MOUNTAIN CROP GENETIC RESOURCES

Report of the

International Workshop on Mountain Agriculture Crop Genetic Resources

Organised by ICIMOD in collaboration with International Development Research Centre (IDRC and Ministry of Agriculture, HMG/Nepal.

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International Workshop on Mountain Agriculture
and Crop Genetic Resources

International Centre for Integrated Mountain Development

Kathmandu, Nepal

Foreword

The International Workshop on Mountain Agriculture and Crop Genetic Resources is an important component of ICIMOD programme activities on mountain agriculture which stipulates the formulation of the medium term strategy for mountain agriculture. The present international workshop was jointly organised by Ministry of Agriculture, His Majesty's Government, Nepal, International Development Research Centre (IDRC) and ICIMOD. The workshop is the first in a series of expert meetings planned for the next year or so and will lead to a major Workshop on Strategies of Mountain Agriculture: A 20-Year Perspective, to be held during 1988 at ICIMOD. The main objectives of these meetings and workshops will be to examine the strategies for striking a balance between development and environmental stability with a goal towards the attainment of longer term sustainability of mountain agriculture.

ICIMOD thanks the agriculturists and crop geneticists from the Hindu Kush-Himalaya, Andeas and the African mountain regions, who have contributed their expertise to the present workshop.

Our particular thanks are due to IDRC for their generous financial support to this workshop. Dr. Ken Riley, Programme Officer, IDRC Regional Office New Delhi, deserves special thanks for his continuing support and contribution in the design and organization of the workshop. The Ministry of Agriculture, HMG is to be specially thanked for their help in organising one-day field visit to the National Agriculture Research Centre, Khumaltar and Kakani Horticulture Farm.

It was a special pleasure to all of us that Mr. Hari Narayan Rajouria, Honourable Minister of Agriculture, inaugurated the Workshop with a stimulating inaugural address.

It is my pleasure to thank all the organizing staff of the workshop for their exceptional efforts, and particularly to Dr. Ram P. Yadav, Dr. Prodipto Roy, Dr. P.L. Maharjan and Dr. Binayak Bhadra, the latter specially for the preparation of this Workshop Report.

Colin Rosser
Director

CONTENTS

Introduction

Mountain agricultural systems are characterized by their extreme diversity and complexity. Many unique crop varieties and animal species are found in mountain environments. Unfortunately much of this diversity is rapidly being lost as a result of growing population pressures, an increasing demand for crops which can be marketed for cash in urban areas and competition from high yielding modern varieties of major crop. Indeed, the situation in many areas is considered extremely serious, and urgent measures are required to ensure that these irreplaceable genetic resources are collected and maintained.

At the same time, crops which are well adapted to one mountain area may prove valuable in improving the agriculture in other mountain regions having similar conditions. Recognizing this, the International Centre for Integrated Mountain Development (ICIMOD), the International Development Research Centre (IDRC) and the Ministry of Agriculture, His Majesty's Government of Nepal, jointly sponsored the International Workshop on Mountain Agriculture and Crop Genetic Resources from February 16-19, 1987 in Kathmandu, to review the special features of mountain agricultural systems, the crops which are adapted to them and opportunities and mechanisms for collection and exchange of genetic resources.

The specific purposes of the Workshop were:

1. to characterize various mountain physical environments and to look for common elements

2. to characterize mountain farming systems to identify common needs and opportunities

3. to describe the range and use of germplasm adapted to mountain conditions including:

   a) native species
   b) adapted landraces of major crop species
   c) genetically improved cultivars of both native and major crops

4. to establish mechanisms for the exchange and multi-location evaluation of germplasm, and the exchange of information on performance and potential use of materials exchanged

5. to discuss the need, desirability or feasibility of establishing a network for mountain crops.

The Workshop was inaugurated by the Honourable Minister of Agriculture, Law and Justice, His Majesty's Government, Mr. Hari Narayan Rajauria. During the inaugural address the Honourable Minister draw attention to the factors that have brought about the imbalances between the population and resources which, in turn, has accentuated both poverty and ecological degradation in the mountain regions of Nepal. He stressed the need and the importance of conserving the diversified crop genetic resources of the mountain regions of the world. He emphasized that the rugged topography, poor physical and institutional infrastructures and considerable climatic variations pose serious hurdles in mountain development. He also said that the tremendous heterogeneity represented by mountain environments, agriculture and the associated farming systems, has generated the most diversified and rich crop genetic resources available to all mankind, and every effort should be made to preserve and conserve these genetic resources.

During the welcome address, Dr. Colin Rosser, the Director of ICIMOD, said that the workshop is the first in a planned series of expert meetings over the next eighteen months leading to a major international workshop in 1988 on **Strategies of Mountain Agriculture: A 20-year Perspective.** He indicated that the central theme of this series of exchanges of professional knowledge and experience would be on the related aspects of mountain agriculture, such as, increasing pressure on traditional hill farming systems and their vulnerable mountain habitats exerted by a relentlessly growing population throughout the Hindu Kush-Himalaya region. He emphasized the urgency of appropriate policy and programme measures to assist the essential transition of hill agriculture from near total dependence on subsistence farming to integration in the market economy of cash crops, animal and forestry products. He also stressed the importance of the preservation of mountain environments through sustained agriculture and farming systems that embody the richly diversified crop genetic resources.

Dr. Geoffrey Hawtin, Associate Director, IDRC, highlighted the need and importance of exchange of germ germplasm in general and between the mountain regions in particular, so that mountain agriculture can be sustained or made more viable and the diversity of genetic resources in these agriculture and farming systems preserved. He stressed not only the need for extending the germplasm exchange networks beyond the Alps and the Andes to the Hindu Kush-Himalaya and other mountain regions, but also the need to analyze the implications of the different problems inherent in the application of crop genetic resources.

The workshop participants consisted of crop geneticists, agriculture specialists and social scientists from the mountain regions of the Hindu Kush-Himalaya, Andes, west Asia and Africa. The forty participants represented Bhutan, China, Ecuador, India, Kenya, Nepal, Pakistan, Peru, Thailand, and USA. The professionals of ICIMOD, IDRC and the Ministry of Agriculture, also participated in the workshop. A field visit to Kakani Horticulture Farm and Agriculture Research Centre at Khumaltar was organized with the help of the Department of Agriculture, His Majesty's Government, Nepal.

The highlights of the workshop discussions are presented in the next two sections: Physical Environment and Mountain Farming Systems and Genetic Resources of Mountain Crops followed by Conclusion and Recommendations. The annexes contain the workshop programme and abstracts of the papers presented at the workshop.

Workshop Discussions

The first day of the workshop dealt with the physical environment and farming systems in the five broad mountain regions of the world, namely, Hindu Kush-Himalaya(including Xizang), Andes, tropical African mountains, north African and mid-eastern mountains. The seven papers presented during the day amply demonstrated that it is necessary not only to consider the geomorphologic and meteorological factors at the macro scale in determining agricultural diversity, but also the micro level differences in altitude, aspects, locations, soil types, and other socio-economic aspects such as accessibility(trade and marketing) and opportunities for migration, transhumance and shifting cultivation. The salient issues raised during the presentations of the papers and the ensuing discussions are highlighted below.

A. **Physical Environment and Mountain Farming Systems**

a) **Hindu Kush-Himalaya Region**

The extreme diversity in the climate, flora and fauna prevailing in the Hindu Kush-Himalaya region was the topic of discussion and deliberation. The main theme was that the great diversity in the micro and the macro climates in the mountains emanates from the geomorphological diversity (Maharjan et al). Furthermore, it was noted that the genetic diversity and vegetational change are influenced by diversity in the soils and the climate. The main determinants of the farming systems are indicated to be the variables of the climatic, vegetational and soil categories. The conclusion was that the agro-ecological zones provide a suitable means of identifying physical determinants of the farming systems' diversity.

The complexity of climate, vegetation, and human activities, particularly the complexity represented by the farming system, and the agroecological zones within the Hindu Kush-Himalaya region, was stressed. The broad relationships existing between the climate and the vegetation were described in an impressionistic manner. In the central Himalaya, for example, three distinct farming systems are noted, namely, **terai farming systems, middle mountain farming systems, and high mountain farming systems.** As expected, due to the warm climate, the terai farming systems are characterized by the dominance of cropping activities, particularly , paddy cultivation. The middle mountain farming systems, on the other hand, are predominantly crop cultivation based, and the temperate climate and high elevations result in the prominence of maize over other crops. The importance of animal husbandry activities also tend to increase with the elevation. In contrast, high mountain farming systems are primarily livestock sector based. There are frequently, transhumance activities associated with this system; a single crop of barley, wheat or millet is also grown. During the discussion, however, it was noted that heterogeneity often implies that these generalisations constitute as much a rule as an exception. An important source of the farming systems' diversity lies in the microlevel climatic differences emanating from changes in the aspect (north or south facing slopes) and the orientation of a specific farm plot.

The diversity prevailing in the socio-economic domain was also presented, although the main attempt was to deal with the classification of the farming systems' diversity, commensurate with a set of **agroecological zones.** The latter has to be consistent with **climatic zones** and associated human interactions with the biotic natural resources of the various **botanical and/or crop zones**(related to climatic and ecological zones).

The problem of classification of the diverse farming systems, in the context of mountain development, indicated that the popular classification approaches have tended to be biased on account of a single differentiating factor, such as, geography, geomorphology, climate, botany, soil types and crops. It was noted that such single factor approaches are bound to gloss over the anomalies as microscopic irregularities which require other discriminating factors to explain the anomalies. Botanical classifications based upon crops or forest vegetation were shown to be unsatisfactory because forests tend to degenerate badly and most of the crops grown have great cultural affinity (so that they do not entirely capture or represent the agro-ecological factors). A classification suitable for conservation, the exchange of genetic resources, and for planned mountain development, must be based on an approach which can simultaneously deal with the critical elements of the agro-ecological zones and the farming systems (such as, climate, soils, botany, and farming practices).

Similarly, in dealing with the agricultural system of the Tibetan mountain regions, it was shown that the three main types of the farming systems were prevalent in Tibet (Cheng Hong). These systems can be presented in terms of the relationships between animal husbandry and crop cultivation activities. The first category can be represented by the **pastoral system**, where the major farming activities consist of animal husbandry. The **pastoral-farming** system consists of nearly equal levels of cropping and animal husbandry activities.

The **agricultural system**, the next category, is found in the lower valley regions where adequate sources of water to grow maize, wheat, barley and buckwheat exist. The **animal husbandry system**, prevalent in the north, west and high elevation south Xizang, have very little or no cultivation due to severe cold conditions, and depend solely on animal husbandry production for subsistence. The transitional **Pastoral farming systems** exist at the periphery of the agricultural areas, with dominant animal husbandry/livestock activities mixed with marginal crop cultivation. The **agricultural system**, in the valleys of the five large and small rivers of Yarlungzabu jiang, Lhasha he, Nyan Qu and Parlungzabu, grows cereals such as, wheat, rice, maize, barley and naked barley. The pastoral farming and agricultural systems may be further divided into three categories, namely, spring sowing single crop system, spring-winter sowing single crop system and the double crop system. The latter is possible only in the deep dissected river valleys of south east Xizang with a warm to hot climate and good water availability.

The farming systems of the middle and high mountain regions of Nepal are dominated by **Hill Farming Systems**, which are limited to river valleys and terraced slopes, with *khet* and *bari* lands **(Pant and Gautam)**. It is based upon **subsistence crop agriculture**, and is characterised by **intensive land utilization** and a heavy **dependence on livestock and forest inputs**. Livestock plays a crucial and decisive role in the hill farming system, as **it is responsible for the transfer of nutrients from forests and pastures to farm lands**. It was, however, noted that increasing livestock numbers is causing the fodder deficit. **Overgrazing and fodder lopping** have contributed to soil erosion and landslides. Maize is the dominant crop in the system, followed by rice, wheat and millet. In the *bari* land, popular cropping patterns are maize based along with finger millet as a relay crop. Mustard, potato and black gram are also grown, whereas soyabeans are often intercropped with maize. Because of wide micro-climatic variations, a high potential was noted for horticultural development within these systems, for both tropical and temperate fruits.

