Summaries of Papers

Reviews

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

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The Hindu Kush-Himalaya (HK-H) region consists of mountains, hills and plateaux 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 up to the western part of NWFP of Pakistan, (b) Karakoram, (c) western Himalaya consisting of eastern part of NWFP of Pakistan, Jammu and Kashmir and Himachal Pradesh (d) Central Himalaya, 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) Henduan Mountain.

Thus HK-H represents the greatest variation in altitude, rising with earth's highest mountain range the Himalaya, and going down to one of the lowest spots on earth. Drained by three of its major river systems the Indus, Ganges and Tsangpo-Brahmaputra, the whole of HK-H is characterized by complexes of mountain systems, climates and vegetation which represents almost global diversity within the region.

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

Vegetation wise, the HK-H abounds 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 forage in Baluchistan, Hindu Kush and the cold deserts of the Tibetan plateau and other rain shadow areas.

In fact, 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 of the HK-H Region. Genetic diversity has been brought out sometimes by trade and migrations, and multiplied for generations. HK-H region consists of very diverse agro-ecological zones, resulting in the creation of diverse farming systems. However, by way of illustration only a few typical examples are summarized below.

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

The High Mountain Farming Systems are generally found in association with transhumance in areas above 3000 m., in the central Himalayas. The climatic conditions often allow only one crop of barley or buckwheat and potato which constitute the main crop. Livestock is 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 per cent of the total land area is comprised of mountain farming systems. As in many other mountain systems, these areas suffer from problems, small and fragmented terrain farm lands, hazards of soil erosion, traditional production systems. The prevalence 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 Taurus Mountains in eastern Turkey and the Zargos Mountains in Iran and Iraq.

The Atlas Mountain Systems dominate the physical geography of the north east and these mountains continue to be unstable. These mountains have four distinct massifs in Morocco. These include a rugged area along the Mediterranean coastline rising to 2200 m in the north, to 3000 to 4000 meters in height as middle Atlas, to the High Atlas towards the south and then falling to lower southernly ranges. From eastern Turkey, south-east through central Iran, a series of mountains predominate, 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 the north east along the Black Sea. The Zagros mountins starts from the north west of Iran forming parallel high tablelands and low basins alternately, the ridges reaching over 4000 m. 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 the 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 with the Caspian Sea in the Elburz range with up to 2000 mm rainfall, special climatic conditions like those in the lower Himalayas are prevalent.

Afghanistan is dominated by the Hindu Kush range, peaking up to 6000-7000 m.

The last range of mountains in the rgion run 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 with in the paper as 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 200,000 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 categorized on the basis of altitude, slopes and nature into the three main types viz, highly dissected, very steep slopes with 1500-3000 metres altitudes and deep gorges predominant, moderately dissected steep slopes (30-100%) 500-1500 metres high with very few gorges, and high plateaux with altitudes 1500-2500 metres high with generally sloping surfaces. Soils vary from gravelly stones to deep loam/clay.

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

In the irrigated area maize, wheat and sorghum are also grown, while certain vegetables like potatoes, tomatoes, onions, cabbage and cucumber are grown in small plots. In the irrigated orchards coffee, banana, grapes and Catha edulis are grown. Catha yields 5-10 times more income than coffee.

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

In fact the countries of west Asia and the 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 now become importers of food, some on a large scale. In 1970, total wheat imported into Arab countries was 4.9 million tonnes and it was 16.7 million in 1983. By 2000 AD the estimated food import requirement will be 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 a mountain farming system must also continue to be productive for effective solution of such growing food deficit.

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 on the north and south slopes of Himalayas has very clear similarity.

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

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

The 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 of disease resistant material for breeding purpose.

MOUNTAIN AND UPLAND AGRICULTURE AND GENETIC RESOURCES IN THAILAND

Sutthi Chantaboon

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 contours in dry evergreen forest and above 400 metre contours. The real highlanders include the Meo, Yao, Lisu, Lahu and Akha tribes who settle the evergreen forests between 1000 metres to 1500 metres altitude. 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 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 of 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 and okra (about 46 species), roots tubers and rhizomes, ginger, shallots etc., animal feed plants, sugar cane, fibre crops, herbs and spices are the major crops.

