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HILL CROPS IMPROVEMENT PROGRAM IN NEPAL

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PROPOSAL

FOR

INTENSIFIED HILL CROPS

IMPROVEMENT PROGRAM IN NEPAL

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Submitted to

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New Delhi

and

Agricultural Research and Production Project

Department of Agriculture

Ministry of Agriculture

His Majesty's Government of Nepal

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A CONSULTANCY REPORT

ON

INTENSIFIED HILL CROPS IMPROVEMENT PROGRAM IN NEPAL

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FOREWORD

In Nepal such crops as finger millet, barley, buckwheat and amaranth are frequently referred to as hill crops due to the fact they are primarily grown in the hills and are of major importance to the hill population. These crops could also be called neglected crops because very little effort has been devoted to their improvement. However, the Department of Agriculture/MOA/HMG/N has come to recognize the importance of these hill crops and is keenly interested in developing an Improvement program. This report is in response to a request from the Department of Agriculture to assess the present situation and the potential of hill crops in Nepal and to formulate an Intensified Hill Crops Improvement Program.

The report is the result of a joint effort and the contributions of many people. Dr. Kishor Sherchand, Plant Breeder, recently received his Ph.D. at Kansas State University and is a member of the Agriculture Botany Division, Department of Agriculture. Mr. Tek Bahadur Shrestha is an Agricultural Economist and a local consultant. Dr. Kenneth O. Rachie, Winrock International consultant, is a Plant Breeder, Agronomist and Research Administrator with over 30 years of professional experience. Mr. A. N. Bhattarai, Chief, Agronomy Division, has, for many years, indicated the need for additional research on hill crops and through his continuous efforts and encouragement plans were formulated and implemented for the development of this Intensified Hill Crops Improvement Program report. Mr. Gopal Rajbhandary, Chief Agricultural Botanist, Agriculture . Botany Division, provided continuous guidance, stimulation and backstopping which resulted in the report becoming a reality. Invaluable assistance and background information have been provided by Mr. Khagendra Man Singh and Mr. Deep Man Sakya of the Agronomy Division. The comments, suggestions and encouragement of Mr. Gary Alex, Program Officer, USAID/N and Dr. Kenneth W. Riley, Program Officer, IDRC, New Delhi were most helpful.

It is visualized that this report will serve as a guide and an inspiration and will go a long way in accelerating the Hill Crops Improvement Program in Nepal.

Carl N. Hittle
Chief of Party
Agricultural Research and Production
Project

ACRONYMS

ADB	Asian Development Bank
ADB/N	Agricultural Development Bank of Nepal
AIC	Agriculture Inputs Corporation
APROSC	Agricultural Projects Services Centre (Kathmandu)
ARPP	Agricultural Research and Production Project
ASD	Agricultural Statistics Division
AVRDC	Asian Vegetable Research and Development Center (Taiwan)
CFRL	Central Food Research Laboratory
CGIAR	Consultative Group on International Agricultural Research (Columbia)
CIAT	International Center for Tropical Agriculture
CIDA	Canadian International Development Agency
CIMMYT	International Center for Maize and Wheat (Mexico)
CP	Crude Protein
DDG	Deputy Director General of Agriculture
DFAMS	Department of Food and Agricultural Marketing Services
DG	Director General of Agriculture
DOA	Department of Agriculture
EAAFRO	East African Agriculture and Forestry Research Organization
FAO	Food and Agriculture Organization of the United Nations
FFT	Farmers' Field Trial
FSP	Farming Systems Program
FY	Fiscal Year
GTZ	German Technical Assistance Agency (Fed. Rep. of Germany)
ha	Hectares
HADP	Hill Agricultural Development Program
HCIP	Hill Crops Improvement Program (USAID/IDRC)
HCTP	Hill Crops Technical Panel
HFPP	Hill Food Production Project
HMG/N	His Majesty's Government of Nepal
IAAS	Institute of Agriculture and Animal Science (Rampur)

IARC	International Agriculture Research Center (eg. ICRISAT, IRRI, ICARDA, IITA and others)
IBPGR	International Board for Plant Genetic Resources (Rome)
ICAR	Indian Council for Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas (Syria)
ICIMOD	International Centre for Integrated Mountain Development (HMG/N, UNESCO, GTZ, SATA)
ICP	Integrated Cereals Project
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Hyderabad, India)
IDRC	International Development Research Centre (of Canada)
IHDP	Integrated Hill Development Project (SATA)
IITA	International Institute of Tropical Agriculture (Nigeria)
IRRI	International Rice Research Institute (Philippines)
K-BIRD	Karnali-Bheri Integrated Rural Development (CIDA)
LAC	Lumle Agricultural Centre (ODA)
LRMP	Land Resources Mapping Project
M or m	Meters
masl	Meters above sea level
MOA	Ministry of Agriculture
mt	Metric tons
ODA	Overseas Development Agency of the United Kingdom
PAC	Pakhribas Agricultural Centre (ODA)
pm	Person months
py	Person years
SATA	Swiss Association for Technical Assistance
TU	Tribhuvan University
USAID	United States Agency for International Development
WI	Winrock International Institute for Agricultural Development (Morrilton, Arkansas, USA)

TERMS

Gazetted	Permanent Civil Servant, Officer Class (I-III)
JT/JTA	Junior Technician/Junior Technical Assistant (Non-Gazetted but permanent)
Terai	East-West strip of plains south of the foothills
Dal	Soup or sauce made from dried, boiled pulses
Pulse	Dried legume seeds; syn: grain legumes, food legumes

NEGLECTED HILL CROPS

English	Local Name	Botanical Name
Finger Millet	Kodo	*Eleusine coracana* (Gaertn.)
Barley, covered	Jau	*Hordeum vulgare*
Barley, naked	Uwa	*Hordeum vulgare*
Common Buckwheat	Mithe Phapar	*Fagopyrum esculentum* (Moench.)
Tatar Buckwheat	Tite Phapar	*Fagopyrum tataricum* (Gaertn.)
Amaranth	Latte, Marshe	*Amaranthus* spp.

A PROPOSAL FOR AN INTENSIFIED HILL CROPS IMPROVEMENT PROGRAM

EXECUTIVE SUMMARY

1. Background

The present population of the non-urban Nepalese hills is about 76 lakhs. However, production of food grains comprising more than 80 percent of the hill peoples' nutrition totals only about 16.2 lakh tons. Of this amount only 10.6 lakh tons are available for consumption equivalent to the annual requirement of only 62.6 lakhs of people. This represents a shortfall of 2.4 lakh tons of edible food grains equivalent to 3.6 lakh tons of the gross harvested crop.

The three major food grains of the hills - maize, rice and wheat - have limited scope for expanding production as most of the more suitable lands (better soils, irrigation) have already been developed. Moreover, there already are major coordinated national improvement programs for these crops. On the other hand, there are four neglected hill grain crops - millet, barley, buckwheat and amaranth - that contribute from 2.61 to 2.86 lakh tons of food grains or 1.9 to 2.15 lakh tons of edible grains (note: total harvested production of the four hill grain crops in Nepal - terai, hills and mountains is estimated at 3.05 to 3.38 lakh tons).

In human food equivalents these four crops provide major sustenance for 11.5 to 12.6 lakhs of hill people or 18.4 to 20.1 percent of all food grains produced in the hills. However, the food deficit is destined to worsen as the hill population increases to 101.4 lakhs by the year 2000 when current production levels of hill crops (or imports) must rise to 16.6 lakh tons annually.

2. The Proposal

The theme of this proposal is that the most effective approach to increasing food production in the hills is to mount an intensified hill crops improvement program (HCIP) focussed on the four neglected crops: millet, barley, buckwheat and amaranth. The long term main thrust of this program will continue to be varietal improvement as the most efficient, least-cost solution to the major constraints of increasing production. Pursuing this approach will require a closely-integrated, multi-disciplinary team approach involving breeding, agronomy, soil science, plant protection, plant physiology, agricultural botany, and socio-economics.

The complexities of breeding four different species for the nearly infinite permutations of agro-ecological conditions and local uses is formidable indeed, and a much greater challenge than faced by any other commodity program in Nepal. Therefore, the plant improvers must have a large pool of indigenous germplasm and introduced materials to work with; and have access to the range of growing conditions in the hills. The former will require a well-organized collecting effort, hopefully with separate support (eg. IBPGR or bilatered agencies) and HCIP must test and evaluate germplasm under a broad range of hill growing conditions (see item number 9, Operational Sites, of this Summary).

A second critical thrust and one that could have an even more rapid impact in the early stages is production management closely integrated with the Farming Systems Program. Again most of the disciplines included under plant or varietal improvement would be involved. Similarly, there is a need to examine approaches to plant protection other than host plant resistance. In this area information will be needed on pest dynamics, effects of cropping systems and cultural practices on crop damage, potential for biological controls, and judicious use of chemical and biological controls.

These three research thrusts will comprise the main core of the hill crops program, but other areas may be included as resources, staff and facilities allow, especially:

1. Product quality studies - on the effects of crop, variety, environment, soils management and handling/storage on grain and fodder qualities.

2. Post-harvest handling - especially more efficient methods of harvesting, threshing, drying and storing the crop.

3. New crops - carry out exploratory studies on promising exotic species of crops for human nutrition, animal feed, and as components of the cropping system.

3. Commodity Mandate

From both the production and improvement perspectives the distinction between different ecotypes of the same species grown under a range of agro-ecological zones become blurred. In fact effective improvement programs for any agro-ecology must work with the full range of genetic diversity. Also, the difference between simply-inherited genetic characters like hulled vs naked barley is a moot one since the naked character can be transferred easily between genotypes. In practice both naked and hulled barleys grow side by side even at the higher elevations. For these and logistic reasons, it is more efficient for a single improvement program to be responsible for the same crop grown in all agro-ecologies in Nepal.

In the case of millet with 84.3 and 86.8 percent of area and production, respectively, grown in the hills, all aspects of the improvement of this crop would be included under the HCIP mandate. The case of barley is similar. This crop with a total production of 24,000 to 57,000 mt (75.6% of the area and 76.5% of the production occurs in the hills) is too important to neglect even in the Terai. Therefore, if no other program is responsible for this crop we

recommend that all aspects of improvement be mandated to the HCIP, at least for the time being. If this recommendation is accepted, barley should be raised in priority level to second place after millet.

4. Program Organization and Scope

The HCIP will be organized as a fully structured, multidisciplinary program with close linkages to the Farming Systems Program, the disciplinary divisions at Khumaltar, seed production, extension, Tribhuvan University; and to external agencies like the IARC's and appropriate national research programs. Because of the special problems and needs of hill crops research and the late program start-up, three development phases are proposed: I (1987/1990), II (1990/2000) and III (2000/2010). For the HCIP to be successful and have a sustained impact careful nurturing and enthusiastic support will be required at least throughout this entire period. Of course the first 13 to 14 years of development will be the most critical.

5. Hill Crops Technical Panel

The formation of a Hill Crops Technical Panel is recommended. The Panel will consist of divisional heads as members, and the DDG for crops will serve as chairman. The Hill Crops Coordinator will be the secretary. Other members may include representatives of the seed industry, farmer's groups and other agencies.

The purpose of this Panel is to advise on technical matters, review progress, help prioritize problem areas, and evaluate future work plans. The Panel will also encourage complementary work among disciplinary divisions and decide on annual allocations from the "Special Projects Fund". This fund will be established in support of related areas of research carried out by some of the disciplinary divisions.

Meetings will be organized by the HCIP Coordinator in advance of the main season, or once a year.

6. Seed Production and Extension

Close links will need to be developed with the Agriculture Inputs Corporation and Extension, both of which are critical for transferring technology. It will be particularly important not only to provide breeder's seeds, but also to help in roguing seed production fields and training AIC technical personnel in growing the new varieties. Ample quantities of seeds and a good distribution network are essential for success of the program.

7. Role of Other Agencies

Hill crops production can also be increased through careful national planning and policy by making inputs like seeds, fertilizers, and pesticides available; assuring timely credit; and carrying out effective extension so that technological inputs are readily available to farmers. The present intensive production and district-based farming systems program can have an important role in boosting hill crops by educating growers and promoting improved technologies. HCIP researchers should participate fully with such production programs.

8. Travel

It is essential that researchers should travel to see the work at other stations, testing sites, and farmer's fields. This is especially important for inspecting trials and other experiments which must be seen at least 2 to 3 times during the growing season. Therefore, there must be ample travel funds, and more extensive use of air travel to save time. A second need for travel is to establish and maintain linkages with foreign scientists - especially those in India, Pakistan and Bangladesh.

9. Operational Sites

The main coordinating center for the HCIP is Lumle near Pokhara; but Khumaltar will serve as the coordinating center until appropriate arrangements are made with the Lumle Agricultural Centre and needed

facilities are provided. There will be a network of four centers, in addition to Lumle, at which one or more gazetted officers will be outposted, six subcenters primary testing sites, and at least four collaborative farming systems sites, plus a large number of farmer's field trials (FFT's). The five centers and six subcenters include:

Centers	Subcenters/Testing Sites
1. Lumle: M,Ba,BW,A (1700m)	1. Doti: M,Ba,BW (620m)
2. Jumla: M,Ba,BW,A (2390m)	2. Surkhet: M,Ba,BW (450m)
3. Marpha: Ba,BW (2550m)	3. Kakani: M,Ba,BW (2030m)
4. Kavre: M,Ba,BW (1700m)	4. Khumaltar: M,Ba,BW (1360m)
5. Rampur: M,Ba,BW (228m)	5. Pakhribas: M,Ba,Bw (1700m)
	6. Tarahara: M,Ba (200m)

Note: M = millet; Ba = barley; BW = buckwheat; A = amaranth.

10. Facilities

The HCIP will require facilities at all five centers, except perhaps at Rampur. It may also be necessary to provide modest facilities (like a store, threshing floor and small equipment) at selected subcenters. Major requirements at Lumle will be for residences, laboratories and offices. Additional facilities on a lesser scale will be needed at the other centers depending on availability of existing staff and facilities. About 70 percent of construction and station development in Phases I and II (totalling Rs. 69 lakhs) will be allocated to the main center, 20 percent will go to the subcenters, and 10 percent will be available for testing sites.

Laboratories and offices will have to be equipped and furnished, glass or plastic/mesh houses constructed, and irrigation/drainage

installed. Some land development work will be needed depending on the situation at each station and site. Although some vehicles will be required, field machinery will be kept to a minimum as being impractical at hill stations.

11. Staffing

A team of scientists led by a well-qualified coordinator will include agronomists, breeders, soil scientists, plant physiologists, plant pathologists, entomologists, agricultural botanists, and socio-economists. The proposed staffing for Phases I to III will include:

Discipline	Development Phase (No) I	II	III	Total Phase III
	No/Grade	No/Grade	No/Grade	
1. Coordinator	1/II	1/I	1/I	1
2. Agronomy	1/II+1/III	1/I+2/II+2/III	1/I+2/II+2/III	5
3. Agri. Botany		1/III	1/II	1
4. Breeding	2/III	1/II+3/III	1/I+3/II	4
5. Entomology	1/III	1/II+1/III	2/II	2
6. Pathology	1/III	1/II+2/III	1/I+2/II	3
7. Physiology	-	1/III	1/II	1
8. Soil Science	1/III	1/II+1/III	2/II	2
9. Socio-Economics	-	1/III	1/II	1
10. Training	-	1/III	1/II	1
TOTAL	2/II+6/III	2/I+6/II+13/III	4/I+15/II+2/III	
All grades	8	21	21	21

Added to this roster would be requisite administrative and technical support (see Section VI). Moreover, training must be organized on a continuing basis as described below.

12. Training

Training is essential to develop effective dedicated and motivated researchers and working staff. Capable, trained staff are the key to the success of the program. Training must be continued indefinitely, although the greatest investment in long term training will be needed in Phases I and II.

In addition to training and travel grants for researchers, national training programs for JT's/JTA's, production technicians, and progressive farmers are scheduled on a sustained basis, so that trained researchers will have supporting staff and workers at the field level.

It is proposed to provide long term training for 5 M.Sc.'s (120 pm) in Phase I; and for 5 Ph.D.'s & 9 M.Sc.'s (396 pm) in Phase II. In addition, short term and in-service training, visitations, international conferences, and other external events are scheduled at the rate of 18 pm in Phase I and 50 pm in Phase II. In country group training for JT's/JTA's, progressive farmers and production technicians would total 30 pm in Phase I and 54 pm in Phase II; and seminars, workshops, monitoring tours internal events would total 28 pm in Phase I and 60 pm in Phase II.

(Note that Phase I covers 3 years; and Phase II is 10 years.)

13. Financial

The total cost of the HCIP for Phases I-III (1987/2010) is Rs. 8.1 crores. The respective cost for Phases I and II (major building Phases) is:

	Category	Total Rs.'000	Total Percent
1.	Staffing/personnel	17864	38.2
2.	Construction	7900	18.9
3.	Equipment	3019	6.5
4.	Expendables/supplies	1317	2.8
5.	Operation	2495	5.3
6.	Training	14181	30.3
	Total	46776	100.0

Phase III (10 years) is estimated to cost Rs. 344.0 lakhs, but construction and long term training are greatly reduced. Average costs per year are: Phase I and II = Rs. 35.0 lakhs and Phase III = Rs. 34.4 lakhs.

14. Program Impact

The total expenditure for Phases I-III of the HCIP is Rs. 8.1 crores. However, the expected payoff is very great owing to the extensive areas covered by hill crops, the cumulative effect of increasing numbers of farmers adopting improved technology, and the rapid advances possible once the research program is fully functional. A 'conservative' model for the incremental hill crops production accruing from research and allied efforts for the 18-year period to 2005 suggests that cumulative production would increase by 81 percent, and that the cumulative increase from technology adoption will total 10.03 lakh tons. If this 'bonus' is valued at Rs. 6000/mt the resulting benefit to Nepal's hill people and national economy would be Rs. 602 crores. Thus, the total HCIP costs for Phase I-III (starting from 1987 to 2010 or 23 years) would amount to only 1.3 percent of this increased production.

A CONSULTANCY REPORT

ON

THE INTENSIFIED HILL CROPS IMPROVEMENT PROGRAM IN NEPAL

I. BACKGROUND

The three major food crops grown under favorable conditions in the hill regions of Nepal are maize, rice and wheat. Fortunately, much improvement has been achieved on these important commodities both at the national and international levels. Moreover, well-organized, international networks for collaborative research, varietal testing, and training exist for them, sponsored by multi-donor International Agricultural Research Centres (IARC's) like CIMMYT in Mexico, ICARDA in Syria and IRRI in the Philippines. In Nepal the improvement and development of these crops are organized as separate nationally coordinated commodity programs. There are, however, several other important hill food crops which have not yet received the attention they deserve and are the subject of this proposal.

1.1 THE NEGLECTED HILL CROPS

At least four species of cereals and pseudo- (non-graminaceous) cereals deserve attention under the proposed accelerated Hill Crops Development Program. These four crops are already sufficiently important in their own right, often perform well under stressful conditions, may have special uses, but are largely neglected both at the national and international levels. Often they are locally important and may provide the major source of nutrition in certain areas where the climate is harsh or the soils too impoverished to successfully grow more fastidious species.

They include the following:

1. Kodo or finger millet (*Eleusine coracana*)
2. Phapar or buckwheat (*Fagopyrum* spp.)
3. Uwa (Jau) or barley (*Hordeum Vulgare*)
4. Latte or Marshe or grain amaranth (Amaranthus spp.)

These four crops are described in more detail in Appendix I.

These crops are largely grown for home consumption on small, subsistence farms. They are sometimes grown as sole crops, but more often they are sown in complex associations or relayed with other cereals (especially maize), oilseeds or pulses. A common virtue is short duration to allow growing them between major rotations or in catch/emergency situations when the major cereals have failed. However, there are also good external markets for some of the crops, especially amaranth grain and finger millet.

1.2 THE AGRICULTURE

1.2.1 The Land

The total area of Nepal is 141,000 km^2 and about 3.13 million hectares, or 22 percent of the land area, are cultivated. Of the total rural population of about 15.3 million (90% of 17 million) about 56% live in the hills/mountains and 44% in the Terai. However, hill lands comprise only 1.5 million hectares (47.9% of the total), are considerably less productive, and have very little potential for irrigation compared with the Terai. At present only 160,000 ha (10.7%) of hill lands are irrigated with possibilities of nearly doubling this area to 300,000 ha by the year 2000. By comparison the Terai has 341,000 ha (20.9%) of irrigable land, but virtually all 1.63 million hectares of this region could be irrigated by the turn of the century.

Agriculture in Nepal is particularly complex owing to the diversity of environments in the country. Three broad agricultural zones may be distinguished based on elevation, topography and soil types: (1) the plains comprising the Terai and Inner Terai (approximately 100 to 300 m.a.s.l.), (2) mid-hills and valleys (about 500 to 2000 m), and (3) the high hills and submountainous region (2000m to 4000m). However, crop adaptation in the hills may be better described by classifying climates in 1000m intervals (eg. 300-1000m; 1000-2000m; 2000-3000m; and 3000-4000m).

Agriculture dominates the Nepalese economy employing more than 90 percent of the 17 million inhabitants (growth rate is 2.66%) and contributes 60 percent of the gross domestic product (GDP). However, per

capita income is very low at only US $140 per annum. Traditional subsistence level production dominates the sector as small holdings. The average farm size is less than 1.25 ha in the hills and 2.11 ha in the Terai.

1.2.2 The Climate

Nepal varies in width from north to south by 130 to 240 km between the latitudes of 26°20' and 30°30'N, but climate changes drastically over short distances as a consequence of elevation. The torrid and subhumid subtropics of the Terai plains is transformed to an alpine climate in only a few hours drive. The average annual precipitation is 1600 mm with 80 percent occurring during the monsoon (June-October), but ranges from only a few hundred millimeters to more than 5 meters in some of the central mid-hills. The moisture gradient increases from west to east. Some hilly areas also receive significant amounts of winter rainfall. Temperatures vary closely with elevation. Mean temperatures in the Terai range from a minimum of about 14°C in January to a maximum of 36°C in July-August. In the hills the corresponding figures are 10°C and 25°C; although much lower temperatures do occur at the limits of agricultural production (about 4000m).

1.2.3 The Soils

The soils of Nepal are derived from young parent materials from the Himalayan massif. The Terai plain is the northern part of the Indo-gangetic depression filled by recent alluvial materials with soils ranging from sandy to silty and underlain by thick gravel in the northern part. The Terai is essentially a flat plain composed of alluvial silts of moderate fertility. Most soils are low in organic matter, nitrogen, phosphorus, and potash with a pH range from 6.0 to 7.5.

Soils of the hills and mountains are also derived from young parent material and are moderately-fertile sandy to silty loams with a low clay context. They are mostly acidic with a pH of 4.5 to 5.5. Many of the hillsides are cultivated on soil scraped into terraces; most of which are very old. However, there is increasing cultivation of newly-cleared lands

without terracing. The intensive use of steep hillsides both from cultivation and overgrazing greatly increases erosion and the silt burden of streams. Frequently sections of these eroded slopes slide away into the valley below.

