MAIZE IN NEPAL: PRODUCTION SYSTEMS, CONSTRAINTS AND PRIORITIES FOR RESEARCH

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NARC

CIMMYT

NARC

The Nepal Agricultural Research Council (NARC) was established in 1991 as an autonomous research organization under the Nepal agricultural Research Council Act of HMG Nepal. NARC has as its objective to uplift the socio-economic level of the Nepalese by developing and disseminating technologies that increase the productivity and sustainability of resources devoted to agriculture. NARC's research programs are carried out in Agricultural Research Stations located throughout the country and with farmers in their fields.

CIMMYT

The International Maize and Wheat Improvement Center (CIMMYT) is an internationally funded, non-profit scientific research and training organization. Headquartered in Mexico, the Center works with agricultural research institutions worldwide to improve the productivity and sustainability of maize and wheat systems for poor farmers in developing countries. It is one of the 16 similar centers supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR comprises over 50 partner countries, international and regional organizations, and private foundations. It is co-sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), the United Nations Development Program (UNDP, and the United Nations Environment Program (UNEP).

HMRP

The Hill Maize Research Project (HMRP) is a collaborative project between NARC and CIMMYT with funds provided by the Swiss Agency for Development and Cooperation (SDC). HMRP was initiated in January 1999 with the objective of increasing the production and productivity of maize in the hills of Nepal through the development and dissemination of new maize varieties and crop management practices. The bulk of the research carried out by the HMPR is conducted in five Agricultural Research Stations of NARC. CIMMYT provides technical support and germplasm.

Intensification of Asia's Rainfed Upland Farming System Project

The "Rising Demand for Maize and Intensification of Asia's Rainfed Upland Farming Systems: Policy Options for Productivity Enhancement, Environmental Protection and Food Security" project is funded by the International Fund for Agricultural Development (IFAD) and implemented under the direct supervision of the CIMMYT Economics Program. Nepal is one of seven countries – China, India, Indonesia, the Philippines, Thailand and Vietnam – where project sponsored research is being carried out.

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Abbreviations

ADB	Agriculture Development Bank
AIC	Agricultural Inputs Corporation
APP	Agricultural Perspective Plan
APROSC	Agricultural Projects Services Center
CDR	Central Development Region
CIMMYT	International Maize and Wheat Improvement Center
CWDR	Central and Western Development Region
DADOs	District Agricultural Development Offices
DAP	Diammonium phosphate
DAS	Days after sowing
DOA	Department of Agriculture
EDR	Eastern Development Region
Ha	Hectare
HH	Household
HMG/N	His Majesty's Government/Nepal
IAAS	Institute of Agriculture and Animal Sciences
ICIMOD	International Center for Integrated Mountain Development
IFAD	International Fund for Agricultural Development
JT/JTAs	Junior Technician/Junior Technical Assistants
Km	Kilometer
MFWDR	Mid and Far-Western Development Region
MoP	Muriate of Potash
NARC	Nepal Agricultural Research Council
NBL	Nepal Bank Limited
NGOs	Non-Governmental Organizations
NMRP	National Maize Research Program
OPV	Open Pollinated Variety
PPCs	Plant Protection Chemicals
PPP	Purchasing Power Parity
PRA	Participatory Rural Appraisal
RBB	Rastriya Banijya Bank
RRA	Rapid Rural Appraisal
Rs	Nepali Rupees
SDC	Swiss Agency for Development and Cooperation
SFDP	Small Farmer Development Program
SLC	School Leaving Certificate
SMS	Subject Matter Specialists
VDCs	Village Development Committees

Acknowledgements

This report is a summary of Rapid Rural Appraisals (RRAs) conducted in 17 districts and Participatory Rural Appraisals (PRAs) conducted in five districts of Nepal. Information was collected during September/ October 1999 and April/May 2001 for the RRAs and PRAs, respectively. Altogether there were eight teams that shouldered the study in 13 hill districts and five terai districts.

We duly acknowledge the painstaking work of the professionals who were involved in the field work and in drafting the district reports. Special thanks to: Messrs. Gopal Siwakoti, Rishi R. Sharma, Ramjee Khadka, Min N. Paudyal and Kiran Joshi who led teams of professionals during these surveys and report preparation. Thanks are also due to Messrs R.B. Katuwal, D.P. Dhakal, U.P. Wagle, N.S. Thakur, C.B. Kunwar, K.K. Misra, R.B. Prasad, B. Shrestha, S. Malla, Y.N. Ghimire, B.P. Sharma, M.R. Gautam, H.K. Manandhar, G.P. Parajuli, S. Aryal, I. Upadhyaya, B. Regmi, G.B. Hamal, K.B. Koirala, S.K. Gami, C. Adhikari, T. Rijal, P.Gautam, H.K. Shrestha and M. Ghimire from the Nepal Agricultural Research Council (NARC).

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Introduction

Background

Maize cultivation is a way of life for most farmers in the hills[1] of Nepal. It is a traditional crop cultivated as food, feed and fodder on slopping *Bari* land (rainfed upland) in the hills. It is grown under rainfed conditions during the summer (April-August) as a single crop or relayed with millet later in the season. In the terai, inner-terai, valleys, and low-lying river basin areas, maize is also grown in the winter and spring with irrigation.

In 1997/1998, maize was grown on about 800,000 ha which represent 25% of the total area planted to cereals in Nepal. In the same period, 1,367,000 tons of maize were produced, representing about 21% of Nepal's total cereal production. The proportion of maize area to total cereals was 30% in the highhills, 40% in the midhills and about 11% in the terai[2]. Maize production as a proportion of total cereal production was 33% for the highhills, 39% for the midhills and 9% for the terai.

More than two thirds of the maize produced in the midhills and highhills is used for direct human consumption at the farm level and the ratio of human consumption to total production is higher in less accessible areas. In the terai, less than 50% of the maize is used for human consumption and a significant part of the production goes to the market.

Maize yields fluctuate seasonally and annually especially in the hills. Although maize yields increased slightly over the past five years, there has been very little yield improvement when compared to nationwide yields 30 years ago. This is probably due to the expansion of maize cultivation into less suitable terrain, declining soil fertility, and the sluggish adoption of improved management practices. While productivity in the country is almost stagnant, the overall demand for maize—driven by increased demand for human consumption and livestock feed— is expected to grow by 4% to 6 % per year over the next 20 years. Thus, Nepal will have to resort to maize imports in the future if productivity is not increased substantially.

In 1999, the Hill Maize Research Project (HMRP) was initiated to provide new technologies to farmers to enable increased and sustainable maize production. The HMRP is funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by the National Maize Research Program (NMRP) of the Nepal Agricultural Research Council (NARC), with technical assistance from the International Maize and Wheat Improvement Center (CIMMYT). The HMRP addresses a wide range of technology and technology dissemination needs from germplasm development and crop management to post harvest. It focuses on regions of Nepal where maize is important in terms of area and diet. The HMRP also supported the Rapid Rural Appraisals that were carried out for this study.

This study is part of a project[3] that promotes sustainable intensification of maize production systems while ensuring equitable income growth and improved food security for poor households that depend on maize. The project is funded by the International Fund for Agricultural Development (IFAD) and implemented under the direct supervision of the CIMMYT Economics Program. Nepal is one of seven countries - China, India, Indonesia, the Philippines, Thailand and Vietnam - where the study is being carried out. As most of the increased demand for maize in Nepal is expected to come from resource poor farmers in slopping uplands in the midhills, the project focuses specifically on upland maize in the midhills.

Objectives

This report characterizes maize production systems in Nepal to help the research system develop the required technology to boost maize production in the country. The specific objectives of the study are to:

- identify and analyze the physical, biological, and socio-economic environment in each of the agro-ecological zones identified for this study;
- identify constraints for increasing maize productivity;
- guide the HMRP on priorities, constraints and the basic socio-economic conditions of farmers in the different agro-ecologies so that it can better target technology development activities; and
- suggest appropriate input, output, marketing, and research related policies that will enable increased maize production in each agro-ecology of the country.

1. **Hills** includes both the midhills and highhills, unless otherwise stated.
2. A definition of these ecological belts is found in the section – General Topography.
3. Rising demand for maize and intensification of Asia's rainfed upland farming systems: policy options for productivity enhancement, environmental protection and food security.

Methodology

Both primary and secondary sources of information were used for the study. Secondary information such as infrastructure and programs were collected from concerned offices at the central, regional, and district levels and also from related Village Development Committee[4] (VDC) offices. Most of the data, however, were generated through Rapid Rural Appraisals (RRAs) carried out in 46 sites. Additional information was also gathered through key informants' surveys that included local leaders, extension personnel, and field observations. Participatory Rural Appraisals (PRAs) were conducted later to collect in-depth information on existing farming practices, varieties planted, and farmers' demand of maize characteristics in the different agro-ecologies.

Sample districts were selected through a series of discussions with NARC and CIMMYT researchers. The main criteria considered for the selection of the districts were:

- representation of different agro-ecological and development regions;
- representation of districts with different accessibility status;
- coverage of different maize production seasons; and
- extent of maize cultivation in the districts.