In 1960 a major development programme 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. were included. The Royal Project set up in 1969 functioned from 1970. About 69 agriculture research projects involving plants and animals were executed to support 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. Pant 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 metres) in the world and also 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 per cent of the area is mountainous where 56 per cent of the population toil hard for bare subsistence.

The Mountain Farming Systems are agroecologically divided into two regions: The Hill Farming System, extending from 500 m. in the south to 2400 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 cropping per year is possible in this belt depending upon the temperature and moisture (irrigation) availability in the crop land. The High Mountain Farming System is prevalent at higher altitudes above 2400 m. 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. Soyabean and blackgram are among the popular legumes. Both tropical and temperate horticulture have high potential in the hills. wheeras the high mountains have potatoes and temperate fruits as potential commercial crops provided the transportation systems for the product and markets are developed. Potato buckwheat, oats are grown as the stable crops at such high altitudes. Livestock is an integral and inseparable enterprise with the farmers in Nepal in general and hills in particular.

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

The paper also strongly urges increased concern for linking international and national organizations for hill area development.

Since the mountains are chronically deficit in food and yet the 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 the purchasing capacity of the masses.

AGRICULTURE IN BHUTAN

D.R. Ghalley

Bhutan an agricultural country is located between 26.5^0 and 29.5^0 north altitude and 88.5 and 92.5^0 east longitude, comprising a total area of 46,500 sq. km., about 74% of which is forest, 5% is under cultivable land and the rest is either alpine or under snow cover.

The southern foothills up to a height of 1500 m. extends to 20 km. north. The inner Himalayas, where the main cultural heart land and important active belt of Bhutan is situated, consists of the middle part of the Kingdom up to a height of 3000 meters. The northern region of the Kingdom rising upto 7000 metres comprises the main Himalayan range. The foothills have a hot, humid climate with temperatures remaining fairly even throughout the year between 15^0c and 30^0c, with 5000 mms of rain fall in some areas, the middle Himalaya have cool temperate climate with annual precipitation of 1000 mm. The western region receives comparatively higher rainfall. In higher areas of far northern part climate is a severe alpine 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, wet land , dryland, Tsheri land 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. Tsheri land is 9.3% which is cultivated in a cycle ranging from 15-12 years. The main crops grown are paddy, maize, millet 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 as orchards mainly to grow apple, orange, cardamom. The main vegetables grown are cabbage, cauliflower, chili, tomato, radish etc. and takes about 1% of the cultivable land of the Kingdom.

Although agriculture is the mainstay for 94% of the labour force of the Kingdom, investment in research has been minimal. However, with the establishment of the Centre for Agriculture Research and Development in recent years, collaborative activities with IRRI, IDRC, CIMMYT and among the SAARC countries, have ushered in some research activities into 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, that researchers should learn the community's environment and that every technical innovation should be supported by a locally existing or innovative 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 describes the approaches adapted to identify 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 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 a workshop which also helped in making rapid appraisal of villages and identifying projects. In the forestry projects, rapid appraisal techniques were adapted to identify grazing area and village requirements and village institutions. Thus, a 'menu' of general findings was 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 the community of development professionals.

The paper concludes that once the village level priorities have been established, 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 the agricultural system of Xizang is influenced by three principal 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: remote geographic location. Third: low productivity. These two factors restricted the devleopment of the economy and caused the ob·ious self-sufficient and closed characteristics of agriculture production in Xizang. In rural area, the important functions are animal husbandry and crop cultivation. These two sectors make up over 85% of the 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 make 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 are mainly agricultural 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 is sown in May or June and harvested in September. 2. The regions of one crop sow in winter. Winter wheat and a small area of winter highland barley are sown in September or October and harvested 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 harvesting of winter wheat can be cultivated. Details of the three factors, three type of regions and three kinds of cropping systems were discussed. Figures of farming system of Xizang were attached.