1.3 THE FARMERS

Farming in the hills is much more difficult and risky compared with valley bottoms and the Terai plains. Land holdings are small (62.3% of households have less than 0.4 ha, and 27.7% have only 0.4-1.0 ha), fragmented, and often fragile. In addition the soils may be degraded, low in fertility and acidic (pH 4.5 - 5.5). Moving about, up and down slopes, requires much energy, and much of the work must be done by hand. Unterraced hill slopes are impractical to irrigate, even if water is available, so that crop production in the hills is highly seasonal resulting in massive underemployment during the dry season.

Hill areas are almost always remote with poorly developed communications networks. Often this means that supplies have to be carried in by packing - either by man or animal. In the same way the produce must be packed out. Even comparatively short hauls of only 5 or 6 miles can easily increase costs by 10 percent or more. As a consequence most hill agriculture does not have access to needed inputs such as chemical fertilizers, plant protectants, implements and fabricated materials.

The agriculture of the hills is old and farmers have developed patterns and systems which are difficult to improve upon. Moreover, their crop varieties are mainly local in origin and lacking in productive potential, though well adapted to prevailing conditions and usage. Since conditions vary so widely depending on topography, elevation, rainfall, soil type, and slope orientation rapid crop improvement will be challenging. Moreover extension services are not so well developed in the hills as in the more accessible valleys and plains.

Much effort is required to grow sufficient food for year-around subsistence with few resources left to purchase farm inputs, provisions and

other necessities, nor to obligate funds for most social events - eg. marriage, births, funerals. As a consequence hill people are often in heavy debt to money lenders and cannot afford to buy inputs or provisions when prices are down nor wait to sell their produce when demand is high.

II. IMPORTANCE, UTILIZATION AND MARKETING

The importance of neglected hill crops is difficult to ascertain directly as a consequence of the lack of accurate production estimates. However, a comparative estimate of food crop production based on the best available information will be attempted. In general the four hill crops are locally important often contributing the major source of human nutrition in certain restricted locales and seasons of the year.

2.1 PRODUCTION OF HILL CROPS

2.1.1 Finger Millet

The production of millet increased by 22 percent during the period 1970/71 to 1980/81; and appears to have increased a further 10 percent from 1980/81 to 1984/85 according to the HMG Agricultural Statistics Division (ASD). More recent information indicates that millet production (including buckwheat) in 1984/85 was 142,000 mt from 134,000 ha. Similar production levels organised by districts and agro-ecological zones for 1978/79 are shown in Appendix II.

An analysis of district production by region and agro-ecological zone is presented in Table II-1. This shows that the Western Region is the largest producer with 33.8 and 34.8 percent of total area and production, respectively. The other three regions were about equal in production at 20 to 24 percent of area and 21 to 23 percent of the tonnage. In respect to agro-ecological zones the major producing region is the mid-hills with 71.0 and 72.6 percent of area and production, respectively. Production in the mid-to higher hills is 13.4 and 14.2 percent of area and production, respectively; while the Terai and Inner Terai produce only 13.2 percent of millet grain production, a level that appears to be declining in recent years in favor of other crops. Moreover, yields in the plains are the lowest (1065 kg/ha) compared with the national average (1105 kg/ha).

There are indications that millet production may be underestimated by official statistics. Aerial surveys conducted by the Land Resources

Table II-1 : Distribution of Millet Production by Region and Agro-Ecological Zone in Nepal 1978/79

REGION	MID-TO HIGH HILLS		MID-HILLS		TERAI/INNER TERAI		TOTAL		PRODUCTION	
	AREA (ha)	PRODUC-TION (mt)	AREA (ha)	PRODUC-TION (mt)	AREA (ha)	PRODUC-TION (mt)	AREA (ha)	%	(mt)	%
EASTERN	4710	6260	19200	19460	5980	5050	29890	24.2	30770	23.0
CENTRAL	4310	4200	15800	17390	7160	6650	27270	22.0	28240	21.1
WESTERN	1100	1250	38160	43250	2470	1980	41730	33.8	46480	34.8
FAR WESTERN	6390	7230	14620	16970	3740	3920	24750	20.0	28120	21.1
TOTAL	16510	18940	87780	97070	19350	17600	123640	100	133610	100
PERCENT	13.4	14.2	71.0	72.6	15.6	13.2	-	-	-	-
MEAN YIELDS (kg/ha)	1147		1106		1065		1105			

Mapping Project (LRMP) in 1985 project much higher production levels of 235,000 ha and 252,200 metric tons - about double the Agricultural Statistics Division figures for that year. A comparison of the two estimates for the area of millet and other food crops in Nepal follows:

Crop	Agri. Stat. Div Area, '000 ha	Agri. Stat. Div Yield kg/ha	LRMP Area, '000ha	LRMP Yield, kg/ha	LRMP/ASD Percent AREA	LRMP/ASD Percent YIELD
Paddy	1377	1968	1417	1536	102.9	78.0
Maize	579	1417	688	1108	118.8	78.2
Wheat	452	1181	504	961	111.5	81.4
Millet	134	926	235	1074	175.4	116.0
Barley*	28	858	74	775	264.3	90.3

* Includes naked barley.

It is curious that LRMP estimates based on a combination of aerial photography and surface sampling are within 'reasonable' agreement with ASD statistics for paddy, maize and wheat; but diverge so drastically for millet and barley. However, a second check based on the known association of maize and millet in the hills is possible. Estimates of this association range between about 40 and 75 percent. If the maize area in Nepal is reasonably accurate (it should not be less than 579,000 ha) and 72.5 percent of maize is grown in the hills the area would be 420,000 ha. If, conservatively, 50 percent of the hill maize is associated or relayed with millet, the area of millet would be 210,000 ha not counting production in the Terai and possibly some sole-cropped millet in the hills. Using a mean yield of 1110 kg/ha for the hills and mountains, production would be 233,100 metric tons, which added to production for the Terai/Inner Terai would total 250,700 metric tons on 229,440 ha, or very close to the LRMP estimate!

2.1.2 Barley

Production of barley for all three agro-ecological zones in Nepal declined by 8.5 percent during the period 1971/72 and 1981/82 to 23,300 mt on 27,020 ha according to the official ASD statistics. The figures for 1984/85 are little changed at 24,000 mt on 28,000 ha; but LRMP estimates for 1985 are considerably higher at 57,500 mt on 74,000 ha. Of these

amounts 35.5 percent of the area and 36.5 percent of the tonnage classify as high elevation barley while 40 percent of the area and production is in the hills. Production in the different agro-ecological zones is calculated as follows:

Zone	Area, %*	Production, %*	Area (ha) ASD	Area (ha) LRMP	Production (mt) ASD	Production (mt) LRMP
Mountain	35.5	36.5	9948	26292	8770	21011
Hills	40.1	39.9	11222	29659	9580	22954
Terai/Inner Terai	24.4	23.6	6830	18049	5650	13535
TOTAL	100.0	100.0	28000	74000	24000	57500
Mean yield (kg/ha)			-	-	858	775

* Calculated from 1981/82 ASD data.

Since there does not appear to be any satisfactory basis for reconciling the discrepancy between the two estimates, the lower or ASD figures will be used for calculation of actual food values. However, the range of total production estimates will be referred to for some discussion purposes.

2.1.3 Buckwheat

In the case of buckwheat the only production estimates available are from the LRMP survey. Production in 1985 is estimated at 23,100 mt from 43,000 ha for a mean yield of 540 kg/ha. Virtually all of the production is presumed to occur in the hills and mountains.

2.1.4 Amaranth

There are no references to amaranth production in Nepal. The only information available is on its importance in the western hills. If, for the sake of discussion, the production of amaranth is presumed to be one-third that of millet for the Far Western Region only, then total production may be as much as 8250 ha and 7,000 mt at an average yield of 850 kg/ha.

2.1.5 All hill crops

Total production of the five hill cereals and two pseudo-cereals in 1984/85 is calculated in Table II-2. All hill crop production is estimated at 1,606,400 mt of which 1,050,500 mt is edible. Of the latter 194,300 is produced by HCIP mandated crops not counting the 44,600 mt (or 33,100 mt edible) contributed by millet and barley in the Terai and for which the HCIP will assume responsibility for improvement.

The fundamental consideration is translating this production into human nutrition. The international banks use a target of 180 kg/caput. However, this factor may not be realistic as it does not allow for substantial nutritional differences between cereal grains, and it is not clear what is included in the estimate. Perhaps a better and more accurate determination of the nutritional impact can be gauged following the steps described below:

(1) Energy needs in Nepal are estimated at 2100 calories per person/day (2070 in 1981). FAO recommends 2600 calories per day.

(2) Major cereals are assumed to contribute 76 percent (1600 calories) of daily requirement or 584,000 calories per year (365 days).

(3) Energy values for the edible portion of each food crop are computed separately in Table II-3 and are derived from Appendix III.

(4) Desirable protein levels should be raised from 47 g/day to 65 g/day = 23.7 kg/person/year.

2.2 IMPLICATIONS FOR CONSUMERS

Given these assumptions current production levels of hill food crops provide the primary energy source for 6.206 million people plus 11.5 to 23.3 kg of protein per caput (48 to 98 percent of requirement). Since the rural hill population of Nepal is currently estimated at 7.65 million

Table II-2 : Calculated Production of seven important food crops in the Nepalese Hills During 1984/1985

Crop	Total Production ('000mt)	Hill Production ('000mt)	Percent in Hills	Percent Edible*	Net Available ('000mt)
National Programs:					
- Paddy	2709	549.9	20.3	49.5	272.2
- Maize	820	594.5	72.5	74.4	442.3
- Wheat	534	201.3	37.7	70.4	141.7
Sub-Total	4063	1345.7	-	-	856.2
HCIP Crops:					
- Millet	251	212.3	84.6	74.2	157.5
- Barley	24	18.4	76.7	73.7	13.6
- Buckwheat	23	23.0	100.0	75.0	17.2
- Amaranth	7	7.0	100.0	86.0	6.0
Sub-Total:	305	260.7	-	-	194.3
TOTAL (All):	4368	1606.4	-	-	1050.5

* Portion remaining after reserving seeds, milling and losses.

Table II-3 : Human food energy and proteins supplied by hill crops in 1985 expressed as persons per year (1600 calories/day) and proportion of annual protein requirement supplied (derived from Table II-2)

CROP	PRODUCTION ('000 mt edible)	PERSON/YEAR EQUIVALENT (584,000 cal.)	PROTEIN/PERSON SUPPLIED (kg/yr)	(PERCENT)
National Commodity Programs:				
- Maize	442.3	2,688,639	15.3	65
- Paddy	272.2	1,608,031	11.5	48
- Wheat	141.7	807,981	23.3	98
SUB-TOTAL	856.2	5,104,651	-	-
HCIP Crops:				
- Millet	157.5	884,589	13.0	55
- Barley	13.6	78,246	20.0	84
- Buckwheat	17.2	98,664	20.4	86
- Amaranth	6.0	40,171	22.8	96
SUB-TOTAL	194.3	1,101,670	-	-
TOTAL (All Crops):	1050.5	6,206,321	-	-

the prime energy needs of 1.44 million people (equivalent to 236,890 mt of maize) must be obtained from elsewhere, most probably the Terai. This deficit will rapidly increase so that by the year 2000 an estimated 10.14 million people will be living in the hills and requiring 1.66 million tons of cereal grains (maize equivalent) annually to satisfy current consumption levels. To achieve self-sufficiency production would have to increase by at least 58 percent over 1985 levels.

Regarding protein nutrition most cereals, with the possible exception of amaranth, are deficient in certain amino acids, especially lysine and tryptophan. Therefore, nutritionists recommend that up to 18-20g of protein per day (28-31% of requirement) be obtained from other sources (eg. 11.25g of animal origin plus 6.5-8.5g CP from pulses).

The importance of the neglected hill crops, specifically the four HCIP mandated species, is evident. The HCIP crops contribute 194,300 mt of edible product or 18.5 percent of the total, providing basic sustenance for 1,101,670 people. Although total food grain production in the hills falls short of self sufficiency for this agro-ecology by about 237,000 metric tons, the improvement of neglected hill crops may offer the best and easiest solution to at least partially fill this gap and toward meeting the larger 600,000 mt short fall by the turn of the century.

Among the four HCIP commodities finger millet is by far the most important. Besides being the highest yielder it is also grown on the largest area, is most widely distributed among the hill regions and has the highest production (est. 251,000 mt in 1985). From these calculations it comprises about 15 percent of all grain crops (edible portion) grown in the hills; and more than 80 percent of the four HCIP crops combined.

2.3 UTILIZATION

Hill crops are important for food, animal feed and inclusion in a wide variety of cropping patterns and systems. They are particularly valued for filling specific niches or needs and because they often succeed in stressful situations where other more 'elite' crops would fail. The

relative importance of these hill crops in different agro-ecological zones is shown in Table II-4 and their distribution in Nepal is illustrated on the maps in Appendix IV.

2.3.1 For Human Food

Several food preparations are made from cracked, ground, parched and popped grains of hill crops. Most common are various forms of porridge-type dishes, flat or unleavened breads, and sweet cakes mixed with ghee and sugar or honey. A favorite preparation of amaranth is popped grains mixed with honey to form a sweet snack. Finger millet is popular both as a solid food and fermented as beer. As much as a fourth or more of the millet harvest is fermented. Millet is particularly appreciated because it can be stored almost indefinitely without deteriorating; and because it digests slowly (apparently due to its fiber content) and thereby sustains hard work throughout the day on a single meal in the morning.

2.3.2 Animal Feed

The harvest residues (straw) of hill crops are extensively used for animal feeds. Green millet may also be used for hay; and the spent brewer's grains are an important animal concentrate.

2.3.3 Cropping Systems

Hill crops are frequently included in complex cropping patterns as illustrated in Appendix V. Millet is particularly versatile as a summer rotation crop in both the plains and the hills. While it is sometimes sole cropped, the more common pattern is in association or relay planting with maize in the hills. Other associations are millet with soybeans or millet followed by potato and wheat in the upper hills.

High elevation barley, grown above about 2500m, is mainly rotated with potato and tatar buckwheat. Common or sweet buckwheat in the mid hills usually follows maize and may be associated or relayed with mustard, pulses and/or millet. Amaranth is most commonly grown in patterns

Table II-4 : Relative Importance of Four Hill Crops in Different Agro-Ecological Production Zones

Crop	WESTERN				CENTRAL				EASTERN			
	High Mtn.	Mid Hills	Siwalik	Terai	High Mtn.	Mid Hills	Siwalik	Terai	High Mtn.	Mid Hills	Siwalik	Terai
Millet	*	***	**	*	**	***	**	*	**	***	*	*
Buckwheat: FT (tatar)	***	**	N	N	***	**	N	N	***	**	N	N
Buckwheat: FE (common)	**	***	*	N	*	***	*	N	*	***	*	N
Barley: High Elevation	***	**	N	N	***	**	N	N	***	**	N	N
Barley: Hills and Plains	N	***	**	*	N	***	**	*	N	***	**	*
Amaranth	***	**	N	N	*	*	N	N	*	N	N	N

*** - Very important.

** - Important.

* - Less important, scattered.

N - Not important, rare.

associated or relayed with maize and millet, especially in the Far Western Region.

2.4 MARKETING

Virtually all the millet produced in Nepal is consumed within the country, and often by the producer or in the home village. However, there is some movement of millet, mainly within the village or between nearby towns as malting and brewing are somewhat specialized operations.

In the case of barley and buckwheat most of the produce is consumed by the grower or traded/bartered within the village and nearby communities. However, a considerable portion of the amaranth harvest is sold to India where it has become a highly relished delicacy. Amaranth is the only hill crop with established export potential.

III. CONSTRAINTS AND STATUS OF IMPROVEMENT

The hill crops suffer from a number of constraints both direct and indirect. Unfortunately, production problems have not been studied except to a very limited extent in millet. Therefore, there is a considerable dearth of information on the principal deterrents to increased production and use of these crops.

3.1 CONSTRAINTS

3.1.1 Indirect Constraints

Hill crops improvement has been generally neglected from the beginning. Only a minor effort on millet has been underway in the Agronomy Division at Khumaltar and at the Agricultural Station at Rampur as an adjunct to the maize program. Only two half-time agronomists have been assigned to work on millet with virtually no continuing activities on the other three crops. No other disciplines were involved, operational funds have been minimal, and facilities are virtually non-existent.

As a consequence of the lack of improvement there is very little technology to extend. While limited testing of millets has been carried out, there have been no demonstrations, and limited minikit trials (only with millet); nor is there any base of information on improved practices like the use of superior varieties, optimal cropping patterns, effective weed control, timely planting, chemical fertilizers and plant protectants.

Hill crops are largely planted with minimal inputs except the farmer's labor, and therefore are not 'eligible' for credit. Moreover, they are often grown under stressful conditions and on marginal lands where other crops would not succeed. Since they are relegated to sub-optimal conditions they also receive less attention for improvement. Despite these handicaps, production may be surprisingly high to wit, the national average yields of millet. Therefore, it may be assumed that yields and overall production could be increased rapidly with relatively modest improvement efforts and use of minimal inputs.

3.1.2 Direct Constraints

These include environmental and biotic deterrents to production. Climate imposes limits in terms of moisture-both the lack and excess of it. Elevation and temperatures are likewise restrictive, but these factors are reasonably well understood. Only tatar buckwheat and high elevation barley are well adapted above about 2500 to 2800m; millet and common buckwheat perform best under moderate conditions; and amaranth fares better in the drier regions of the western hills.

The soils of the hills and upland regions can be limiting as they are largely derived from young parent materials and mainly classified as inceptisols or alfisols. These soils are mostly highly weathered and low in exchangeable cations. Soils on steep slopes are more fragile than on the plains or in the valleys and require much greater care in use and management.

Except for some minimal experience with millet little is known about the biotic constraints of the hill crops. The most serious disease problem of millet is likely to be blast disease (Pyricularia sp.) which is very similar (even identical) to the organism attacking rice. In some areas leaf blight (Helminthosporium sp.) and wilt or foot rot (Sclerotium rolfsii Sacs.) may also be important. Little information is available on diseases of the other crops, although powdery mildew may occur on barley and buckwheat. Among insect pests of millet, stem borer (Sesamia sp.) can cause significant damage under certain conditions. The occurrence and importance of these and other diseases and pests must be studied as a high priority activity when the HCIP becomes established. A more detailed description of the biotic constraints of hill crops is presented in Appendix VI.

The constraints described above may be summarized in terms of priority needs for future research:

1. Development of adapted, stable, high yielding varieties combining desirable agronomic attributes, pest resistance, stress tolerance, and appropriate to the needs and uses of hill agriculture.

2. Determination of optional cropping patterns, cultural practices, pest management, and seed processing for each crop and its major agro-ecological zones.

3. Training researchers, extensionists, seed producers, and production specialists to accelerate improvement, expedite technology transfer, and generally develop the hill crops industry.

These urgent needs can only be met when a multidisciplinary team is formed to include both biological scientists and socio-economists working in close integration with farmers, extensionists, and their colleagues in other divisions, programs and stations.

3.2 CURRENT STATUS OF HILL CROP IMPROVEMENT

3.2.1 Investigations Underway in Nepal

The only significant activities underway on hill crops in Nepal are minimally supported studies on millet at Khumaltar and Rampur (Chitwan Valley). In 1985 these included seven district trials or experiments carried out at seven locations ranging from 228 to 2000 m elevations. Advanced trials consisted of 10-12 cultivars planted as a sole crop or in relays with maize (depending on local custom). Other experiments tested plant populations, genotype interactions with associated maize, and new germplasm (150 lines).

As a consequence of this and previous work on millet 714 exotic genetic stocks were obtained from India and 110 local landraces were collected from Nepal. From evaluation and testing of these materials two improved varieties were named and released in 1980: Dalle-1 (IE 780 from India) for the Inner Terai and mid-hills, and Okhale-1 for the mid-hills

and higher elevations. In addition some promising new materials have been identified like NE 1703-34 for monoculture in better environments; Rampur Local for the Chitwan Valley; and NE 3801-2 was found promising at Khumaltar, Kavre and Lumle. It is presumed these investigations will be continued and expanded in the future.

Some preliminary evaluations on buckwheat were carried out at Khumaltar in 1979. These included eight varieties all of which exceeded the local check (933 kg/ha) in yield. The two highest yielders were Khumjung Tite (1275 kg/ha) and Tokyo (1195 kg/ha). At Kakani (2030m) the local check (888 kg/ha) was best, but Tokyo (850 kg/ha) was a close second. In a preliminary trial at Khumaltar some new entries showed potential among 38 entries tested. Anethra Palpa and Tite (Garihara) yielded 1130 and 1110 kg/ha respectively; compared with only 633 kg/ha for the local check. Overall, 17 out of 38 entries surpassed the performance of the local. This suggests there is excellent scope for improving buckwheat yields in Nepal.

Some collecting and introduction of amaranth germplasm were done on a minimal scale, but there is currently no activity on this crop. In the case of high elevation (mainly naked) barley there is no record of any previous work. However, the wheat program (CIMMYT collaboration) has introduced and is evaluating about a 100 naked barley lines. Details on the on-going research on hill crops are presented in Appendix VIII.

Although farming systems research has largely ignored the secondary hill crops some limited socio-economic studies have been carried out mainly in Kavre and Kaski districts. These results indicate that millet is traditionally grown as a low purchased input commodity, but it is vital to survival during unfavorable or crisis conditions. However, as conditions improve-eg. irrigation becomes available - farmers will shift from millet to rice. Under rainfed conditions in the hills the 'natural' cropping pattern is maize with relay millet. Thus, millet is a kind of bonus requiring very little additional input, despite the additional labor for transplanting, weeding and threshing.

3.2.2 Research Outside Nepal

There are no international centers mandated for finger millet, buckwheat or amaranth. However, ICARDA in Syria now has a mandate for conducting barley research in the CGIAR system with a barley breeder stationed at CIMMYT whose major emphasis is producing barley germplasm for high elevation areas. The Rodale Research Center of Kutztown, Pennsylvania (USA) is concentrating on amaranth breeding and quality studies and distributes some advanced genetic stocks. As a consequence of recent interest in this crop at least 26 countries have carried out exploratory studies or have an ongoing interest in amaranth. Some countries, especially India, Nigeria, and USA, have several dispersed projects on this crop.

The International Centre for Maize and Wheat (CIMMYT) in Mexico has a long history of barley improvement. More recently the ICARDA in Syria has assumed the global mandate for barley, but also has staff placed at CIMMYT for this commodity. However, several western countries including those in the Middle East, Northern Europe, the USA, Canada (Winnipeg), the Andean countries of South America, Kenya and Ethiopia, India, USSR, China, Korea, Japan and Australia have significant research activities on barley. Perhaps the most relevant information and genetic materials for Nepal would be available from the Coordinated Barley Improvement Program at Karnal, India; and ICARDA/CIMMYT.

There are probably no major programs on buckwheat improvement, although significant activities on this crop are underway in Canada (Manitoba) USA (Pennsylvania), Japan (especially Hokkaido and Nagano), China, and in India. However, all of these studies are presumed focussed on common buckwheat and not on the tatar or bitter types. There is a good market for buckwheat in Japan to make noodles for which it is necessary to import grain, especially from Canada.