The Mountain Farming Systems, due to higher elevations and adverse climate, are primarily **livestock oriented**, with cropping depending entirely on livestock manure. Cultivation is limited to the lower slopes and the relatively fertile patches of narrow valley floor (along the rivers). The dominant crop is maize followed by wheat and rice, with rice/maize-wheat and buckwheat-naked barley cropping patterns respectively on the lower and higher elevations. Potatoes are grown at still higher elevations. The agro-climate of the mountains is very conducive to temperate fruits, such as apple, peach, plum, apricot. Great potential exists in fruit development for making whisky and concentrated juices in these areas, keeping in view the transportation hurdles. Potential for vegetables is also notable in these areas, particularly for seed production.

Therefore, it was concluded that for the improvement of hill agriculture, it is necessary to develop hill crops, livestock, horticulture and agro-forestry within a systems perspective. Improvement of input delivery systems, marketing and the use of integrated farming system research is needed.

b) **The Andean Mountain Region**

The environment, demography, social organization of production and the farming systems of the Andes are similar yet distinct with respect to that of Hindu Kush-Himalaya region. A case study of a peasant farming community of Amaru Cusco (Peru) was very informative. The rich and complex adoption and selection of crops and animals was shown to result from the particular climate, orography and the soil of the high Andes (**Mateo and Tapia**). The major agro-ecological zones, namely, *west inter-andean valley(yunga alta), quechua, puna, suni highland, lakeshores and eastern slopes*, traverse the Andes from west to east. These also correspond to the *homogeneous zones of productions* that was presented. Animal husbandry is important in high altitude zones, such as, puna, suni and the lakeshores, as in the case of Hindu Kush-Himalaya. The *suni* highland areas grow barley, quinoa, kaniwa and tubers of various kinds. The *puna* highland zones grow bitter potato species (*S. juzepzukii, S. curtilobum*) along with barley, kaniwa and tubers. Maize is a very important crop in the lower altitude *quechua* zone, although potato, barley and fafa beans, peas, and terwi are also grown. The *west valley* agro-ecological zone has maize, fafa beans, and fruits, as important products, along with potato, quinoa and tubers. It may be noted that animal husbandry systems in *puna* and *suni* zones are, respectively, based on *alpaca* and *llama*. The latter is important also in *quechua*, and *eastern slope* zones. Ruminants and goats are predominant in *west valley, quechua, suni and lakeshore* agro-ecological zones.

The special characteristics which are responsible for the evolution and sustenance of mountain agriculture and the large population of the Andes were indicated to be **domestication of crops and animal species, food conservation and storage systems, transportation and accounting systems.** The use of *quolqas* (large stone silos), for grain storage and the accounting system based on *Kipu* (knots) date back to the Inca period. The paper notes the edaphic conditions and the characteristics of indigenous soil classification systems, indicated above. The presentation also included the three main *homogeneous zones of production(HZP)* for Cusco, Peru. The maize, potato-cereal-legumes, potato-muyuys-range HZP's, respectively, were found at lower (3500 masl), middle (3600-3800 masl) and high(above 3800 masl) altitudes.

During the discussion it was pointed out that the demographic factors (migration) affecting the nature of the farming system, particularly with respect to other crops apart from maize and potato in the Andes, was not clearly understood. It was indicated that the increasing population pressure in the Andes has induced a significant degree of crop diversification. The other important crops grown are naked barley, wheat, oats, beans and lupines. Horticultural crops are not as well developed on account of the constraints of accessibility and markets. It was further added that, ruminants, hogs, and horses have been imported from the new world into the livestock sector. The replenishment of soil nutrient in the farming system was indicated to be a significant degree of animal manure applied in the fields in the Himalayas and the Andes. The use of fertilizer is, however, low on account of the high cost of fertilizer transport. The subsidy required is provided in some countries through low interest credits to buy modern inputs.

An important question emerged at this stage about the potential and feasibility of exchanging germplasm between the Andes and Himalaya, which are similar in many respects. It was stressed that action on this aspect is apparently still lacking, despite the realization of good potential and feasibility.

The discussion then moved towards the effect of accessibility, transport and other marketing services which change and affect the very structure of subsistence farming activities, moving more towards commercialised agriculture (with cereal cropping activities being substituted by horticulture and livestock activities). It was suggested that it is very important to examine and understand the role of livestock/animals within the farming system. The bias, which has emphasized crops so far, is being corrected in farming systems research in many countries. The homogeneous zones of production and the various factors/criteria which may be used in delineating these zones were discussed. It was noted that meteorological data and climatic aspects alone could not be used in the zonal classification. The indigenous names, such as, "puna" do describe relatively homogeneous production zones, which already take into account a diverse set of factors well known to the local inhabitants, such as, quality of soils, moisture and the established (feasible) production activity. It was further emphasized that micro-ecological factors, such as aspect and orientation, heavily influenced the type of crops that can be grown in an area.

c) **West Asia, North and Tropical African Mountain Regions**

The diverse mountain environments and the farming systems found there *describe tropical African mountain environments and their farming systems* in some twenty African countries (Ethiopia, Uganda, Tanzania, Rwanda, Burundi, Kenya, E.Zaire, and the islands of Madagascar and Reunion are notable for mountain environments) and therefore, represent an equal or greater degree of diversity in climate and botany as compared to the Andes or the Himalaya. The heterogeneity of tropical mountain environments also result in diverse farming systems in the African setting. The farming systems in these areas are largely dominated by rainfed mixed agriculture. These farming systems may be further divided into two broad types, namely, the **equatorial mountains/high lands** and the **sub-tropical mountains/high land farming systems (Getahun and Kirby)**. The first type of farming system is characterized by an intensive agricultural system based on horticulture, integrated with root/tuber crops and vegetables. The livestock sector is fairly important in this system for manure, as in the case of the Hindu Kush-Himalaya or the Andean region. Cultivation is done entirely by the hoe and cash crops such as tea, coffee, pyrethrum, *chat* are common.

The second type of farming system is dominated by cereal crops and utilizes plough agriculture. The major crops include cereals (wheat, maize, paddy), pulses and oil seeds. Animal husbandry is also important in this system. The highlands, lying between the first and second types of farming systems, show a transition between these two systems. For example, the eastern highlands of Ethiopia show both intensive and extensive farming systems, with a mixture of cereal and horticulture crops being cultivated. The diversity of food and cash crops is particularly high in the Ethiopian and the Arusha-Kilimanjaro region (Tanzania). There are about 169 types of crops grown in the Harar highlands (Eastern Ethiopia) and about 111 types in Arusha-Kilimanjaro region, many of which are cereals, oil crops, fruits, beverage crops, fibre crops, grain legumes, vegetables, bulbous roots, tubers, condiments and drug (medicinal) plants. Some of these crops are rare and are nationally and regionally important, for example, *tef* (**Eragrostis abyssinica**), *Lathyrus, Guizotia, abyssinica, Ensete ventricosum, Colcus edulis, Coccinia abyssinica, Catha edulis and Carthamus tinctorius.*

Mr. Potts presented his paper on *mountain physical environment and farming systems in west Asia and north Africa.* The environments of the west Asian and the north African mountains are also very complex although they are quite dry compared to the monsoon-dominated Himalayas. The presentation focused on details from the representative environment and the farming system of the Yemen Arab Republic. The tropical highland climate with an arid to semi-arid moisture pattern, and a bimodal rainfall regime, give rise to four main types of farming systems in this region. The **rainfed cropping system** is mainly based upon cereals(wheat, barley) along with legumes (cowpea, lentils) intercropped with sorghum. The **irrigated cropping system** grows maize, wheat, sorghum, along with vegetables and alfalfa. The **irrigated orchards** grow coffee, kat (catha edulis), grapes and banana. The **grazing system**, utilizing the tribal grazing rights, consists of cattle, sheep, goats, donkeys and camels (**Potts**). It was stressed that recent changes in opportunities for jobs in the adjacent oil-exporting countries have resulted in a large out-migration. This has undermined the majority of the farming systems in these mountain areas.

The discussion started with issues related to the recent trade imbalance in many countries of the region, such as, Yemen. It was indicated that, due to a large amount of the food being imported in the middle-eastern countries (which has had adverse effects on the agricultural sector), food security has become an important issue in these areas. It was thought that due to the oil boom in the middle-east, migration away from farms has become a serious problem; marginal fields are being abandoned in many areas. It was further suggested that the demand for livestock products has induced growth in animal husbandry activities and created over-grazing and erosion in many mid-eastern mountain areas.

However, due to falling oil prices, it is now seen that off-farm employment opportunities in many of the middle-east countries are also declining. The adverse effects on the hill areas have come about because of reduced employment opportunities outside and those farmers coming back to these hills find fewer alternatives. The increased pressure on these areas and the decline in the general fertility and productivity indicates the nature of the problems these areas face when exogenous factors change. These changes have, generally, tended to enhance genetic erosion in these mountains. In this context it is important to consider the approaches that can be used to identify and design sustainable development initiatives. Specific instances of the **diagnostic** survey used for physical infrastructure development, the **agro-ecosystems analysis** used for village development, the forestry **rapid appraisal** and the **farming systems survey** carried out for farmers in the AKRSP area of Pakistan were also discussed (**Hussain**). These techniques have been useful in identifying critical problem areas, village level priorities (for feasibility analysis), establishing an outline agenda for (prioritisation of) research and planning, and in making recommendations for village-level action-plans. The discussion further concluded that understanding of mountain environments required the researchers (and government/donors) to be able to learn about the hill farmers and their perspectives on their mountain environment. The process of learning was regarded to be of great importance in the context of preventing genetic erosion in the mountains.

B. Genetic Resources of Mountain Crops

The second day of the workshop was devoted to the genetic resources of mountain crops. The ten papers presented during the day focused upon the genetic resources of cereals, fruits, root and tuber crops from the Andean mountains, the Himalaya region, the Tibetan plateau, and the northern hills of Thailand. A couple of papers focused upon the diversity of genetic resources in general, for example, the paper on Thailand by **Chantaboon**

Sutthi and the paper on phytogenetic and zoogenetic resources of the Andes by Tapia and Mateo. Other papers concentrated upon the exchange of crop genetic resources carried out by the National Bureau of Plant Genetic Resources, New Delhi, India.

Two distinct and separate approaches to the categorization of plants were discernible during the presentation. The standard approach of classifying crops in terms of cereals, fruits, root and tuber crops, may be contrasted with the classification through end-use of these crops. For example, mountain and upland agriculture and genetic resources in Thailand have been described by **Chantaboon Sutthi** using the latter approach. He provided a detailed account of the farming systems and a detailed inventory of cultivated plants. The plants have been categorized in terms of *swidden* (shifting cultivation) and *non-swidden* crops. They are examined in terms of **(a) primary, (b) secondary, and (c)** socic-economic **and medicinal** use categories. The **primary** use is further divided into types of use, such as, staple food, vegetable, root-tuber-rhizome and animal food. The **secondary** use category consists of sub-categories: food and snacks, fibre and utensil and others. The last category has further sub-categories: **religious & ceremonial, decoration & cosmetic, cash, medicinal** etc. The classification of crops by other contributors was by traditional categories: cereals, fruits, tubers etc. However, it should be noted that **King and Vietmeyer, Mateo and Tapia,** find a great advantage in looking at these categories in the context of local indigenous names. The latter throw a considerable light on the place of these plants/crops in agro-ecological zones (so called homogeneous zones of production).

The traditional categorization (in terms of cereals, fruits etc.) are adequate to describe the components of the agricultural farming systems; however, they are not suitable for looking at change in crops grown and the factors influencing that change. The division of crops according to their uses provides various advantages. For example, the use categorization provides a useful means of identifying the various processes of change in the cultivation of diverse crops and plants.

It should be noted that a number of factors are responsible for the adoption of newer crops in the mountains and often the same factors are responsible for the abandonment of older, traditional crops or varieties. For example, the agricultural systems in Thailand are seeing a drastic change over the past decades, on account of economic and commercial factors and due to developmental interventions **(Chantaboon Sutthi)**. Similar changes were indicated in other parts of the Himalaya region **(Anwar and Bhatti, Tej Pratap, Bhattarai et al)** as well as the Andean region **(Tapia and Mateo, King and Vietmeyer, Tola et al)**.