Rapid Rural Appraisals were conducted in 17 districts representing different administrative regions and maize growing environments (Map 1). Among the survey districts, Sankhuwasabha, Sindhupalchok and Bajhang are in the highhills; Panchthar, Nuwakot, Lamjung, Baglung, Pyuthan, Salyan, Dailekh, Achham, and Baitadi are in the midhills; Udayapur and Dang are in the inner-terai; and Jhapa, Bara and Bardia are in the terai[5].

The terai/foot hills, midhill and high-hill environments are indicated in Map 2. Although these maps accurately represent elevation bands, they do not indicate whether the area is cropped or if maize is grown there. For example, in the river basin, only a narrow strip is cropped because the steep slopes do not permit cultivation.

With the help of District Agricultural Development Offices (DADOs) three (VDCs) were selected in each of the high-hill and mid-hill districts and two VDCs were selected in each of the terai districts for RRA. The VDCs were selected in such a way that they represented maize cultivation practices in the district. At least one remote VDC with poor access to markets was selected in each district. The major maize production characteristics of the selected VDCs are presented in Table 1. In addition PRAs were conducted in five RRA sites - Ranitar of Panchthar, Simpalkavre of Sindhupalchok, Bhulbhule of Lamjung, Birpath of Achham and Feta of Bara district. A PRA was also conducted in Dhunche VDC of Rasuwa district (which was not included in the RRA) to capture additional variability in maize production systems in the highhills.

Macro-level information on population, land use, transport and communication, input and output prices, major crops, cropping patterns, and crop calendar were gathered during meetings held in each VDC. The VDC officials were then requested to identify people from different ethnic, socio-economic, and income status representing different sections of the communities. These individuals were subsequently included in group interviews.

Survey Tools and Methods

A standard questionnaire was the primary instrument for gathering information through the RRAs in all seven Asian countries collaborating in the project. This questionnaire was modified for the Nepalese context after initial testing. The first part of the questionnaire was dedicated to gathering VDC level information while the second part was used for group interviews. A common checklist was also used to collect information through PRAs for in-depth information on farming systems, practices, preferences, and problems. Open-ended questions were put to farmer groups who were encouraged to discuss them. Researchers provided guidance during these discussions.

In each VDC, informal interviews were also carried out with people from different sections of the community including farmer leaders, traders, teachers, and extension workers. Farmers' maize fields and grain stores were frequently visited and discussions were held on farming practices and production constraints. The findings were validated through discussions with the village elite, VDC officials, and knowledgeable persons in the village.

Survey Dates

September was considered the best month to collect maize production and production cost information as most of the maize is harvested by then. Field visits for the RRA were initiated during the second week of September 1999 (after the summer harvest) and the fieldwork was completed by the end of October 1999. The PRAs were

4. VDC is the lowest political/administrative unit.
5. For ease of presenting the results of this study, districts in the inner-terai and terai are referred to as the **terai**.

Table 1: Major characteristics of the surveyed VDCs.

District & Region	VDCs	Maize Varieties Reported	Maize Seasons	% Land Irrigated	Road Access	Distance to Market	No. of Household	Population
Sankhuwa-sabha (EDR-HH)	Sitalpati	Local & Improved	S	65	No	7 km	833	5598
	Manakamana	Local & Improved	S	45	Seasonal	3 km	1237	6084
	Diding	Local & Improved	S	50	No	12 km	559	3336
Sindhupal-chok (CDR-HH)	Sanosirubari	Local & Improved	S	-	Seasonal	5 km	577	3303
	Kubinde	Local & Improved	S	-	Seasonal	5 km	547	2772
	Simpalkavre*	Local & Improved	S	5	No	25 km	552	2586
Bajhang (FWDR-HH)	Hemantabada	Local	S	18	No	10 km	460	3128
	Kotdewal,	Local & Improved	S	10	No	3 km	474	3900
	Kailash	Local	S	12	No	9 km	288	1872
Panchthar (EDR-MH)	Ranitar *	Local	S,Sp	3	Seasonal	12 km	1040	6057
	Phidim	Local & Improved	S,Sp	29	Seasonal	In VDC	940	5266
	Panchami	Local	S,Sp	32	Seasonal	In VDC	2038	9749
Nuwakot (CDR-MH)	Tupche	Local, Improved & Hybrid	S.Sp	6	Black top	In VDC	971	5517
	Deurali	Local & Improved	S,Sp	-	Seasonal	10 km	743	3842
(CDR-MH)	Khadgabhanja	Local, Improved & Hybrid	S,Sp	7	Black top	In VDC	1105	5986
Lamjung (WDR-MH)	Bhulbhule*	Local & Improved	S,Sp	1	No	25 km	610	3090
	Baglungpani	Local & Improved	S,Sp	11	No	12 km	519	2671
	Bhoteodar	Local & Improved	S,Sp	40	Black top	In VDC	630	3505
Baglung (WDR-MH)	Dhamja	Local & Improved	S	18	No	15 km	483	3236
	Bihun,	Local & Improved	S,Sp	12	No	10 km	1154	10000
	Pala	Local & Improved	S,Sp	33	Seasonal	5 km	648	4412
Pyuthan (MWDR-MH)	Okharkot	Local & Improved	S	17	Seasonal	-	751	4754
	Bangesal	Local & Improved	S,Sp	33	Gravel	2 km	599	3728
	Bhingri	Local & Improved	S	31	Gravel	In VDC	870	4922
Salyan (MWDR-MH)	Khalanga	Local & Improved	S	25	Gravel	In VDC	990	5776
	Sejuwaltakura	Local & Improved	S	10	No	5 km	569	3250
	Dhanabang	Local & Improved	S	13	Seasonal	In VDC	705	3904
Dailekh (MWDR-MH)	Toli	Local & Improved	S	6	No	20 km	399	2493
	Kalbhairab,	Local & Improved	S	9	No	2 km	713	3787
	Dandaparajul	Local & Improved	S,Sp	6	Seasonal	In VDC	728	4328
Achham (FWDR-MH)	Bayala	Local	S	56	No	In VDC	431	3553
	Dhaku	Local	S	21	No	2 km	264	1948
	Birpath*	Local	S	11	No	20 km	320	2070
Baitadi (FWDR-MH)	Dehimandu	Local	S	13	Seasonal	In VDC	587	3553
	Gurukhola	Local	S	29	Seasonal	5 km	600	3971
	Shikharpur	Local	S	15	Seasonal	10 km	663	4333
Jhapa (EDR-T)	Topgachi	Local, Improved & Hybrid	S,W,Sp	-	Black top	In VDC	4500	23290
	Garamani	Local & Improved	S,Sp	37	Black top	5 km	3500	15612
Udayapur (EDR-IT)	Katari	Local & Improved	S,Sp	60	Gravel	In VDC	2375	14200
	Beltar	Local & Improved	S,Sp	4	Seasonal	13 km	1500	7500
Bara (CDR-T)	Feta*	Improved & Hybrid	S,W,Sp	-	Black top	In VDC	1000	5019
	Nijgard	Improved & Hybrid	S,W,Sp	-	Black top	In VDC	3240	15693
Dang (MWDR-IT)	Rampur	Local & Improved	S	34	Gravel	In VDC	1600	11000
	Chailahi	Improved	S	57	Black top	In VDC	2200	23267
Bardiya (MWDR-T)	Sanushree	Local & Improved	S	97	Seasonal	In VDC	2266	12542
	Khairapur	Local & Improved	S	60	Gravel	5 km	1192	6468

EDR= Eastern Development Region, CDR= Central Development Region, WDR= Western Development Region, MWDR= Mid-Western Development Region, FWDR= Far-Western Development Region, HH= Highhills, MH= Midhills, IT= Innerterai, T = Terai, Sp= Spring, S=Summer, W= Winter.

* PRAs were conducted in these sites and in one site in Rasuwa district, which was not included in the RRA.

conducted during April-June 2001 to supplement the RRA data and to gain an in-depth understanding of farming systems, practices, and problems.

Data Analysis and Presentation[6]:

The findings of the RRA survey were summarized by districts and presented during the Third Planning Meeting of the HMRP[7] that was attended by senior NARC scientists engaged in maize development in different parts of the country. The maize production agro-ecologies were re-defined as per the suggestion of the participants into five[8] and the results summarized accordingly.

The information gathered was used for the characterization of maize production systems, identification of priority constraints and setting an agenda for maize research and development (R&D) in Nepal. Details on the approach and methodology used for identification of priority constraints and setting an agenda for maize R&D are presented in subsequent sections.

Limitations

The study is based on information collected through RRAs and PRAs conducted during visits to selected VDCs in thirteen hill districts and five terai districts. No detailed household level information was collected. As the data have not been analyzed statistically, no probability can be attached to the data presented.

Since farmers in rural Nepal rarely keep records of farming activities, the reliability and accuracy of the data depends heavily on a farmer's ability to recall information and inconsistencies and memory bias could have crept into their responses. Such biases are, however, minimized by allowing farmers to discuss the matters in groups, such that even though one or two farmers could not recall the relevant information correctly, a fairly accurate description of the desired information could be produced collectively.