IV. THE NEED

There is an urgent need to improve the lot of the Nepalese hill farmer, the poorest rural community in this country and perhaps in most of southern Asia. A coordinated, integrated and multidisciplinary Hill Crops Improvement Program (HCIP) represents the most critical first step in addressing this need. This program will assume responsibility for improving finger millet, barley, buckwheat and amaranth in close collaboration with the Farming Systems Research Program. The effort will be challenging because of the relatively difficult conditions under which these crops are grown, lack of information on them, and dearth of both international or other external backup support. There are no international centres responsible for finger millet, buckwheat nor amaranth; and only limited interest in high elevation/naked barley at ICARDA and CIMMYT.

Initial program development is likely to be slow as there is limited background information on hill crops, staff will need to be trained at experimental sites established in the hills, germplasm must be assembled and collected, and experience gained on these new crops. Therefore, a longer lead time will be required for the HCIP than other coordinated commodity programs.

4.1 MAIN FEATURES OF THE HCIP

The Hill Crops Improvement Program can be one of the most effective commodity improvement activities in Nepal. However, it will be essential to carefully plan the program's structure, organization and strategies. As a basis for implementation the following program features are recommended:

1. Startup should begin as soon as possible, but not later than mid-1987, with coordinated support from HMG/N, USAID, IDRC and others.

2. An extended lead time will be required for reasons described above. The development Phases I, II and III should therefore

be projected for a 23 year period and through the Eleventh 5-Year Plan or to the year 2010.

3. Initial efforts and resources should concentrate on finger millet as the most important and promising of the four crops. Investigations and improvement of barley, buckwheat, and amaranth will be taken up as second priorities as the program develops.

4. The IBPGR should be approached to participate and assist with collecting land races of the important hill food crops. Other sources of assistance may be the West German GTZ and the Japanese JICA. First priority should begin with collecting millet.

5. Training, especially long term for higher degrees, should be so planned and ordered as to best serve the needs of the program, rather than become a 'reward for joining'. Preference should be given to staff already in the program who have demonstrated capacity to advance and long term commitment.

6. The diverse nature of hill crops and their growing environments dictates the need for some decentralization and multiple research and testing sites. However, the best of these based on facilities and accessibility will be named as the main-coordinating centre. This will necessitate frequent, convenient travel to and from stations and testing sites. (See Item 16.)

7. The complexities of hill crop problems and their improvement will require a multidisciplinary team approach. It will necessitate constant assessment of priorities, and relegate the study of non-relevant, esoteric phenomenon to the distant future.

8. In the absence of strong national and international (IARC) backup support, the HCIP could effectively use the services of short term consultants to help organize research activities and monitor future developments. Knowledgeable and experienced scientists may be coopted from India, USA, Canada, and Japan for this purpose.

9. Varietal improvement beginning with germplasm collection and evaluation will become the main thrust of the program as the most rapid, practical and effective means of increasing and stabilizing productivities of hill crops both under present conditions and in the foreseeable future.

10. Hill crops are normally grown in complex farming systems and must be so improved as to serve the best interests of the hill farmer. Therefore, the HCIP must be closely integrated with the Farming Systems Research for the hill regions. Thus, FSRP studies would represent the final stage of technology evaluation.

11. The HCIP must simulate real farmer's conditions. Therefore, a considerable proportion of testing and evaluation, particularly in the advanced stages of development, should be carried out on farmer's fields, under typical growing conditions and by soliciting experienced farmers in evaluating the technology.

12. Program flexibility should allow for the possibility of new crops finding niches in the hills or even replacing existing species (eg. cold tolerant, short-duration wheats or triticales replacing barley). The HCIP should encourage and/or participate in testing and evaluating these 'new' crops as time and resources permit.

13. The inclusion of barley as one of the neglected hill crops is an anomalous situation in terms of program affiliation since barley is almost always dealt with by major small

grains programs (eg. wheat, durum, barley and triticales). However, HCIP will develop testing sites and will be more directly concerned with cropping systems at high elevations (eg. above about 2500 m). Therefore, the HCIP should assume responsibility for all barley in Nepal from the Terai to the submountainous regions since it is much more efficient for one commodity program to address the various aspects of plant improvement of the same species grown under a range of ecological conditions and uses.

14. The HCIP should, in addition to varietal improvement, seek ways to grow hill crops more efficiently, with less inputs and labor, and in systems designed to conserve or even upgrade the resource base. These studies to be undertaken jointly with the FSRP may consider innovations like minimum tillage and advanced weed management approaches; and alley cropping or 'live mulching' with perennial legumes including nitrogen fixing trees (NFT's), bushes, shrubs and herbs adapted to the hills.

15. The HCIP structure will provide for a Hill Crops Technical Panel drawn from HMG divisions and departments or other agencies as relevant to the aims and goals of its program. The function of the HCIP will be advisory to help review and monitor progress, aid in coordinating activities with other departments, and offer advice on the future approaches and activities.

16. The most daunting challenge for the HCIP is the vast range of agro-ecological conditions under which hill crops are grown -- from elevations of about 100 m up to 4000 m; rainfall from 400 mm to 5000 mm; and extremely variable soil conditions, topography, and uses. Therefore, to be effective the program must work at several sites representative of the major hill growing region. It will be necessary to outpost 1-3 gazetted officers (usually an

agronomist and/or breeder and, perhaps a plant protectionist) at each of the four centers, and for the Coordinator and other senior officers to travel frequently to the various centers, subcenters and testing sites (2-3 times a season).

The execution and success of the HCIP are the immediate responsibility of the program researchers and their technical staff . However, this, like other operational programs, can only function effectively if central administration and the donors support the program enthusiastically and ensure that administrative needs are dealt with promptly. This means that recruitment must be pursued vigorously, funds released on time, contracts executed promptly, bills settled when due, and staff paid their salaries/entitlements regularly and up-to-date. Since all the HCIP staff will be outposted, and mainly to remote hill stations, their special problems and personal difficulties should receive sympathetic consideration including special compensation for hardship conditions whenever applicable.

4.2 INSTITUTIONAL DEVELOPMENT

The process of establishing a nationally coordinated Hill Crops Improvement Program will involve defining the program's goals and objectives, developing an organizational structure, setting priorities, defining strategies, outlining the sequence of activities and executing the work plan as expeditiously as possible. By relating goals and objectives to institutional and production constraints it is possible to structure an effective, functioning program and to outline the strategies by which a series of targets may be reached. However, the primary key to successful implementation will be capable leadership, particularly in the coordinator's post. It will be necessary to build the HCIP virtually from the ground up. Staff will need to be recruited and trained, multidisciplinary activities organized, and day-to-day operations directed in such a way as to achieve the program's goals as efficiently as possible. It will also be necessary to establish close linkages with several HMG agencies, two or more donors, representatives of ICARDA/CIMMYT, and hill crops scientists from several other countries.

4.2.1 Institutional Framework and Linkages

The coordinated Hill Crops Improvement Program is one of eleven national commodity improvement and development programs. It is responsible to the Ministry of Agriculture through the National Agricultural Research and Services Center under the Department of Agriculture. This relationship as proposed by Pradhanang (1984) is shown in Figure IV-1.

The new HCIP will function independently, but will promote close linkages with the seven disciplinary division headquartered at Khumaltar: Agronomy, Plant Pathology, Entomology, Agriculture Botany, Soil Sciences, Agricultural Engineering, and Agricultural Extension, See Figure IV-2.

4.2.2 Primary Research and Testing Sites

The first step will be to select a few main centers representing diverse hill ecolcgies where much of the work can be carried out on HCIP crops-especially millet. One of these centers can serve as the seat for coordination. Several other sites or subcenters will be needed to allow studying and testing each of the crops over a range of environments under which the four hill crops are grown in Nepal. In addition, the Farming Systems Research Program has a series of sites selected to represent actual farmer's growing conditions. Those appropriate to hill crops would be included in the HCIP network. A description of the proposed HCIP centers and testing sites is given in Table IV-1, and the locations are shown on Figure IV-3. More detailed information on some of the centers is included in Appendix VII.

The preferred site for the HCIP coordinating centre would be the Lumle Agricultural Centre near Pokhara. It is ideally located in a mid-hills environment; is the center of the most intensive millet cultivation in Nepal; and is strategically located relative to a broadway of ecological conditions in terms of elevation, rainfall, topography and soils. Moreover, it is readily accessible to both the air and the national highway network serving Pokhara, and particularly when a new all-weather road is constructed from Pokhara to Lumle and beyond. The station has excellent

Figure IV-1 : Suggested Crop Research Organization Chart

(Pradhanang, 1984)

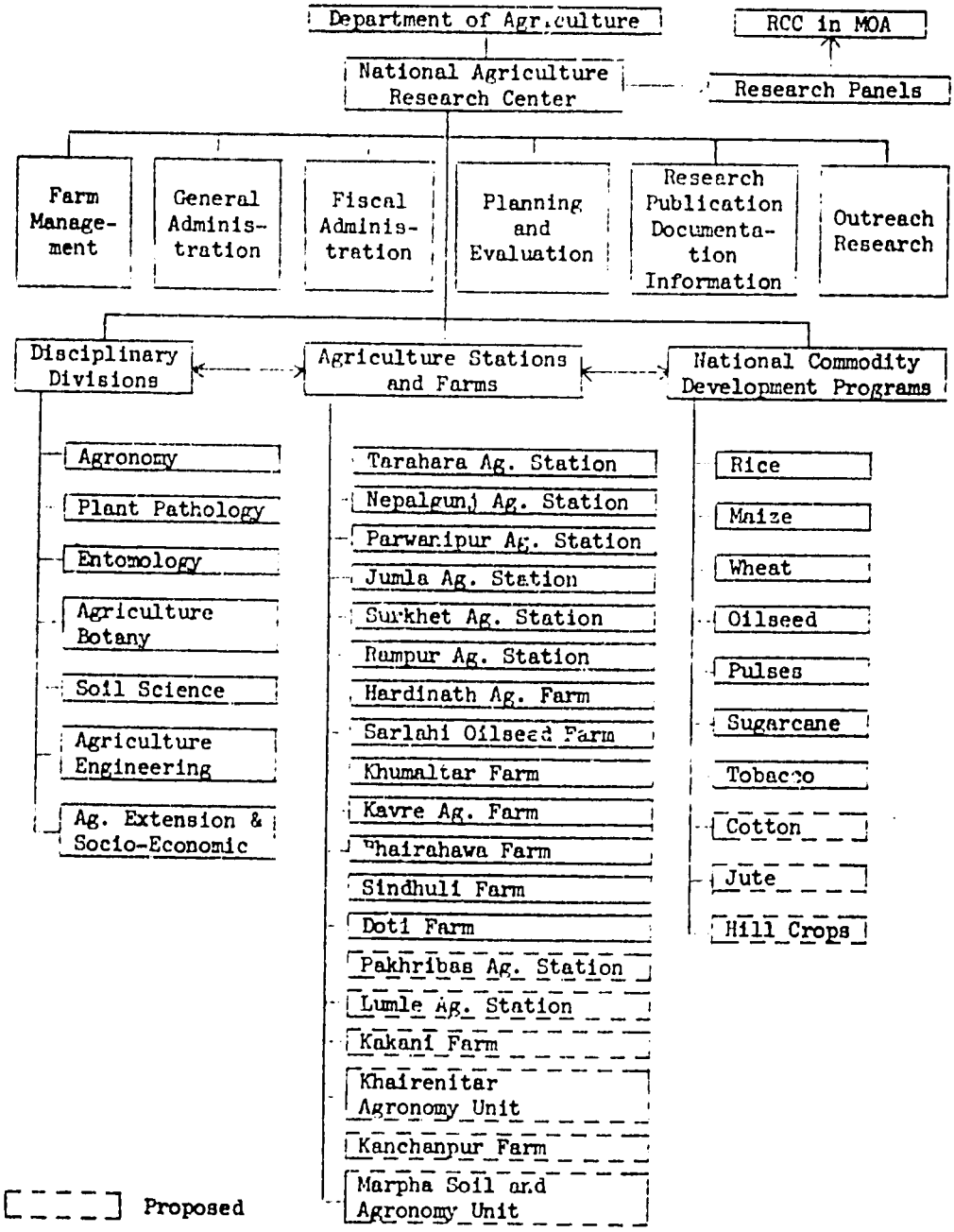

Figure IV-2 : Hill Crops Program Institutional Framework and Functions

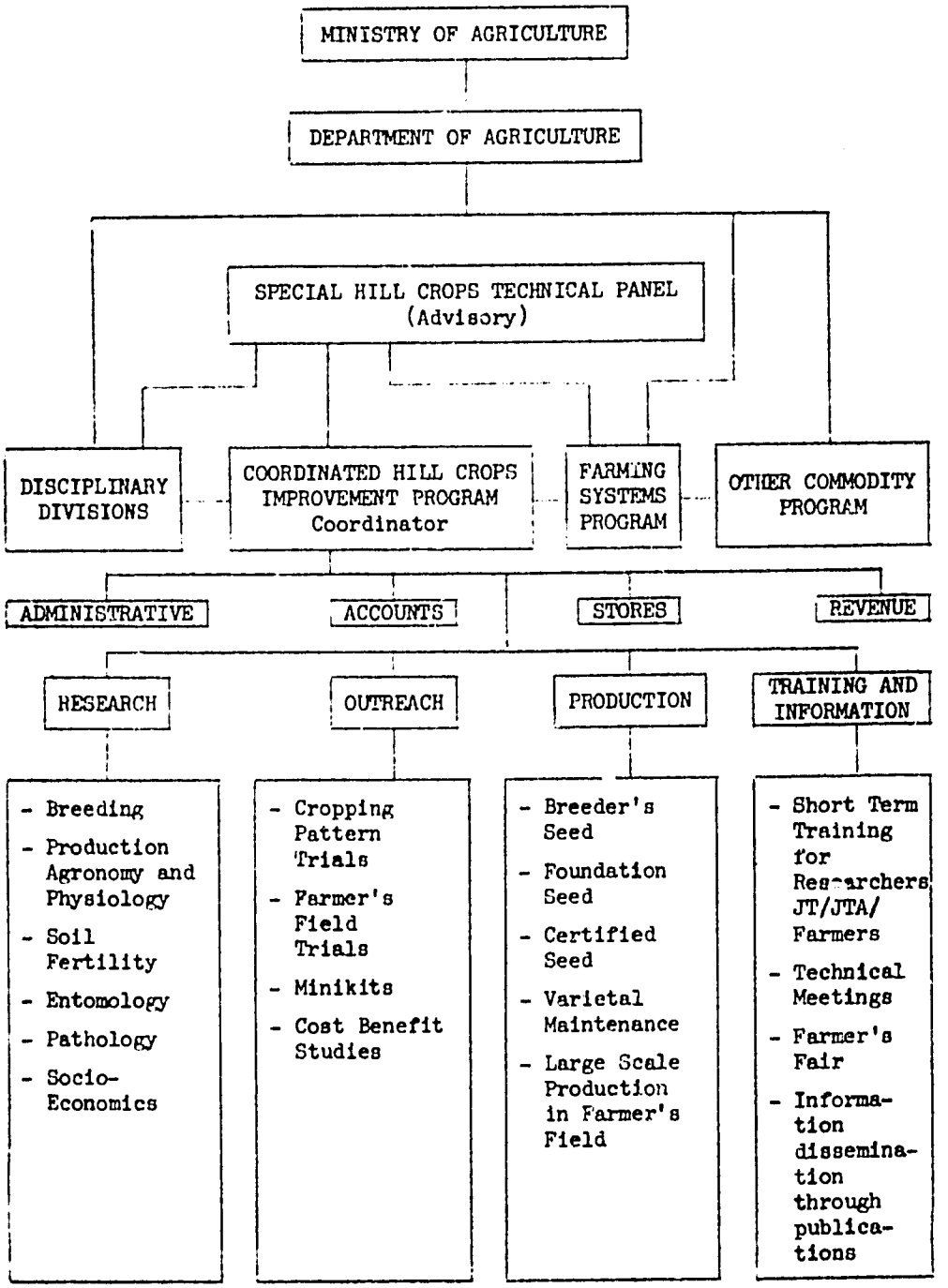

Figure IV-3 : LOCATION OF PROPOSED RESEARCH CENTRES AND TESTING SITES FOR THE INTENSIFIED HILL CROP IMPROVEMENT PROGRAM

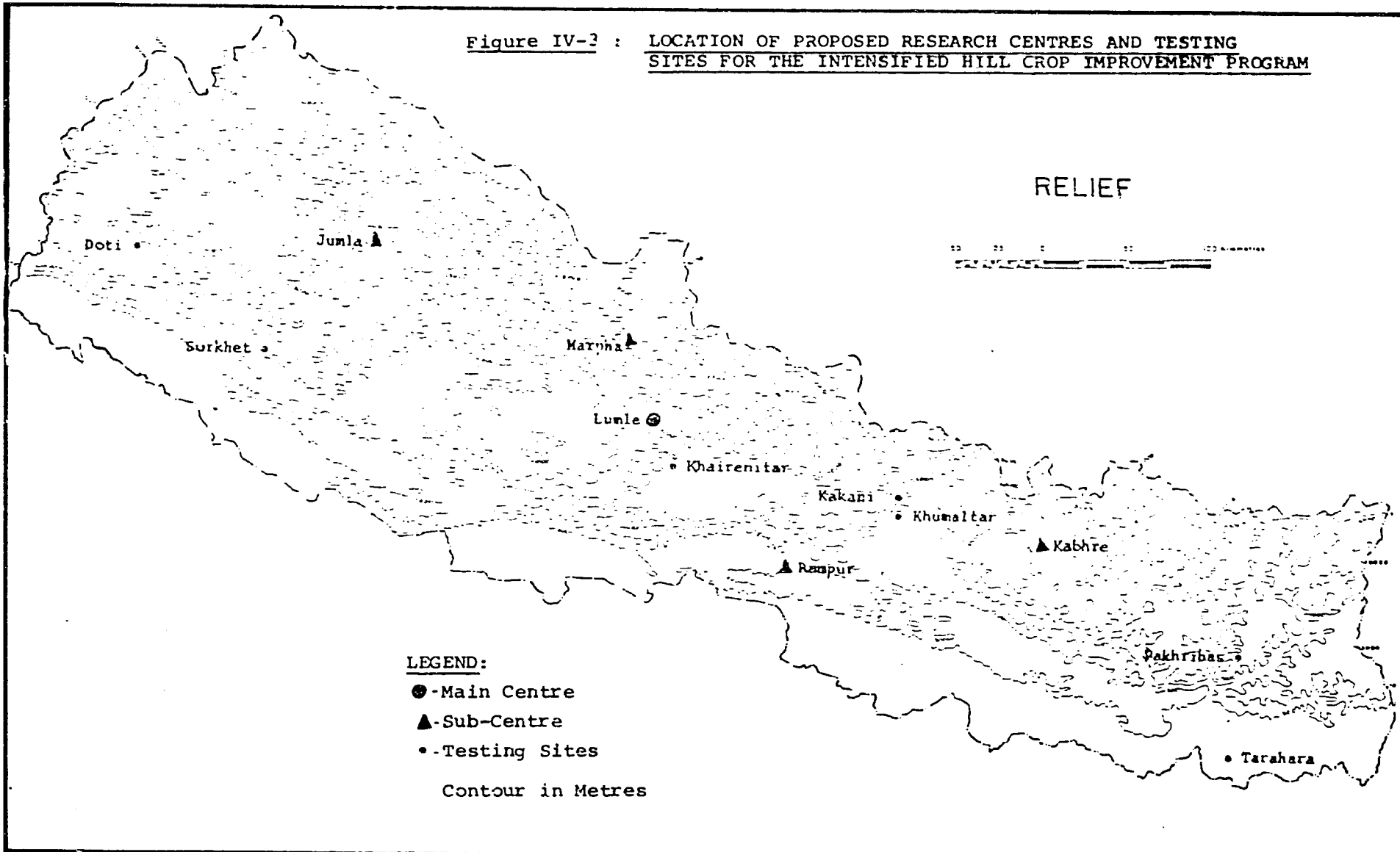

Table IV-1 : Research Centers and Testing Sites Proposed for the Hill Crop Improvement Program

SITE	Region 1/	Elevation (m)	Rainfall (mm)	TEMPERATURES (°C) Summer Max.	Summer Min.	Winter Max.	Winter Min.	Farm Area (ha) 2/	CROP PRIORITIES 3/ Mil	B/HE	B/PH	BW/C	BW/T	AM
CENTERS:														
- LUMLE	W	1670	5100	23.1	16.6	12.9	5.1	35(17)	***	**	***	**	**	**
- JUMLA	MW	2387	970	23.9	13.8	14.0	-4.7	2	**	***	*	***	***	***
- MARPHA	W	2610	450	20.7	12.4	10.9	-1.7			***		***	***	*
- KAVRE	C	1700	1900	26.0	12.0	18.0	4.9	(13)	**		**	***		*
- RAMPUR	C	228	2020	33.1	23.9	22.8	7.6	100	**		**	*		
SUBCENTERS:														
- DOTI	FW	620	1300	28.9	21.5	16.0	8.6	8(3)	**		**	**		*
- SURKHET	W	450	1500	30.1	22.3	19.3	5.4	35	*		*	*		
- KAKANI	C	2030	2400	22.9	14.3	14.4	2.3	10	**	*	**	**	*	*
- KHUMALTAR	C	1360	1300	26.4	18.8	17.1	1.3		*		**	*		*
- PAKHRIBAS	E	1760	2250	23.9	16.9	15.1	5.2		**	*	*	**		*
- TARAHARA	E	200	1700						*		*			

1/ MW = Mid Western; FW = Far Western; W = Western; C = Central; E = Eastern.

2/ Total area in hectares; (cultivated area in ha.).

3/ Crop priorities: MIL = finger millet; B/HE = barley-high elevation; B/PH = barley-plains/hills; BW/C = common buckwheat; BW/T = tatar (bitter) buckwheat; AM = amaranth.
*** = very important research site;
** = important for testing, agronomy, plant protection;
* = mainly testing, preliminary evaluation.

facilities, good land, and will soon connect into a regional electric power grid. However, arrangements with the ODA operated center and provision of facilities may take some time. Although one of the other centers could serve as the Coordinator's office, the best choices are considered to be Khumaltar, Khairenitar or Rampur on account of communications and travel requirements, if arrangements with LAC cannot be worked out within a reasonable period of time.

4.2.3 Collaboration with the FSP

The HCIP will collaborate closely with the Farming Systems Program, both to help develop new innovations and as a final evaluation of advanced materials and technologies. The principal farming systems sites overlap but complement the sub-center network. Those sites most relevant to the hill crops include:

		Region	Elevation, m	Rainfall, mm
1.	Chauri Jahari, Rukum:	MW	700	1100
2.	Pumdi Bhumdi, Pokhara:	W	1000	4000
3.	Khumaltar, Kathmandu:	C	1360	1200
4.	Khandbari, Sankhuwasabha:	E	730	1200

4.2.4 Linkages with Farmers

Advanced technologies must be tested on farmer's fields and under conditions the farmer himself uses. Only in this way can HCIP researchers identify important constraints and access feedback on the technology. The numbers and sites of farmer's trials will vary depending on program development and other factors. Seeds and minikits would be distributed separately to extensionists, production specialists and farmers; but in all cases the program should seek feedback on local reactions to new technologies and varieties however distributed.