The rate of genetic erosion in some areas is alarming and is found to be high in most of the mountain regions of the Hindu Kush-Himalaya, the Andes, and the African mountains. The need for deliberate intervention on the part of researchers and other scientists is a matter of considerable urgency if the genetic diversity of the mountainous agricultural systems is to be preserved, in the face of increasing vulnerability to low land market economic forces and the threat of over-specialization in crop cultivation (Chantaboon Sutthi; Tola et al, King and Vietmeyer). It may be further added that genetic erosion should be checked as far as possible through various ways of crop rehabilitation and reorientation of crop extension activities. The germ plasm collection, distribution and exchange, along with species research, are vital to achieve these goals.

Extensive deliberations concentrated upon the nature and diversity of the genetic resources present in these mountain regions within each type of the crop. Amongst the various uncommon crop species considered, a significant amount of time was spent during discussion upon the potential and prospects for cereals such as *chenopodium*, finger millet, arid and naked barley, upland paddy, maize. Tubers and beans were also dealt with, although the latter was not intensively deliberated upon. The discussions also focused upon the prospects for exchange of germplasm between Andean, Himalayan and African regions and the need to set up networks and institutional links between and among the countries of the region, at the national and the regional level, especially for the exchange and conservation of germplasm.

The genetic diversity existing in the mountains, and the continuing genetic erosion may be dealt with in terms of the following categories of crops;

a) Cereals (both conventional and non-conventional indigenous species)
b) Tubers and Root Crops, and
c) Fruits and Medicinal Plants

Occasionally, the discussion also took on beans and fodder crops, although deliberations on these did not take up enough time to warrant separate treatment. The importance of this type of crop was, however, realised and fodder was included in the Crop Exchange Table prepared during the final day of discussion and recommendation.

a) Cereal Crops

The crop genetic variability of various cereal plants, particularly the common species such as paddy, wheat, maize, barley, and finger millet, is indicated to be quite high in the Hindu Kush-Himalaya region, as well as in the Andean and African mountain regions. The adoption of high yielding varieties of these crops has again caused a considerable rate of genetic erosion of various land species.

The various cereal/crop genetic resource activities undertaken in various parts of the mountain areas are exploration, conservation, characterization and utilization (or breeding). In many mountainous countries and regions the absence of significant achievements in conservation and utilization of various land species has been caused by lack of long-term priority given to germplasm activities, lack of skilled manpower in research and low budgetary allocations, inadequate even for well established germplasm research activities. **Bhattarai et al** have indicated this to be the case in Nepal, for example, and a similar situation prevails in Bhutan, Pakistan and some African countries.

In the Hindu Kush-Himalayan region, various cereal crops have been collected and analyzed, although conservation and utilization in breeding have not been entirely successful. For example, in the Nepal Himalaya, some collection and analysis of rice, maize, wheat, barley and finger millet have been carried out. Similarly, the wheat and rice varieties of Pakistan are observed to be quite considerable (**Anwar and Bhatti**). In Pakistan the wheat species collected and analyzed include *Triticum aestivum, T. Durum, T. turgidum and T. polonicum.* The rice varieties collected from Baluchistan belong to the species *oryza sativa.* The immense climatic, topographical and edaphic variations reflect corresponding changes in the developmental characteristics of these crops. *T. aestivum* populations display differences in awning, pubescence, straw thickness and other traits. Similarly, diversity in several genetic and agro-morphological traits as observed in indigenous rice varieties. Some wheat varieties (*Triticum sphaerococum*) were found to be highly drought resistant.

In the Indian Himalaya, the role of the National Bureau of Plant and Genetic Resources (NBPGR) in India, has been quite considerable in exploration, characterization and exchange of crop genetic resources *(Joshi and Paroda).* Activities included the collection of 10,000 samples of wheat, maize, amaranth, buckwheat, cheropod, millet, mustard, beans and peas, from many parts of India, between 1980-1986, from Jammu and Kashmir to Tripura and Assam. These germplasms were evaluated for various agro-morphological characteristics and important donors and elite lines were identified and multiplied for distribution (more than 33,000) to crop improvement programmes, user agencies and international research institutions.

Similarly, the pattern of variability of important high land crops, such as millet *(Elensine Coracana (L) Gaertn)* with altitude has been studied in detail. The structure of yields has been evaluated on the basis of phenotypic characteristics *(Mann).* The eighteen varieties tested at three elevations indicated a heterogeneous pattern of adaptability. For example, the **total grain bearing area** has a direct relationship with yield. Analysis indicates that the influence of the environment tended to differ considerably from one to the other. The yield contributing factors tended to possess average adaptability at high altitude mountain conditions and thus provides a good basis for using these cultivars in breeding programmes to improve yields.

The introduction of modern varieties of the crops has generally tended to displace many native crops and cereals. The conservation and development of these native crops, such as *amaranth, quinoa, chocho (Lupinus mutabilis)*, and tubers, such as Oca *(Oxalis tuberosum)*, melloco *(Ollucus tuberosum)* have been emphasized repeatedly. It has been indicated that although the cultivation of Chenopod declined recently, it is still being cultivated in many parts of the Himalayan range, such as, Jammu and Kashmir, Himachal Pradesh, Utrakhand, Sikkim, the Khasi Hills of India, in Nepal and parts of China **(Tej Pratap)**. The nutritive value of these grains is high, as they contain 16% protein, 7% fat and nearly all the amino acids in appreciable quantities. This crop is very suitable for mountain agriculture on account of its adaptability to mixed farming, relatively short phenological calendar and ability for easy germination and establishment. However, the crop may face extinction if it is scientifically neglected and not developed to its highest potential.

After the examination of the status of valuable native Andean crops in the mountains of Ecuador, it was indicated that, despite being a major centre of plant genetic diversity within the Andean region, Ecuador has depended on only a few species for domestic consumption and export, such as, maize, potato, barley, wheat, beans and fafa beans **(Tola et al)**. Native Andean grains such as quinoa *(Chenopodium sp)*, chocho *(Lupinus mutabilis)*, amaranto *(Amaranthus sp)* and tubers, such as, melloco *(Ollucus tuberosum)*, oca *(Oxalis tuberosum)* have been relegated to a minor position, despite their potentially high utility in mountain regions. However, these species are still predominant in the fields of poor farmers. The recent progress made in germplasm collection, farm trails and culinary demonstrations of quinoa in Ecuador indicates that other Andean crops may be similarly promoted in other mountain regions.

In the context of the overall Andean region, the crops and animal resources indicate a rich diversity and a tremendous potential for future collection, development and extension. **(Tapia and Mateo)**. Furthermore, the evolution of the farming system in the Andes represents a high degree of integration of cereals, root crops and tubers with the unique Andean camelid. The grain crops discussed were Quinoa, Kaniwa, Kiwicha, Tarwi, along with tubers, Oca, Olluco and Mashua. The root crops considered were Maca, Jimaca, Ajipa, Arracacha, Yacan *(Jiquima)* along with native fruits, Chirimoya, Pacae, Huagra-manzana, Tumbeo, Capuli, Lucuma etc. The South American camelid, such as, Llama, Alpaca, Vicuna, Huanaco, and domesticated birds (poultry) and rodents have potential for further promotion in various mountain environments. The present efforts devoted to collection and establishment of crops and animal germplasm banks have been indicated along with the responsible institutions.

In the Himalayan region, which is far from being a unique case, the comparative study of wild and domesticated barley has thrown considerable light on the potential for genetic improvements in various crops **(Shao, Zhou and Li)**. The genetic unity of wild and cultivated barley has been demonstrated after a comparative analysis of different species of wild and cultivated barley from the northern and the southern slopes of the Himalaya. The morphological, cytological, genetic and ecological analysis supports the thesis of genetic unity within the wild and domesticated varieties. This has provided a better understanding of the process of barley evolution and has tremendous practical importance because wild barley, which is highly disease resistant, provides the original material for disease resistant breeding. It was emphasized that similar possibilities exist with respect to other crops such as rice, wheat and maize, with tremendous potential benefit to all mankind.

b) **Tuber and Root Crops**

The evaluation of Andean root and tuber crops indicated the potential for exploitation of at least nine major root and tuber crops from the high lands of South America to the Himalayan and African mountain regions **(King and Vietmeyer)**. The presentation focused on the distribution, habitats, cultivation, utilization, nutritional value of maca *(Lepidium meyenii)*, ulluco *(Ullucus tuberosus)*, Oca *(Oxalis tuberosa)*, Anu *(Tropaeolum tuberosum)*, Arracacha *(Arracacia xanthorrhiza)*, Achira *(Canna edulis)*, Mauka *(Mirabilis expansa)*, Ajipa or Jicama *(Pachyrhizus tuberosus)*, and Yacon or chicama *(Polymnia sonchifolia)*. The sources of seeds, germplasm and information for the crops were indicated. The need for basic and applied research on diseases, pests and post-harvest processing techniques of these crops was emphasized so that they could be transferred to other eco-geographic zones. The establishment of a coordinated **network of international crop exchange should be promoted** between countries with mountain environments to facilitate the diffusion and exploitation of these valuable crop genetic resources.

The tubers and root crops specifically from the Hindu Kush- Himalaya and the African mountain regions were not highlighted, although it was indicated that a diverse set of potatoes and yams were available in these areas also. In the high altitude areas in the Himalayas it was reported that potato cultivation provides an important contribution to the food supply and therefore, there was a need to develop a disease and drought resistant potato *(Solanum sp.)* crop suitable for these high altitude areas, which are prone to frost. It was also indicated that some species of potato from the Andes have leaves with a sticky substance on them which glues small insects *(nematodes)* to the leaves. Such genetic characteristics are desirable and may be bred into other potato species which would then be able to control insect attacks.

c) **Fruits and Medicinal Plants**

In dealing with the crop genetic resources of Nepalese mountains, it has been pointed out that there exists a good store of tropical and temperate fruits and valuable medicinal plants in various agro-climatic niches in the Himalayas (**Bhattarai et al**). Amongst the medicinal plants, *Digitalis, Atropa belladona, Chrysanthemum, Ceneraiaefolium* are grown in the temperate zone herbal farms. The subtropical medicinal plants grown are *Rauwolfia serpentina, Cympopogon winterianus, C. matinii, Mentha ariensis and Dioscoria floribunda.* The various activities undertaken in Nepal are exploration, conservation, characterization of fruits and medicinal plants. It was, however, noted that development of species for extension and domestic cultivation has been limited on account of various financial and accessibility constraints in Nepal and Bhutan Himalayan regions.

The discussion on activities related to the fruit genetic resources of the mountains of Pakistan (**Bhatti and Anwar**) and India (**Joshi and Paroda**) concentrated on the collection and conservation of various fruit germplasms for peach, apricot, plum, almond, cherry, apple, grapes, walnut, pear, pomegranate, quince, mulberry and fig. The species samples collected by PARC in Pakistan (NWFP and Baluchistan) were 96,227,137 respectively for the years 1982,1983, and 1986. These are maintained in clonal repositories. The cutting of fruit trees for firewood and the distribution of grafted fruit seedlings pose a severe threat to indigenous fruit varieties and cause genetic erosion.

Similarly, germplasms in India are maintained on various types of fruits at NBPGR and at various horticulture stations in the states of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir.

In view of the great potential contribution which fruit, vegetable and fodder trees can make towards the growth of mountain economy, elements of future strategies were outlined. These elements consist of collection of local germplasm, introduction of high value crops, establishment of mountain crop research systems, farming system research and international cooperation in the exchange of information and germplasm through exchange visits and seminars (**Bhattarai et al**).

A lively discussion ensued on the tolerance of toxins in amaranthus, chenopodium and quinoa. It was pointed out that several washings were adequate for the removal of these toxins for human consumption. The discussion then moved to issues of germplasm exchange: lupins were commercially cultivated in Ethiopia and Kenya, along with the introduction of tree tomatoes and passiflora during the sixties and the regular exchange of plants occurred between Ethiopia and Ecuador. The differences in altitudinal and geographic cropping limits (due to temperature and rainfall) between the Andes and the Himalaya were pointed out. The need for agro-ecological zonations for both the regions was indicated so that source and target areas for crop exchange could be demarcated. These conclusions were further elaborated during discussion on the final day of the workshop and the Crop Exchange Table worked out as shown in the following section.