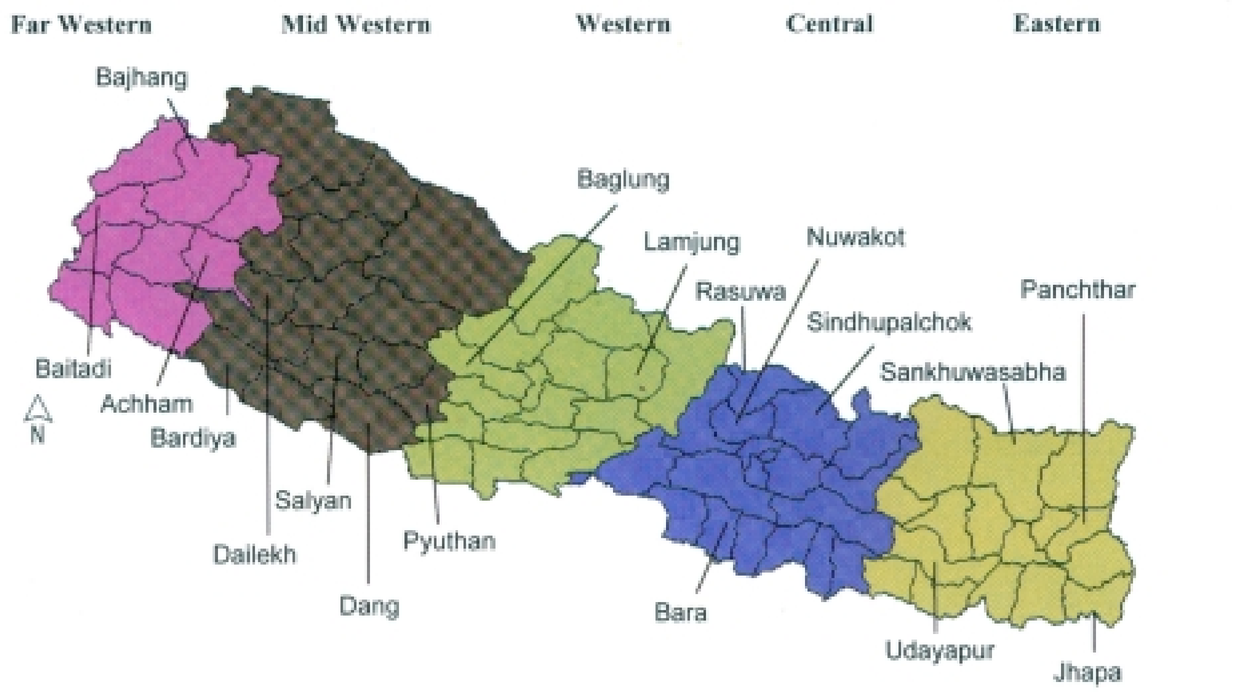
The paucity of VDC level data in remote areas was another problem encountered by the study team. In these cases, the number of households by ethnic group, average literacy rate, total cultivated area, and average farm size were estimated through discussions with VDC officials and other local knowledgeable persons.

The broad classification of districts into highhills, midhills and terai by the Nepalese government are followed in this study. However, the classification of the districts into those ecological belts is sometimes arbitrary, as a district may not have similar elevation and topography in all of its physical area. Part of a district classified as highhills might have a significant area of midhills and vice versa. Therefore, the characterization and recommendations made for the agro-ecologies are indicative only, and may not necessarily represent the entire district in a specific agro-ecology.

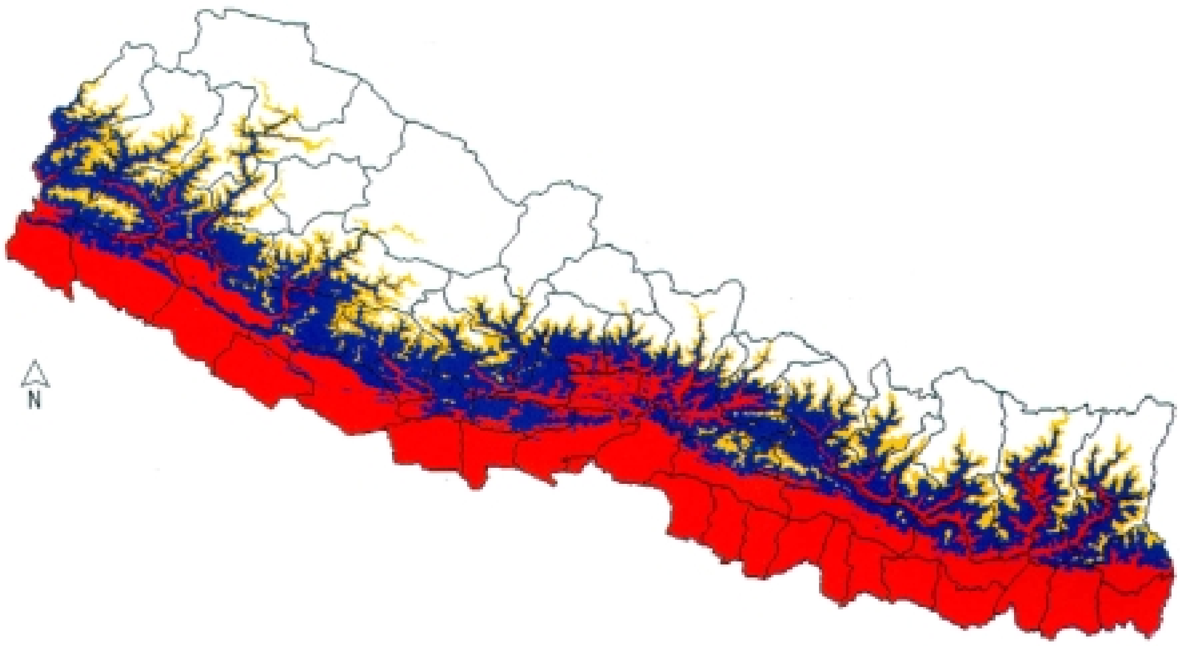
●●●

6. The data presented in this report were generated through RRA/PRA surveys, unless otherwise stated.
7. 11-14 December 2000.
8. 1- midhills of the eastern development region, 2- midhills of central and western development regions, 3- midhills of mid-western and far-western development regions, 4- terai and inner-terai and 5- highhills.

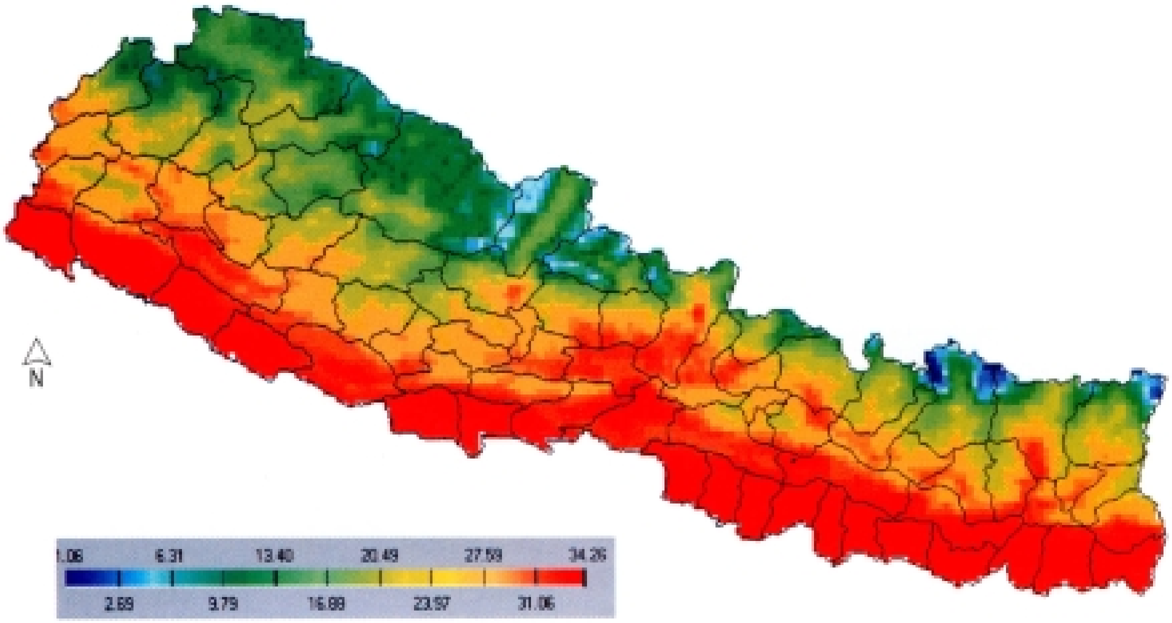
Map 1. Administrative regions and districts where RRA & PRA surveys were conducted.



