) - *Pusa*, Purple Long, *Pusa* Purple Cluster, PH-4, *Pusa Kranti, Pant Samrat, Azad Kranti, Arka Navneet, Pant Rituraj*, T-3, *Jamuni, Arka Kasumkar, Panjab, Bahar.*
- Chilli - *Andhra Jyoti, Bhagyalakshmi, Kouilpatti*
- Cauliflower - *Pusa Deepali, Pant Subhra*, Improved Japanese, *Pusa* Synthetic, *Pusa* Snowball-1, *Pusa* Snowball K-1
- Carrot - Pusa Yamdagni
- French Bean - VL Boni -1
- Mushroom - *Hara Madhu, Pusa Sarbati, Pusa Madhuras, Arka Rajhans, Arka Jeet, Durgapura -Madhu*

Annex 6
Various Fruit Varieties of Balochistan, Pakistan

Almond

Pastasha
DFDC Late
Kaghazai
Mongphali
Non Pareil
Texas

Apple

Granny Smith
Starking Delicious
Gloucester - 69
Kids' Range
Spartan
Katy
Tydesman Early Worcester
Staskrimsan
Belgolden
Smoothee
Summer Red
Gala
Katja
Topred
Anna
Fuji
Ultra Red
Delbard Jubilee
Royal Gala
Golden Blush
Jonathan
Hybrid

Apricot

Goldrich
Beogeran
Hard Grand
Prete
Den Gaetano
Peshawar-II
Char Maghz
Narai
Sardai

Cherry

Bing
Black Tatarian
Black Circadian
Early Rivers
White Heart

Exotic Olives

Frantoio
Pendolino
Moraiolo
Leecino
Coratino
Bianocolila
Carolea
Ottobratica

Grape

Kighish
Haitha

Annex 7

Suitable Varieties of Vegetables for Mountainous Areas of Pakistan

- Beans - Contender
- Cabbage - Golden Acre (early variety), Drain Head (late crop)
- Carrot - Nantes, Chantency
- Cauliflower - Snow Ball, Snow Drift
- Chinese Cabbage - Granat, Michihili
- Lettuce - Great Lake
- Okra - Perkinson Spineless
- Onion - Texas Sweet Grano, Shangshu
- Peas - Arkel, Green Drift
- Pepper - Yellow Wonder, California Wonder
- Potato:
  - Balochistan - Eigenheimer, Patrons, Multa, Atlantic (all white)
  - NWFP - Utimus (red, 1958), Desiree (red), Cardinal (red, 1972), Patrones (white), Multa (white), Cosima (white, 1977), Atlantic (white)
  - Northern Areas - Desiree (red), Cardinal (red), Diamond (white)
  - Punjab - Ultimus (red, 1958), Desiree (red), Cardinal (red), Patrones (white), Ajax (white, 1975), Wilja (white ,1976), Atlantic (white), Lal-e-Faisal (red, 1982), Diamond (white)
- Radish - All Season, Minnow
- Squash - Petra, Caserta, Grey Zucchini
- Table Beet - Betroit Dark Red
- Tomato - Maglobe, Roma
- Turnip - Purple Top, Golden Ball (for very high altitudes)

(Alam 1993)

Annex 8

Genetic Resource Diversity in Pears and Apricots in Mountain Areas of Pakistan

Vernacular name of variety	Distinguishing feature as reasons for folk selection (existing agroclimatic adaptation)
A. Apricot	
Ali Shan Kakas joo	Late
Alman joo	Good quality
Apo choli	Large size
Beru choli	Small size
Blafo choli	Small, red
Bro choli	Late maturing
Brook choli	-
Brum joo	White
Brun joo	-
Cho choli	Juicy
Chun choli	Sweet pith
Duda-sanang joo	-
Dudar joo	-
Duspaong choli	Selections due to specific agro-ecological characters
Gakateen joo	-
Gario joo	-
Ghaka joo	-
Ghom choli	-
Ghulam joo	-
Gurdaalo choli	Like peach
Habi joo	Very late
Halman choli	Best quality
Halwar choli	-
Hongool choli	-
Kacha choli	Hard, good to keep
Kaka shikanda joo	-
Karfoo choli	White apricot

Vernacular name of variety	Distinguishing feature as reasons for folk selection (existing agroclimatic adaptation)
Karopiam joo	-
Kartach joo	Very early, white
Kartaksha	Early, juicy
Kazangi choli	Sweet
Khakas choli	Kernel partly split
Khanemish joo	-
Khashanda choli	Good taste
Kho choli	Bad taste, sour
Khustar choli	-
Koropian joo	Early
Mamoor choli	-
Mamoor joo	-
Marghlam choli	Early, good quality
Marpho choli	Red apricot
Miting choli	Sour, kernel used for oil
Moen joo	-
Odumar choli	Partially red
Pharang choli	Dry apricot
Rashikin joo	Early
Sapastan choli	Sour, kernel used for oil
Sara choli	-
Sara karfo choli	Early
Shakanda choli	Sticky
Shakar choli	Sweet
Shanda choli	Small size, early
Shikanda joo	-
Skardu area	
Snair choli	Selections due to specific agro- ecological characters
Stun choli	Late maturing
Stun kuban choli	-
Surasune joo	Good quality
Tacho choli	-
Warfo choli	Pith used for oil
Yakab yak choli	Selections due to specific agro-ecological characters
Yakar choli	Reddish
B. Pear	
Bap Tango	Early
Batang	Large, pear shape, sweet

Vernacular name of variety	Distinguishing feature as reasons for folk selection (existing agroclimatic adaptation)
Gadaray Tango	-
Khan Tango	Small, round
Khapa	Sour
Khar Nak	Large, hard
Khawaga maiwa	Small, round, sweet
Mamusay	Small to medium, round, early
Nag Tango	Large, apple shape, hard
Nar	Oblong to pear shape
Nashpati	Medium to large, sweet
Parao	Large size, pear shape
Shakar Tango	Sweet medium size
Shal Tango	-
Shin Kulay	Medium, apple shape
Spin Tango	Small, round
Sur Tango	Small, round
Tang	Large, pear shape

(Partap 1993)

Participating Countries of the Hindu Kush-Himalayan Region

- Afghanistan
- Bangladesh
- Bhutan
- China
- India
- Myanmar
- Nepal
- Pakistan

International Centre for Integrated Mountain Development

4/80 Jawalakhel, G.P.O. Box 3226, Kathmandu, Nepal

Telephone : (977-1) 525313
e-mail : distri@icimod.org.np
Facsimile : (977-1) 524509, 536747
Cable : ICIMOD NEPAL