Conclusions and Recommendations

On the final day of the workshop, participants divided themselves into two discussion groups as follows:

Group A - Special Features of Mountain Agriculture and Farming Systems.

Group B - Mountain Crop Genetic Resources.

An extensive and in depth discussion took place in both the groups. During the final plenary session, the following summary of discussions and recommendations was adopted.

a) **Discussion Of Group A On Mountain Farming Systems**

1) *Characteristics of Mountain Farming Systems*

It was, first of all, recognized that any effective research and development in farming systems must take into account the complex nature of Mountain Farming Systems(MFS). The following characteristics set MFS apart from other agricultural production systems:

a) **Fragility:** Mountain Farming Systems, although consisting of considerable diversity in ecosystems and genetic resources, are generally extremely fragile due to steep slopes, erodable soils, intense rainfall, intensive cultivation and uncertain markets. Consideration of the issue of stability is needed in introducing change in MFS.

b) **Diversity:** MFS over short distances exhibit different micro ecosystems(different crops, varieties, cropping patterns, etc.). Altitude is a major factor influencing this diversity. It was suggested that with increasing altitude this diversity narrows and more simple MFS are found. Aspect(direction of slope), slope and soil type are other important components of this diversity.

c) **Community-linked production:** MFS, particularly those with grazing or agro-forestry components, imply community issues(allocation of resources, cooperative production), distinct from individual issues involved in private production in MFS. Community organization in MFS may be weakening as rural-urban links are made.

d) **Information Limitation:** MFS have little documented information available both within a country and between regions. Language considerations limit access to some national information (Spanish, Chinese). The high mountain farming systems are particularly lacking in documented studies.

e) **Low Political Priority:** MFS due to their remoteness and complexity, are usually accorded the lowest priority for research and development activities in most national strategies, after those of lowland rainfed and irrigated production systems.

f) **Dynamic Evolution:** MFS are changing to meet new physical and cultural influences. Some influences(out-migration, erosion) are of critical concern in the consideration of the future of MFS. Other changes (shifts in production patterns - potatoes for buckwheat in Bhutan) reflect the positive dynamic adjustment of MFS to these influences.

Recommendations on Mountain Farming Systems

In view of the issues and characteristics indicated above, greater emphasis is needed on systems research of MFS. Additional support to national programmes in conducting research on the biological and physical components of MFS is suggested.

The implication is that governments, donors, and researchers must consider longer-term support and commitment to research and development activities in MFS. Major advances in research or development of lowland agricultural systems occurred only after the cumulative effort of many years of research and development support. The above characteristics of Mountain Farming Systems must be carefully considered if improved mountain farming systems are to be developed for greater productivity and stability.

2) *Components of Mountain Cropping Systems*

a) A holistic approach to research in mountain areas is clearly essential in view of the extreme complexity of the issues involved. Nevertheless, it was decided to concentrate the discussion on cropping systems and the components of cropping systems, in order to arrive at some specific recommendations in line with the overall theme of the meeting, i.e., the exchange of information and germplasm between different mountain regions. This is also consistent with the fact that this meeting is the first of a series to be hosted by ICIMOD to look at different aspects of mountain agricultural systems, leading to a symposium in 1988 in which these various aspects will be integrated.

b) The value of the exchange of information between various countries and mountain complexes was stressed. Such information exchange could include, but would not be limited to, topics such as training, land preparation and cultivation techniques, irrigation and drainage techniques, rotation and appropriate tools.

c) In view of the increasing importance of potatoes in many areas, this crop should receive some priority in the future exchange of germplasm and information between various regions. Knowledge about traditional potato and bitter potato cultivation and post-production techniques of the Andes, for example, could prove very valuable in the Himalayas. Ways should be sought to strengthen the interaction between these regions, and also others where potato cultivation is important. CIP, which is already active in germplasm and information exchange, is probably best placed to continue to coordinate these activities. However, extra donor and other assistance may be required in order to focus more attention on traditional high mountain systems of cultivation.

   The prominence given to potatoes in the discussion does not imply that other crops were considered of secondary importance, but rather that there was insufficient time to consider all the species and that, in any case, this topic would be addressed by Discussion Group B.

d) It is often difficult to conduct conventional agronomy and yield trials in mountain environments. More work should be done on developing and/or disseminating information about alternative experimental designs appropriate to mountain conditions.

Recommendation for Information Exchange

1) It was recommended that consideration be given by ICIMOD to producing a regular newsletter to facilitate information exchange on mountain agricultural systems covering all major mountain complexes in the world. This would be an informal 'newsletter' rather than an international scientific journal. The utility of such a newsletter would be greatly enhanced if it were to be produced in both English and Spanish.

2) A large data base on Andean agriculture is being developed in Peru and this information is available to researchers worldwide. Similar data bases should be developed for other mountain complexes.

3) Exchange visits of scientists between different mountainous regions is

a very effective way of exchanging information and knowledge. ICIMOD and donor agencies should consider ways of encouraging and supporting such scientific exchanges.

b) Discussion Of Group B On Mountain Crop Genetic Resources

1. It was recognized that exchange of mountain crop germplasm is needed in order to develop more stable, sustainable and productive mountain agricultural systems and to improve the conditions of those who depend on agriculture in mountainous regions. Information on the crops themselves, where they are adapted, how they are used, is an important component of such exchanges.

2. A table was developed containing lists of mountain crop species which could be exchanged between regions or countries. This table, shown below, is to serve as a guide to facilitating the bilateral exchange of mountain crop germplasm.

3. It was recommended that each country provide a brief description for each of the crops that can be exchanged. The description is to include:

   - Altitude range, aspect and slope where the crop is grown.
   - Average rainfall.
   - Soil pH.
   - Cropping Systems.
   - Yields.
   - Dates planted and harvested.
   - Special traits.
   - Uses.
   - A line drawing of the crop.

   The address of the scientists and institutions that can provide the germplasm for each crop and a short description of the procedure required to exchange germplasm should be provided from each country.

   It was recommended that ICIMOD compile these descriptions into a booklet for distribution.

4. In many countries, government regulations or policies make exchange difficult. It was recommended that participants draft a strong letter to their respective governments, reflecting the consensus at this meeting that increased exchange between different mountain regions in the world is necessary to develop improved agricultural systems.

5. The following types of exchanges were recommended:

   a) Direct exchange of mountain germplasm material. This should start immediately with country-to-country exchange of true seeds.

   b) Exchange of small groups of scientists.

   c) Multi-disciplinary expeditions of 5-7 members, including farmers from different Andean countries, to different countries in the Himalayas, and vice versa. Organizations such as ICIMOD, IBPGR, IDRC and national governments should be involved in facilitating these exchanges. Such expeditions could lead to much greater understanding about how mountain crops can best fit into new environments.

6. Roots, tubers and perennial crops require tissue culture methods for exchange and conservation. Suitable methods of tissue culture should be worked out for these crops.

7. There is need to match up similar environments in different regions in order to increase the probability of successful introduction. Several methods of describing and classifying environments should be examined, including climatological and geographic descriptors and uses of indicator crops in classifying environment. The local uses of the crops to be exchanged is an important factor in understanding the cultural environment.

8. Participating countries should exchange highly variable land races rather than genetically homogenous lines. This will improve the chances of adaptation and help to promote more stable production.

9. National institutions have the primary responsibility for collecting, storing and improving many of the mountain crops.

   a) Stress should be laid on improving the national capability for storing germplasm of these crops.

   b) Collection of many mountain crop species is needed urgently to conserve the valuable genetic diversity which is being lost in many cases.

10. International Agricultural Research Centres have a role to play in collecting, documenting, conserving and exchanging those mountain crops for which they have a mandate. National scientists should make use of the resources of these international centres.

11. In the exchange of crop material, suitable quarantine regulations must be observed to prevent the spread of pests, diseases or nematodes.

12. Improved communications and information in mountain regions is an important agent in the evolution of mountain agricultural systems from subsistence towards cash crops. The crops being exchanged or improved must reflect the present and expected evolution of these systems.

13. The use of computers as a valuable tool for documenting genetic resources and classifying environments is encouraged.

14. It was recognized that ICIMOD has a central role to play in collecting and disseminating information, and in facilitating the exchange of people between mountain regions.

CROP EXCHANGE TABLE

	Andes		Hindu Kush -Himalaya		Africa	
TYPE	Native crops to be sent out	New crops for introduction	Native crops to be sent out	New crops to be introduced	Native crops to be sent out	New crops to be introduced
Creal/Grains	Amaranthus spp.LR Chenopodium LR (Quino, Kanawa)	Amaranthus spp.LR Chenopodium spp.LR Eragrastis tef Hordium spp.PE Fagopyrum spp.	Amaranthus NP,IN Hordium spp.LR,NP,IN Fagopyrum,NP,PA,IN Eleusine spp.LR,NP Panicum LR,NP,IN Triticum spp.LR,PA,IN Zea mays spp.PA,IN Oryza Sativa spp.PA,IN	Amaranthus NP,IN,AF Hordium spp. LR,CH,IN Triticum spp. LR,IN Zea mays spp. IN High Alt. disease res. Res. Oryza Sativa PA,IN Fine rice PA	Eragrostis tef Hordium spp. LR Triticum spp. Oats	Amaranthus Chenopodium quinoa Fagopyrum spp. LR
Tubers/Roots	Arracacia spp.LR Oxalis tuberosa Tropaeolum tuberosum Ullucus tuberosus Polymnia sonchifolia Lepidium meyenii Solanum,(bitter hi.al.)		Colocasia spp. LR,IN	Oxalis tuberosa LR,NP,CH Solanum bitter potato CH,NP Ullucus tuberosus NP,CH Lepidium meyenii NP,CH Pollymnia sanchifolia NP	Coleus adulis Coccinia abyssinica	
Legumes, Pulses, Oilseeds	Lupinummutabilus Vicia faba	Disease resistant Lens culinaris Brassica spp.	Vicia faba PA Lans culinaris IN,NP Brassica spp IN, CH Horsegram-Dolychis Biflorus NP Blackgram Phaseolus mungo NP Glysine Max NP Cannabis spp. IN Agropyrum CH	Brassia spp. IN,CH Campestris CH Nepis CH Cicer spp. PA Phaseolus calcaratus IN Blackgram NP Pisum sativum Var aravensepeir NP	Vicia faba Lathyrus sativa Lupinus albas Cicar spp. Guizotia abyssin (Niger) Trifolium	Brassica spp. Perilla fruitescins Lihum sp. Madhuca butyracea Oil crops requested !
Fodder trees	?	Request from NP	(?)Brassiopsis glomerata NP		Numreous available from ILCOT	
Fruits	Carica spp. Cyphomandra spp. Prunus Calpuli Opuntia Passiflora spp.	Vegetables dis.res.	Apricot,Peach, Apple Walnut, Pear PA	Appricot res. fruitfly, PA Apple, Cashew PA Walnuts, Pecannuts IN Sunflower res. PA		
Medicinal Plants	+	Cardamon	Medicinal Plants NP	Medicinal Plants IN Tea, Olive 2000m PA		

Legend to Crop Exchange Table

1. In most cases it is stated that well known crops requested such as, maize, wheat, rice, refer to high altitude cold resistant and/or disease resistant crops or land races.

2. Spp = any number of species LR = various land races NP = Nepal IN = India PA = Pakistan CH = China AF = Africa(East African highlands).

Summary of Recommendations

I. *General Recommendations*

There should be:

1) Increased emphasis and long term support for mountain agriculture research and development

2) Increased collection, preservation and maintenance of potentially useful mountain agriculture germplasm

3) Mutual exchange of germplasm between similar mountain agriculture areas

4) Continued scientific exchanges on mountain agriculture

5) Continued lobbying among scientists and politicians to stress the importance, uniqueness and fragility of mountain agriculture systems.

II. *Specific Recommendations*

1) The exchange of information can be achieved by (a) newsletters, (b) background on suitable crops including agronomic, cultural, post harvest and food preparation information.