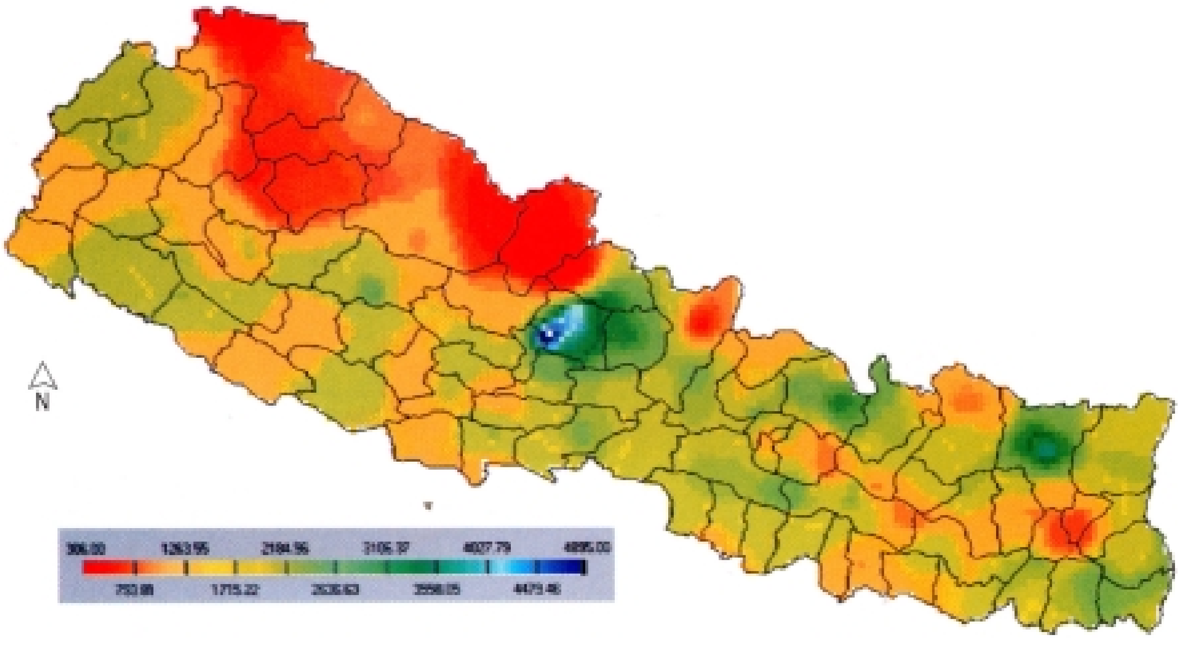
Map 2. Distribution of lowland (red), midhills (blue) and highhills (yellow) maize growing environments.



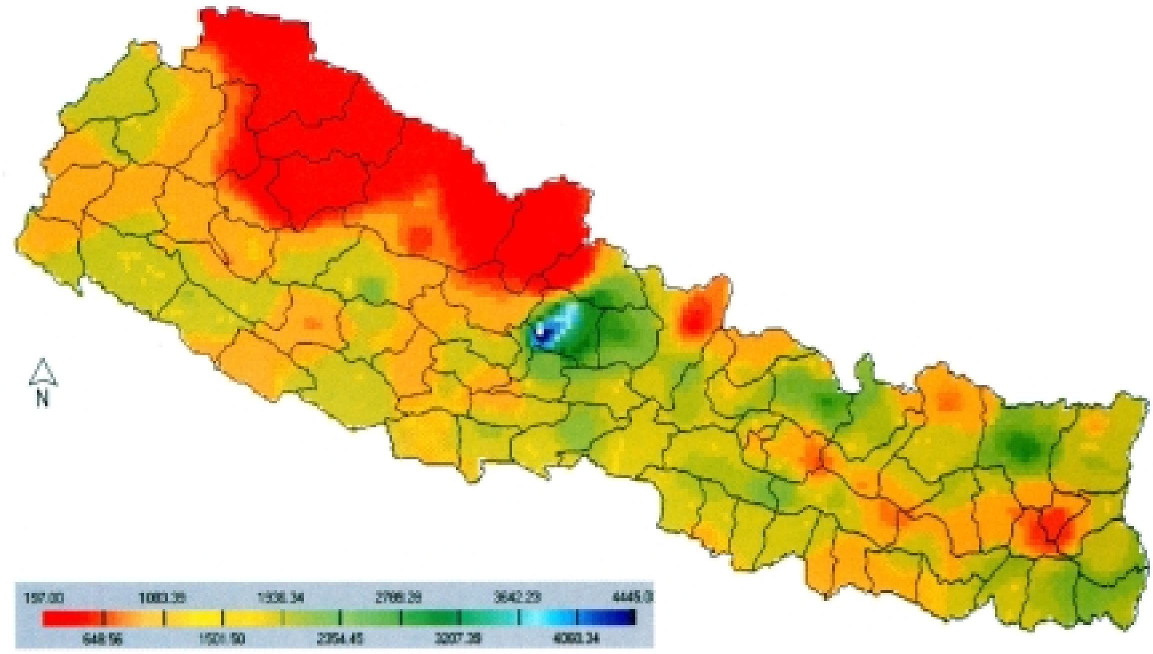
Map 3. Long-term mean maximum temperature (degrees C) during the 5-month optimal season.



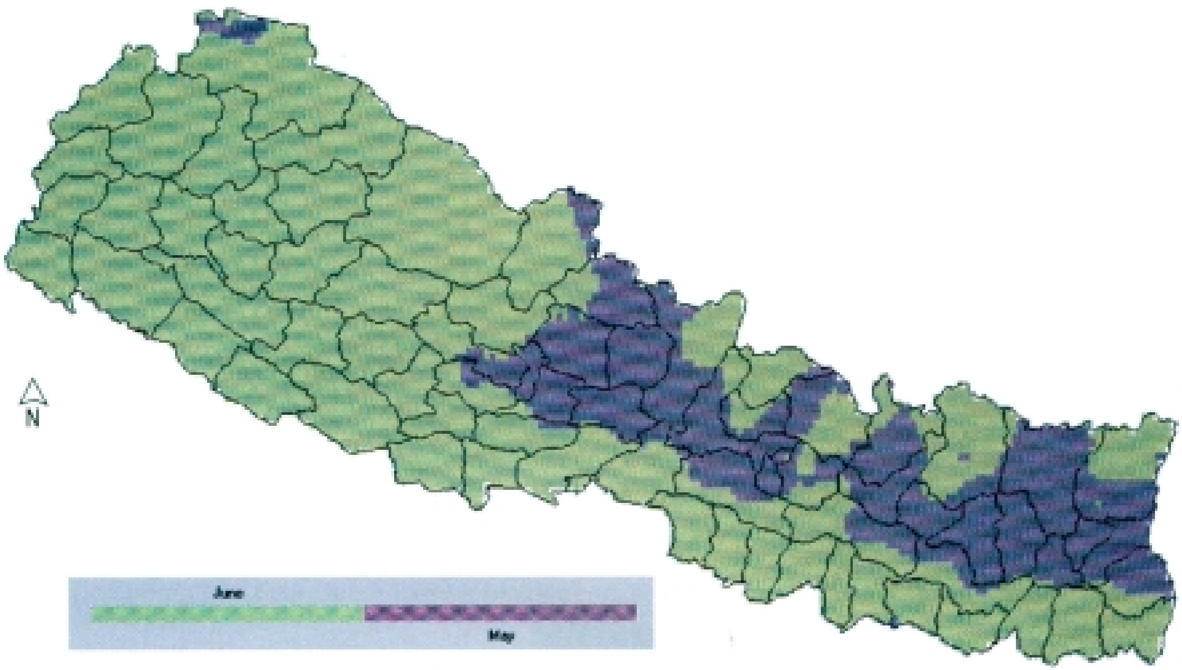
Map 4. Long-term total annual rainfall (mm).



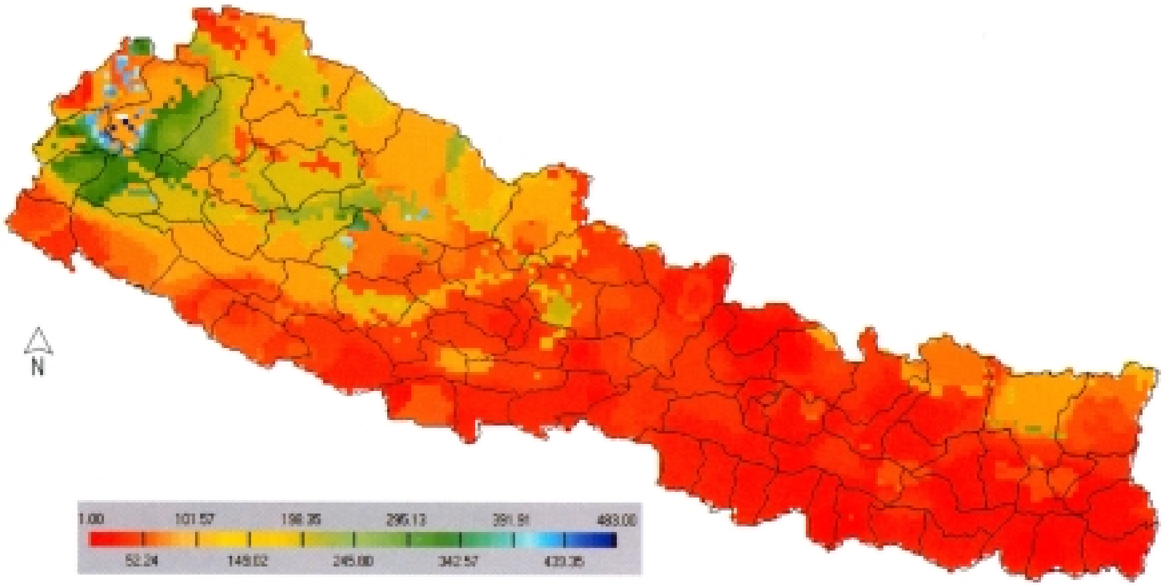
Map 5. Long-term accumulative rainfall (mm) occurring during the optimal 5-month growing season.