AN EVALUATION OF ANDEAN ROOT AND TUBER 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 suggests that some of these roots 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 potential in terms of meeting the food requirement of the mountain regions could be listed as below:

Root Crops

Lapidium meyenii:
- cultivation up to 4500 metres. Shows potential outside region of Andes.

Arracasia Xanthorriza Bancrofe:
- is a herbaceous perennial that produces large, thick edible carrot shaped starchy roots.

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

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

Tubers:

Ullucus tuberosus	grown at altitudes of
Oxalis tuberosa	500-4000 m.
Tropaeolum tuberosum	

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

Polymnia sonchifolia:
- sweet taste, watery quality considered as pleasant refreshment

It is significant that these root 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 the way from north to south in the western coastal region of the South American continent. Therefore, it constitutes both tropical and sub-tropical latitudes and altitudes and 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 native 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 native food species of above 2,000 m are given in the following table.

MAIN ANDEAN NATIVE FOOD SPECIES ABOVE 2,000 M *

COMMON NAME	SCIENTIFIC NAME	BOTANICAL FAMILY
GRAINS		
Quinoa	Chenopodium quinoa	Chenopodiaceae
Kaniwa	Chenopodium pallidicaule	Chenopodiaceae
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 and Lupinus as grains, tubers and roots such as yacon, arracacha assume importance both in the native 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 a source of protein and means of transport for the hills and are called mountain camels or camelids. Guinea pigs, locally called cuy (Cavia parcellus), are an important source of protein.

Collaborative work on the genetic resources of Andean mountains among the different mountainous countries of the world could open up large scale sharing of benefits, as in the case of potato 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 climatic conditions. On 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 the southern Andes.

Rainfall is a major limitation, only 349 mm/year, mean annual temperature is 10.4^0 C (12.3^0 C in December, 3.2^0 C in April).

Animal and crop 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 loam). Maize is the predominant crop. Barley and faba beans are found to a lesser extent.

- Plains: 3450 to 3600 masl. Soils are deep and good (mostly clay loam 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 who 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 metre elevation within 23^0 N and S latitude. These mountain systems are estimated to cover a land mass of about 1 million sq. km., 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 east African countries (Kenya, Uganda, Tanzania, Rwanda, and Burundi) make up 76% of this environment. 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 environment is the main human habitation area and is agriculturally important, often dominating the national and region crop and livestock economy. This is because of the favourable climate 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 environment. 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, Ethiopia. These are often referred to as intensive small holdings agricultural systems. In these areas, depending on altitude, cultivation of tea, coffee, pyrethrum, kat, maize, banana, beans, and root and tuber crops dominate. Dairying is also important.

Highlands further away from the equator ($6\text{-}20^0$), represented by the central and northern Ethiopian and southern Tanzanian environment, 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 6^0 and 8^0 S often show transition between these two broad farming systems. Horticulture/hoe farming systems represent more sustainable agriculture, while 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 northern. Tanzania. Getahun (1972) reported 169 types of crops cultivated by farmers in the Harar Mountains in eastern 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 their environment and are under high risk of genetic erosion.

INDIGENEOUS CEREAL CROP GENETIC RESOURCES IN THE MOUNTAINS OF PAKISTAN

Rashid Anwar and M.S. Bhatti

Pakistan is a sprawling mass of land lying between 23^0 N - 38^0 N and 61^0 E - 77^0 E. There are different mountain ranges in the north 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 samples of different crops were collected through seven plant collecting expeditions during 1981-86. Cereals constitute over 70% of the collection. 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 indigenous 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 come under HYV rice and only 2% area is under indigenous varieties. A shift from subsistence to commercial cultivation due to newly exploited irrigation water resources is considered 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 character. 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 reasons.