2) The germplasm exchange should be initiated by a list of (a) what crops are available from which institution and country and (b) the needs of each country (a preliminary list is being prepared). The germplasm exchange should initially include a wide range of genetic material(e.g., land races or populations). Information on the performance of the exchanged material must also be made available.

3) Germplasm storage of mountain agricultural crops must be decentralized using facilities of National Centres, and of international institutes for their mandate crops.

4) The exchange of personnel between different mountain areas should involve scientists, policy makers and farmers.

III. *Methodology Research*

Specific methodology questions were also raised:

1) How to characterize mountain agriculture environments: It was suggested that indicator crops, agro-ecological, agro-meteorological and socio economic factors might all be required.

2) How to exchange germplasm: What are the mechanisms, regulations and protocol necessary? How can roots, tubers and fruit crops be exchanged safely to prevent spread of viruses?

3) What is the best strategy of exchange? Should there be a wide range of diversity, e.g., land races or segregating populations? Should exchange be between similar zones or from widely differing geographic areas?

4) What is the best strategy for testing? Should they be tested in common environments and multi-locational trials? Can testing be simplified? How can one determine gene X environment interactions?

IV. *Strategies for Accomplishing the Recommendations*

The discussion groups also recommended various strategies to accomplish their recommendations.

1) Exchange of mountain crop germplasm through bilateral collaboration between national research centres as well as existing international centres, gene banks and through networks whenever possible.

2) ICIMOD should assist and support

   a) the exchange of information and documentation

   b) coordinate collaboration and exchange between mountain systems

   c) the whole system approach to mountain agricultural development (e.g., crops, trees and animals)

3) The exchange of information and genetic material should be initiated and reinforced by a further exchange of visits. It was recommended that initially two scientists working on Himalayan mountain crops visit the Andes, bringing with them Himalayan crop germplasm. During their visit they should be involved in collecting Andean crop germplasm, and become familiar with the cultivation and use of these crops in the Andes. An exchange visit would then take place, followed by larger expeditions which should include farmers.

Annex 1.

Workshop Programme

DAY ONE

Opening Session

WELCOME — Dr. Colin Rosser
Director, ICIMOD

OPENING — Mr. Hari Narayan Rajauria
Hon'ble Minister of Agriculture, Law and Justice

INTRODUCTION TO THE WORKSHOP

Dr. Geoffrey Hawtin
Associate Director, IDRC

Session 1

MT. PHYSICAL ENVIRONMENT AND FARMING SYSTEMS

CHAIRMAN — Geoff Hawtin

RAPPORTEURS — Tola, B.Bhadra, G.Potts

Hindu Kush-Himalaya Region
Ram P.Yadav & P.L.Maharjan

Agricultural System of Xizang
Cheng Hong

Mountain Farming System in Nepal
J.C. Gautam and Mahesh Pant

High Mountain Environment and Farming Systems in the Andean Region of Latin America
N. Mateo and M. Tapia

Session 2

Tropical African Mountain Environment and Their Farming Systems
Amare Getahun

North African and Mid-Eastern Mountain Environment and Their Farming Systems
Gordon Potts

Approaches and Techniques for Assessing Mountain Environment
Tariq Husain

DISCUSSANT — Daniel Galt - ARPP, Nepal

DAY TWO

Session 3

GENETIC RESOURCES OF MOUNTAIN CROPS

CHAIRMAN — Mario Tapia

RAPPORTEURS — Ken Riley, Amare Getahun, Prodipto Roy

Indigenous Cereal Crop Genetic Resources in the Mountains of Pakistan
Rashid Anwar

Collecting Fruit Genetic Resources in the Northern Mountains of Pakistan
M. Sadiq Bhatti

Session 4

Pattern of Variability of Eleusine Coracana (L) Gaertn to High Altitude and its Influence on the Structure of Yields

Surinder K. Mann

Chenopodiums and other Mountain Crops used in Himalayas of India

Dr. Tej Pratap

Crop Genetic Resources of Nepalese Mountains

A.N.Bhattarai, B.R.Adhikary and K.L.Manandhar

Unity of Genetic Population for Arid Barley and Cultivated Barley in Himalayan Area

Shao Qiquan, Zhou Jeqi and Li Ansheng

Mountain and Upland Agriculture and Genetic Resources (Thailand)

Sutti Chantaboon

Session 5

Status of Valuable Native Andean Crop in the High Mountain Agriculture of Ecuador

J. Tola Cevallos, C. Nieto, E.Parolta, R.Castillo

The Andean Phytogenetic and Zoogenetic Resources

M.Tapia, Nicholas Mateo

An Evolution of Andean Root and Tuber Crops: Genetic Resources for Mountainous Environments

Steven R.King and Noel D. Vietmeyer

Mountain Crop Genetic Resources with Special Emphasis on Ethopia

Dr. Melaku Worede

Mountain Crop Genetic Resources (Morocco)

Mr. Azzedine Douiyssi

Session 6

INTERNATIONAL COOPERATION ON MOUNTAIN CROPS GENETIC GERM PLASM

Role of NBPGR Exploration, Characterization and Exchange of Mountain Crop Genetic Resources

B.D. Joshi and R.S. Paroda

DAY THREE

FIELD TRIP

DAY FOUR

Session 7

CHAIRMAN Mario Tapia, Hawtin

RAPPORTEUR Nicholas Mateo, Steven King, P.L. Maharjan

GROUP DISCUSSION

Group A Special Features of Mountain Agriculture and Farming System

Group B Crop Genetic Resources of Mountain Crops & Genetic Germ Plasm Collection, Conservation and Exchange

Session 8

GROUP DISCUSSION (contd.)

Session 9

CONCLUDING SESSION/GROUP PRESENTATION

CHAIRMAN Dr. Colin Rosser

Recommendations and closure of the workshop

Annex II

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33. Dr. Prodipto Roy

34. Mr. P.L. Maharjan

35. Prof. Zhang Rongzu

36. Dr. Binayak Bhadra

37. Dr. Kk Panday

38. Dr. Mahesh Banskota

Annex III

List of Workshop Papers

An Evolution of Andean Root and Tuber Crops: Genetic Resources for Mountainous Environment	Steven R. King and Noel D. Vietmeyer
Agricultural System of Xizang	Cheng Hong
Approaches and Techniques for Assessing Mountain Environment	Tariq Husain
Chenopodiums and other Mountain Crops used in Himalayas of India	Dr. Tej Partap
Collecting Fruit Genetic Resources in the Northern Mountains of Pakistan	M. Sadiq Bhatti
Crop Genetic Resources of Nepalese Mountains	A.N. Bhattarai, B.R. Adhikary and K.L. Manandhar
High Mountain Environment and Farming Systems in the Andean Region of Latin America	N. Mateo and M. Tapia
Hindu Kush-Himalaya Region	Ram P. Yadav and P.L. Maharjan
Indigenous Cereal Crop Genetic Resources in the Mountains of Pakistan	Rashid Anwar
Konso Agriculture and Its Plant Genetic Resources	J.H.M. Engels
Mountain and Upland Agriculture and Genetic Resources (Thailand)	Sutthi Chantaboon
Mountain Crop Genetic Resources with Special Emphasis on Ethopia	Dr. Melaku Worede
Mountain Crop Genetic Resources (Morocco)	Mr. Azzedine Doulyssi

Mountain Farming System in Nepal	J.C. Gautam and Mahesh Pant
North African and Mid-Eastern Mountain Environment and Their Farming Systems	Gordon Potts
Pattern of Variability of Eleusine Coracana (L) Gaertn to High Altitude and its Influence on the Structure of Yields	Surinder K. Mann
Potatoes, Genetic Resources and Farmer Strategies: Comparison of the Peruvian Andes and Nepal Himalaya	E. Rhoades
Role of NBPGR Exploration, Characterization and Exchange of Mountain Crop Genetic Resources	B.D. Joshi and R.S. Paroda
Status of Valuable Native Andean Crop in the High Mountain Agriculture of Ecuador	J. Tola Cevallos C. Nieto E. Parolta R. Castillo
The Andean Phytogenetic and Zoogenetic Resources	M. Tapia Nicholas Mateo
Tropical African Mountain Environment and Their Farming Systems	Amare Getahun
Unity of Genetic Population for Arid Barley and Cultivated Barley in Himalayan Area	Shao Qiquan, Zhou Jeqi and Li Ansheng
Agriculture in Bhutan	D. R. Ghalley

Annex IV
Summaries of Papers

Reviews

ENVIRONMENTAL DIVERSITY AND ITS INFLUENCE ON FARMING SYSTEMS IN THE HINDU-KUSH HIMALAYAS

P.L.Maharjan, B.Bhadra, P.Roy,
R.P.Yadav, Z. Rongzu

The Hindu Kush-Himalaya (HK-H) region consists of mountains, hills and plateaus of Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh and Burma. It is between 22^0-38^0 N latitude and 60-150^0 E longitudes. The elevations in the HK-H region range between 150 m to 8800 m and the average altitude exceeds 4000 m for the entire ranges which consist of (a) Hindu Kush starting from N-W Afghanistan and leading upto western part of NWFP of Pakistan, (b) Karakorum, (c) western Himalaya consisting of eastern part of NWFP of Pakistan, Jammu and Kashmir and Himachal Pradesh (d) Central Himalayan, consisting of Uttar Pradesh and Nepal, (e) Eastern Himalaya formed by Sikkim, Bhutan, Arunachal Pradesh, Assam, Meghlaya, Tripura, Nagaland, Manipur (consisting of ranges such as Eastern Himalayas, Naga Hills, Chin Hills, Khasi Hills), (f) Tibetan plateau, and (g) Henduan Mountain.

Thus HK-H represents greatest variation in altitude with earth's highest mountain range the Himalaya and nearly touching one of the lowest spots on earth. Drained by three of its major river systems such as Indus, Ganges and Tsangpo - Brahmaputra, the whole of HK-H have been characterized by complexes of mountain systems, climates and vegetation which nearly exhausts the global diversity within the region.

Climatically, the world's highest rainfall (more than 5000 mm. annually) area such as Cherapunji in the Eastern Himalayan region to cold trans Himalayan areas (receiving less than 40 mm. rainfall annually) lie in this region. The temperatures drastically vary with altitudes as well as the prevailing wind conditions.

Vegetation wise, the HK-H is abound with tropical wet forest in NE Himalayas, dry moist forest in the central Himalayas, dry scrub land steppe vegetation in western Himalaya to almost desert like scrub and forages on Baluchistan, Hindu Kush and cold deserts in Tibetan plateau and other rain shadow areas.

Infact, wide climatic and geomorphic diversity have offered many opportunities for cultivation of food crops, fibres, fruits, medicinal plants, fodder and fuelwood trees in the extensive valley, terraced hill and mountain slopes, and cultivable mountain tops in the HK-H Region. Genetic diversity have been brought out sometimes by trade and migrations, and multiplied for generations. HK-H region consists of very diverse agro-ecological zones, the implication of which for farming systems are immense and lead to diverse systems of farming. Therefore, by way of illustration only a few typical examples are summarised here under.

A study of hill farming systems in Pakistan found that a number of farming systems have evolved as a varied and distinct ecological conditions of the hilly and mountainous terrain of the north Pakistan. Comparision of two agroclimatic zones at different altitudes, indicate that a better access, better land quality, lower altitude (sub-tropical with more growing seasons) and irrigation facilities make a tremendous difference in costs, cropping intensity, production, marketing and opportunities for off-farm employment. In contrast rainfed cultivation and lower cropping intensity and lower employment prevail in high and more difficult terrain.

The High Mountain Farming Systems are generally found in association with trans-humance in areas above 3000 m., in the central Himalayas. The climatic conditions often allow only one crop of barley or buck wheat and potato constitute the main crop. Livestocks are of major importance in this farming system.

MOUNTAIN PHYSICAL ENVIRONMENT AND FARMING SYSTEMS IN WEST ASIA AND NORTH AFRICA

Gordon Potts, IDRC, Cairo

Including the countries in North Africa and those of West Asia, about 14 percent of the total land area is comprised of the mountain farming systems. Like in many other mountain systems, these areas suffer from problems, small and fragmented terain farm lands, hazards of soil erosion, traditional production systems. Prevalance of several mountain ranges present diverse situtions in the region. The major tropical features of the region constitute the Rift-Atlas mountains along the coast of Morocco and Algiers, the Taures Mountains in the eastern Turkey and the Zargos Mountains in Iran and Iraq.