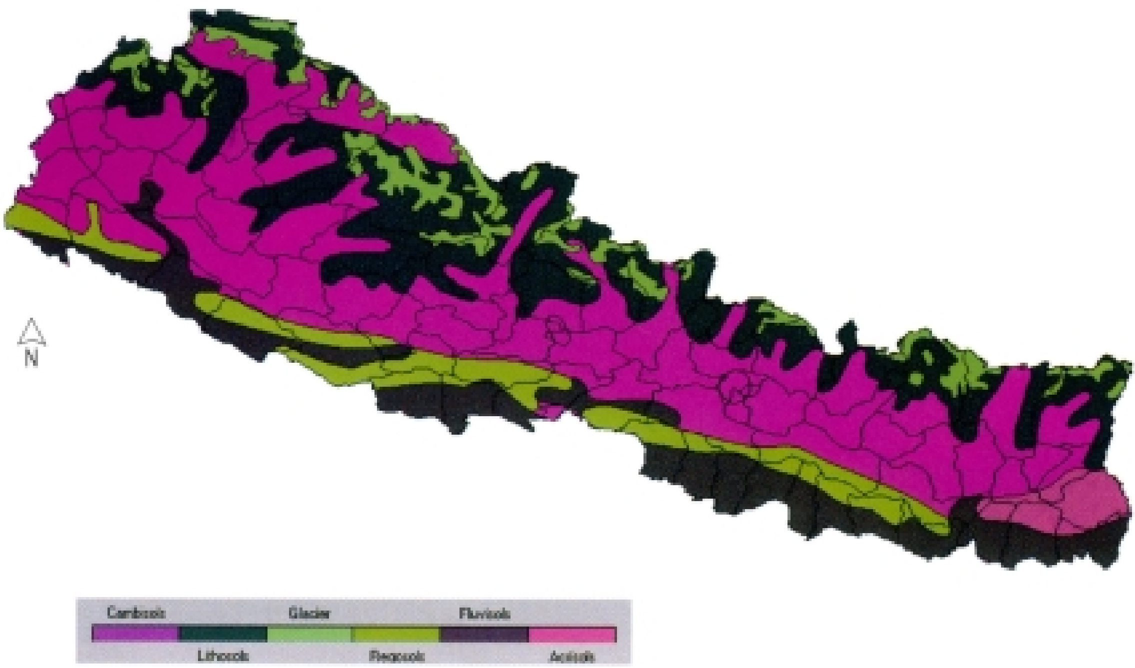
Map 6. The month which begins the optimal 5-month growing season based on long-term averages.



Map 7. Long-term average three month dry season precipitation (mm).



Map 8. Distribution of major soil groups.



Maize Agro-Ecologies of Nepal

General Topography

Topographically, Nepal is broadly divided into three east west running ecological belts: the terai in the south along the border with India, the midhills in the center, and the highhills in the north along the boarder with Tibet, China. The terai consists of flat land that extends from the Indo-Gangatic plains and lies up to 800 m. The midhills are in the range of 800 m and 1,800 m and comprise steeply sloped lands with many small valleys. The highhills, which lie above 1,800 m [9], are steep sloped snowy mountains with few valleys. These three ecological belts - constitute 35%, 42%, and 23% respectively, of Nepal's total geographical area (147,480 sq. km).

Only about 16% of Nepal's total land area is cultivated. Of this, the terai, where 38% of the land area is cultivated, is the most important. Maize is the third most important crop here after paddy and wheat. The second most important agricultural land area is the midhills where 15% of land is cultivated. Maize, followed by paddy and wheat are the most important crops grown in this belt. In the highhills where only about 4% of the land is cultivated, livestock rather than crops play an important role.

Maize is cultivated in very diverse environments in Nepal[10]. The field survey reflected enormous diversity among different maize production systems, regionally, seasonally, and from one micro climatic zone to another. Even at the VDC level, there are considerable variability in soils, temperature, and rainfall, particularly in the hills.

General Characteristics of Maize Production Agro-ecologies

The five maize production agro-ecologies mentioned earlier are used in the study: the midhills in the eastern development region, midhills in the central and western development regions, midhills in the mid-western and far-western development regions, all of the terai and all of the high hills. While there may be some overlap between agro-ecologies and variations in the importance and use of maize and cropping practices, these agro-ecologies serve as a useful framework in which appropriate technologies can be developed and recommended. The major characteristics of these agro-ecologies are summarized below.

Eastern midhills (Agro-ecology-1)

This agro-ecology comprises the area between 800 to 1800 m in the eastern development region. Maize is planted on sloping *Bari* land with pre-monsoon rains and is usually relayed with millet, potato, and other crops, and harvested before the end of the monsoon rains. There is limited scope for winter crops due to limited rainfall during winter[11]. Except for areas near major cities farmers have limited access to roads and markets. In some areas, farmers walk up to 25 km to reach the nearest market. Maize is the principal food crop and is primarily used for home consumption. Maize is not a significant source of cash although it can be bartered or used for payment of farm laborers. Trade in maize is largely localized to the VDC. Ruminants are an important component of the farming system and provide milk, meat, animal traction, and manure. The average farm size is about 0.55 ha and family members carry out most farm operations. Women head around 22% of households as men go out to work in urban areas, India or in the Gulf States.

Central and western midhills (Agro-ecology-2)

This agro-ecology has similar characteristics as agro-ecology-1 but has better road and market infrastructure that facilitates the cultivation of high value crops such as vegetables. There are more and wider valleys, which includes Kathmandu (capital city) and Pokhara. Relay millet and soybean are more important here than in the eastern midhills, although the cultivation of millet is declining (largely a consequence of the labour intensive nature of millet cultivation and the shortage of labour from young people leaving the countryside in search of employment elsewhere). Average farm size is 0.70 ha per household and livestock is an integral part of the farming system. Maize is the major staple with as much as 59% of total production consumed as human food. Because livestock products, including milk and meat, are the main sources of cash income, about 34% of maize production is fed to animals.

9. Maize is rarely grown above 2500 m altitude.
10. The area under major maize production systems is presented in Annex-1.
11. Less than 200 mm winter rainfall during the months of November to March.

Mid-western and far-western midhills (Agro-ecology-3)

This agro-ecology comprises the area between 800 to 1800 m in elevation in the mid-western and far-western development regions. The physical environment is similar in many ways to the mid-hill ecologies mentioned above, except that the monsoon rains begin about one month later and there is enough precipitation for winter cropping[12]. The maize-wheat system predominates as the area under maize-millet relay decreases as one moves westward. Access to roads and markets is poor with roads often accessible only in winter. Maize and wheat both play an important role in the food security of the farm family. Maize is used almost exclusively for human consumption and is commonly prepared as *Roti* (homemade bread). Women head about 14% of households as adult males leave to find work in other parts of Nepal or India. The average farm size is about 0.75 ha and family members carry out most farm operations.

Terai, inner-terai, and foothills (Agro-ecology-4)

This agro-ecology is located in the lowlands of the terai, inner-terai and valleys below 800 m. Since a significant proportion of the land here can be irrigated, it has greater potential for productivity growth[13]. *Khet* land maize is planted in winter or spring in rotation with rice, while *Bari*[14] land maize is planted in the summer in rotation with mustard or other cash crops. For the most part, farmers have easy access to markets and roads. Fertilizers and to a lesser extent hybrid maize seeds are used. Maize is used for food and feed and is also an important cash crop. The average farm size is over one ha.

Highhills (Agro-ecology-5)

The high hills agro-ecology comprises maize producing areas between 1800 m and 2500 m. Maize is generally planted during the pre-monsoon rains and because of the cool temperatures requires 6 to 8 months to mature. Maize is grown either as a single crop or in rotation with potatoes. In higher altitudes, three crops are grown in two years under maize based cropping systems[15]. Vegetables are cultivated as cash crops in a few areas with access to markets. Generally, however, the high hills are quite remote and access to markets and roads is limited. Maize is the principal food crop and is primarily used for home consumption.

Bio-Physical Environment

Climate

Since Nepal is a relatively small country its topography is a much more important determinant of climate than lattitude or longitude. In general, there are three thermally similar zones: the lowlands, the midhills and the highhills (Map 2). The lowland is located in the terai and valleys. The midhills form a band that runs through the center of the country, which is more or less parallel to the northern and southern borders of the country. The high hills are extensions of the midhills and are widely dispersed. They tend to be isolated pockets and rarely form a large continuous area.