FRUIT GENETIC RESOURCES IN NORTHERN MOUNTAINS OF PAKISTAN

M.S. Bhatti and R. Anwar

In the north there are towering mountain ranges comprising of Karakoram and Hindu-Kush. Many 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 the very early migration of man. Once introduced and established in the new area, fruits were exposed to evolutionary forces as a result of which a secondary centre of genetic diversity developed. And immense pool of fruit germplasm does exist in the northern mountains; therefore, the region can be considered as an 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 a view point of collecting fruit genetic variability for conservation. During the former two expeditions, the scion-wood of fruits was 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 periods as orthodox seeds. Therefore, the expedition during 1986, collected the mature fruits and seeds which were extracted for conservation in the gene bank. Considerable genetic variability in number of fruit species exists in the area. The variability of 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 by genetic erosion, either slowly or drastically, where fruit trees were cut down for fire wood and other purposes. The Agriculture Department in the area is releasing about one million grafted fruit plants of improved varieties every year which pose a 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 millet 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 m. Environment-II: Shimla 1780 m. and Environment III: Mashobra - 2192 m. 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 m.) appeared to be very poor. The regression coefficients were also worked out for each variety. They varied 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.

EXPLORING UNDEREXPLOITED CROPS OF HIMALAYAN MOUNTAIN AGRICULTURE: CHENOPODS.

Tej Pratap

Chenopodium, a pseudo-cereal, 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 switch-over of agriculture from non-commercial polyculture system to commercial monoculture, Chenopods declined steadily in use and cultivation; presently it enjoys the status of a minor grain crop in many isolated hill communities 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.

Investigation of the folklore reveals its staple food status in the past but the socio-economic survey revealed that it is now cultivated in different areas with different considerations. For food, its cultivation is presently associated with tough geographic conditions and poor economy, where access to urban influence or roads is normally difficult. For alcoholic preparations minor cultivation occurs almost without any regard to the above factors. Generally considered non-commercial, grains do find commercial value in certain areas and are costlier than Amaranthus and Fagopyrum. There are also cutlural and religious reasons for continuing its 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 such as 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 3-5^0 C and do not have any photoperiodic requirements. The crop faces extinction not for its quality but due to scientific neglect of its development to meet/suit the 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 landlocked country in the southern part of Himalaya. It is sandwiched between China and India.

Nepal is situated between 26^0 and 20'N to 30^0 10'N and 80^0 15'E, 88^0 10'E, with a rectangular shape. Though the latitude variation is so small, Nepal has an almost tropical to alpine environment in various parts of the country due to the tremendous topographical variation in altitude (60 m to 8000 m). This topographical variation along with the direction of the slope of the mountain, wind direction etc. has created a tremendous number of mini environments for crop growth.

The presence of numerous mini environments together with the food and cultural habits and religious beliefs of the people residing in the area have established diverse 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 the high mountain. These diverse and numerous mini environments have produced thousands of land races with great variation in the character of widely grown crops like rice, maize, wheat, finger millet, barley, pulses, oil crops etc. The Himalayan belt and adjacent areas are possibly the original home of many crops like rice, buckwheat, 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 mountains, 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 crop programmes are not capable of collecting, maintaining and using the local germplasm properly, due to limitations of money and facilities.

Great potential exists for the collection, evaluation and utilization of the local germplasm of various crops and introduction of some new possible crops in the Nepalese mountain for the benefit of human beings.

STATUS OF VALUABLE NATIVE ANDEAN CROPS 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 on a 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, grains: Oxalis tuberosa, Tropaeolum tuberosum Ullucus tuberosus, Arracacia xanthorrhiza: Cyphomandra betacea, and 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, INDIA 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 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, foxtail millet, finger millet, pearl millet, barnyard millet, mustard, french beans, cowpea, soybean, lentil, black gram, green gram, horse gram, okra and chillies. The mountain regions of Jammu and Kashmir, Himachal Pradesh, UttaraKhand 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 variability was observed in the material collected from a wide agro-ecological zone. The variability observed in rice, maize and grain amaranth is worth mentioning.

The gerplasm has been evaluated for various agro-morphological characters for more than one season. The important donors for crop improvement and elite lines were identified and multiplied for distribution to 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 beans were released for cultivation. Two catalogues, one on grain amaranth and the other on French beans, have been published and catalogues on lentil, soybean, minor millet, buckwheat, and updated catalogues on amaranth and French bean are under preparation. More than 33000 genetic resources of mountain crops were supplied to user agencies both within and outside the country.