4.2.5 The Hill Crops Technical Panel

The formation of a special Hill Crops Technical Panel (HCTP) is strongly recommended. The purpose of this panel is to advise on technical

matters, help prioritize problem areas, and decide on annual allocation of the "Special Projects Fund" to be established in support of related areas of research executed by other disciplinary divisions. Membership in the Panel should include those divisions and other agencies whose expertise and facilities are needed by the HCIP. If possible Division Heads should serve as members; otherwise they should nominate a senior scientist to serve in their stead. These members should include:

1. Agronomy
2. Agricultural Botany
3. Soil Science
4. Plant Pathology
5. Entomology
6. Socio-Economics
7. Extension
8. Farming Systems Program
9. Seed Industry (Agricultural Inputs Corporation)
10. Farmer's Groups
11. DOA Representative (DDG for crops)
12. Other organizations or groups (Ad Hoc)

Meetings should be held twice a year at the beginning of the two major seasons. If possible, the DDG for crops will chair the meeting and the HCIP coordinator would act as secretary and will fix the agenda. The usual agenda could be as follows:

1. Brief review of past season's results
2. Cropping systems studies with hill crops
3. Results of experiments from disciplinary divisions
4. Brief report from farmer group/seed industries
5. Presentation of future plans
6. Discussion on problems and recommendations
7. Allocation of special project funds*
8. Visits fields or laboratories as convenient.

* A more orderly and expeditious procedure would be through deliberations of a smaller group consisting of the DDG (Crops), two rotating Division representatives and the HCIP Coordinator.

4.2.6 Multidisciplinary Approach

The multidisciplinary or team approach to solving complex plant improvement problems is superior to the individual or discipline oriented approach. Researchers of different talents and academic backgrounds will devote their attention to dealing with problems in different ways and by various means. The collective approach will ensure the involvement of inter and intra group responsibilities leading to better participation in the program. The fixing of priorities for different activities, and the mobilization of resources will also be done more effectively by the team approach. One way to foster and encourage inter-disciplinary collaboration is to create informal technical sub-groupings within the program. These groups should meet and work together on functional areas of "thrusts" where specific disciplines are related to secondary roles. For example, the following groups would be most important at the outset.

1. Plant Improvement. Chaired/moderated by a senior plant breeder; to include plant protection specialists, agronomists, physiologists, agricultural botanists, socio-economists.

2. Crop Growth/Management. Chmn: agronomist, or soil scientist. Other members: physiologist, entomologists; pathologists, breeders, and socio-economists.

3. Plant Protection. Chmn: pathologist or entomologist. Others: plant breeders, agronomists, soil scientists and others.

These groups need not organize frequent regular meetings, except for seasonal planning. Rather, the best and most effective get-together could be in the field or laboratory to observe and discuss problems as they occur and jointly decide on a course of action. It is assumed the HCIP Coordinator would be a working scientist and would attend most group meetings. He/she should also organize regularly scheduled, all-program meetings more frequently in the early stages (e.g. every week), but not

less frequently than once a month. Whenever possible, outsiders from other divisions, stations, and agencies (eg. horticulture, botany, engineering, extension) should be invited to both the subgroup and program meetings.

4.2.7 Planning

The planning process is critical to the multi-disciplinary approach. It must be done carefully and reflect the collective wisdom of the entire program as well as any key outsiders who are coopted for the process. It is recommended that planning be done for each major growing season and according to a three-step procedure:

1. Initial preparation. Detailed plans are drawn up by individual scientists/heads of sections.

2. Group review. Plans prepared by section heads are presented to the respective groups (e.g. plant pathologist plans are reviewed by the plant protection group). Plans are modified and improved as per agreed upon comments and suggestions.

3. Program review. Plans and proposals screened by the respective groups are consolidated by the coordinator and presented to the Hill Crops Technical Panel (described previously).

This planning procedure should be aimed at prioritizing problem areas, focussing attention on major issues, eliminating irrelevant/unproductive experiments or activities, and avoiding duplication. It will also help assure a higher standard of individual performance. and foster a spirit of cooperation - amongst the team members.

Wherever possible, GH experiments[1/] and other plantings should

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1/ GH experiments refer to green house, glass house or plastic house experiments.

be used as efficiently as possible. For example, the germplasm collections and breeder's nurseries should be evaluated for several purposes: (i) disease reaction by pathologists, GH; (ii) pest reaction by entomologists (if not protected); (iii) tolerance of drought, water logging, pH extremes; (iv) growth habit and morphological characteristics - physiologists, agronomists and soil scientists.

4.2.8 External linkages

All hill crops scientists should be aware of improved materials and technology developed both inside and outside Nepal. These innovations should be tested for their adaptability and superiority under Nepalese conditions. The most helpful organizations are the international research institutes like ICARDA, CIMMYT, and ICRISAT as they are specifically mandated to serve countries like Nepal. However, several national institutions may have more directly useful genetic materials and experience for hill crops not included in IARC programs. These include:

1. Finger millet. Mysore Agricultural University (Bangalore campus) in India; East African Agriculture and Forestry Research Organization (EAAFRO) headquartered at Muguga near Nairobi, Kenya with research done at Serere, Uganda; and possibly, national crops programs of Bangladesh and Sri Lanka. The world collection (IE numbers) is also stored at ICRISAT and the USDA (FT. Collins, Colorado).

2. Buckwheat. There are very few major buckwheat improvement programs. Perhaps the best for Nepal are programs in Manitoba Province of Canada; Pennsylvania State University in USA; Hokkaido and Nagano prefectures - especially Shinatu University (Nagano) Japan, and ICAR of India. Chinese germplasm may also be useful; but Russian strains may be less appropriate as they are all summer types whilst the Nepalese materials are autumn types.

3. Amaranth. The best source of germplasm and information would be the Rodale Research Center at Kutztown, Pennsylvania and the University of California at Davis in the USA. However, the IARI, New Delhi, India; University of Nairobi, Kenya; Zambia Seed Co., Lusaka; INIA in Mexico City; and Unversidad Nacional de Cuzco in Peru may also provide useful sources of genetic diversity and information.

4. Barley. The best sources of genetic materials and information are ICARDA in Syria and CIMMYT in Mexico. Other sources of technology are the USDA in Beltsville Maryland; the cereal research programs at Winnipeg, Canada; Kenyan Department of Agriculture; and the Coordinated Barley Improvement Program at Karnal, India.

The most useful materials from these sources will be their germplasm, elite lines, and genetic segregating populations from which HCIP scientists can select desirable, adapted lines and useful parental stocks. Moreover, the training programs at some of these external institutions and particularly at the IARC's will be very beneficial to HCIP staff. Therefore, the establishment of linkages with both IARC's and other appropriate external institutions should be pursued aggressively. International scientists working on hill crops should be consulted about the HCIP program, and Nepali scientists should keep close contact and communicate freely with their counterparts at IARC's and other national hill crops programs.

4.2.9 Coordination

Coordination should be done by putting all the hill crops under one umbrella, the coordinated "Hill Crops Improvement Program". This will allow integration of staff and resources and focussing them on the most urgent problems.

The ideal pivotal center for research on hill crops would be the station at Lumle near Pokhara and radiating its activities to different

stations and sites throughout the hill zone. Alternatively one of the other centers or subcenters could serve this purpose until satisfactory arrangements can be worked out with LAC (e.g. Khumaltar). The program coordinator and several senior staff will be based at the related main center, but they must have generous travel allowances to permit frequent visits to experimental sites in the different regions.

4.3 TRAINING

Training is an essential aspect of institutional development and must be continued indefinitely. However, it will be particularly critical at the outset to train young scientists and technicians thereby enabling the new programs to become functional as quickly as possible. Training goals at the post graduate, group, and in-service levels for Phase I and II are outlined below:

4.3.1 Phase I (1987/1990) Training

1. Postgraduate: to be carried out mainly in India and the Philippines with theses problems to be done at IARC's or in Nepal:

		pm
- Agronomy (1 M.Sc.)		24
- Breeding (1 M.Sc.)		24
- Pathology (1 M.Sc.)		24
- Entomology (1 M.Sc.)		24
- Soil Science (1 M.Sc.)		24
Total 5 M.Sc.'s	Sub-total	120

2. Group training

- JT's, JTA's, progressive farmers	30
- Workshops, seminars, study tours	28

3. International workshops and conferences

(2 persons x 1 month x 3 years)	6

		pm
4.	In-service training at IARC's	
	(2 per year x 3 months each x 2 years)	12
	Sub-total	76
	Phase I Total:	196

4.3.2 Phase II (1990/2000) Training

Training must continue throughout the 1990's and beyond. In fact, it will be necessary to increase the level of training, particularly at the postgraduate level, to meet the expanding needs of the three programs. Phase II projections (10 years) are:

		pm
1.	Postgraduate:	
	- Agronomy (1 Ph.D. & 3 M.Sc.'s)	108
	- Soil Science (1 Ph.D.)	36
	- Pathology (1 Ph.D. & 1 M.Sc.)	60
	- Entomology (1 Ph.D.)	36
	- Breeding (1 Ph.D. & 2 M.Sc.'s)	84
	- Physiology (1 M.Sc.)	24
	- Agriculture Botany (1 M.Sc.)	24
	- Socio-economics (1 M.Sc.)	24
	(Total = 5 Ph.D.'s & 9 M.Sc.'s) Sub-total	396
2.	Group training (within Nepal):	
	- Within country (JT's, JTA's, farmers)	54
	- Workshops, Seminars, monitoring tours	60
	Sub-total	114
3.	International seminars, workshops, conferences	
	(2 persons x 1 month x 10 years)	20
4.	In-service training at IARC's	
	1 per year x 3 mo x 10 year	30
	Sub-total	50
	Phase II Total:	560

A total of 756 person months of training are projected during the 13 year period (1987-2000). This includes 516 pm of post graduate training resulting in 5 Ph.D.'s and 14 M.Sc.'s in addition to 240 pm of short term and group training. Thus, the HCIP will achieve reasonable professional capabilities by the turn of the century.

V. OPERATIONAL STRATEGIES

The first prerequisite towards increasing food production in the hills will be the development of an effectively functioning Hill Crops Improvement Program.

The program must be capable of generating a continuing flow of improved technologies for the different agro-ecologies of the hills. These will be disseminated to farmers in collaboration with extension, credit agencies and community development projects like IHDP, HFPP, HADP, and K-BIRD. Once the institutional aspects have been resolved the primary goals and scope of the program need to be defined.

5.1 PRIMARY GOALS AND MAJOR OBJECTIVES

The primary goal of the coordinated Hill Crops Improvement Program is to raise and sustain the production and productivities of neglected hill cereals in Nepal. Therefore, the major objective of this program should conform with this goal and would include:

1. Coordination of all research activities in a multi-disciplinary approach to generate appropriate technologies to raise production.

2. Continuation of the ongoing testing and verification of new technologies in the farmers fields, in the different agro-climatic regions, to identify the best materials and practices.

3. Organization, coordination and participation in all activities relating to hill crops improvement and production.

4. Development and maintenance of seeds (breeders seed) of improved varieties of hill crops, and help to increase seed production for the distribution of improved varieties.

5.2 SPECIFIC OBJECTIVES

The formulation of the specific objectives of the program can only be done on the basis of an intimate knowledge of the problems, farm needs, and genetic materials available, and the capabilities of the program itself. It will not be wise to tackle all the problem areas at one time, before trained staff have been recruited, or facilities developed, nor before the institutional linkages have been well established. Therefore, program activities are setforth as short and long term programs. Phase I (1987/1990), and Phase II (1990/2000), and Phase III (2000/2010).

Most of the short term objectives of the program are fundamental and should be continued. Once sufficient progress has been made, some of the activities may decline in importance. The overall activities should include the following:

5.2.1 Phase I (1987/1990)

Major emphasis in Phase I will be given to millet and secondarily to barley since millet production, including that in the plains, may comprise more than 80 percent of all four hill crops combined. As time permits and staff is recruited and trained the program can begin working on buckwheat and amaranth.

5.2.1.1. Genetic improvement

Collect, introduce, maintain, evaluate and test the basic germplasm from both local and exotic sources. The importance of collecting local germplasm cannot be overstressed. Select desirable characters like

yield, earliness, standability, plant type, shattering resistance, robust growth, disease and insect resistance, and grain quality. Recombine elite lines to increase yield and other productive characters, incorporate pest (including diseases) resistance and drought tolerance. Recombination can be initiated first in finger millet, but a considerable backlog of barley technology from external sources (esp. IARC's) remains to be tested and evaluated. Buckwheat must be collected, assembled and evaluated before crossing is started. Similarly, crossing of barley and amaranth should not be initiated until trained staff are available to work on these crops and the full range of available genetic stocks has been evaluated.

5.2.1.2. Plant protection

Evaluate the germplasm and the segregating material in collaboration with the breeder to identify host plant resistance to the major diseases and pests of the hill crops. Develop appropriate control measures for major diseases and pests which are least harmful for humans, animals and environment. Major emphasis would be placed on plant resistance. Surveys of the pest and disease situation in Nepal will be made. The most serious and difficult pest of millet is blast disease. This problem amply justifies the majority of plant protection efforts during at least the early years of the program.

5.2.1.3. Cultural practices

Develop optimal production practices for different hill crops right from tillage/sowing to harvest, post harvest and storage for different growing conditions. Carry out studies on production costs and assess the comparative benefit of growing hill crops in relation to other crops. Again, initial focus should be given to millet and secondly to barley.

5.2.1.4. Crop nutrient requirements

Determine the nutrient requirements of different hill crops growing in the major agro-ecologies of Nepal. Also, study species and varietal response to varying levels of chemical and organic manures; and conduct cost/benefit analysis relative to local conditions.

5.2.1.5. Hill crops in cropping systems

Evaluate the role of hill crops in different cropping systems by closely coordinating with FSP, in relation to the suitability and acceptability of varieties and practices for the growers. Collaboration with FSP will also help as the final stage in assessing improved technology.

5.2.1.6. Quality evaluations

Evaluate the organoleptic qualities and nutrient aspects of hill crops as affected by variety, environment and management (particularly varying levels of nitrogen). These studies will necessitate close collaboration between the agricultural botanist, plant breeder and soil scientist.

5.2.1.7. Seed production

Assume responsibilities for maintaining and producing nucleus and breeder's seeds of both released varieties and advanced lines (pre-release). Program staff should also help train seed producers to ensure that genetic purity and seed quality standards are met. In early stages of production it will be necessary to aid certification agencies in rogueing seed production fields.

5.2.1.8. Strengthening the program

There will be short and long term training for research, extension and production staff. There will also be a training program

for lower level staff of both research and extension (JT's and JTA's) and finally, for progressive farmers. Dissemination of information will be done through publications, demonstrations and minikit trials.

5.2.2 Phase II (1990/2000)

The objectives for Phase II will be similar to those for Phase I. The level of activity and momentum on millet and barley must not slacken, but become increasingly sophisticated. The buckwheat program will be expanded and some increased attention may be given to amaranth. Finally, when these crops are adequately accommodated some preliminary, low profile exploratory studies may be carried out on some potentially promising exotic species. The latter project may better be done in collaboration with Agriculture Botany and/or Tribhuvan University.

5.2.2.1. Genetic improvement

The collection, introduction and evaluation of both local and exotic germplasm and segregating material, done in previous years, should begin to provide desirable materials for the breeder. Multiple pest and disease resistant sources will be combined into improved strains. Germplasm collections should be continued. Intensify hybridization of all species, including barley and buckwheat. Initiate some exploratory studies on exotic hill species mentioned above, as time and facilities permit.

5.2.2.2. Plant protection

The activities described in Phase I will be continued, especially the work on millet blast which is expected to be a long term struggle (from experience with rice blast). The screening of local, exotic and segregating materials for pest resistance must be accelerated in close collaboration with plant breeders. The long term objective will be to incorporate multiple sources of resistance into improved lines and varieties.

5.2.2.3. Cultural practices

The current program will be continued but increasing emphasis must be given to resource management in low input hill cropping systems. Some of the newer concepts on minimal tillage methods, alley cropping, 'live mulching', and use of herbicides for both general and selective weed control need to be explored in the context of HCIP commodities. Socio-economic studies on cost/benefit analysis of new technologies will continue in conjunction with cultural practices investigations.

5.2.2.4. Quality improvement

These studies will continue along the lines begun in Phase I, but will be expanded when an Agricultural Botanist completes his M.Sc. training. In the early stages of Phase II primary emphasis should be given to assessing organoleptic properties (milling, cooking, baking, appearance, texture and taste). Later, the proximate principles, amino acid spectrum and other nutrient values should be looked at. Then, in the latter years there may be opportunities to analyze some of the more promising exotics introduced for preliminary study.

In most hill crops the fodder is a very important by product of the crop. Species and varietal differences, effects of environment, handling and storage will need to be assessed on a continuing basis.

5.2.2.5. Post Harvest handling

Hill agriculture offers limited scope for mechanization, but farmers could benefit greatly from improved methods of threshing; and more effective, low cost crop drying (e.g. solar) and storage.

Other specific activities described for Phase I including crop nutrient studies, collaboration with Farming Systems, seed production and

strengthening the program will be continued taking into account new developments and any shifts in program priorities, especially with regard to new species.

5.2.3 Phase III (2000/2010)

This will be essentially a continuation of Phase II, but should be preceded by major program review to determine whether the priorities, strategies, approaches, and program execution are appropriate and will continue serving the best interests of Nepal in the 21st Century. This should be a time for stock taking and determining the most rational program organization for the future. An example of some of the questions that might be addressed at this time include:

1. Does finger millet deserve the status of a separate, coordinated program on account of its continuing importance and special research needs?

2. Is the selection of species and priorities accorded them appropriate to conditions and needs of the 21st century; and what changes are indicated?

3. Are some overlooked hill crops or recently introduced exotics of sufficient importance or show sufficient potential to be included in the HCIP?

4. Are new research approaches implicating special training and additional facilities indicated for dealing with enduring, intractable production constraints?

5. Are administrative structures and resource limitations seriously deterring program execution and efficiency; and what actions may be needed to alleviate these problems?

The main purpose of the review will be to provide guidance and give legitimacy to any fundamental changes in program direction, structure, and priorities. It is recommended that one or two respected international scientists or research administrators (non-Nepalese) be included on the review panel.

The resources and staffing requirements for HCIP in Phase III will not differ appreciably from those of Phase II, except for needed promotions and salary increments. Moreover, most of the construction and the major long-term training components will have been completed by the end of Phase II.

5.3 RESEARCH PRIORITIES

Among the four crops assigned to HCIP millet dominates both as a sole crop and mixed or relayed with other species. It is also the most widespread hill crop with production in all five regions from the plains to the upper hills. As such it is at least four times more important in terms of production than the other three crops combined. For this reason millet will receive first priority in all aspects of improvement.

The second most important hill crop, also grown extensively from the plains to the highest elevations up to 4000 m, is barley. Buckwheat is important mainly in the mid-hills to high elevations. Buckwheat and barley are really the only satisfactory choices above about 2600 to 3000 m. However, the present importance and potential of amaranth, which is mainly confined to the drier western hills of Nepal, is largely unknown. Therefore, studies on this crop will remain exploratory until a better assessment of the current production and future can be made.

Among the different program activities described for Phases I and II a ranking of priorities has been made in tabular form in the following tables:

	Functional area	Table
5.3.1	- Plant Improvement	V - 1
5.3.2	- Plant Protection	V - 2
5.3.3	- Management and Plant Growth	V - 3
5.3.4	- Product Quality	V - 4
5.3.5	- Socio-Economics	V - 5

5.4 SOME SPECIFIC STRATEGIES FOR HILL CROPS

The four crops assigned to the HCIP differ markedly in growth habit, adaptation and use. Therefore, the same improvement methods cannot be used for all four crops. Nevertheless, the following general guidelines do apply to the four crops:

1. At the initial stage, attention should be focussed on the two most important crops - millet and barley - for rapid improvement, so that such improvement will have an immediate impact on hill agriculture considering the limited resources and time.

2. Investigation on buckwheat should be taken up as the second priority activity during Phase I. However, it is unlikely that time, facilities and staff will be available for much effort on amaranth except at a few selected locations during Phase I. Work on these secondary species may be expanded somewhat in Phase II as the program becomes better established and staff are trained.

3. Technology on the hill crops should be imported from all possible sources, especially from ICARDA/CIMMYT for barley, India and EAAFRO for millet, Canada and Japan for buckwheat, and Rodale Research Center and India for Amaranthus.

Table V-1: Proposed Research Priorities for Plant Improvement on Hill Crops (1987/2000)

Crop	Region[1/]	Selective Collection	Systematic Collection	Introduction	Observation, Evaluation	Varietal Testing	Recombination	Selection	Remarks
PHASE I:									
- Millet	MH/P		***	***	***	***	***	***	Collaborate with India.
- Barley	HE/MH/P	**		**	*	**			ICARDA/CIMMYT, Canada
- C. Buckwheat[2/]	MH/P		***	***	***	***	**	**	Collaborate with Canada, Japan,
- T. Buckwheat[3/]	HE	**		*	**	**	*	**	Collaborate with Canada,
- Amaranth	MH/HE	**		**	*	*			Collaborate with Rodale.
PHASE II:									
- Millet	MH/P	*		**	***	***	***	***	India, EAAFRD.
- Barley	HE/MH/P			***	***	***	*	*	Evaluate at high elevation.
- C. Buckwheat[2/]	MH/P	*		**	***	***	***	***	Canada, Pennsylvania, Japan.
- T. Buckwheat[3/]	HE	*	*		***	***	***	***	Screen for cold tolerance.
- Amaranth	MH/HE		**	***	**	**	*	*	Rodale, Mexico, Peru, Kenya.
- Exotics	MH/HE			***	**	**		*	IBPGR, Ethiopia, Peru.

Note: * = low priority; ** = medium priority; *** = high priority.
1/ Region: MH = mid hills; P = plain; HE = high elevation (about 2000 to 4000 m).
2/ Common buckwheat.
3/ Tatar buckwheat.

Table V-2: Proposed Priorities for Plant Protection on Hill Crops (1987/2000)

Crop	Region[1/]	Plant Pathology					Entomology				
		Surveillance	Identification	Yield Loss	Screening	Control Measures	Surveillance	Identification	Yield Loss	Screening	Control Measures
PHASE I:											
- Millet[2/]	MH/P	**	**	**	***	*	**	*	**	***	***
- Barley[3/]	HE/MH/P	*	*	*	**		*	*	*		*
- C. Buckwheat[4/]	MH/P	**	**	*	**	*	*	*	**	***	**
- T. Buckwheat[4/]	HE	**	*	*	**		*	*	*	*	*
- Amaranth	MH/HE	*	*	*	*	*	*	*			*
PHASE II:											
- Millet[2/]	MH/P	*	*		***	*	*			***	**
- Barley[3/]	HE/MH/P	*	*	*	**		*	*	*	**	*
- C. Buckwheat[4/]	MH/P	*	*		***	*	*			***	**
- T. Buckwheat[4/]	HE	*	*	*	**		*	*	**	***	**
- Amaranth	MH/HE	*	*	*	**		*	*	*	**	***
- Exotics	MH/HE		*		*			*		*	**

Note: * = low priority; ** = medium priority; *** = high priority.

1/ Region: MH = mid hills; P = plains; HE = high elevation (about 2000 - 4000 m).

2/ Major emphasis on blast diseases; secondarily on stem rot.

3/ Powdery mildews and yellow rust.