The Atlas Mountain Systems dominate the physical geography of North-East these mountians continue to be unstable. These mountains have distinct four massifs in Morocco. These include a rugged area along Mediterranean coastline rising 2200 m in the North to 3000 to 4000 meters in height as Middle Atlas, to the High Atlas towards south and then falling to lower southernly ranges. From eastern Turkey south-east through central Iran a series of mountain predominates, one range folding into another. In Turkey rings of mountains enclose a series of inland plateaux, Mount Ararat being the highest (5165 m) in the east. Fresh and salt ranges in Turkey, thus are, Taurus Mountains along the eastern Mediterranean and Poutine Mountains in north east area along the Black Sea. The Zagros mountain starts from North west of Iran forming parallel high tablelands and low basins alternately, the ridges reacing over 4000 meter high sweeping south and east to the Arabian Sea. The Elburz range also starts in the North-west and passes along the south edge of Caspian Sea. It is a narrow range with the volcanic cone of Mt. Damavand rising to 5604 m. Strong winds and wide temperature variations make much of Iran unsuitable for supporting population. However along Caspian coast in the Elburz range with upto 2000 mm rainfall special climatic conditions like those in lower Himalayas are prevalent.

Afghanistan is dominated by Hindu Kush range peaking upto 6000-7000 m.

The last range of mountain in the region runs along the south-west edge of the Arabian pennisula, primarily in the Yemen Arab Republic. This range has received the most scholarly attention of all the ranges in the region. So a detailed mountain agriculture environment of this range has been dealt in the paper as a representative of this diverse region.

Of the 8.6 million (1981) peoples in the Yemen Arab Republic 89% reside in the rural areas spread above 200000 km^2 of the country's territory. Of this 75% of the territory lies in the mountains. Agriculture contributes 37% to the GNP (1980). Yemen mountains are categorised on the basis of altitude, slopes and nature mainly into the three types viz, highly dissected, very steep slopes with 1500-3000 meters altitudes and deep gorges predominant, moderatley dissected steep slopes (30-100%) with 500-1500 meters high and very few gorges, and high plateaux with altitudes of 1500-2500 meters high with generally sloping surfaces. Soils vary from gravelly stones to deep loamy and clay.

Rainfed crops mainly are wheat, barley and legumes like cowpea and lentils are inter-cropped with sorghum (yield 0.5-3.0 t/ha).

In the irrigated areas maize, wheat and sorghum also are grown, while certain vegetables like potatoes, tomatoes, onions, cabbage and cucumbers are grown in small plots. In the irrigated orchards coffee, banana, grapes and kot (catha edulis) are grown. Kat yields 5-10 times more income than coffee.

Out migration from mountains to oil-wealth Arabian countries is breaking down the traditional tribal system and stability in agriculture production.

In fact countries of west Asia and north African Region are producing at a lesser rate than the annually rising rate of 4.3% of growth of demand for food. Many countries have become now become improters of food, some on large scale. In 1970, total wheat imported in Arab countries was 4.9 million tonnes and it was 16.7 million in 1983. By 2000 AD estimated food import requirement is 48.5 million tonnes. In view of this, these countries many without oil reserves must attempt to maximize production from the arable land. Countries with mountain farming system must also continue to be productive for effective solution of such growing food deficit solution.

UNITY OF GENETIC POPULATION FOR ARID BARLEY AND CULTIVATED BARLEY IN HIMALAYAN AREA.

Shao Qiquan, Zhow Jegi and Li Ansheng

The study on the genetic population of different types of wild barley (Hordeum, spontaneum, H. agriocsithon convar. lagunculiform convar euagriocsithon convar nudun and cultivated barley) shows that the composition of the varieties in North and South slopes of Himalayas has a very clear similarity.

The two rowed wild barley has been recorded in South slope of Himalayas in India, Afganistan, Nepal and was recorded natural wild population in North part of Afganistan. Six rowed wild barley found in the South-western part of China was agreed to be the ancestor of cultivated six-rowed forms.

The bottle-shaped wild barley is morphologically stable. Wide distribution of the bottle-shaped wild barley is similar to that of the six-rowed wild barley. Quite the same forms of six-rowed wild barley was discovered in Nepal, in southern slopes of Himalayas. This similarity indicates the unity of genetic population of barley in this area and shows the different forms of wild barley over there have a really wide distribution and as a natural species have their own population. The morphological, cytological and genetical observation and ecological analyses support this unity.

Existence of many forms of wild types of barley is not merely of theoretical importance to designate the evolutionary process of barley, it has a very high practical value as a source for disease resistant material for breeding purpose.

MOUNTAIN AND UPLAND AGRICULTURE AND GENETIC RESOURCES IN THAILAND

Sutthi Chantaboon

The mountain and upland agriculture in Thailand have been a kind of slash and burn or what is called Swidden cultivation. There are about 9 hill tribes of which low hill and high valley people include Karen, Lua, Sin and Khamu. These groups establish their communities below 1,000 metre contour in dry evergreen forest and above 400 metre contours. The real high landers include the Meo, Yao, Lisu, Lahu and Akha tribes who settle as the hill evergreen forests between 1000 metres to 1500 metres altitudes. These groups have different methods of cultivation. In the past the latter groups relied on opium as their principal cash crop while the former groups maintained stable communities and even constructed irrigated rice terraces.

The former group of tribes practise what is called cyclical swiddening which is secondary forest cultivation i.e. cyclical bush fallow land rotation. This form of cultivation is also a type of slash and burn which allows the vegetation to regenerate for subsequent clearing. This method provides the basis for permanent settlement. Some village rites of these tribes are of over 200 years old.

The latter group of hill tribes of people also practise what is called Pioneer Swiddening i.e. primary forest cultivation or shifting cultivation. This pattern of cultivation is conducted by felling and burning the biomass and growing crops on the cleared land for as long as possible varying from one to 20 years depending on fertility levels and composition.

The cyclical swiddens have traditionally followed basically three types of land tenure viz., communal estates, mixed private and public tenure and private ownership. The agricultural wisdom exercised by widdeners is considerable and covers a wide range of activities starting from felling & selection of cultivation sites to the technology on harvesting of crops. Highlanders principally follow rice based farming system. Several other crops classified by use such as food crops, vegetables such as chinese mustard to okra (about 46 specis), roots tubers and rhizomes ginger, shallot etc. animal feed plants, herbsand spices, sugar cane, fibre crops are the major crops.

In 1960 a major development program was mounted with the objective of stopping swidden agriculture, replacing opium cultivation by other crops and promoting permanent agriculture. Since then, new improved crops have been introduced. Research work also commenced around 1960 and set up a highland experimental section at Doi Mussur and new crops such as coffee, avocado, macadamia nuts, cherry etc. also were included for introduction. The Royal Project set up in 1969 functioned from 1970. Above 69 agriculture research projects involving plants and animals were executed to support the hill agriculture. Definite changes in the cultivation of rice and other crops have been observed in the agricultural scenario. However, there is a need to preserve the traditional strains or crops along with the introduction of new types of crops in the area.

MOUNTAIN FARMING SYSTEMS IN NEPAL

M.P. Panta and J.C. Gautam

The paper presents interesting paradoxes about Nepal. One of the most scenic and beautiful countries of the world is also one of the least developed countries. It has the highest mountain (more than 8000 meter) of the world and also a very fertile land at less than 100 metres above sea level. Nepal's economy is predominantly agricultural, but is marked by low productivity and very slow rate of technological dissemination. About 77 percent of the area is mountainous where 56 percent of the population toil hard for bare subsistence.

The Mountain Farming Systems are agrologically divided into two regions: The Hills Farming System extending from 500 metres high in the South to 2400 metres high in the North. The climate in this region is mostly warm temperate. The Hill Farming Systems are limited to river valleys and terraced slopes. Double or triple croppings per year are possible in this belt depending upon the temperature and moisture (irrigation) availability in the crop land. The High Mountain Farming System is prevalent in higher altitudes beyond 2400 metres above sea level. Generally only one crop per year, is possible in this agro-ecological region of the country. Both these groups however are put together for general description and recommendation in the paper.

In the hills, maize is the most important crop followed by rice wheat and millet while in the irrigated low land terraces rice based patterns predominate. Soyabeans and blackgrams are among the popular legumes. Both tropical and temperate horticulture have high potential in the hills. The high mountains have potatoes for pasture and temperate fruits cultivation provided the transportation systems for the product markets are developed, although potato buck-wheat, oat are grown as the main stable crops in such high altitudes. Live-stock is an integral and inseprable enterprise with the farmers in Nepal in general and is more so with those of the farmers in the hills in particular.

The strategies suggested to develop mountain farming systems in Nepal points that farming system approach needs to be adopted. In order to check the ever increasing soil erosion in the hills, agro-forestry must be a part of the research program. Integrated research to increase productivity of livestock and crop sector is very much lacking and needs added attention. Women in Nepal have been playing crucial role in agriculture and to women development activities need to be carried on . Similarly, generation of technology for the mountains need to be integrated with the supply of inputs and other related services.

The paper also strongly urges to feel concerned for linking international and national organisation for the hill area development.

Since the mountains are chronically deficit in food and yet majority of Nepal's population reside in this region, it is very essential that long term solutions are sought by generating additional incomes in these areas so as to increase purchasing capacity of the poor masses.

AGRICULTURE IN BHUTAN

D.R. Ghalley

The agricultural country Bhutan is located between 26.5 ^{0} and 29.5 ^{0} North altitude and 88.5 and 92.5 ^{0} East longitude comprising of total area of 46,500 sq. kilometers, about 74% of which is under forests, 5% under cultivable land and the rest is either under alpine shrubs or under snow cover.

The southern foot-hills upto 1500 mts. in altitude is extended to the 20 km. North. The inner Himalayas where the main cultural heart land and important active belt of Bhutan is situated, consists of middle part of the kingdom upto a height of 3000 meters. The Northern region of the kingdom rising upto 7000 meters comprises of the main Himalayan range. The foot hills have a hot humid climate with temperatures remaining fairly even throughout the year between 15 ^{0}c and 30 ^{0}c with 5000 mms of rain fall in some areas, the middle inner Himalayas have cool temperate climate with annual precipitation about 1000 mm, and the western region receives comparatively higher rainfall. The higher and more northern region has a severe alpine climate with annual precipitation of about 400 mm.

The soil type consists of sandy loam and clay loam in most parts of the country. The agricultural land is classified into five categories, namely, wetland , dryland, Tsheriland shifting cultivation, orchard land and kitchen garden land. About 23.5% of the total cultivable land is wetland. Paddy is the main crop and maize potatoes and other vegetables are also grown in the area. Dryland consists of 51.8% of the cultivable land, maize is the major crop and wheat, barley, potato, millet, buckwheat, mustard etc. are also grown as miner crops. Tsheriland is 9.3% which is cultivated in a cycle ranging from 15-12 years. The main crops grown are paddy, maize, millets and barley. In order to make a rational use of Tsheriland, Bhutan needs appropriate assistance from outside. About 14.4 of cultivable land is used in orchard mainly to grow apple, orange, cardamum. Main vegetables grown are cabbage, cauliflower, chilly, tomato, radish etc. consists about 1% of the cultivable land of the Kingdom.

Although agriculture is the main-stay for 94% of the labour force of the kingdom, investment on research had been minimal. However with the establishment of Centre for Agriculture Research and Development in the recent years, collaborative activities with IRRI, IDRC, CIMMYT and among the SAARC countries have usured into some research activities in rice, wheat and maize.

APPROACHES AND TECHNIQUES FOR ASSESSING MOUNTAIN ENVIRONMENT

Tariq Hussain

The primary objective of the paper is to explore approaches that can be used to identify and design sustainable development initiatives. The secondary objective concerns the identification of research priorities through different approaches. However, the approaches discussed belong to sets used previously in both mountainous and plain areas. The approach assumes that a community of mountain dwellers is an invaluable source for knowledge, the researchers should learn the community's environment and that every technical innovation should be supported by locally existing or innovative locally sustainable management system. Thus the paper opines that the challenge for research and planning is to graft upon the resources and management of mountain dwellers so that they themselves may better manage their resources for themselves and their children.