On average the midhills are 5 to 8 degrees cooler than the terai and 3 to 8 degrees warmer than the high hills (Map 3). The rate of plant development, the incidence of diseases, and the life cycle of insect pests are largely governed by temperature. Plants develop more rapidly in the lowlands compared to the midhills and develop more rapidly in the midhills than the highhills. Furthermore, *turcicum blight* is most problematic in cooler environments and conversely insect pests, whose rate of reproduction is correlated with temperature, are most problematic in the lowlands and least problematic in the highhills. In the terai/inner-terai and foothills, temperatures during the winter months allow the growth of a maize crop with irrigation.

Rainfall amount is not correlated to elevation and generally does not constrain maize production during the summer season. The eastern, far-western and mid-western development regions of Nepal receive similar amounts of total annual rainfall. The central and western development regions receive considerably more rainfall than the other regions, with some locations in Kaski district receiving more than 5 m of rainfall annually (Map 4).

Most rainfall occurs during the summer months when temperatures are also favorable for maize growth. Except for isolated areas in Dhankuta and Terhathum districts in eastern Nepal and some areas in the far-western regions, rainfall does not constrain maize production during a typical cropping season (Map 5).

12. More than 200 mm winter rainfall.
13. This domain needs to be sub-divided to adequately address the environmental variability that results from physiography and divergent planting dates. However, for the purpose of this paper the broader classification will be retained.
14. Khet is irrigated low land (rice field) and Bari is rainfed upland.
15. Maize (February/March to September/October) or potato (February/March to July/August) – wheat (October/November to May/June) – finger millet (May/June to November/December).

The start of the summer rains varies with location. The hills of the eastern and central development regions receive rainfall approximately one month before the terai and the hills of the mid-western and far-western development regions of the country (Map 6).

The far-western development region receives considerably more rainfall during the three driest months of the year (Map 7). The significant fall/winter rainfall in the far and mid-western development regions probably explains why the maize-wheat cropping system predominates in these regions but not elsewhere in the country. Similarly, the maize-millet systems, common throughout the midhills of the eastern half of the country, can exploit the late season moisture, as maize is generally harvested before the end of the rainy season but millet continue to develop until the cessation of rain.

Soil Types

At the macro level there are very few soil groups in Nepal. In the non-maize cropped highhills, soils are classified as either glacial or lithosols (shallow, rocky soils). In the midhills soils are broadly classified as cambisols. These soils are geologically young soils which do not have well defined soil horizons. The soils in the terai are of alluvial origin and are classified as either regosols (high sand content) or fluvisols (limited sand content). Although this broad classification system (Map 8) provides insight into the age, origin, and certain broad soil characteristics, it does not provide information as to how these soils should be managed. Furthermore, it does not capture the extensive variation that can exist in soil characteristics at a more local level. Soils within a VDC, for example, can vary considerably from farm to farm and even within a farm depending on the local parent material of the soil, the amount of erosion that has occurred, and the location of the field within the watershed.

Farmers often describe soils in their field by texture and color. In most VDCs visited in the hills, clay-loam, sandy-loam and silty-loam soils are the major textures reported by farmers. In terms of color, brown and gray were most commonly reported in the *Bari* land. Black soil was reported to be prevalent in some patches, especially in *Khet* lands. Similarly, red soil was reported in patches in high-altitude *Bari* lands. White and yellow soils were rarely reported. In the *terai,* mostly sandy loam and loam types of soils were reported. In addition, clay soils were reported in survey VDCs in Jhapa (*terai*) and Udayapur (*inner-terai*) districts (both in the eastern region).

Farmers reported black clay as the most fertile soil. However, this soil is not suitable for maize cultivation except in drier years, as it holds water longer than other soil types and tends to waterlog. Land preparation is difficult in clay soils, especially red clay. Brown and gray colored loams are the most suitable for maize cultivation. A summary of advantages and disadvantages of common soils is presented in Table 2.

Institutional Environment

Line Agencies

All development, finance, communication and administrative related offices are located in the district headquarters. The responsibility of agricultural extension rests with the District Agriculture Development Offices (DADOs) and service centers/sub-centers under them. Each service center is responsible for providing agricultural services to two to seven VDCs. Difficult access in most of the hill districts, large areas to be covered and the lack of resources, makes it difficult for JT/JTAs to provide technical services to all of the VDCs to which they are assigned. Several NGOs also are involved in providing technological information and

Table 2: Advantages and disadvantages of different soil types.

Soil Type	Advantage	Disadvantage
Black Clay	High Productivity (Good for rice)	Difficult to plow Yield declines if rainfall is high
Red Clay	Medium Productivity	Difficult to plow Yield declines if rainfall is high
Brown/gray loam	High productivity in normal years Easy to plow	Yield declines if rainfall is low
Sandy loam	Easy to plow	Low Productivity Yield declines substantially if rainfall is low
Silty loam	Medium Productivity (Good for orchard)	Difficult to plow
White/yellow		Very low productivity

support to farmers, though their coverage is limited to smaller areas and specific subjects only.

Cooperatives and Users' Groups

Nepalese farmers help each other at a time of need. They realize the benefits of working together and have established formal and informal[16] groups. Informal groups are community based, belong to the same faith, have specific traditions, and share the same natural resources. Through the efforts of governmental and non-governmental organizations (NGOs), several formal users' groups, producers/ marketing groups, and saving/credit groups have been organized at the village level.

Among the survey VDCs in the highhills and midhills, organized farmers' cooperatives were reported in the district headquarters only. In the terai, six out of ten VDCs had cooperatives within them. Some forest, drinking water, and irrigation users' groups were reported. Similarly, women's groups have been initiated to raise the income and increase awareness of their members. Vegetable and milk producers/ marketing groups are located in relatively accessible VDCs. District Agriculture Development Offices have initiated different commodity groups according to the Agricultural Perspective Plan (APP) strategy in pocket areas defined by them.

Sources of Inputs

The Agricultural Inputs Corporation (AIC), a public sector undertaking, was the only institution marketing fertilizers until a few years ago, when its monopoly ceased following changes in government policy. It was envisioned that the private sector would step into supply these inputs, but this has not come to pass. The private sector does supply inputs to terai districts, but supplies limited quantities in the eastern and central midhills and almost none in the mid-western and far-western midhills and highhills. Some NGOs have been supplying seed, fertilizer, and plant protection chemicals in some areas for vegetable cultivation, but not for maize.

Negligible amounts of pesticides are used in maize production in the midhills and highhills. However, pesticide use is common among farmers in the central terai. All of the pesticide used, especially in the terai, is purchased from agrovets in nearby markets.

Farmers normally select local and advanced generation open-pollinated varieties (OPVs) maize seeds from the previous year's production or get them through exchange with farmers whose maize crop is exceptionally good. The DADOs and AIC supply limited quantity of improved OPV maize seeds. The DADO also provides small amounts of maize and cereal seeds free to progressive farmers through minikits and for demonstration purposes. However, this arrangement is not based on farmers' demand but on the DADO's program. Agrovets supply a limited amount of hybrids and improved OPV maize seeds in comparatively accessible areas. Their interest, however, remains on hybrid seed, which has higher profit per unit of seed sold.

Farmyard manure is one of the inputs that every household uses in maize fields. Though farmyard manure is also used for other crops, the largest part of the manure is used for maize production.

Credit Institutions

The Agriculture Development Bank (ADB) is the main institutional source of agricultural credit. Some borrowing from ADB was reported in each VDC, though farmers mentioned that it was difficult to obtain a loan and that the amount received was much smaller than required (10-50% of the requirement) in the hills. Farmers often have to resort to non-institutional sources of credit such as moneylenders in the village or shopkeepers from nearby markets at higher interest rates (25-60% per annum) than the bank (15-21% per annum). Other commercial banks such as the Nepal Bank Limited and Rastriya Banijya Bank supply some credit for non-agricultural purposes. Borrowing from these banks was negligible in the hills.

The Small Farmer Development Program (SFDP) of ADB and cooperatives together supply 25-75% of the agricultural credit in the terai. Agrovets often provide inputs on short-term credit. In addition, some NGOs and commercial banks also provide a limited amount of credit to terai farmers.

Prices of Farm Inputs and Outputs

Fertilizer, pesticides, hybrids and improved OPV seeds are the main purchased inputs. Manure and stover are normally not traded. Use of hired labour is not common in the hills except during peak times. Most farm operations are done with family and exchange labour. Payment for labour is often made in kind[17] (Table 3).

16. Formal groups are those that are formally registered and maintain an office, while informal groups are those that are formed by mutual understanding only.
17. The wage rates reported in Table 3, especially for the mid-western and far-western hills, have been converted to money equivalent by using the value of the grain that was paid for the labor.

Table 3: Average prices of farm inputs and outputs.

