

## Annex 1.

### Workshop Programme

DAY ONE		
Opening Session		Session 2
WELCOME	Dr. Colin Rosser Director, ICIMOD	Tropical African Mountain Environment and Their Farming Systems Amare Getahun
OPENING	Mr. Hari Narayan Rajauria Hon'ble Minister of Agriculture, Law and Justice	North African and Mid-Eastern Mountain Environment and Their Farming Systems Gordon Potts
INTRODUCTION TO THE WORKSHOP	Dr. Geoffrey Hawtin Associate Director, IDRC	Approaches and Techniques for Assessing Mountain Environment Tariq Husain
Session 1		DISCUSSANT Daniel Galt - ARPP, Nepal
MT. PHYSICAL ENVIRONMENT AND FARMING SYSTEMS		DAY TWO
CHAIRMAN Geoff Hawtin		Session 3
RAPORTEURS Tola, B.Bhadra, G.Potts		GENETIC RESOURCES OF MOUNTAIN CROPS
Hindu Kush-Himalaya Region Ram P.Yadav & P.L.Maharjan		CHAIRMAN Mario Tapia
Agricultural System of Xizang Cheng Hong		RAPORTEURS Ken Riley, Amare Getahun, Prodipto Roy
Mountain Farming System in Nepal J.C. Gautam and Mahesh Pant		Indigenous Cereal Crop Genetic Resources in the Mountains of Pakistan Rashid Anwar
High Mountain Environment and Farming Systems in the Andean Region of Latin America N. Mateo and M. Tapia		Collecting Fruit Genetic Resources in the Northern Mountains of Pakistan M. Sadiq Bhatti

Session 4	Session 6
<p>Pattern of Variability of Eleusine Coracana (L) Gaertn to High Altitude and its Influence on the Structure of Yields Surinder K. Mann</p> <p>Chenopodiums and other Mountain Crops used in Himalayas of India Dr. Tej Pratap</p> <p>Crop Genetic Resources of Nepalese Mountains A.N.Bhattarai, B.R.Adhikary and K.L.Manandhar</p> <p>Unity of Genetic Population for Arid Barley and Cultivated Barley in Himalayan Area Shao Qiquan, Zhou Jeqi and Li Ansheng</p> <p>Mountain and Upland Agriculture and Genetic Resources (Thailand) Sutti Chantaboon</p>	<p>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</p>
	<b>DAY THREE</b>
	<b>FIELD TRIP</b>
	<b>DAY FOUR</b>
	<b>Session 7</b>
	<p><b>CHAIRMAN</b> Mario Tapia, Hawtin</p> <p><b>RAPPORTEUR</b> Nicholas Mateo, Steven King, P.L. Maharjan</p>
	<b>GROUP DISCUSSION</b>
	<p><u>Group A</u> Special Features of Mountain Agriculture and Farming System</p> <p><u>Group B</u> Crop Genetic Resources of Mountain Crops &amp; Genetic Germ Plasm Collection, Conservation and Exchange</p>
<b>Session 5</b>	<b>Session 8</b>
<p>Status of Valuable Native Andean Crop in the High Mountain Agriculture of Ecuador J. Tola Cevallos, C. Nieto, E.Parolta, R.Castillo</p> <p>The Andean Phytogenetic and Zoogenetic Resources M.Tapia, Nicholas Mateo</p> <p>An Evolution of Andean Root and Tuber Crops: Genetic Resources for Mountainous Environments Steven R.King and Noel D. Vietmeyer</p> <p>Mountain Crop Genetic Resources with Special Emphasis on Ethiopia Dr. Melaku Worede</p> <p>Mountain Crop Genetic Resources (Morocco) Mr. Azzedine Douiyssi</p>	<p><b>GROUP DISCUSSION (contd.)</b></p>
	<b>Session 9</b>
	<p><b>CONCLUDING SESSION/GROUP PRESENTATION</b></p> <p><b>CHAIRMAN</b> Dr. Colin Rosser</p> <p>Recommendations and closure of the workshop</p>

## Annex II

### Participant List

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35. Prof. Zhang Rongzu

36. Dr. Binayak Bhadra

37. Dr. Kk Panday

38. Dr. Mahesh Banskota

## **Annex III**

### **List of Workshop Papers**

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



**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

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#### 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  $22^{\circ}$ - $38^{\circ}$  N latitude and  $60^{\circ}$ - $150^{\circ}$  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, Meghalaya, Tripura, Nagaland, Manipur (consisting of ranges such as Eastern Himalayas, Naga Hills, Chin Hills, Khasi Hills), (f) Tibetan plateau, and (g) Hengduan 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 terrain farm lands, hazards of soil erosion, traditional production systems. Prevalence of several mountain ranges present diverse situations in the region. The major tropical features of the region constitute the Rift-Atlas mountains along the coast of Morocco and Algiers, the Taurus Mountains in the eastern Turkey and the Zagros Mountains in Iran and Iraq.