4/ Mildews likely to be important.

Table V-3: Proposed Priorities for Management and Plant Growth Research on Hill Crops (1987/2000)

Crop	Region 1/	Sowing Date	Plant Density	Water Irrigation	Plant Nutrition	Tillage	Weed Control	Cropping Pattern	Alley Cropping	Seed Treatment	Post Harvest	Remarks
PHASE I:												
- Millet	MH/P	**	**	*	**	**	**	***	*	*	*	Studies conducted at several sites.
- Barley	HE/MH/P	*		*	*	*		*		*		- ditto -
- C. Buckwheat 2/	MH/P	**	**	*	**	**	*	***		*	*	- ditto -
- T. Buckwheat 3/	HE	*	*	*	**	*		*		*		Above 2300 m.
- Amaranth	MH/HE	*	*	*	*	*		**				Concentrate in west.
PHASE II:												
- Millet	MH/P	*	**	*	**	**	**	***	**		**	Intensify studies with farmer.
- Barley	HE/MH/P		*	*	***	*		**		*	*	Extend adaptive range,
- C. Buckwheat 2/	MH/P	*	**	*	**	**	***	**	**		**	Intensify adaptive range,
- T. Buckwheat 3/	HE		*	*	**	*	*	**		*	*	Study under cold stress,
- Amaranth	MH/HE	*	**	*	**	**	*	***	*	*	**	Increase emphasis on FSR,
- Exotics	MH/HE	*	*		*			*				Exploratory only.

Note: * = low priority; ** = medium priority; *** = high priority.

1/ Region: MH = mid hills; P = plains; HE = high elevation (2000 to 4000 m)

2/ Common buckwheat.

3/ Tatar buckwheat.

Table V-4: Proposed Priorities for Product Quality Research on Hill Crops (1987/2000)

Crop	Preparation and Storage					Nutritive Value[1/]			Remarks
	Milling Outturn	Baking Quality	Cooking Time	Acceptability	Storability	Proximate Princ.[x]	Food Value	Fodder Quality	
PHASE I:									
- Millet	*	*	**	***	*	*		*	Evaluate for malting quality esp. white seed.
- Barley	*		*	**	**			*	Evaluate naked barley for keeping quality.
- C. Buckwheat	*	*	**	***	**	*		*	Note tannins, any bitter principles.
- T. Buckwheat	*	*	**	***		*		*	Begin assessing bitter principle.
- Amaranth	*	*	*	**	*			*	Special emphasis on popping quality.
PHASE II:									
- Millet	*	**	**	***		***	***	***	Commence detailed nutritive value studies.
- Barley		*	**	*	**	*	**	*	Determine feeding value, malting power.
- C. Buckwheat	**	**	*	***	*	**	***	**	Begin assessing anti-metabolites.
- T. Buckwheat	**	**	*	***	*	**	***	*	Quantify bitter principle.
- Amaranth	*	**	**	**	**	**	**	*	Evaluate both grain and vegetable types.
- Exotics			*	**	*	**	*		Acceptability of new crops and assess proximate principles.

Note: * = low priority; ** = medium priority; *** = high priority.

1/ Proximate principles are proteins, carbohydrates, oil-fats and fibers; actual value is based on more detailed analysis (amino acids, fatty acids, minerals, vitamins) and digestibility.

x - Princ. = Principles.

Table V-5: Proposed Priorities for Socio-Economic Research on Hill Crops (1987/2000)

Crop	Survey of Trends	Data Collection	New Technologies	Farmer's motivation	Production Cost/ Benefit	Marketing	Export Potential	Remarks
PHASE I:								
- Millet	***	***	**	***	***	***	**	Initial focus on production economics.
- Barley	*	*	*	*	*	*	*	Identify uses, markets.
- C. Buckwheat 1/	***	***	*	***	**	**		Determine marketing patterns.
- T. Buckwheat 2/	*	**		**	*	*	*	Characterize consumers preferences.
- Amaranth	*	*		*		**	***	Assess demand potential Nepal & India.
PHASE II:								
- Millet	**	***	***	**	***	**	**	Study beer and malt food potential.
- Barley	**	*	*	**	*		**	Determine export potential - China/ Tibet.
- C. Buckwheat 1/	***	**	***	**	***	*	*	Focus on production economics.
- T. Buckwheat 2/	**	**	*	**	**	*	***	Determine export potential - China/ Tibet.
- Amaranth	***	*	**		*	**	***	Assess consumer trends: Nepal & India.
- Exotics	*		**					

Note: * = low priority; ** = medium priority; *** = high priority.

1/ Common or "sweet" buckwheat.

2/ Tatar or bitter buckwheat.

4. All major activities will be based on a multidisciplinary approach, so that problems receive the benefit of collective wisdom for rapid, effective solutions.

5. Experiments and trials should be conducted over a diverse range of agro-climatic conditions. Combined analysis will be used so that definite conclusions can be drawn therefrom. The annual workplan will ensure a proper distribution of activities throughout the year.

5.4.1 Prospects for Millet Improvement

Once underway progress should be quite rapid, since these hill crops have been largely neglected. The impact will be particularly significant for millet on account of its widespread production. Moreover, this crop possesses exceptional yield potential under Nepalese conditions. Repeated experiments have shown that mere selection within landraces can result in lines capable of yields up to and exceeding 4 mt/ha under favorable circumstances.

While the primary preoccupation of the millet scientists at the outset will be to stabilize production mainly through developing resistance to pests (especially blast), there is also good scope for increasing yielding potential through study of yield components and their recombination. There are also good opportunities to improve grain quality: malting and diastatic power, seed size, protein content, and acceptability. The unique malting character of millet provides an industrial base for this crop deserving of further study. In particular, white pearly seeded types can be used in the processing of highly nutritious, easily digested malt foods.

Progress in genetic improvement of field crops often depends directly on the ease and numbers of crosses made. In the case of highly

self-pollinated finger millet, crossing is painstaking and time-consuming. Therefore, some initial studies should be made to determine the most efficient and rapid method of controlled crossing of this species. This might involve different techniques of hand emasculation, hot water or hot air pollen inactivation, use of gametocides, earhead bagging with impermeable material, and other methods. An interesting and simplified technique for mass crossing of sorghum is to cover the pre-flowering earhead with plastic over which an opaque kraft bag is placed to reduce heat buildup. The buildup of humidity under plastic prevents pollen grains from shedding until external pollen can be introduced.

5.4.2 Buckwheat Improvement

The two buckwheat species - both common and tatar-are equally interesting for their exceptional range of adaptation from 100 m up to 4000 m. They also appear to have export potential-mainly to Japan (for making noodles) and to China where the Tibetans particularly relish this cereal. The breeding implications for buckwheat are interesting. Common buckwheat (F. esculentum M.) is heterostyllic allogamous, and therefore an outcrossing species; while tatar buckwheat (F. tataricum K.) is an autogamous or mainly self-pollinated species. Since there are advantages in both systems breeders may wish to convert certain lines of each species to both allogamy and autogamy. Other interesting options may be to elimate bitterness in F. tataricum K. and to introduce perenniality from the wild F. cymosum M. - if interspecific crossing is possible.

5.4.3 Barley Improvement

The methods and techniques of barley improvement are well known. However, there is a considerable amount of untested materials and other technologies from external sources that may be adapted to Nepali conditions. Therefore, the first order of activity should be to introduce and evaluate the new technologies, mainly from ICARDA/CIMMYT and from India.

5.4.4 Amaranth Improvement

Amaranth is a particularly attractive species on account of its excellent grain quality, dual use as a vegetable and fodder, tolerance of low moisture conditions, and efficient C_4 carbon assimilation pathway (similar to maize and sugarcane). Aside from the nutritional implications, the amaranth also has good potential as a village industry (making of popped sweetcakes) and export to India. The main difficulty at present is to determine how important and widespread is amaranth cultivation in Nepal and to have some idea about its future potential. This could be a high priority activity for socio-economics with HCIP support. In the meantime there is considerable technology that can be introduced and evaluated mainly from the USA (Rodale Research Center), Mexico and the South American Andean Region.

5.4.5 Exploratory Studies on Exotic Species

New crops have been an alluring opportunity throughout history. In fact several of Nepal's major crops, like maize, potatoes, tobacco, chillies; and several other vegetables, fruits and fodder crops were introduced in comparatively recent, post-Colombian times. However, there remain a number of untried hill crops, especially from the Andean region of South America and from the highlands of East Africa, that should be tried in Nepal. Among these are the False Banana (*Musa ensete*) and tef (*Eragrostis tef*) from Ethiopia; Quinoa (*Chenopodium quinoa*), Tarwi (*Lupinus mutabilis*), and three root crops (*Ulluca*, *Oxalis* and *Daucus spp.*) from the Andean Region. Also, from South America are cold tolerant forms of common dry beans (*Phaseolus vulgaris*), lima bean (*Ph. lunatus*) and the scarlet runner bean (*Ph. coccineus*).

In addition, there are improvements in familiar crops like short duration wheats and triticales; and in new, cold tolerant sorghums, pearl millet (bajra), and Italian millet (*Setaria italica*).

Some of these may find unutilized niches in the highlands, contribute significantly to total food availability, improve nutrition, and bring more income to hill agriculture. It is therefore recommended that HCIP allot a modicum of its efforts to support some exploratory studies on exotic new hill crops in collaboration with Agriculture Botany, Tribhuvan University, and other agencies, mainly in Phases II and III.

5.5 FORMULATION OF A WORKPLAN

The formulation of a workplan will be carried out by each of the program's disciplinary heads in consultation with the HCIP Coordinator. The Coordinator will then meet with other members of the program to interact with them on the overall program of work for the season. On reaching a consensus and finalizing the plan, it will be presented to the Hill Crops Technical Panel for discussion, recommendation, improvement, and final agreement.

A basic understanding of the constraints, and an intimate familiarity with the research methodologies and program capabilities, will form the basic background to develop the working plan for each season. In formulating a workplan, it is essential to be knowledgeable about the background of previous work, resources of the research stations, staff and labor capabilities, operational facilities available, costs involved, seeds on hand and so on. Once the process has been started, it becomes continuous.

VI. FACILITIES-STAFFING-BUDGET

The facilities, equipment, personnel, and operating budgets necessary to strengthen the coordinated Hill Crops Improvement Program are projected separately for Phases I and II. However, most of the construction, equipment, furnishings, and a portion of the training are scheduled during Phase I (1987/1990).

6.1 PHASE I DEVELOPMENT (1987/1990)

The coordinating center for the HCIP is proposed for establishment at Lumle; but four other centers will have key roles in program activities including Jumla, Marpha, Kavre, and Rampur; and at least six stations/farms will be used as secondary and testing sites (see Table IV-1). Since there may be a delay until an agreement is worked out with the ODA group at Lumle, Khumaltar is proposed as the interim coordinating center. Moreover, other aspects of program development such as donor support, construction, and procurement of essential equipment and supplies are likely to be somewhat delayed.

However, it would be essentiel to nominate the Coordinator-Designee as soon as possible so that he can move promptly ahead in marshalling resources, planning, initiating construction, procuring material and recruiting and training staff. This arrangement will assure that the program takes off vigorously and expeditiously. Thus, 1987 would be considered the first year for HCIP and the schedule of developmental activities during Phase I would be the following:

YEAR	ACTIVITIES
- (1986)	Prepare and submit proposal to HMG/N and donors. If approved in principal, nominate Coordinator-Designee to initiate program. Continue current research activities on hill crops.

YEAR	ACTIVITIES
1 (1987)	Coordinator-Designee to expedite agreements on main center and other stations, initiate construction, order equipment and supplies, recruit and train staff. Expand current research activities as resources and facilities become available.
2 (1988)	Coordinator and center staff moves to designated centers as soon as facilities become available. Continue recruitment, and commence long and short term training abroad. Recruit and assign staff to secondary centers. Accelerate technical program.
2-B (1989/1990)	HCIP is fully functional technically and administratively.

6.1.1 Staffing and Personnel

Post		Proposed	Starting Year*	Total Person Years	Cost Rs. '000
1. Gazetted Officer					
G.I:	Coordinator	1	1	3	126
G.II:	Agronomist	1	2	2	60
G.III:	Asst. Soil Scientist	1	1	3	72
	Asst. Entomologist	1	1	3	72
	Asst. Agronomist	1	-1	4	96
	Asst. Breeder	2	-1+1	7	168
	Asst. Pathologist	1	1	3	72
		8	-	-	666

* Year 1 = 1987

Post		Proposed	Starting Year*	Total Person Years	Cost Rs. '000
2. Non-Gazetted Technical					
NG.I:	Junior Technician	4	+1+2 (2 ea)	10	140
	Mechanic	1	1	3	42
NG.II:	JTA	4	-1+1 (2 ea)	14	168
NG.III:	FA's+Lab. Asst.	6	-1+1+3 (2 ea)	16	133
	Driver	1	1	3	27
		ST 16	-	-	510
3. Administrative Staff					
G.III:	Administrator	1	1	3	45
NG.I:	Accountant	1	1	3	37
NG.II:	Accountant	1	3	1	10
	Adm. Asst.	1	3	1	10
NG.III:	Adm. Asst.	1	1	3	25
NG.IV:	Storekeeper	1	1	3	19
NG.V:	Peons	2	1+2	5	25
	Guards	3	1(x2)+2)	8	40
		ST 11	-	-	211
4. Field Labor					
Permanent labor		18	-	-	440
Casual labor		-	-	-	90
				ST =	530

Total permanent staff - end of Phase I = 53

Total salaries/wages/allowances - Phase I = Rs. 1,917,000

* Year 1 = 1987

6.1.2 Construction and Station Development

The interim center at Khumaltar will not require any construction, but considerable development will be needed at the proposed main coordinating center (Lumle). Construction and development of Lumle should be started as soon as possible and largely completed by year 3 (1990).

	Cost Rs. '000
1. Construction main center	
- Office building (renovation)*	800
- Laboratory building	700
- Store	120
- Threshing floor, garage, workshop	250
- Residence: 4 individual quarters	1000
- Residence: 4 duplexes (16 units)	1600
ST =	4470
2. Construction - 2 larger subcenters	
- Staff quarters: 2 duplexes	400
- Stores/labs/services	200
ST =	600
3. Construction - 2 smaller subcenters	
- Staff quarters	250
- Stores/threshing	150
ST =	400
4. Construction - 7 testing sites	700

* If existing building is available

	Cost Rs. '000
5. Station development	
- Coordinating center:	
. Land development/irrigation	50
. Glass/plastic houses	150
. Screen houses/head house	50
. Irrigation pump, tubing, tank	140
	390
- Other centers:	
. Fencing	40
. Land development/irrigation	100
. Screen/plastic houses	80
. Irrigation equipment, tanks	120
	340
ST =	730
TOTAL (1-5)	6900

6.1.3 Non-Expendable Equipment

The category includes vehicles and farm equipment, laboratory equipment and office equipment/furnishings.

1. Vehicles and farm equipment

Item	Estimate Rs. '000
- Small pickup trucks: Toyota diesel	200
- Motor cycle (3) and bicycles (5)	80
- Single plot thresher-small (3)	120
- Seed drier, IRRI type (1)	30
- Seed cleaners, graders (1)	20
- Sprayers, hand (5)	6
- Bench type seed cleaners (2)	10
- Sweepnets (10)	1
- Air-conditioners (1) and room dehumidifiers (2)	40
- Miscelleneous	10
Sub-Total	517

All station equipment requiring a power source e.g. threshers, seed cleaners, and driers should be fitted with electric motors whenever possible, and can usually be so ordered. In a situation, where an electricity source is not available or reliable, these machines could also be retrofitted with small diesel engines.

2. Laboratory equipment and furnishing

The list of lab equipment, instruments and furnishing is intended primarily for Lumle. Some items may also be used in Entomology, Pathology and Soil laboratories at Khumaltar.

Items	Estimate Rs. '000
- Mills scales (8)	10
- Gram scales (15)	90
- Binocular microscopes w/attachment (2)	80
- Moisture meters (2)	40
- Seed germinator (1)	40
- Deep freezer-upright (1)	30
- Refrigerators (2)	50
- Cameras w/attachments (2)	20
- Miscellaneous	10
Sub-Total	370

3. Office equipment

- Typewriters (2 Nepali and 2 English)	30
- Photocopy machine (1)	30
- Slide projector w/screen	12
- Overhead projector (1)	10
- Lithomachine, electric and manual (2)	50
- Laboratory tables/furnishing	800
Sub-Total	932

Total non-expendable (1-3) Rs. 1819

6.1.4 Expendable Equipment and Supplies

This will include operational supplies and expendable equipment needed for both field and laboratory research at the main and sub-stations during Phase I (3 years).

Items	Estimates Rs. '000
- Fertilizers and soil amendments	130
- Seeds	20
- Pesticides	20
- Field work supplies (bags, string, paper, tags, labels, etc.)	40
- Plant pots, growing medium	25
- Office supplies	35
- Miscellaneous	20
Sub-Total	290

6.1.5 Operations and Miscellaneous

This item includes the support for operation, equipment maintenance, travel, report printing, and discreet support to collaborate with other departments and programs of the HMG/N. The expenses which will be involved for disciplinary divisions, sub-centers and testing sites, will help to manage some of the intangible expenses which might incur to carry out research on hill crops.

This expenditure includes the expenses incurred with the type of experiments to be conducted with different disciplinary divisions, stations and testing sites. This expenditure is to be estimated and negotiated each year separately with concerned agencies.

Items	Estimated Cost Rs. '000
- Maintenance of equipment and machineries	100
- Collaboration with disciplinary divisions/ centers and testing sites	240
- Travel: in-country	200
- Report printing and sundry expenses	40
ST =	580

6.1.6 Training; Long and Short Term

The cost of training as projected in "Institutional Development" for Phase I of the Hill Crops Improvement Program (3 years) is calculated with the assumption that Ph.D. level training would require 36 m/m and M.Sc. level training would take 24 m/m. The projected total cost is as follows:

	Kind of Training	Duration pm	Estimated Cost Rs. '000
1.	Post graduate 5 M.Sc.'s	120	2520
2.	Short term training at IARC's	12	480
3.	Group training (JT's/JTA's + progressive farmers)	30	90
4.	Seminars, conferences, monitoring tours (National)	28	98
5.	International seminars, monitoring tours, visitations	6	240
	Total	196	3428

6.1.7 Budget Summary-Phase I (1987/1990)

The first three years represent the most critical period for the hill crops program. Staff must be recruited and trained, major construction carried out, equipment ordered, plans made, and programs executed. This heavy task, together with providing leadership, guidance to the hill crops scientists, and overall coordination will rest primarily with the coordinator. He and the program will also be under heavy pressure to produce tangible results earlier than should be expected to gain public support, strengthen staff morale, and assure continuation of the program in Phase II. The magnitude to this challenge can be summarised from the budget summary shown below:

Category			Estimate Rs. '000	Percent of Total
1.	Salaries and allowances		1917	12.8
2.	Construction*/station development			
	- Main center	= 4470		
	- Two larger subcenters	= 600		
	- Two smaller subcenters	= 400		
	- Testing sites (7)	= 700		
	- Station development (all)	= 730		
		ST	6900	46.2
3.	Non-expendable equipment			
	- Vehicles & farm equipment	= 517		
	- Lab. equipment & furnishings	370		
	- Office equipment/furnishings	932		
		ST	1819	12.2
4.	Expendable equipment & supplies		290	1.9
5.	Operations and miscellaneous		580	3.9
6.	Training: long and short term		3428	23.0
		GRAND TOTAL Rs.	14,934	100

* Building construction costs less station development = 6170

6.2 PHASE II DEVELOPMENT (1990/2000)

Crop improvement is a continuously evolving process. Some change in emphasis will occur as certain hill crops develop greater potential, while others decline in importance. It is not unlikely that totally new production technologies or crop species begin to show exceptional promise and amply deserve the HCIP's attention. Therefore, program strategies must remain flexible.

6.2.1 Upgrading and New Staff

Early gains made in Phase II could be rapid and derive mainly from introducing and adapting improved technologies from elsewhere and because initial efforts on previously neglected crops can result in quantum advances. However, a residue of hardcore problems and refinement of existing technology will require increasing efforts and technical competence for further advancement. Specifically; there is expected to be an increasing need for more sophisticated studies on product quality, chemical analysis, and plant growth processes by the latter 1990's. Thus it is proposed to upgrade (recruit or train) staff G-I posts in the fields of Coordinating Agronomy; G-II posts in Agronomy, breeding, entomology, pathology, and soil science; to add new positions in agricultural botany, plant physiology, socio-economics, and training and to further strengthen agronomy, breeding, pathology, entomology, and soil science in Phase II. In effect, this would add two more G-I's, three more G-II's and eight additional G-III posts together with appropriate technical support staff. Some additional administrative staff will be required, mainly at subcenters.

The upgrade and new posts proposed for Phase II would add the following to the Phase I staffing pattern:

Post		Proposed Total	Starting Year	Total Person Years	Cost Rs. '000
1.	G-I upgrades	2	1+5	15	630
2.	G-II upgrades	3	2+4+5	22	660
3.	G-III new positions	8	1+2+3+4 (x2)	68	1632
4.	Support staff				600
				ST =	3522

On this basis it is possible to project estimates of Phase II staffing and personnel costs which should also include allowance for within rank promotion, normal increments, and other increases.

6.2.2 Staffing and Personnel

		Estimated Costs (Rs '000)
1.	Gazetted officers:	
	- Current posts (end of Phase I)	2040
	- Additional posts	3522
	- Promotions, other increase (40% of 1+2)	2225
	ST =	7787

		Total p.y		
2.	Non-gazetted research support:			
	- Current costs (end of Phase I)			2050
	- Additional JT's (2)	16		230
	- Additional JTA's (4)	30		360
	- Additional Lab and Field Assts (4)	30		270
	- Promotions, other increases (40% of 1-4)			1160
			ST =	4070

3.	Administrative staff			
	- Current costs (end of Phase I)	110		870
	- Additional NG-III Adm. Asst. (4)	30		270
	- Promotions/increases (45% of 1+2)	-		510
			ST =	1650

4.	Field labor	
	- Current costs - permanent labor	1250
	- Current costs - casual labor	250
	- Additional permanent labor (5)	400
	- Additional casual labor	150
	- Increases (20% of 1+2+3)	400
	ST	2440

Total permanent staff end of Phase II = 85

Total salaries/wages/allowances - Phase II = Rs. 15,947,000

6.2.3 Construction and Station Development

Major construction will have been largely completed during Phase I, but some additional residences, station development and plastic houses will be needed mainly at subcenters.