Inputs	Agro-ecology				
	Eastern Midhills	Central/western Midhills	Mid/far-western Midhills	*Terai/Inner-terai*	Highhills
Fertilizers (Rs/kg)[a]					
DAP	22	21	21	20	20
Urea	11	11	10	8	8
MoP	8		9	11	10
Plant Protection Chemicals					
Liquid (Rs/100 ml)[a]	101	64	100	131	75
Powder (Rs/kg)[a]		159	28	83	100
Manure (Rs/kg)[a]	1	1	1		
Maize Seeds (Rs/kg)[a]					
Local	17	12	9	16	16
Improved		21	15	21	21
Hybrid		62		92	
Labor					
Male (Rs/person/day)[a]	37	68	81	80	68
Female (Rs/person/day)[a]	27	56	63	67	60
Power rental					
Animal (Rs/pair/day)[a]	175	178	147	172	169
Tractor (Rs/hr)[a]				353	
Land rent (Rs/ha)[a]				15,563	
Irrigation fees (Rs/ha)[a]				147	
Maize grain (Rs/kg)[a]					
Farm gate	13	10	8	9	12
Nearest market		11	10	10	14

Note: [a] US$1=Rs. 68.40 (Sept.-Oct., 1999)
Differences in prices of plant protection chemicals and hybrid maize seeds are due to different brands and associated qualities.

Fertilizer prices were similar in all districts except for minor variations due to different transporting and handling charges. Wide variations were, however, observed in pesticide prices. Most farmers in the hills do not know the types of pesticides to use for specific problems and simply ask for an appropriate pesticide and pay the price that is demanded. Farmers in the terai, on the other hand, buy pesticides at competitive prices as there are several agrovets operating in the principal markets.

Among the study sites in the hills, use of hybrid maize seed was recorded in the Nuwakot district of the Central Development Region where its price was Rs 62 per kg[18]. Prices of improved OPV maize seed ranged from Rs 15 to 21 per kg in the survey year in the midhills. In the highhills, average prices of local and improved maize seed was recorded at Rs 16 and 21 per kg, respectively. The large variations in prices were associated with both the quality and cost of handling the seed. Similarly, the price of local maize seed ranged from Rs 9 to Rs 17 among the study sites in the midhills and Rs 16 per kg for the highhills. Maize seed prices were higher in the eastern and lower in the western part of the midhills.

Daily wage rates ranged between Rs 37 to Rs 81 for males and Rs 27 to Rs 63 for females in the midhills. It was recorded at Rs 68 and Rs 60, respectively for male and female labour in the highhills. The hiring rate for a pair of bullocks (including the operator) ranged from Rs 147 to Rs 178 per day in the midhills and Rs 169 in the highhills. The variations in wage rates were higher in highhills compared to midhills. Tractors or similar power driven machines are not used in the midhills and highhills.

The farm gate price of grain maize ranged from between Rs 8 and Rs 13 per kg and the prevailing price at the

18. US$1=Rs. 68.40 (September/October 1999)

nearest market ranged between Rs 10 and Rs 13 in the midhills. Prices were higher in the highhills than the midhills. Grain prices were normally the same for local, improved or hybrid maize genotypes.

Among the terai districts, the price of hybrid maize seed was Rs 92 kg^{-1}, six times higher than local maize seed. However, the farmgate price fetched by hybrid maize grain was the same for local and improved OPVs. The average daily wage for agriculture labor was Rs 80 for male and Rs 67 for female, a wage difference about Rs 13 per day between males and females. A pair of draft animals cost Rs 172 per day and rent of a tractor was Rs 353 per hour (Table 3).

Infrastructure

In general, infrastructure includes roads, drinking water, irrigation facilities, institutions, and other development activities. As these indicators do not give the full picture of infrastructure development, a combined index developed by the International Center for Integrated Mountain Development (ICIMOD), Kathmandu, is used in this study to explain infrastructure in the different agro-ecologies. Critical social and health related information in addition to the information mentioned above were included to prepare the combined socio-economic and infrastructure development indicators. Per capita development budget allocation was included in the infrastructure category, along with other standard measures such as density of roads, health institutions, infant mortality rates, coverage of safe drinking water, literacy rates, and population per bank and post office. A total of 18 indicators were used to show aspects of socio-economic, institutional, and infrastructural development. All 75 districts were ranked according to this index. Table 4 shows a summary of this index where the lowest value (mid-western and far-western midhills) indicates the worst and the highest value (eastern midhills) indicates the best region in terms of socio-economic and infrastructure development. The terai and the central and western midhill ecologies have similar socio-economic and infrastructure development indices.

Table 4: Socio-economic and infrastructural development index

	Agro-ecology	Index
1	Eastern mid-hills	0.63
2	Central and western mid-hills	0.61
3	Mid-western and far-western mid-hills	0.24
4	Terai/inner-terai	0.61
5	High-hills	0.30

Source: Calculated based on data from *Districts of Nepal: Indicators of Development* (1997).

Within the different agro-ecologies variability in the index is very large in the highhills; the index for the highhills of mid-western development region is as low as 0.04, whereas it is 0.87 for the highhills of the western development region. In the terai agro-ecology, the index ranges from 0.56 (mid-western development region) to 0.71 (eastern development region), indicating that the eastern *terai* has better socio-economic and infrastructure facilities.

Accessibility Status

All the study districts are connected to the rest of the country by road, except Bajhang district in the far-western highhills. A 109 km Khodpe-Chainpur fair weather road is under construction to connect the Bajhang district headquarters, out of which Khodpe-Bitthad 32 km is motorable in winter. The remaining 77 km Bitthad-Chainpur section is expected to be completed within the next five years.

Road access is far better in the terai than in the hills. All study VDCs in the terai reported having road access, while only 3 out of 9 VDCs in the highhills and 17 out of 27 VDCs in the midhills reported having road access. Accessibility status of VDCs are presented in Table 1.

Markets and Marketing Practices

None of the VDCs in the highhills reported having markets. People in these villages walked from 3 to 25 km to reach the nearest market. Eleven of the 27 VDCs in the midhills reported having a market[19] within the VDC. The average distance to the nearest market for other VDCs in the midhills ranged from 2 to 25 km. The study VDCs in the terai have better access to markets compared to those in the hills. Out of the 10 study VDCs in the terai, seven have a market. The average distance to the nearest market for other VDCs in this agro-ecology was 5 to13 km (Table 1).

The type of market changes substantially as one goes from east to west Nepal. Periodical (mostly weekly) markets where agricultural products and livestock are sold are common in eastern Nepal. The producers and consumers trade several agricultural and livestock products among themselves. A barter system also prevails on a limited scale. In contrast, traders largely control markets in western Nepal, with trade mainly between producers to traders, and traders to consumers.

Most farmers in the highhills, eastern midhills and mid-western and far-western midhills do not sell large quantities of maize. However, smaller quantities are often brought to market centers to buy other consumables.

19. Most of them were small markets that catered to nearby areas only.

Sometimes people buy maize from farmers in their own or adjoining village. During lean months, many people in remote hills areas often get maize from larger farmers as advance payment for labour.

In the terai and highly accessible areas in the central and western mid-hills, farmers with larger quantities of maize sell to traders at the farmgate while those with smaller quantities transport it to traders' shops or godowns in nearby trading centers. Some winter and spring maize in accessible areas are sold from the field to contractors who harvest and transport the maize.

Irrigation Facilities[20]

The main source of irrigation water is springs and rivers in the hills (midhills and highhills). Farmers divert the water using local materials. Though agency managed irrigation systems are also reported, their contribution is low in the hills. In contrast, agency managed irrigation systems dominate in the terai. Larger canals from perennial rivers (*Kankai* in Jhapa, *Gandak* in Bara, and *Babai* in Bardia) and deep tubewells are major sources of water in these systems. Farmer managed systems mainly use shallow tubewells and smaller rivers for irrigation in the terai. The irrigation status of each surveyed VDCs is presented in Table 1.

Processing and Post-harvest Facilities

Good cobs are selected after the harvest and tied into bunches (*Jhutta*) of 2-6 cobs. These bunches are sun dried for 4-5 days before being placed in *Sulis* or *Thankros* (open stores made of timber or bamboo poles). The remaining cobs, which are small, immature or partially diseased, are shelled and stored in *Bhakari*/*Dalos* (bamboo baskets) and used for daily consumption. Maize is stored in *Sulis/Thankros* until December or later, when it is removed, shelled manually, and stored in bamboo baskets or wooden stores for consumption or sale.

The existence of power-operated maize grinding mills in the hills depends largely on road access since transportation cost of diesel by porter can be prohibitive. All the study VDCs reported having a few water-operated grinding mills (*Ghattas*) in the VDC. Most of these mills are owned and operated by locals who charge in kind (5-10% of the grain to be milled) for the service. Traditional manual grinding stones are also used in remote villages.

Each of the study VDC in the *terai* has numerous power-driven multipurpose mills for grinding maize. People keep maize in open stores or in traditional stores made of wood, mud, or bamboo. Four out of ten VDCs in the *terai* reported having power driven corn shellers. Despite that, the majority of the farmers shell by hand.

Socio-Economic Characteristics

Households and Ethnicity

The number of households in the study VDCs varied from 288 to 1,237 in the highhills, from 264 to 2,038 in midhills, and 1,000 to 4,500 in the terai. No specific trends in the number of households per VDC appear from east to west.