The Atlas Mountain Systems dominate the physical geography of North-East these mountains 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 reaching 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 peninsula, 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<sup>2</sup> 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, moderately 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 improvers 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, Zhou Jie and Li Ansheng

The study on the genetic population of different types of wild barley (Hordeum spontaneum, H. agriocisthon convar. lagunculiform convar euagriocisthon 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 species), roots tubers and rhizomes ginger, shallot etc. animal feed plants, herbs and 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 inseparable 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  $26.5^{\circ}$  and  $29.5^{\circ}$  North altitude and  $88.5$  and  $92.5^{\circ}$  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  $15^{\circ}\text{C}$  and  $30^{\circ}\text{C}$  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 minor 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 infrastructure 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 restricted the development 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 husbandry makes 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 crop 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 Bancroft:

- is a herbeaceous 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:

<u>ullucus tuberosus</u>	grown at altitudes
<u>oxalis tuberosa</u>	2500-4000 metres
<u>troparolum tubersum</u>	grown at altitudes

##### Pachyrhizus tuberosum:

- they grow well in hot and wet tropics

##### Polymnia sonchifolia:

- sweet taste watsy quality considered as 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
<b>GRAINS</b>		
Quino	<u>Chenopodium quinoa</u>	Quenopodiaceae
Kaniwa	<u>Chenopodium pallidicaule</u>	Quenopodiaceae
Kiwicha	<u>Amaranthus caudatus</u>	Amarantaceae
Tarwi	<u>Lupinus mutabilis</u>	Leguminosae
<b>TUBERS</b>		
Oca	<u>Oxalis tuberosa</u>	Oxalidaceae
Olluco	<u>Ullucus tuberosus</u>	Baselaceae
Mashua	<u>Tropaeolum tuberosum</u>	Tropaeolaceae
<b>ROOTS</b>		
Maca	<u>Lepidium meyenii</u>	Cruciferae
Jimaca, Ajipa	<u>Pachyrrhizus ahipa</u>	Leguminosae
Arracacha	<u>Arracacia xanthorrhiza</u>	Umbeliferae
Yacon "Jiquima"	<u>Polymnia sonchifolia</u>	Compositae
<b>COMMON FRUITS</b>		
Nuez del Peru	<u>Juglans peruviana</u>	Juglandaceae
Chirimoya	<u>Annona cherimola</u>	Anonaceae
Pacae, "guamos"	<u>Inga feuillei</u>	Leguminosae
Huagra-manzana	<u>Crataegus stipulosa</u>	Rosaceae
Capuli	<u>Prunus serotina</u>	Rosaceae
Mora de Castilla	<u>Rubus glaucus</u>	Rosaceae
<b>OTHER FRUITS</b>		
Ciruela del Fraile	<u>Bunchosia armeniaca</u>	Malpigiaceae
Tumbo, curuba	<u>Passiflora mollissima</u>	Passifloraceae
Tintin	<u>Passiflora pinnatistipula</u>	Passifloraceae
Lucuma	<u>Lucumabifera</u>	Sapotaceae
Capuli, "uchuba"	<u>Physalis peruviana</u>	Solanaceae
Sacha tomate	<u>Cyphomandra betacea</u>	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 world 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 generally 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 within 23 degrees N and S latitude. These mountain systems are estimated to cover 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 agriculture 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 Southern Tanzanian environments, are dominated by Cereal/Oxen-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 broad 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 extent 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. Fernandes, et al. (1985) and Oldkingati, 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 MOUNTAINS OF PAKISTAN

Rashid Anwar and M.S. Bhatti

The Pakistan is a 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 the north and west of the country. The mountain provinces of North West Frontier Province (NWFP) and Baluchistan occupy more than 50% area. These regions were explored and in total 1605 samples 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. ha. respectively. Spread of high yielding varieties (HYV) has posed severe threat to the indigenous varieties. The high yielding varieties of wheat 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 in climate, 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 PAKISTAN

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 primary 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 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 dormant season and budded/grafted onto root-stock nursery to establish clonal repository or living collections. Recently it has been confirmed that seeds of temperate fruits can be conserved for long period as orthodox seeds. Therefore, the expedition 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

Surinder K. Mann

A collection 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 revealed 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 adaptability 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, Uttarakhand (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 cultural 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 amino acids 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 establishment 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

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

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 to 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 diversified 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

J. Tola, C. Nieto, E. Peralta, R. Castillo

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 Chenopodium quinoa, Lupinus mutabilis, Amaranthus spp, considering grains: Oxalis tuberosa, Tropaeolum tuberosum Ullucus tuberosus, Arracacia xanthorrhiza among tubers and some other species i.e. : Cyphomandra betacea, Prunus capuli.

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, mustard, 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.