		Estimate Rs. '000
1.	Plastic/glass houses (3)	150
2.	Residences: 2 duplexes	400
3.	Additional: subcenters and testing sites	450
	ST =	1000

6.2.4 Non-Expendable Equipment

1.	Small pickup truck (1)	200
2.	Two wheel tractors (3)	150
3.	Motorcycles (3) + bicycles (6)	150
4.	Threshers/driers/seed cleaners/other	220
5.	Laboratory equipment (new staff)	100
6.	Scales/ovens/microscopes/germinator/freezer	280
7.	Office equipment	100
	ST =	1200

6.2.5 Expendable Equipment and Supplies

1.	Current costs (as in Phase I)	725
2.	Spare parts/repairs for equipment	65
3.	Additional 30% of 1+2	237
	ST =	1027

6.2.6 Operations and Miscellaneous

		Estimate Rs. '000
1.	Current costs (as in Phase I)	1450
2.	Additional: 30% of 1	435
	ST =	1885

6.2.7 Training - Long and Short Term

Kind of training	m/m	Cost Rs. '000
1. Post graduate: 5 Ph.D's and 9 M.Sc's (India, Philippines)	396	8316
2. Group training (JT's, JTA's and farmers)	54	162
3. Seminars, conferences monitoring tours (within Nepal and India)	60	195
4. International seminars, workshops, visitations	22	880
5. In service training at IARC's: 1 per year x 3 mo x 10 year	30	1200
	ST =	10753

A total of 562 p/m of short and long term training will be carried out during Phase II.

6.2.8 Budget Summary - Phase II

The summary estimates for Phase II are listed below:

Category	Cost Rs. '000	Percent of Total
- Staffing and personnel	15947	50.1
- Construction/station development	1000	3.1
- Non-expendable equipment	1200	3.8
- Expendable equipment/supplies	1027	3.2
- Operations and miscellaneous	1885	5.9
- Training - short and long term	10753	33.8
Total Rs.	31812	

The total cost of Phases I and II is Rs. 46,746,000. Of this amount Phase I comprises only 31.9 percent because of its shorter period. Construction amounted to 46.2 percent of Phase I cost but only 3.1 percent of Phase II. Staff/personnel costs and training are the two major line items in Phase II - 50.1 and 33.8 percent, respectively; compared with 12.8 and 23.0 percent for staff/personnel and training respectively in Phase I. There is an obvious distortion in Phase I resulting from high construction costs.

6.3 PROJECTIONS FOR PHASE III (2000/2010)

Concerned agencies and donors, especially HMG/N, USAID and IDRC must recognize the special needs for hill crops improvement and development. Full program establishment and functioning will not occur until after the turn of the century for the following reasons:

1. Late start in establishing the program. The first year of operation is projected as 1987.

2. There is, in effect, no existing program for hill crops - unlike other major commodities; and some hill crops have not yet been seriously studied in Nepal.

3. There is no international backup support for these crops except barley, which is included in the mandate of ICARDA. Several developed countries also have barley improvement programs.

4. Improvement methodologies for hill crops (except barley) are not yet well developed. Therefore, some initial exploratory studies will be needed to develop research techniques and procedures.

5. Hill stations are not as well developed as those in the plains. Moreover, research in the hills is more difficult owing to limitations of land, lack of soil and site homogeneity, and impracticability of mechanization. Also, travel and movement between hill sites and stations is much more difficult and energy demanding.

As a consequence of this situation the big payoff from hill crops improvement is not likely to occur until the early years of the 21st century. Therefore, full program support must be provided for at least the next 23 years.

Projections for Phase III would be as follows:

Category		Cost Rs. '000
1.	Total costs of Phase II less long term training	21060
2.	Increased staff positions (10% of staff costs)	1590
3.	Training: 2 Ph.Ds and 4 M.Sc's, 120 pm	2520
4.	Training short term: as in Phase II	2430
5.	Promotions and increases 30% of 1 and 2	6800
	Total	34400

6.4 SUMMARY OF COSTS - PHASES I - III (1987-2010)

The full costs for the first three development phases of the Hill Crops Improvement Program are as follows:

Phase		Cost Rs. '000	Percent of Total	Cost/year Rs. '000
I:	3 years	14934	18.4	4978
II:	10 years	31812	39.2	3181
III:	10 years	34400	42.4	3440
	Grand Total	81146	100.0	3528

Annual program costs have declined from Phase I to Phases II despite substantial increases in staffing, promotions, and normal increments. This is because major capital investment for construction will be largely completed during Phase I,

VII. PROGRAM IMPACT

Predicting the potential effects of research and technology advances is difficult at best as many factors are involved. Moreover, conditions and needs change for a number of reasons sometimes negating the potential of otherwise sound advances. Plant pests are particularly difficult to assess - as old disease and insect problems are solved existing forms tend to mutate or totally new pests may appear.

On the other hand, unexpected breakthroughs may occur that are both cumulative and catalytic and lead to new directions in development. Among the most interesting such possibilities are radically different forms of existing crops that find new roles in the farming systems or cause new cropping patterns and uses to develop. These new 'forms' may evolve as earlier maturing varieties, tolerance of previously limiting physical stresses (e.g. drought, waterlogging, pH, or temperature extremes), multiple pest resistances and/or improved product quality or uses. Therefore, hill crops researchers, in collaboration with their farming systems colleagues, should be constantly vigilant for any such innovative possibilities arising from new component technologies.

There is already some technology developed by HMG/MOA divisions and stations and available from international institutes and countries that can be tested and adapted to conditions in the Nepal hills. However, this backlog of information and elite germplasm is less bountiful than that available for major crops like rice, maize and wheat. This means the HCIP will have to become more self-reliant and innovative in developing its own base materials and improvement methodologies. This need not be a serious impediment to advance, since the HCIP will, in the end, become stronger and collectively more self-confident. However, it must be recognized that initial progress will be slower than may be expected from similar programs on major cereals, oilseeds, and pulses. Nevertheless, once momentum is attained, advances can occur more rapidly and make an even greater impact on hill agriculture than any of the other commodities.

7.1 PROJECTIONS

Based on past experience with similar crops and situations it is possible to prepare an illustrative model to show how an effective hill crops improvement effort can impact on Nepal's agricultural economy and on the food needs of a large segment of the hill population. However, it must be assumed that staff is recruited promptly and trained as scheduled, that facilities are provided without delay, and that necessary operational procedures (like travel) are streamlined and made more attractive; and that adjunct agencies and programs (extension, seed production, agricultural inputs) function efficiently.

Base production of the four HCIP mandated hill crops is around 300,000 tons annually (1985). Given a full program startup by 1987 it should be possible to achieve a modest impact on national production by the end of the Eighth 5-Year Plan for example:

Year	Production Estimates ('000 mt) Without Technology	With Technology Increment	With Technology Production	Increase Over Base
1985/1992	300	0	300	0
1993	300	1	303	3
1994	300	1	306	6
1995	300	2	312	12
1996	300	3	322	22
1997	300	3	331	31
1998	300	4	344	44
1999	300	4	358	58
2000	300	4	373	73
2001	300	6	395	95
2002	300	6	419	119
2003	300	7	448	148
2004	300	7	479	179
2005	300	7	513	213
TOTAL	4200	-	5203	1003

7.2 PROGRAM COSTS IN PERSPECTIVE

If the additional value of the 13 year cumulative increase is assessed at Rs. 6,000/mt, then the gross benefit to Nepal would be Rs. 601.8 crores or 14.2 times the entire cost of all three phases (23 years) of the HCIP. In fact, the total cost of the program would be fully repaid from the additional production attained by 1995.

These projections are not wildly improbable. In fact they are conservative. Witness India during the "Green Revolution". Wheat production on a much vaster scale increased three-fold in a shorter time period. Another case was pearl millet (bajra), which increased in production by

80 percent on virtually the same area (yield increase) in only 4 years following a single innovation - the release of Hybrid Bajra No. 1.

7.3 IMPACT ON CONSUMERS

In conclusion it can be fairly stated that few if any investments can pay such bountiful dividends as applied agricultural research. In particular, support for Nepal's hill crops could prove to be the most profitable of all investments as it would benefit the largest number of the poorest segment of society. By 2005 an additional 12 lakhs of people could derive their major sustenance from the increased production of hill crops resulting from improved technology generated by the HCIP.

APPENDIX I: DESCRIPTIONS OF THE IMPORTANT NEGLECTED HILL CROPS OF NEPAL

1.1 FINGER MILLET (*Eleusine coracana* Gaertn.)

This cereal is extensively grown in Nepal ranking fourth in the importance after rice, maize and wheat. Most of the production occurs in the hills in rainfed areas. It is also cultivated to a lesser extent in the Terai up to about 2500 m, but more commonly occurs between about 1000 and 2000 m. In Nepal, millet is frequently grown in association or relay systems with maize. Yields are both respectable and reliable at around 900 to 1100 kg/ha. It is particularly valued for its storability, malting qualities, and slow digestibility (preferred during periods of hard physical labor). Some of the finger millet species and wild relatives are further described below:

1. *Eleusine coracana* (Afro-Asiatic type): 2n = 36 chromosomes; shorter glumes, lemmas and spikelets. The panicles may be top curved, incurved or open types. All three types of finger millet are found in Nepal. The number of spikelets per finger vary. Top-curved types tend to have more spikelets than the other two. In the higher elevation where rainfall is low, the more dominant type is top-curved, whereas in the mid hills where rainfall is high during the growing season, the open type is more common.

2. *Eleusine coracana* (African highland type): 2n = 36 chromosomes; longer lemmas, glumes and spikelets. The spikelets are non-shattering and seeds remain attached to the glumes. It is mostly found in damp areas above 1200 m elevation in the African highlands of Malawi, Rhodesia, and even in the more northerly areas of the Union of South Africa.

3. *Eleusine indica* (Goose grass): 2n = 18 chromosomes. This smaller plant is the wild relative of finger millet. It has a

narrow rachis; relatively short glumes, lemmas and spikelets. It is believed that E. africana evolved from E. indica by the doubling of its chromosomes. This wild species also occurs in Nepal.

4. Eleusine africana: 2n = 36 chromosomes; semi-wild type; it is a larger plant, with wider rachis and thicker stems; and has longer glumes, lemmas and spikelets; succeptible to shottering than E.indica. It is believed that E. africana was the progenitor of E. coracana. Both E. coracana and E. africana occur naturally in the cultivated fields of East Africa. However, this wild form has not been found in Asia. According to Kennedy - O'Byrne, E. coracana either developed by the selection of a large grain mutant of E. africana or as a selection from naturally doubled E. indica.

1.2 BARLEY (Hordeum vulgare)

This cereal and buckwheat are the two dominant high elevation food crops in Nepal above about 2500 m where 36.5 percent of production occurs. However, barley is also important in the mid-hills (40 percent of production) and in the plains (23.5 percent of production). Barley is important because of its shorter duration (as compared to wheat), cold tolerance, low moisture requirements, and wide adaptation. Although tolerant of poor, alkaline soils, it does not tolerate poor drainage. The grain is consumed mainly as a porridge or bread, while the straw is used as fodder.

Nepal's Himalayan range has a rich diversity of barley genetic stocks, especially the intermedium, six rowed types. This region may be the center of origin of some of the barley varieties, especially naked barley. According to Dr. Kihara (1952/53), barley varieties existing in Nepal are mainly of two types: (i) low land and (ii) high land. Highland types predominate in the country and may be either hulled or hulless (naked), a character controlled by a single gene. The highland barley varieties

can be long, short or intermediate awned types. Barley has 2n = 14 chromosomes.

Barley is also an important staple of diet in the hills. Both covered (hulled) and naked (hulless) barley varieties are grown side by side, but naked barley is mainly cultivated at higher elevations (usually above 2500 m).

1.3 BUCKWHEAT (Fagopyrum spp.)

This pseudo-cereal consists of two cultivated species: F. esculentum K. and F. tataricum K. with 2n = 16 chromosomes. A third, wild species, F. cymosum M., also occurs in the hills from about 1500 to 3000 m mainly along riversides and as a 'companion' crop of tatary buckwheat. The common or 'sweet' species, F. esculentum, is widely cultivated from the terai plains (except on paddy lands) up to about 2300 m. Tatary or bitter-seeded buckwheat is grown from somewhat above 1500 m (usually above 2000 m) up to 4000 m, near the upper limit for cultivated crops in Nepal. At lower elevations, such as in the terai, common buckwheat may be grown in winter by seeding in October/November; while in the hills it may be grown as an early spring or summer crop. Buckwheat is used mainly for making unleavened bread and as a porridge. It is particularly popular amongst Tibetan origins.

Buckwheat is more common in the marginal lands of mid to high elevations where soil fertility and irrigation facilities are limited. The growing period, seed rate, and cropping patterns of cultivated buckwheat are closely related to the elevation. The species of buckwheat grown in Nepal are further described below:

1. Common buckwheat (F. esculentum M.): It is sweet (non-bitter) in taste, and wherever climatic conditions are favorable, the sweet varieties are preferable to other buckwheat species. Common

buckwheat is also widely grown in China, Soviet Union, Japan and Canada. It is mainly used for making noodles in these countries.

2. Tatary or bitter buckwheat (F. tartaricum K.): This species is mainly grown at higher elevations in Nepal. It is more cold tolerant and higher yielding than common buckwheat at higher elevations where it is mainly grown as a barley-buckwheat rotation.

3. Wild and perenial buckwheat (F. cymosum M.): This wild, perennial form of buckwheat is usually found growing alongside tatary buckwheat. The distribution of wild buckwheat is from about 1500 m to 3000 m and perhaps as a companion weed around tatary-buckwheat fields. Tatary buckwheat may have evolved from the wild type.

1.4 AMARANTH (Amaranthus spp.)

This pseudo-cereal is comprised of several species including both grain and vegetable types. In addition, several weedy forms occur widely throughout the world from the tropics to temperate regions. A. hypochondriacus, a native of Mexico, appears to have migrated to Nepal in the post-Columbus era. It has become increasingly popular among the hill people, particularly in the mid and far western regions. It is highly edible, has excellent nutritional value, and can be used to make a variety of dishes. The grain may be popped and mixed with honey (laddoos), ground and made into flat bread, or used in other forms. Other species of amaranths used for grain are A. cruentus (Mexico) and A. caudata (Andean). While amaranth is widely adapted, it is mainly grown in the mid and upper hills of western Nepal in various cropping systems, particularly those involving maize. An undetermined amount of amaranth is exported to India where a good demand for the grain has developed.

Amaranth is a C_4 carbon pathway plant with a high level of photosynthetic and water use efficiency. For these reasons it is particularly well adapted to the drier western foot hills of the Himalayas.

In Nepal, amaranthus is either grown as a mono crop or mixed with other summer crops such as millet or summer beans. It is frequently observed growing in patches bordering millets or other summer upland crops, and on field bunds.

Some of the important amaranthus species are described below:

1. A. hypochondriacus: This is the dominant species found in Nepal being used mainly for its grain. This species was probably domesticated in Central Mexico and later brought to this part of the world. It is considered the highest grain yielding type. Seeds are white, tan, gold or brown in color.

2. A. caudatus: This species is mainly grown in South America as a high yielding grain crop. It is photoperiodically sensitive, has a narrow range of adaptation and is more suitable to equatorial regions. However, it may be useful for breeding purposes.

3. A. cruentus: This species is grown in Mexico as a grain crop and in West Africa as a leafy vegetable. Seeds can be white, tan, brown or black.

4. A. hybridus: Members of this species vary widely in their morphology and use. Some types are leafy vegetables; some are used as dyes; others are grown as ornamentals; and some are weedy amaranthus. The seeds of this species are white, brown or black.

5. A. tricolor, A. dubius, A. lividus and A. palmeril: These are other forms of the species which may be grown as leafy vegetables or ornamentals depending on the region and accustomed use.

APPENDIX II. ESTIMATED AREA AND PRODUCTION OF FINGER MILLET THROUGHOUT NEPAL 2035/36 (1978/79)

Areas in Hectares
Production in mt.

Development Area/Districts	Finger Millet Area	Finger Millet Production	Average Production mt/ha
I. EASTERN REGION			
A. Mid-to high hill Agro-Eco. Zone			
01. Taplejung	1400	2300	1.64
02. Sankhuwasabha	2310	2860	1.23
03. Solukhumbu	1000	1100	1.10
Total:	4710	6260	1.33
B. Mid-hill Agro-Eco. Zone			
01. Panchthar	3730	3360	0.90
02. Illam	2430	2860	1.18
03. Terahthum	2120	2790	1.32
04. Dhankuta	4210	3970	0.94
05. Bhojpur	2000	2000	1.00
06. Khotang	1110	1260	1.14
07. Okhaldhunga	2200	2040	0.93
08. Udaypur	1400	1180	0.84
Total:	19200	19460	1.01
C. Terai and Inner Terai Agro-Eco. Zone			
01. Jhapa	900	820	0.91
02. Morang	1000	950	0.95
03. Sunsari	1020	1140	1.12
04. Saptari	870	720	0.83
05. Siraha	2190	1420	0.65
Total:	5980	5050	0.84
EASTERN REGION TOTALS:	29890	30770	1.03

APPENDIX II. (Cont'd...2)

Development Area/Districts		Finger Millet Area	Finger Millet Production	Average Production mt/ha
II. CENTRAL REGION				
A. Mid-to high hill Agro-Eco. Zone				
01.	Dolakha	900	600	0.67
02.	Sindhupalchok	2930	3140	1.07
03.	Rasuwa	480	460	0.96
	Total:	4310	4200	0.97
B. Mid-hill Agro-Eco Zone				
01.	Ramechhap	2370	1900	0.80
02.	Sindhuli	2370	2400	1.01
03.	Kabhre	1990	2490	1.25
04.	Bhaktapur	180	180	1.00
05.	Lalitpur	1280	1100	0.86
06.	Kathmandu	1400	1300	0.93
07.	Nuwakot	1800	2600	1.44
08.	Dhading	2010	2060	1.02
09.	Makawanpur	2400	3360	1.40
	Total:	15800	17390	1.10
C. Terai and Inner Terai Agro-Eco. Zone				
01.	Dhanusha	2730	2530	0.93
02.	Mahottari	1420	1420	1.00
03.	Sarlahi	680	570	0.84
04.	Rautahat	550	480	0.87
05.	Bara	280	260	0.93
06.	Parsa	300	290	0.97
07.	Chitwan	1200	1100	0.92
	Total:	7160	6650	0.93
	CENTRAL REGION TOTALS:	27270	28240	1.04

APPENDIX II. (Cont'd...3)

Development Area/Districts	Finger Millet Area	Finger Millet Production	Average Production mt/ha
III. WESTERN REGION			
A. Mid-to-high hill Agro-Eco. Zone			
01. Manang	550	570	1.04
02. Mustang	550	680	1.24
Total:	1100	1250	1.14
B. Mid-hill Agro-Eco. Zone			
01. Gorkha	2700	2130	0.79
02. Lamjung	5950	7170	1.21
03. Tanahu	5420	6800	1.25
04. Kaski	7000	7700	1.10
05. Parbat	2250	2600	1.16
06. Syangja	7000	8400	1.20
07. Palpa	1940	1550	0.80
08. Myagdi	800	800	1.00
09. Baglung	1500	1770	1.18
10. Gulmi	1800	2230	1.24
11. Arghakhanchi	1800	2100	1.17
Total:	38160	43250	1.13
C. Terai and Inner Terai Agro-Eco. Zone			
01. Nawalparasi	1380	1110	0.80
02. Kapilbastu	450	390	0.87
03. Rupandehi	640	480	0.75
Total:	2470	1980	0.80
WESTERN REGION TOTALS:	41730	46480	1.11

APPENDIX II. (Cont'd...4)

Development Area/Districts	Finger Millet Area	Finger Millet Production	Average Production mt/ha
IV. FAR-WESTERN REGION			
A. Mid-to-high hill			
01. Dolpa	650	750	1.15
02. Kalikot	700	790	1.13
03. Mugu	450	500	1.11
04. Humla	700	800	1.14
05. Jumla	1300	1140	0.88
06. Bajura	1000	1250	1.25
07. Bajhang	970	1200	1.24
08. Darchula	620	800	1.29
Total:	6390	7230	1.13
B. Mid hill Agro-Eco. Zone			
01. Rukum	200	250	1.25
02. Rolpa	620	720	1.16
03. Pyuthan	1200	1400	1.17
04. Salyan	4300	4700	1.09
05. Jajarkot	1300	1580	1.22
06. Dailekh	1500	1800	1.20
07. Surkhet	550	600	1.09
08. Acchham	900	1060	1.18
09. Doti	1300	1580	1.22
10. Baitadi	900	1060	1.18
11. Dadeldhura	1850	2220	1.20
Total:	14620	16970	1.16
C. Terai and Inner Terai Agro-Eco. Zone			
01. Dang	400	480	1.20
02. Banke	940	930	0.99
03. Bardiya	500	550	1.10
04. Kailali	1400	1400	1.00
05. Kanchanpur	500	560	1.12
Total	3740	3920	1.05
FAR-WESTERN REGION TOTALS:	24750	28120	1.14
NEPAL:	123640	133610	1.08

APPENDIX II. (Cont'd...5)

APPENDIX II. AREA IN PRODUCT BY REGION AND RANK

			Tank
I.	EASTERN REGION AREA CULTIVATED	29,890	II
II.	CENTRAL REGION AREA CULTIVATED	27,270	III
III.	WESTERN REGION AREA CULTIVATED	41,730	I
IV.	FAR-WESTERN REGION AREA CULTIVATED	24,750	IV

DISTRICTS BY REGION ABOVE 2350 HA AREA IN CULTIVATION

I. EASTERN REGION

A. Mid-Hill Agro-Eco. Zone

01.	Panchthar	3730
02.	Dhankuta	4210
03.	Illam	2430

CENTRAL REGION

A. Mid-Hill Agro-Eco. Zone

01.	Sindhupalchok	2930
02.	Ramechhap	2370
03.	Sindhuli	2370
04.	Makawanpur	2400

B. Terai and Inner Terai Agro-Eco. Zone

01.	Dhanusha	2730

II. WESTERN REGION

A. Mid-Hill

01.	Kaski	7000
02.	Syangja	7000
03.	Lamjung	5950
04.	Tanahu	5420
05.	Gorkha	2700

III. FAR-WESTERN REGION

A. Mid-Hill Agro-Eco. Zone

01.	Salyan	4300
	GRAND TOTAL:	55540 = 44.9% of total

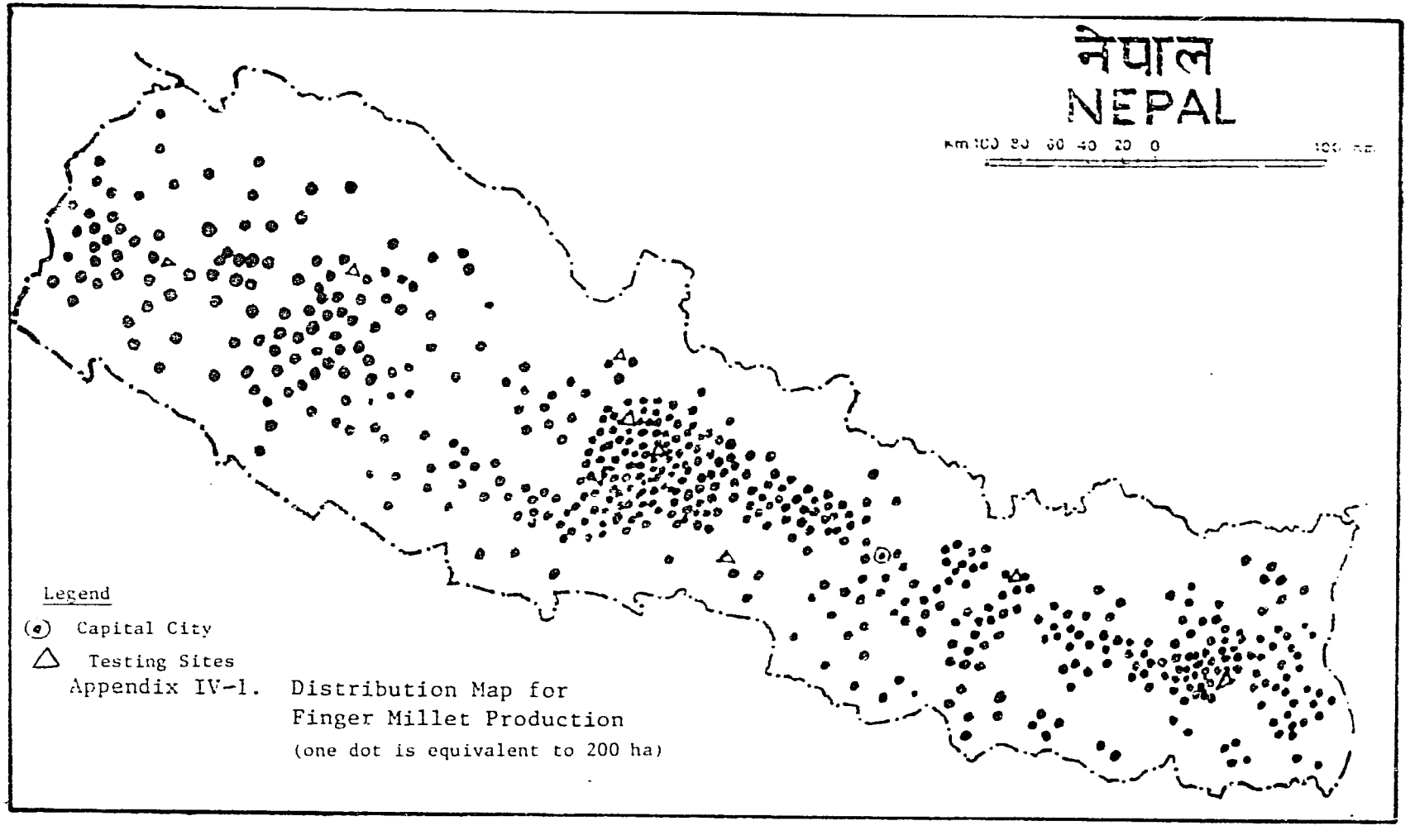
APPENDIX III. NUTRIENT COMPOSITION OF CEREAL GRAINS (per 100g)