The paper then goes into describing the approaches adapted in identifying the programmes/projects pertaining to village-level physical infrasturcture development, land reclamation and development, forestry development, winter feed and livestock development and wheat farming system. The approaches included Diagnostic Survey adapting frequent Dialogues by multi-disciplinary teams with the villagers leading to over 250 village level infrastructure development projects.

In order that such projects are meaningfully managed by the villagers, Agro-ecosystem Analyses (AA) for Development was carried out. This helped to interlink village level community goals with the individual private production and consumption objectives leading to improvement in agricultural productivity on a stable, sustainable and equitable basis. The paper presents the pattern analysis of two villages (Pasu and Oshi Khandaso). This was followed by workshop which also helped in making rapid appraisal of village and in identifying projects. In the forestry projects, rapid appraisal techniques were adapted to identify grazing area and village requirements and village institutions. Thus 'menu' of general findings were prepared for different village situations.

Given the history of difficulties with centralized, aggregative research and planning, alternative systems of village level learning experience deserve serious consideration by community of development professionals.

The paper concludes, that once the village level priorities have been established, a village level feasibility needs to be undertaken, whether this feasibility is conducted through village dialogues or village level statistics (or both), villagers need to be involved in evaluating the technical and institutional context of proposed projects.

AGRICULTURAL SYSTEMS OF XIZANG

Cheng Hong

The formation of agricultural system of Xizang is influenced by three principle factors. First: high elevation. It is estimated that the land above 4500 m makes up 78% of the whole area; over 4000 m, 86%. Second: remoted geographic location. Third: low productivity. These two factors restircted the devleopment of economy and caused the obvious self-sufficient and closed characteristics of agriculture production in Xizang. In rural area, the important production are animal husbandry and crop cultivation.These two sectors make up over 85% of total agriculture output value of Xizang. The farming system of Xizang is actually expressed by the relationship between animal husbandry and crop cultivation and between different crops. Three type of regions may be divided according to the relationship between pastoral and farming i.e. 1. The regions which mainly are animal husbandry makes up over 70% of the total animal and agriculture output in these regions. 2. Transitional regions of pastoral-farming where the output value of animal husbandrymakes up 30-70% of the total animal husbandry and agriculture products. 3. The regions which mainly are agriculture with the output of animal husbandry below 30%of the total animal husbandry and agriculture output. There are three basic regions of cropping system and combination of crops in Xizang. 1. The regions of one crop sow in spring. Highland barley is the only crop which sow in May or June and harvest in September. 2. The regions of one corp sow in winter. Winter wheat and a small area of winter highland barley sow in September or October and harvest in August or September of the next year. 3. The regions of Double-cropping. The staple crop in this system are winter wheat. Another crop of maize or buckwheat or double crops of rice after the winter wheat was harvested can be cultivated. Details of the three factors, three type of regions and three regions of cropping system were discussed. Figures of farming system of Xizang were attached.

AN EVALUATION OF ANDEAN ROOT AND RUBER CROPS: GENETIC RESOURCES FOR MOUNTAINOUS ENVIRONMENTS

Steven King and Noel D. Vietmeyer

The Andes is well known as the centre of origin and diversity of potato - Solanum tuberosum the world's most important tuber. The Andeans, in fact have domesticated numerous other root and tuber crops which are endemic to the highlands of South America. The work of Andean and other scientists suggest that some of these root and tubers exhibit great potential for utilization in the mountainous regions of Africa and Asia. Consequently, increased utilization and development of these crops can lead to increased food self-sufficiency for mountainous regions within and outside the Andean zone.

Some of the important roots and tubers that have agronomic and nutritional potentials in terms of meeting the food requirement of the mountains regions could be listed as below.

Root Crops

Lapidium meyenii:
- cultivation up to 4500 metres. Shows potential within Andean outside region

Arracasia Xanthorriza Bancrofe:
- is a herbeceous perenial that produces large, thick edible carrot shaped starchy root

Cana edulis :
- it is also grown to a limited extent in Asia and the Pacific. The leaves and rhizomes are used as livestock feed

Mirabilis expansa:
- it is well adapted to mountainous environments and is comparable to potatoes in nutritional values. It is cultivated from 2800-3200 metres.

Tubers:

ullucus tuberosus	grown at altitudes
oxalis tuberosa	2500-4000 metres
troparolum tubersum	grown at altitudes

Pachyrhizus tuberosum:
- they grow well in hot and wet tropics

Polymnia sonchifolia:
- sweet taste watsy quality consideredas pleasant refreshment

It is significant that these roots and tuber crops are now being promoted for utilization also in other mountainous regions of the world.

THE ANDEAN PHYTOGENETIC AND ZOOGENETIC RESOURCES

M. Tapia and N. Mateo

Andean mountains cross all along from North to the South in the western coastal region of the South American continent. Therefore it constitutes tropical and sub-tropical latitudes and altitudes range up to 4000 metres from sea level. In seven of the Andean countries, area located above 2000 metre high is about 2 million hectares. This region has its special nature plants and animal species. In fact, Andean region of Ecuador, Peru and Bolivia is recognized as one of the eight centres of origin of crop plants in the world. The main Andean nature food species of above 2,000 m is given in the following table.

MAIN ANDEAN NATIVE FOOD SPECIES ABOVE 2,000 M *

COMMON NAME	SCIENTIFIC NAME	BOTANICAL FAMILY
GRAINS		
Quino	Chenopodium quinoa	Quenopodiaceae
Kaniwa	Chenopodium pallidicaule	Quenopodiaceae
Kiwicha	Amaranthus caudatus	Amarantaceae
Tarwi	Lupinus mutabilis	Leguminosae
TUBERS		
Oca	Oxalis tuberosa	Oxalidaceae
Olluco	Ullucus tuberosus	Baselaceae
Mashua	Tropaeolum tuberosum	Tropaeolaceae
ROOTS		
Maca	Lepidium meyenii	Cruciferae
Jimaca, Ajipa	Pachurrhizus ahipa	Leguminosae
Arracacha	Arracacia xanthorrhiza	Umbeliferae
Yacon "Jiquima"	Polymnia sonchifolia	Compositae
COMMON FRUITS		
Nuez del Peru	Juglans peruviana	Juglandaceae
Chirimoya	Annona cherimola	Anonaceae
Pacae, "guamos"	Inga feuillei	Legunimosae
Huagra-manzana	Crataegus stipulosa	Rosaceae
Capuli	Prunus serotina	Rosaceae
Mora de Castilla	Rubus glaucus	Rosaceae
OTHER FRUITS		
Ciruela del Fraile	Bunchosia armeniaca	Malpigiaceae
Tumbo, curuba	Passiflora mollisima	Pasifloraceae
Tintin	Passiflora pinnatistipula	Pasifloraceae
Lucuma	Lucumabifera	Sapotaceae
Capuli, "uchuba"	Physalis peruviana	Solanaceae
Sacha tomate	Cyphomandra betacea	Solanaceae

* Maize and potato are not mentioned due to their worldwide distribution

Of these crops, quinoa, kaniwa, Amaranthus, Lupinus as grains, the tubers and roots such as yacon, Arracacha assume importance of significant both at the nature and outside areas.

There are several species of animals, native to this region. Of these domesticated mammals such as Llama and Alpaca are very important both as source of protein and means of transports for the hills and are called mountain camels or camelids. Guinea pigs locally called cuy (cavia parcellus) is an important source for protein.

Collaborative works on these genetic resources of Andean mountains among the different mountainous countries of the wrold could open up the large scale sharing as in the case of potatoes and maize crops in the past.

HIGH MOUNTAIN ENVIRONMENT AND FARMING SYSTEMS IN LATIN AMERICA

N. Mateo and M. Tapia

A clear-cut definition of "high mountains" is not available from literature or researchers in Latin America. A practical one, used by the government of Peru, defines "high mountains" as those lands above 2000 m.a.s.l.

The particular climate, topography and exposure of the high Andes, as well as the needs and socio-political organization of its inhabitants, have resulted in a very rich and complex adaptation and selection of crops and animals.

Soil formation processes are characterized by intense erosion and sedimentation. In general, soils are not well developed. In the Northern humid Andes many Inter-Andean valleys enjoy drier climate conditions. In western slopes, soils are of volcanic origin, while the eastern soils are genrally of sedimentary origin. The Andean "altiplano" is a high level mountain basin at over 3500 m. In the mountain slopes and highlands of the Andean countries, lithosols predominate (41%). the estimated percentage of poor and good soils is 36 and 23 respectively. Traditionally, farmers use indicator plants to identify the quality of soils.

One of the well documented cropping system sites called Coporaque has the following farming systems characteristics. This area is considered as dry Inter Andean Valley on the west side of Southern Andes.

Rainfall is a major limitation only 349 mm/year, mean annual temperature is 10.4 degrees centigrade (12.3 degrees centigrade in December, 3.2 degrees centigrade in April).

Animal and crops production are mainly for subsistence with limited marketing and/product exchange. The range of hectares owned by a single farmer is 0.25 to 7.0 usually with plots at different altitudes. All the family members participate in farm work.

The three distinct Homogenous Zones of Production are described below:

- River floor: 3350 to 3450 masl. Soils are alluvial, highly fertile (mostly sandy loams). Maize is the predominant crop. Barley and faba beans are found to a lesser extend.

- Plains: 3450 to 3600 masl. Soils are deep and good (mostly clay loams with little or moderate slope). Terraces are common. The main crop is barley. Other important crops include faba beans and quinoa. Important rotations are: barley-faba, beans-quinoa-potatoes, and potatoes-barley-faba beans-quinoa-potatoes.

- Slopes: 3600 to 3750 masl. Terraces prevail. The most important activity is animal production. alfalfa predominates as a cultivated species, a few barley and faba beans plots can be found. Identified rotations included faba beans-barley, and potatoes-faba beans.

In general, the terraces are irrigated. This technology has existed for centuries as an answer to limited rainfall.

The widespread use of barley is possibly due to the guaranteed market prices offered by the malt factories. Alfalfa is important for those farmers that migrate temporarily because it thrives well under low management.

TROPICAL AFRICAN MOUNTAIN ENVIRONMENTS AND THEIR FARMING SYSTEMS

Amare Getahun

The tropical African mountain environment is here taken to mean the topographically raised land mass and massif above 1500 meter elevation whtin 23 degrees N and S latitude. These mountains systems are estimated to cover a a land mass of about 1 million square kilometers, less than 4% of the total land mass of the African continent (ILCA, 1986). There are 20 countries, including the islands of Madagascar and Reunion, with mountain environments. Ethiopia and the Eastern Africa countries (Kenya, Uganda, Tanzania, Rwanda, and Burundi) make up 76% of these environments. Ethiopia alone contributes nearly 43% of the total. Countries with a high percentage of mountain environment include Rwanda (84.4%), Burundi (48.8%), Ethiopia (40.1%), Reunion (21.9%), Tanzania (20.2%), and Kenya (19.9%).

In these countries, the mountain environments are the main human habitation areas and are agriculturally important, often dominating the national and region crop and livestock economy. This is because of their favourable climates and productive soils. These mountains are also important watershed and constitute major forestry resources.

Farming systems in these areas, largely dominated by small-holder rain-fed mixed agriculture, are very diverse, matching the diversity of the physical and biological environments. Mountains close to the equator (0-6 degrees) are dominated by Horticulture/Hoe agriuculture and are represented by highlands in N. Tanzania, Kenya, Uganda, E. Zaire, Rwanda, Burundi, SW. Ethiopia. These are often referred to as intensive small holder agricultural systems. In these areas, depending on altitude, cultivation of tea, coffee, pyrethrum, chat, maize, banana, beans, and root and tuber crops dominate. Dairying is also important.