Name of foodgrain	Food energy (cal)	Moisture (%)	Protein (g)	Fat (g)	Total carbo-hydrate (g)	Ca (mg)	Fe (mg)	P (mg)	Tryptophan (% of protein)	Lysine (% of protein)
Rice	345	13.7	6.8	0.5	78.2	10	3.1	160	1.0	3.8
Maize	355	12.0	9.2	3.9	73.7	20	3.5	256	0.6	1.9
Wheat	333	-	13.3	2.0	71.0	41	10.5	372	1.2	2.6
Millet	328	13.1	7.3	1.3	72.0	344	6.4	283	1.39	2.19
Amaranth	391	9.3	15.3	7.1	63.1	490	22.4	455	1.4	5.0
Buckwheat	335	11.0	11.7	2.4	72.9	114	15.5	282	NA	3.95
Barley	336	12.5	11.5	1.3	69.6	26	3	215	NA	2.2

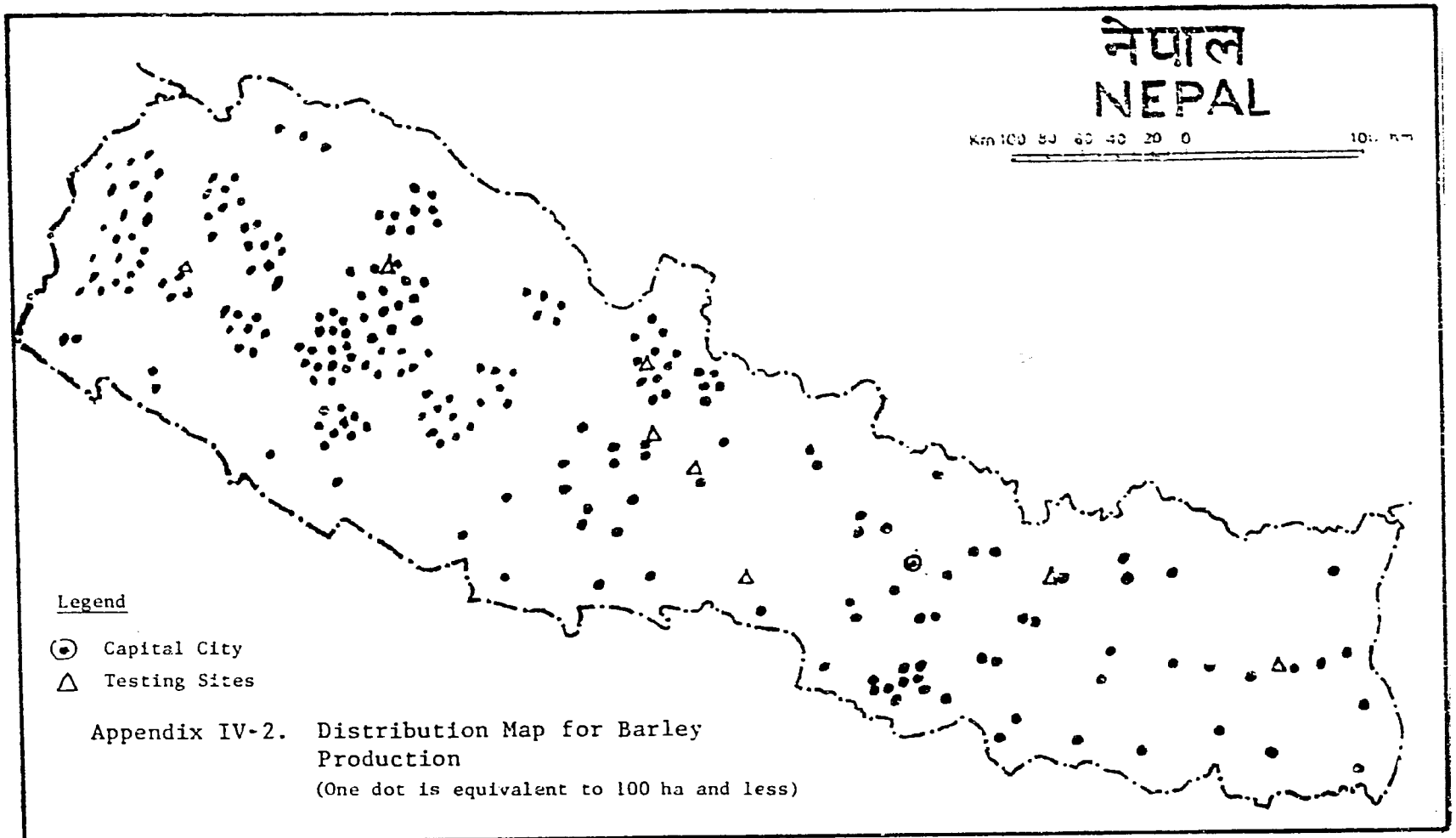
Source: Indian Farming, 1983

Central Food Laboratory, Kathmandu, Nepal

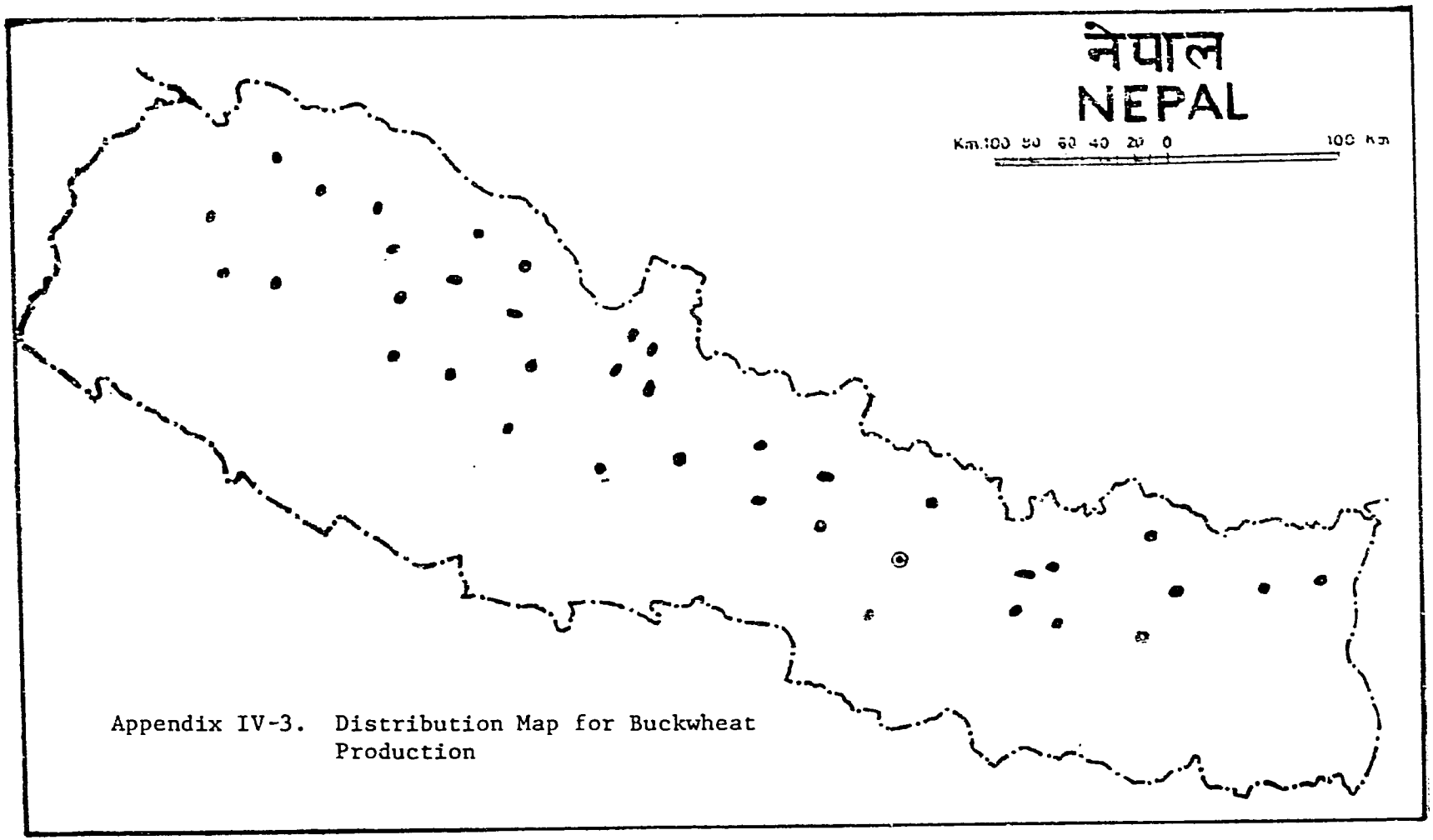
Indian Food composition table, Hyderabad, India



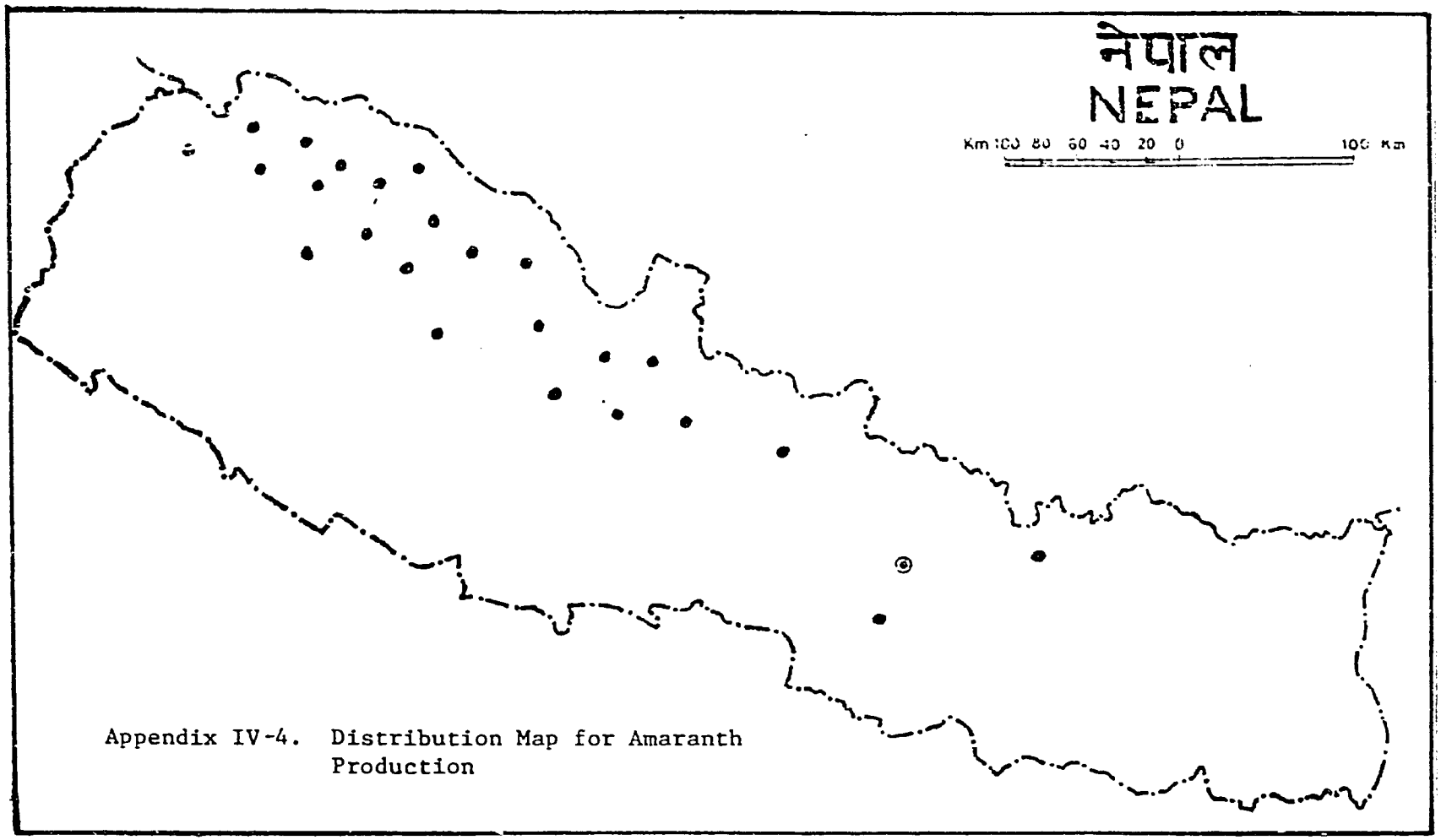
Appendix IV-1. Distribution Map for Finger Millet Production
(one dot is equivalent to 200 ha)



Appendix IV-2. Distribution Map for Barley Production
(One dot is equivalent to 100 ha and less)



Appendix IV-3. Distribution Map for Buckwheat Production

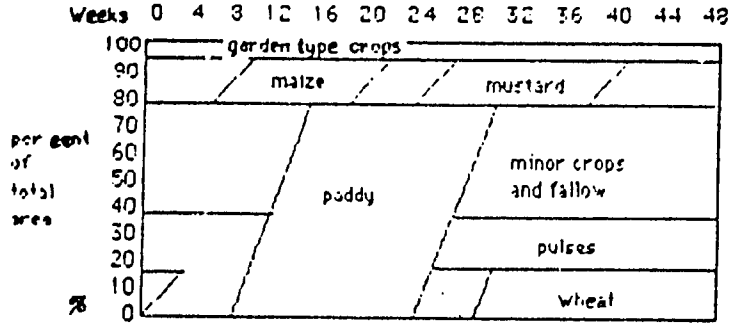


Appendix IV-4. Distribution Map for Amaranth Production

APPENDIX V-1

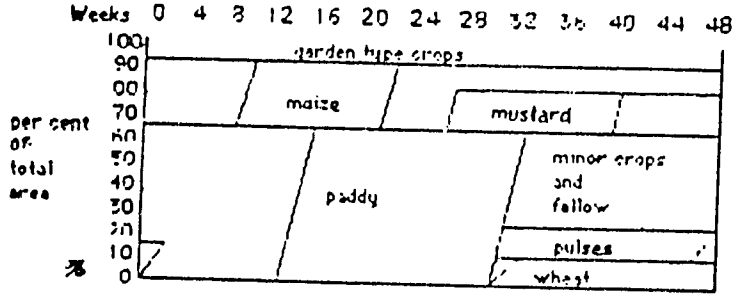
Cropping Pattern-Main Terai Farming System

FAR WESTERN DEVELOPMENT REGION



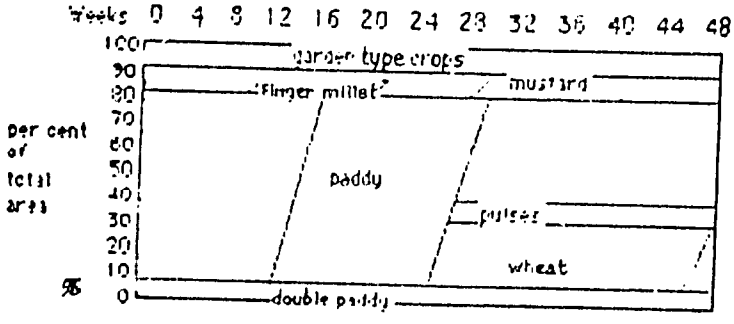
Cropping Pattern-Main Terai Farming System

MID WESTERN DEVELOPMENT REGION



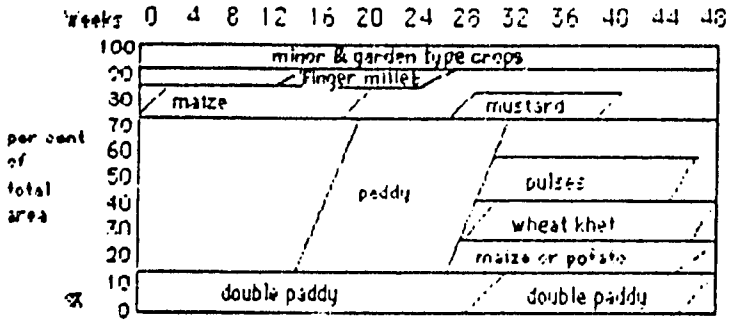
Cropping Pattern-Main Terai Farming System

WESTERN DEVELOPMENT REGION

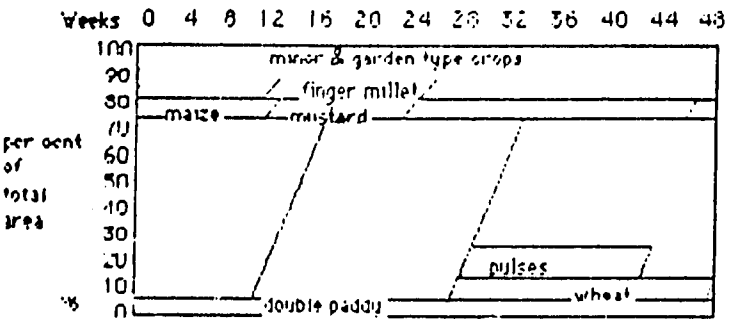


APPENDIX V-2

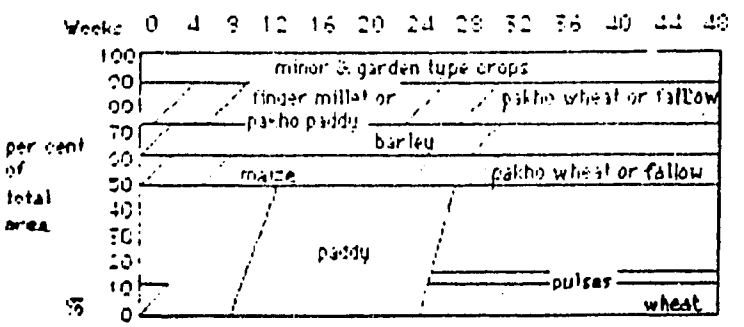
Cropping Pattern-Main Terai Farming System
CENTRAL DEVELOPMENT REGION



Cropping Pattern-Main Terai Farming System
EASTERN DEVELOPMENT REGION



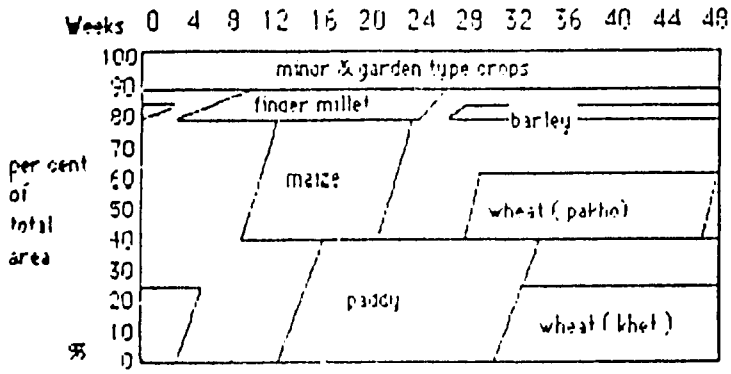
Cropping Pattern-Middle Mountain Farming System
FAR WESTERN DEVELOPMENT REGION



APPENDIX V-3

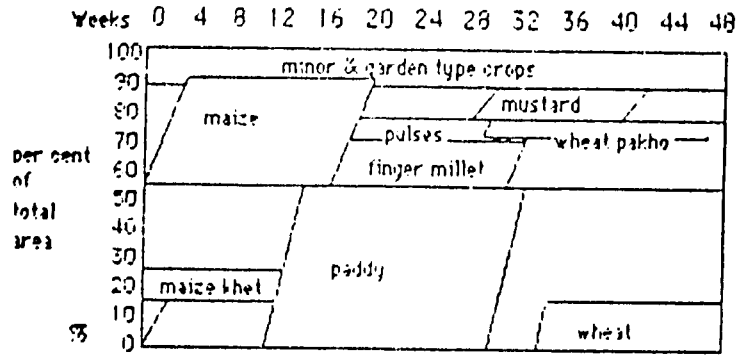
Cropping Pattern-Middle Mountain Farming System

MID WESTERN DEVELOPMENT REGION



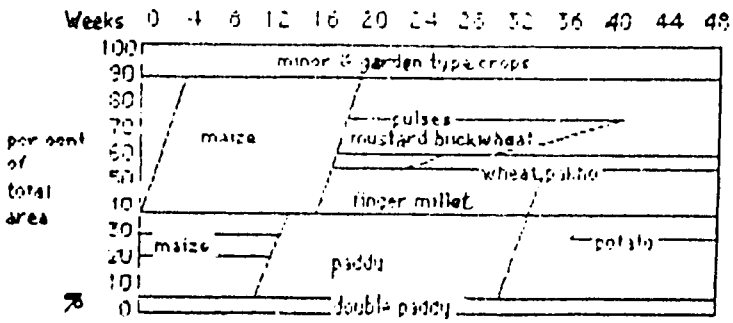
Cropping Pattern-Middle Mountain Farming System

WESTERN DEVELOPMENT REGION



Cropping Pattern-Middle Mountain Farming System

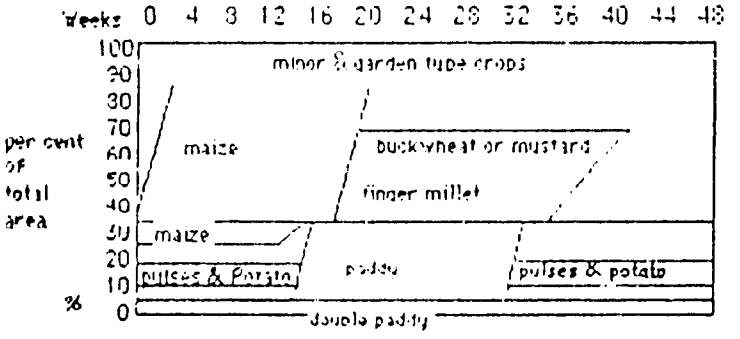
CENTRAL DEVELOPMENT REGION



APPENDIX V-4

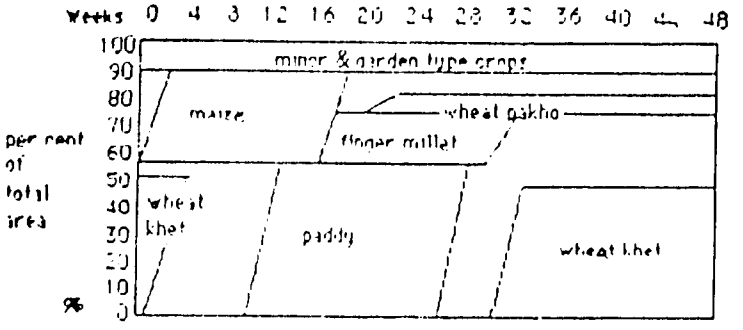
Cropping Pattern-Middle Mountain Farming System

EASTERN DEVELOPMENT REGION



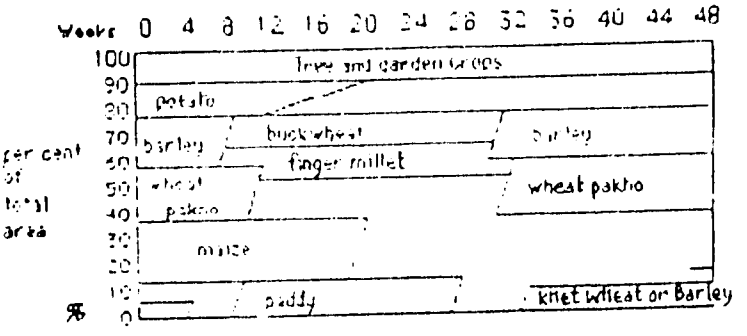
Cropping Pattern-Middle Mountain Farming System

KATHMANDU HILL SLOPES



Cropping Pattern-High Mountain Farming System

ALL REGIONS



APPENDIX VI. SOME IMPORTANT DISEASES OF HILL CROPS

6.1 Finger Millet

Blast caused by Pyricularia sp is a major destructive leaf disease of finger millet in the hills and inner terai areas. The disease has caused enormous loss of finger millet grain yield. The damage is particularly high if the infection occurs in the seedlings before transplanting. Although an accurate estimate of loss has not been made, the disease may cause not less than 10 percent reduction in yield overall. In other countries blast has been reported to cause as much as 80 to 90 percent loss in grain yield. Moderately higher temperatures (29-30°C) favor the disease and seedlings are more susceptible than mature plants.

Leaf blight caused by Helminthosporium nodulosum. The disease occurs both in the hills and terai but the incidence is quite low compared with blast disease. Disease symptoms occur mainly on leaf blades as varying size brown spots or lesions. The lesions are also observed on stems, leaf sheath and spikes in severe cases. The disease has been studied very little in Nepal.

Foot rot and Wilt caused by Sclerotium rolfsii: Recently the disease was recorded in the terai areas and the incidence is very sporadic. Symptoms of the disease appear as pale green and stunted plants, but the damage is insignificant. However, it may flare up in wet soils with susceptible varieties.

6.2 Barley

Yellow rust caused by Puccinia striiformis. This is one of the most destructive foliage diseases of barley. It is mainly prevalent in the hills. This rust is a disease of cool climates with average temperatures of about 15°C and intermittent rain or dew. As the name indicates the

pustules of the rust are linearly ordered on leaf blades and leaf sheaths and they are yellow in color. In Kathmandu valley, there is hardly any variety which is resistant to the disease. In one of the experiments on yield loss in barley, the disease is known to cause about 25 to 30 percent yield loss and 20-25 percent reduction in 1000 grain weight. The loss due to the disease depends on growth stage when the crop is attacked.

Powdery mildew caused by Erysiphi graminis. Powdery mildew is another important leaf disease of barley. It occurs in areas of high humidity and moderate temperatures of 15-20°C. The incidence of the disease is higher in the hills than in terai areas. This mildew causes damage to the leaf and other foliar parts. In severe cases, the whole plant except the root is infected. Loss estimation has not been carried out. However, if the infection occurs at the seedling stage, plants will not head nor produce grains.

Covered smut caused by Ustilago hordei. Covered smut is an endemic disease of barley. It occurs both in the higher hills and lower valleys and in the foot-hills of Nepal. The disease is quite distinct in causing damage to the head which becomes smutted. The disease incidence increases each year if proper control measures are not taken - especially seed treatment. The loss of grain yield is directly proportional to the percent of smutted heads. A moderate climate is favourable to the disease.

Barley stripe caused by Pyrenophora graminea is the next important leaf disease of barley. As the name indicates, the characteristic symptom is leafstriping. The disease is seed borne and is favored by a soil temperature not exceeding 15°C. Because of its low temperature requirement, the disease is quite common in the higher hills and has caused considerable damage.

Spot blotch caused by Cochliobolus sativas is also an important leaf disease of barley. The pathogen causing the disease may be disseminated

through seeds and soils or by means of air if the temperature is 20°C or higher. With wet weather, epidemics may occur. The disease is more common in lower valley regions. The disease has not caused more than 10% yield loss in any case.

6.3 Buckwheat

Some of the listed diseases of buckwheat are as follows:

1. Powdery mildew: caused by Erysiphe polygon
2. Leaf blight: caused by Cercospora fagopyri
3. Leaf spot: caused by Ascochyta italica

Systemic studies have not yet been done on the buckwheat diseases listed above.

6.4 Amaranth

1. Blight: Alternaria amaranthi (not yet studied).

APPENDIX VII. DESCRIPTIONS OF HILL CROPS RESEARCH CENTERS VISITED DURING PREPARATION OF THE HCIP PROPOSAL

A. LUMLE AGRICULTURAL CENTRE

The Station

Lumle Agriculture Centre is located about 12 miles from Pokhara town which is the headquarters for the Western Development Region. The farm is located on a south-facing slope and is adjacent to Lumle and Kande Villages mostly inhabited by Gurung and Brahmin communities. The main occupation of the area is farming upland crops like maize, millet, wheat and barley; and rice in the valleys.

The Centre (LAC) is on the tourist trekking route - Pokhara/Jhomsom Trail. In the near future, an all weather motorable road between Pokhara and Baglung will be constructed which will be within a half hours drive from Pokhara, a large city with all necessary facilities.

Location and Environment

Panchayat: Lumle Gaon Panchayat
District: Kaski
Elevation: 1700 meters
Total area: 57 ha
Cultivated area: 19 ha
Temperature:
- Summer: 23.1°C and 16.6°C
- Winter: 12.9°C and 5.1°C

Annual precipitation: 5000 mm
Soil type: variable
pH range: 4.5 to 5.5
Irrigation: not available

Physical facilities:

Adequate meteorological facilities
Store house: available
Threshing floor: available
Electricity: currently run by diesel generator
Office building: several (total of 80 separate buildings on the site)
Residential building: available for LAC staff

Current Activities

The LAC follows an integrated approach in crops, livestock, horticulture, and forestry in which the fields of extension, training and research are closely meshed. This center focuses attention mainly on the adjoining districts.

Special Recommendation:

Given the existing facilities at LAC, it's proposed road linkage between Pokhara and LAC, as well as the accessibility of several diverse agro-ecological sites, we strongly recommended that LAC be chosen as the main center for the proposed Hill Crop Improvement Program.

B. JUMLA AGRICULTURE FARM

The Farm and Surroundings

The Jumla Agriculture Farm is located within Jumla Khalanga Bazaar and is mainly inhabited by Brahmins, Chhetris, Thakuries, some Mugels and others. Jumla Khalanga Bazaar is also the headquarters for Karnali Zone. The major occupation of the area is farming and growing of subsistence crops. Some temperate fruit crops are also grown for off-farm sales.

Location and Environment

Panchayat: Mahat Gaun (village) panchayat

District: Jumla

Elevation: 2290 meters

The farm is located at the river basin within the vicinity of Jumla Khalanga Bazaar

Total area: 1.6 ha

Temperatures:

Summer: 23.9°C and 13.8°C

Winter: 14.0°C and 4.7°C

Annual precipitation: 700 mm

Soil type: Silty loam

pH: 6.0 to 6.5

Irrigation: Yes

Physical Facilities

Agro-meteorology: available temperature recorder, rain gauge, sunshine recorder, anemometer, hygrothermograph, evaporation pan, soil thermometer

Store house: two

Threshing floor: one

Electricity: yes

Office building: three

Residential housing:

one family house

two single house

Current Activities

Different experiments and trials: Summer - 4

Winter - 7

FFT - 2

Seed multiplication:

Summer = 0.5 tons

Winter = 1.5 tons

Training: 4 sessions per year

Local Amenities

Schools: one high school and one technical school run by United Mission to Nepal

Post Office: yes

Health post: one district hospital

Air strip: yes, about a kilometer from the farm

Requirements for the Farm

The Jumla Farm requires considerable development to serve the HCIP: (i) residence (10 staff), (ii) threshing floor (concrete) (iii) two zinc-roofed stores, (iv) one laboratory for soils and plant protection, (v) more land - 3 to 4 ha, (vi) wheat thresher and (vii) small pumping set.

C. MARPHA AGRICULTURAL FARM

The Farm and Surroundings

Marpha Agriculture Center is basically a horticulture center intended for termperate fruit and vegetable development. The farm is located facing east on the Kali Gandaki river basin surrounded by high mountains on the east and west sides. The surrounding areas are mostly inhabited by Thakalies and other Tibeto-Burman ethnic groups. The station lies on the main trekking route of Pokhara-Jomson Trail.

Main occupation: farming and partly tourism.

Cash crops: temperate fruits and vegetables.

Other crops: Naked barley, buckwheat, potato, wheat, mustard, beans and others.

Location and Environment

Panchayat: Marpha

District: Mustang

Elevation: 2550 meters

Total area: 8.75 ha

Temperature:

Summer: 20°C and 12°C

Winter: 10°C and -1.7°C

Annual precipitation: 400 mm

Soil type: Sandy loam to loam

pH range: 7.0 to 8.0

Irrigation: available

Physical facilities

Agro-meteorology: available temperature recorder, rain gauge, sunshine recorder, anemometer, hygro-thermograph, soil thermometer, other.

Store house: 2-3

Threshing floor: 1-2

Electricity: run by hydro-power of (260 KW)

Office building: 1-2

Residential building: exists

Current activities: following an integrated approach in horticulture and crops improvement in both research and extension. The focus is mainly on the surrounding areas of Mustang district.

Farmer's Reaction to Barley and Buckwheat Improvement Program

Farmers in this area with its present horticultural growth potential and future road linkage are more inclined towards cash crops like fruits and vegetables. Hence, the question may arise whether the farmers of this region will readily accept a cereal crop development program. In addition, they already have satisfactory yields of barley and buckwheat with local cultivars. On the basis of this limited survey, it is felt that the farmers of the region will be interested in supporting the program only if they obtain superior high yielding varieties of barley and buckwheat.

D. KAVRE AGRICULTURE RESEARCH FARM

The Kavre Farm was visited by the External Consultant in April 1985. It is located 165 km east/northeast of Kathmandu at the end of a slow, tortuous drive (and paved road). From the village above the Farm it is a good hour's trek down to the site. The Farm itself is in a pleasant setting in important growing areas for millet and buckwheat at about 1700 m and with 1900 mm annual precipitation. Good crops of wheat and triticale were observed at the time of the visit. Also, many farmers in the vicinity had planted buckwheat, but the shortage of winter rains had greatly stunted growth so that the crop was beginning to flower with less than six inches of growth.

Facilities

Kavre Farm has very minimal facilities even for a hill station. There is a large threshing floor and some old residences and office buildings. Two new - 2-story buildings were under construction, but were rather crude. They were not wired for electricity nor fitted with a water system. Cultivation is done by animal draft and partly by hand. Approximately 13 ha are under cultivation and partially irrigated.

Recommendation

Kavre is representative of an important hill area in the Central Region. It will be particularly useful for research on millet, barley and buckwheat if facilities are provided. Most urgent needs would be for staff residences, office and stores.

Kavre is not suitable as a coordinating center on account of its remoteness, lack of road access, unavailability of electricity, and difficulty of communication. The need for the Coordinator and other senior officers to travel frequently to several hill crops stations and sites would become difficult and time-consuming. Other problems are lack of 'reasonable' amenities like schools, hospitals and a stimulating intellectual environment.

E. RAMPUR AGRICULTURE STATION

The Rampur Station was visited twice by the External Consultant; in April 1985 and again on April 25, 1986. It is located in Chitwan in the Inner Terai and on a good paved road about four hours from Kathmandu. The elevation is 228 m and annual rainfall is about 2000 mm. The land area is ample with about 220 ha under cultivation both at the maize station and at the Institute of Agricultural and Animal Science (IAAS). A range of soil types is available from gravelly sandy loam to heavier silty soils suitable for paddy rice.

Facilities

The Rampur Station is one of the best endowed centers in Nepal. It is located near a major highway network, is on the electric power grid, has access to a telephone network, enjoys good supplies of domestic and irrigation water, and has ample cultivated land. There are several residences, offices, stores and other facilities. Moreover, there is a

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large academic community with the nearby IAAS and the horticultural station at Yagyapuri.

Recommendation

The need for a center in the terai and Inner Terai for hill crops research is secondary to that of the other main stations in the hills. Nevertheless, it will be necessary to test and evaluate some crops in a plains environment - especially millet and barley. Rampur, being representative of both the Terai and Inner Terai, is ideal for this purpose. Therefore, the HCIP should station one G-III officer with some technical assistance to carry out the necessary but minimal testing of hill crops in the region. Very little if any facilities or equipment would be needed at the station.

APPENDIX VIII. THE ON-GOING RESEARCH PROGRAM (1986)

Finger Millet

1. Introduction of Local and Exotic Germplasm. Evaluation and Disease nursery.
2. Initial Evaluation Trials. (IET)
3. Advanced Varietal Trials (Mono and relay) (AVT)
4. Effect of Phytohormons Treatment of Finger Millet Seed
5. Minikit distribution and Farmer's Field Trials (Mono and relay)
6. Date of Seeding Trials
7. Variety cum Fertilizer Trials

Barley

1. Introduction of Local and Exotic Germplasm. Evaluation and Disease nursery.
2. Initial Evaluation Trials
3. Advanced Varietal Trials
4. Observation Nursery
5. Farmer's Field Trial
6. International Barley Yield Trials (ICARDA).

Buckwheat

1. Introduction of Local and Exotic Germplasm. Evaluation and Disease nursery.
2. Observation nursery

Amaranthus

1. Introduction of Local and Exotic Germplasm. Evaluation and Disease nursery.
2. Initial Evaluation Trials
3. Observation Nursery.

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THE CONSULTANCY

BIODATA OF EXTERNAL CONSULTANT

Kenneth O. Rachie. Born on October 15, 1923 and reared on a farm in south-western Minnesota. He completed B.Sc., M.S. and Ph.D. degrees in Plant Breeding and Agronomy at the University of Minnesota (1954). He then joined the University of Arizona as a forage crops specialist and served as Professor of Field Crops at Abu Ghraib College of Agriculture near Baghdad, Iraq, for one year, (UA/USAID contract). On October 1, 1955 he joined the Rockefeller Foundation to serve in the following capacities.

- Plant geneticist, sorghum and Millets; Mexico (1955 - 57) and India (1957 - 67).
- Professor of Plant Breeding: Makerere University, Kampala, Uganda (1968 - 1971).
- Assistant Director and Program Leader, Grain Legume Improvement Program: IITA, Ibadan Nigeria (1971 - 75).
- Associate Director General (Research): CIAT, Cali. Colombia (1975 - 78).
- Program Officer (Associate Officer, Associate Director): The Rockefeller Foundation, New York (1979 - 1982).
- Chief of Party, Sumatra Agriculture Research Project (USAID/IADS contract) - Padang, W. Sumatra, Indonesia (1982 - 1984).

Rachie has also served on several short term missions of four weeks or longer with the Rockefeller Foundation, IADS, USAID and World Bank to Niger, Ethiopia, Uganda (1980), mainland China, Zambia, Nepal, Burkina Faso, and Jamaica. Major research accomplishments include: contributions to the development of sorghum and pearl millet hybrids in India; tropical cowpeas, soybeans, and pigeonpeas at IITA (Nigeria); and in establishing international collections of sorghum, millets, and tropical grain legumes. Other activities have involved agricultural research administration and grants-in-aid in support of plant research. He retired from the Rockefeller Foundation after 29 years of service on September 1, 1984. At present, he holds two part time appointments: (1) Winrock International Senior Associate, and (2) University of Florida Adjunct Professor of Plant Pathology.

EXTERNAL CONSULTANT ACTIVITIES

April 5 - May 8, '86

DATE	ACTIVITIES AND CONTACTS
April 5 - 6	Travelled from Clermont, Florida to New Delhi, India.
April 7	New Delhi: Consulted with K.W. Riley, IDRC Program Officer; and G.B. Baird, Winrock International Representative.
April 8	Travelled from New Delhi to Kathmandu; consulted with C.N. Hittle, ARPP/Winrock International.
April 9 a.m.	Meeting in Agriculture Botany Division at Khumaltar on hill crops program with: - Gopal R. Rajbhandary, Chief Agriculture Botanist - Kishore Sherchand, Agriculture Botany Division - Deep Man Sakya, Agronomy Division - Badri Kayastha, local consultant - Tek Bahadur Shrestha, local consultant - C.N. Hittle, ARPP/Winrock International
April 9 p.m.	Met with P.P. Gorkhaly, Director General - HMG/DOA and C.N. Hittle, ARPP/WI.
April 10	Travelled to Pokhara with K. Sherchand, D.M. Sakya and K.M. Singh; visited the Gorkha District and town; and toured the Khairenitar Agricultural Farm: - R.C. Gupta, Officer-in-Charge - Madhav Joshi, Agronomist - S.K. Adhikary, Engineer - P.L. Fedon, Manpower Development (GTZ)
April 11 a.m.	Travelled to Pumdi Bhumdi, Farming Systems Program Site, met with N.B. Chhetri, Y.P. Gautam and B.K. Singh.

April 11 p.m.	Travelled to LAC (Lumle) partly by road (to base camp) and by trek.
April 12 - 13	Visited LAC and met with: - Chandra Kumar Sen. Agronomist - Graham Garrod, LAC Manager - Kenny Bell, Planning Unit - Ms. M. Buchanan-Smith, Planning Unit - Jagadish Raj Baral, APROSC (Kathmandu) - Beatriz Del Rosario, PCARRD (Philippines) - Shyam K. Paudel, APROSC
April 14 - 15	Kathmandu - met with: - Gary E. Alex, USAID/N - C.N. Hittle, ARPP/WI - S.S. Bal, ARPP/WI - R.C. Hawkins, ARPP/WI - R.Q. Lacsina, ARPP/WI
April 16	Khumaltar - met with: - K. Sherchand, Agriculture Botany Division - Tej Prasad Giri, Farm Manager - Surkhet - Chandra B. Karki, Division of Plant Pathology
April 17 - 22	Kathmandu/Patan - worked on report in collaboration with K. Sherchand and WI.
April 23	Khumaltar - met in Division of Agriculture Botany with: - G.R. Rajbhandary, Chief Agri. Botanist - K.C. Sharma, Chief Entomologist

- P.M. Amatya, Chief Plant Pathologist
- Ranjit Shah, Chief Soil Scientist
- L.R. Pathak, Soils Science
- D.B. Tamang, Agronomy
- D.M. Sakya, Agronomy
- K. Sherchand, Agri. Botany
- C.N. Hittle, ARPP/WI

April 24 — Kathmandu - met with H. Jesse Dubin, CIMMYT/ARPP to discuss Barley Production.

April 25 - 26 — Kathmandu - worked on report and had meeting on research stations and sites with:

- K. Sherchand, Agriculture. Botany
- Tek Bahadur Shrestha, local consultant
- D.M. Sakya, Agronomy

April 27 — Khumalter - meeting with:

- K. Sherchand, Agricultural Botany
- D.M. Sakya, Agronomy
- C.N. Hittle, ARPP/WI
- K.W. Riley, IDRC (new Delhi)

April 28 — Travelled to Rampur Agricultural Station to inspect headquarters site for Grain Legumes with:

- M.P. Bharati, Agronomy
- K.W. Riley, IDRC
- C.N. Hittle, ARPP/WI

April 29 a.m. — Kathmandu - meeting at Directorate of Agriculture with:

- A.M. Pradhanang, Deputy Director General, DOA
- G.R. Rajbhandary, Chief Agri. Botanist
- K. Sherchand, Agri. Botany Division
- M.P. Bharati, Agronomy Division
- K.W. Riley, IDRC

April 29 p.m. Khumalter - meeting on IDRC funding for HCIP with:

- G.R. Rajbhandary, Chief Agricultural Botanist
- K. Sherchand, Agri. Botany Division
- K.W. Riley, IDRC

April 30 Khumaltar - final meeting on the HCIP proposal with Division Heads and others:

- G.R. Rajbhandary, Chief Agri, Botanist
- K.C. Sharma, Chief Entomologist
- P.M. Amatya, Chief Plant Pathologist
- M.P. Panth, Chief, Farming Systems Division
- J.R. Joshi, Agronomy
- D. Joshy, Soil Science
- J.C. Gautam, Project Coordinator, ARPP
- L.R. Pathak, Soil Science
- Bimal K. Baniya, Agri. Botany
- Ashok Mudwary, Agri. Botany
- K. Sherchand, Agri. Botany
- D.M. Sakya, Agronomy
- D.B. Tamang, Agronomy
- Tek B. Shrestha, local consultant

- C.N. Hittle, ARPP/WI
- G.E. Alex, USAID
- H.J. Dubin, CIMMYT
- R.C. Hawkins, ARPP/WI
- W.H. Freeman, WI
- K.O. Rachie, WI

May 1 - 3	Kathmandu - worked on hill crops report; met with K. Sherchand, C.N. Hittle and others.
May 4	Kathmandu - meeting on hill crops proposal with:

- A.M. Pradhanang, Deputy Director General (Crops)
- G.R. Rajbhandary, Chief, Agri. Botanist
- J.C. Gautam, ARPP Project Coordinator
- C.N. Hittle, ARPP/WI

May 5	Travelled to Kakani Agricultural Farm

- B.K. Baniya, Agricultural Botany
- C.N. Hittle, ARPP/WI

May 6 - 8	Completed report. Left for India and USA.