Highlands further away from the Equator (6-20 degrees), represented by the Central and Northern Ethiopian and Souther Tanzanian enviornments, are dominated by Cereal/Oxem-plough agriculture. Depending on the altitude and latitude, the major crops grown include cereals, pulses, and oil crops. These systems are often referred to as extensive small-holder farming systems. Animal production is important. The highlands lying between 6 degrees and 8 degrees latitude often show transition between these two broard farming systems. Horticulture/Hoe farming systems represent more sustainable agriculture, while the Cereal/Oxen-plough systems are not so and need corrective measures.

The genetic diversity of the crops grown in the tropical African highlands is very high, particularly in the Ethiopian mountain systems, and to a lesser extend in the Arusha-Kilimanjaro region of N. Tanzania. Getahun (1972) reported 169 types of crops cultivated by farmers in the Harar Mountains in E.Ethiopia. Fernandus, et al. (1985) and Oldktingati, et al. (1985) reported that there were over 111 crops cultivated and used by the Chagas. Many of these crops and their cultivars are endemic to these environments and are under high risk of genetic erosion.

INDEGENEOUS CEREAL CROP GENETIC RESOURCES IN THE MOUNTAISN OF PAKISTAN

Rashid Anwar and M.S. Bhatti

The Pakistan is sprawling mass of land lying between latitude 23 degrees N - 38 degrees N and longitude 61 degrees E - 77 degrees E. There are different mountain ranges in thenorth and west of the country. The montane provinces of North West Frontier Province (NWFP) and Baluchistan occupy more than 50% area. These regions were explored and in total 1605 smaples of different crops were collected through seven plant collecting expeditions during 1981-86. The cereals constitute over 70% of the collections. Wheat and rice are the most important food crops among the cereals and cultivated over an area of 7.34 and 2.0 m hec. respectively. Spread of high yielding varieties (HYV) has posed severe threat to the indegeneous varieties. The high yielding varieties of whear occupied 62% area in the mountains. The wheat collection includes Triticum aestivum (sub species compactum and sphaerococcum), T.durum, T.turgidum and T.polonicum. The genetic erosion in local rice varieties varies from one region to another. In NWFP, the rate of replacement is slow as 60% rice area is under indigenous varieties. In Baluchistan 98% area has become under HYV of rice and only 2% area by indigenous varieties. A shift from subsistence to commercial cultivation due to newly exploited irrigational water resource is considered to be a major cause of genetic erosion in Baluchistan province. Entire rice collection belongs to one species Oryza sativa.

There was immense variation inclimate, topography and edaphic factors in the area of expedition. These factors are reflected in corresponding change in developmental characters. In the area, T aestivum populations display differences in awning, pubescence, straw thickness and other traits which are associated with differences in altitude, aspect, soil moisture regime, cultural practices and social isolation. Similarly indigenous rice varieties in Baluchistan were highly diverse for several genetic and agro-morphological traits.

FRUIT GENETIC RESOURCES IN NORTHERN MOUNTAINS OF PAKSITAN

M.S. Bhatti and R. Anwar

In the north there are towering mountain ranges comprising of Karakorum and Hindu-Kush. Many of temperate fruits have been in cultivation since very early times in the northern region of Pakistan. Apricots and Peaches were domesticated first in China. The primay centre of origin of Pyrus genus is considered to be central Asia and Himalayan India and Pakistan. Most probably the stone fruits were introduced to Pakistan through China during very early migrations of man. Once introduced and established in the new area, fruits were exposed to evolutionary forces as a result of which secondary centre centre of genetic diversity developed. Immense pool of fruit germplasm do exist in the northern mountains, therefore, the region can be considered as important centre of diversity for most of the temperate fruits. The Plant Genetic Resources Unit of Pakistan Agricultural Research Council explored the mountainous area, through three different collecting expeditions during 1982, 1983 and 1986 with view point of collecting fruit genetic variability for conservation. During the former two expeditions, the scion-wood of fruits were collected during the dorman season and budded/grafted onto root-stock nursery to establish clonal repository or living collections. Re ently it has been confirmed that seeds of temperate fruits can be conserved for long period as an orthodox seeds. Therefore, the expdition during 1986, collected the mature fruits and seeds were extracted for conservation in the genebank. Considerable genetic variability in number of fruit species exist in the area. The variability in plants belonging to genera Prunus, Pyrus, Malus and others is due to great extent, to their propagation through seeds. Apricots are extremely variable in Gilgit and Baltistan. With few exceptions all the sites visited were found to be threatened with genetic erosion either slowly or drastically, where fruit trees were cut down for fire wood and other purposes. Agriculture Department in the area is releasing about one million grafted fruit plants of improved varieties every year which poses severe threat to the indigenous varieties.

PATTERN OF VARIABILITY OF ELEUSINE CORACANA (L.) GAERTN. TO HIGH ALTITUDE AND ITS INFLUENCE ON THE STRUCTURE OF YIELD

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A colelction of Eleusine coracana germplasm numbering 167 was procured from milled coordinated centre Bangalore in order to study the pattern of Phenotypic variability. All the varieties were sown at three different locations i.e. Environment-I: Khaltu 1350 metres ASL; Environment-II: Shimla 1780 metres ASL and Environment III: Mashobra - 2192 metres ASL.

After three years of trials at these three locations 18 varieties were selected for further studies. Evaluation of the genotypes was done on the basis of the other phenotypic characters which have direct bearing on yield viz. total grain bearing area (including Mean area general fingers/ear head + Mean area of odd fingers/ear head). Analysis of variance revealted that environments differed significantly between themselves in their influence on the various yield components. The influence of high altitude environment (2192 metres ASL) appeared to be very poor. The regression coefficients were also worked out for each of the variety. They vary significantly. In almost all the varieties it was around 1.00 or less than one 1.00 implying that yield contributing factors possess average adaptibility to high altitude mountain conditions.

ROLE OF CHENOPODIUM IN THE HIMALAYAN MOUNTAIN AGRICULTURE: A CASE FOR CONSERVATION AND DEVELOPMENT

Tej Partap

Chenopodium, a pseudocereal, was a dominant food crop of the subsistence stage polyculture agroecosystem of many mountain areas throughout the Himalayan range. It was an accepted staple food for many mountain communities. However, with the switchover of agriculture from non-commercial polyculture system to commercial monoculture, Chenopods declined steadily in use and cultivation; and presently it enjoys the status of a minor grain crop of many isolated hill communities in parts of the Himalayan range, covering areas in Jammu and Kashmir, Himachal Pradesh, Uttrakand (some pockets) and there are reports of its cultivation from Nepal, Sikkim (Teesta valley) and Khasi hills. Records of its cultivation in mountain regions of Formosa (China) and Japan are also available.

Investigations on the folklore reveal its staple food status in the past but the socio-economic survey revealed that it is now cultivated in different areas with difference considerations. Such as for food its cultivation is presently associated with tough geographic conditions and poor economy of the families, where access to urban culture or roads is normally difficult. For reasons of alcoholic preparations minor cultivation occurs without any regard to above factors, mostly. Generally considered non-commercial grains do find their commercial value in certain areas and are costlier than Amaranthus and Fagopyrum. There are also cutlural and religious reasons for continuing this cultivation.

In terms of nutritive value these grains are comparable to most of our present day staples. They have 66% carbohydrates, 16% protein, 7% fats besides all essential amoniacids in appreciable quantities. Suitability of the crop for mountain agriculture can be counted for many reasons like its excellent adaptation to mixed farming, relatively short phenological calendar (90, 120, 130 days) and germination and establishemnt over wide range of physico-chemical conditions. The grains germinate at temperatures as low as 3-5 degrees C and do not have any photoperiodic requirements. The crop faces extinction not for its quality but due to scientific neglect to develop it meet/suit requirements of changed culture and agriculture.

CROP GENETIC RESOURCES OF NEPALESE MOUNTAINS

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Nepal is a small land locked country in the southern part of Himalaya. It is sandwiched between China and India.

Nepal is situated between 26 degrees and 20'N to 30 degrees 10'N Latitudes and 80 degrees 15'E 88 degrees 10'E Longitudes with a rectangular shape. Though the latitudes variation is so small, Nepal has almost tropical to alpine environment in various parts of the country due to the tremendous topographical variation in altitude (60 m to 8000 m from the sea level). This topographical variation along with the direction of the slope of the mountain, wind direction etc. have created tremendous number of mini environments for crop growth.

Presence of numerous mini environments together with the food and cultural habitats and religious beliefs of the people residing in the area have established diversed farming system and cropping patterns in various parts of the Nepalese mountains.

Cropping pattern varies from three cereal crops in a year (Rice-Rice-Wheat or Maize-Rice-Wheat) in tropical belt to one crop in a year pattern in high mountain. These diverse and numerous mini environments have produced thousands of land races with a great variation in the characters of the widely grown crops like rice, maize, wheat, fingermillet, barley, pulses, oil crops etc. The Himalayan belt and the adjacent areas are possibly the original home of many crops like rice, buck wheat, amaranthus sp. etc. Thousands of land races with diverse characters are available in some food crops like rice, wheat, maize etc.

Some local and many foreign expeditions have been organized to collect the germplasm wealth of Nepalese mountain specially in food crops. Many national and international organizations have evaluated these land races for their useful characteristics.

In Nepal a strong and dynamic research system is yet to be developed. In the important cereal crops like rice, maize and wheat the research system is comparatively better. However, even these crops programs are not capable of collecting, maintaining and using the local germplasm properly in breeding better varieties due to limitation of money and facilities.

A great potential exists in collection on evaluation and utilization of the local germplasm of various crops and introduction of some new possible crops in the Nepalese mountain for the benefits of human being.

STATUS OF VALUABLE NATIVE ANDEAN CROPS INSERTED IN THE HIGH MOUNTAIN AGRICULTURE OF ECUADOR

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Features of the highland Ecuadorian agriculture (2900-3800 m) are: poor development, high population density, soil erosion, scarce credit and technical assistance, steep topography and stressed environments.

In spite of being a primary centre of plant genetic diversity, conquest and colonial influence have prevailed in Ecuador to be dependent of few introduced species for consumption and exportation.

Since 1980 new priorities defined for the National Institute of Agriculture Research (INIAP) and the support of the International Development Research Center (CIID-Canada), have preserved the still wide genetic variability of native Andean species like <u>Chenopodium quinoa</u>, <u>Lupinus mutabilis</u>, <u>Amaranthus</u> spp, considering grains: <u>Oxalis tuberosa</u>, <u>Tropaeolum tuberosum</u> <u>Ullucus tuberosus</u>, <u>Arracacia xanthorrhiza</u> among tubers and some other species i.e. : <u>Cyphomandra betacea</u>, <u>Prunus capuli</u>.

These species are predominant in the fields of the poorest farmers of the highlands, being cropped in associated patterns in time and space. Quinoa is a good example of the progress obtained considering collection, characterization, genetic breeding and out-farm impact.

ROLE OF NBPGR IN EXPLORATION, CHARACTERIZATION AND EXCHANGE OF CROP GENETIC RESOURCES

B.D. Joshi and R. S. Paroda

Thirty five explorations to the mountainous regions of India from 1980 to 1986 were carried out by the Scientists of the National Bureau of Plant Genetic Resources. A total germplasm of more than 10,000 collections was made representing rice, wheat, maize, amaranth, buckwheat, chenopod, foxtailmillet, fingermillet, presemillet, barnyard millet, mustartd, french bean, cowpea, soybean, lentil, black gram, green gram, horse gram, okra and chillies. The mountain regions of Jammu and Kashmir, Himachal Pradesh, Uttara-Khand area of Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Tripura and

Assam were covered. The collection sites ranged from 600 m to more than 4000 m above mean sea level. A great deal of variabilities was observed in the material collected from wide agro-ecological zone. The variability observed in rice, maize and grain amaranth is worth mentioning.

The gerplasm has been evaluated for various agromorphological characters for more than one season. The important donors for crop improvement programmes and elite lines were identified, multiplied for distribution to the user agencies. Based on multilocation evaluation in the mountain regions. 'Annapurna' in grain amaranth, CXM 12P2-3 in rice bean, PLB 10-1 and PLB 14-1 French bean were released for cultivation. Two catalogues one on grain amaranth and other on french bean have been published and catalogues on lentil, soybean, minor millet, buckwheat, amaranth (ii) and french bean (ii) are under preparation. More than 33000 genetic resources of mountain crops were supplied to user agencies both within and outside country.