Ethnic grouping is localized. *Rai/Limbu* are the dominant ethnic groups in the eastern midhills, while *Tamang/ Sherpa* and *Magar/Gurung* together are the dominant ethnic group in the central/western midhills. *Brahmin/ Chhetri* is the single largest ethic group in the mid-western and far western midhills (Table 5). In the *terai*, *Brahmin/Chhetri* (37%) and *terai* ethnic groups such as *Tharu*, *Yadav*, *Mallah*, *Kalwar*, *Teli*, *Kanu*, *Dhimal*, *Darai*, *Danuwar* and Muslims together (50 %) comprise the majority of the households.

Table 5: Ethnic composition of the survey sites.

	Agro-ecology	Percentage of Total Households					Female Headed Households (%)
		Brahmin / Chhetri	Tamang / Sherpa	Rai / Limbu	Magar / Gurung	Others	
1	Eastern midhill	23	8	45	10	14	22
2	Central and western midhill	35	20	1	23	21	11
3	Mid-western and far-western midhillshill	69	0	0	12	19	14
4	Terai/Inner-terai	37	0	8	5	50	15
5	Highhills	42	22	5	6	25	7

20. Increase in irrigated area has negative impact on summer maize area because it permits substitution of irrigated rice for rainfed maize. However, it has a positive impact on the winter and spring maize area.

There are more female heads of households in areas where the *Matwalis* (other than Brahmin/Chhetri) live. While this might mean that females are highly regarded and given more decision power by other communities compared to *Brahmin/Chhetris*, it also indicates that more *Matwali* men go out for employment. This is supported by the fact that *Magar, Gurung, Rai, Limbu* and *Thakuri* are preferred in the military services both within and outside Nepal.

Farmer Types

At the village level, farmers are categorized as large, medium, and small based on the amount and quality of land he or she owns. In the highhills and mid-western and far-western midhills medium and small farmers were reported while large, medium, and small farmers were reported in other agro-ecologies.

The second criterion used to categorize farmers – other sources of income- however, differed from place to place. In the eastern midhills, farmers were categorized as those producing cash crops such as large cardamom, tea, and broom grass and those not producing cash crops. In the central and western midhills farm households were categorized as those having or not having income from outside employment. In the mid-western and far-western midhills and high hills, the main distinguishing feature was whether there was earning through temporary jobs outside the village or not. In the terai, the second criterion used to categorize farmers was whether they have an off-farm source of income from cash crops or a business (Table 6).

Large and medium farmers often lead the community towards new technology. Large farmers were early adopters of technology in the terai and central/western midhills, whereas medium farmers were early adopters in the eastern midhills. Small or poor farmers lag behind in technology adoption because they lack resources to buy seed and fertilizer and are risk averse because of limited resources; if the new crop fails they have nothing to eat. In the mid-western/far-western midhills and highhills, those who go out to work often come back with some seeds of improved varieties but the lack of knowledge of fertilizers and farming practices result in poor performance and loss of confidence in the variety.

Table 6: Classification of farmers in the community.

Agro-ecology	First Criterion	Second Criterion
Eastern midhills	Large Medium Small	Income from cash-crops No cash crops
Central and western midhills	Large Medium Small	At least one person has off-farm employment No off-farm employment
Mid-western and far -western midhills	Medium Small	At least one person has off-farm employment No off-farm employment
Terai/inner-terai	Large Medium Small	Income from cash-crops or a business No income from cash crops or business
Highhills	Medium Small	At least one person has gone out of the village for work No one has gone out for work

Literacy and Level of Education

Average literacy rates are highest in the terai and lowest in the highhills. In midhills agro-ecologies, literacy rates are higher in the eastern and central/western mid-hills than in the mid-western/far-western mid-hills. This partly explains the adoption behavior of farmers in the respective agro-ecologies. Passing the School Leaving Certificate (SLC) examination is an important indicator of education level in Nepal. On average about 16% of the population in the terai passed this level. Only 7% of people in the highhills attained this level. The survey results show that a higher proportion of people in the eastern mid hills (12%) passed the SLC than other midhills (Table 7). Disparity in educational attainment is very high in the highhills. Illiteracy is as high as 67% in the far-western part of this agro-ecology against about 28% in the east.

While illiteracy is higher among females in the country as a whole, the situation is worse in the mid-western/ far-western midhills and highhills. Here, the women interviewed said they had limited involvement in decision-making on farm activities.

Land Holding and Tenure Systems

The average farm size is 0.71 ha per household in the highhills and 0.55 to 0.75 ha per household in the different agro-ecologies of the midhills. The average farm size is larger in the western part of the midhills than in the

Table 7: Distribution of population by literacy and education levels.

Agro-ecology	Illiterate (%)	Literate but no SLC (%)	SLC or higher education (%)
Eastern midhills	30	58	12
Central and western midhills	38	55	7
Mid-western and far-western midhills	43	47	10
Terai/Inner-terai	30	54	16
Highhills	50	43	7

eastern. In the comparatively newly-settled terai, the average farm size (1.19 ha/household) is larger than the highhills and midhills (Table 8). This is one reason that farming in the terai is more commercialized than other agro-ecologies.

Owners farm the majority of the land. In general, renting land is more common in the terai than in the hills. Among the midhills, renting land for cultivation is more common in the eastern midhills than in central/western and mid-western/far-western midhills. Table 8 shows that as much as 52% of households in the eastern midhills cultivate rented land, while this practice is negligible in the mid-western/far-western midhills. This is partly attributed to higher opportunity of employment and production of cash crops such as tea and cardamom in the eastern midhills.

Very few landless laborers are reported in the highhills and midhills. A higher proportion of households in the terai (7%) are landless compared to the highhills and midhills (Table 8). This is the reason that hired labor is more common in the terai than in the hills.

Utilization of Maize

Most maize produced in the hills is used for home consumption[21]. The proportion, however, varies from place to place and community to community. For example, more grain is converted into local drinks by the *Matwali* (Other than Brahmin/Chhetri) communities. A larger proportion of maize is fed to animals in accessible areas where poultry and dairy industries are established.

Around 71% of maize is used for direct human consumption in high hills. Similarly, 54 to 73% percent of maize is used for human consumption in the midhills on average. More maize is used as human food in the western parts of the midhills than in the eastern. Contrary to the hills, a larger proportion of maize in the terai (about 46%) goes to the market. Only about 27% is consumed at home, 15% is used for animal feed, 9% for making alcohol, and 3% is kept for seed (Table 9). The utilization pattern, however, differs from place to place depending upon the food habits of the people. For example, more maize is used for direct human consumption in Udayapur and Dang (in the inner-terai) than other study sites in the terai. In one survey site in central terai, 95% of maize production went to the market with the remaining used for domestic animal feed.

Table 8: Distribution of households by land tenure system.

	Agro-ecology	Average Farm Size (ha/HH)	Percentage of Households				
			Land owners	Share croppers	Fixed rent payers	Land-less	Mortgaged
1	Eastern mid-hills	0.55	44	33	19	4	0
2	Central and western mid-hills	0.70	81	16	0	3	0
3	Mid-western and far-western mid-hills	0.75	92	1	5	1	0
4	Terai	1.19	73	15	6	7	1
5	High-hills	0.71	79	11	8	4	0

Level of Income and Poverty

The average income level in Nepal is one of the lowest in the world. More than half of the population survives on less than one dollar per day. Furthermore, the rate of income growth is lower than that of other South Asian countries (Nepal South Asia Centre, 1998). The Nepal Living Standard Survey Report (CBS, 1997) shows that urban income levels are more than double the rural income levels, reflecting wide intra-country disparities

21. Almost all good grains are used for home consumption while rotten and insect damaged grains and leftovers are fed to animals.

in per capita income. Among the agro-ecologies, central and western midhills has the highest level of average per capita income (US$ 185), followed by the terai (US$ 135). The highhills and eastern midhills have an average per capita income of US$ 109 and US$106, respectively[22] (Table 10).

In general, poverty can be defined as "a state of economic, social, and psychological deprivation occurring among people or countries lacking sufficient ownership, control or access to resources to maintain a minimum standard of living" (World Bank 1980). Although, income is often considered a proxy for or an indicator of poverty the above definition implies that poverty can not be explained by just low income.

The level of food sufficiency can be a simple criterion to assess the poverty situation of a country, especially of developing countries; as well being is associated with food sufficiency in these countries. Households that are food sufficient throughout the year have a minimum material standard of living. Following this definition APROSC (1998) defined poor as those who do not have enough resource to feed its family throughout the year. Numbers of poor and above poor households estimated by the study are summarized in Table 11.

Table 9: Utilization of locally produced maize (Unit: % of production).

Agro-ecology	Human food	Animal feed	Beverage	Sold	Kept for seed
Eastern midhills	54	16	24	4	1
Central and western midhills	59	34	0	2	4
Mid-western and far-western midhills	73	14	4	6	3
Terai/Inner-terai	27	15	9	46	3
Highhills	71	15	11	1	2

Table 10: Distribution of per capita income.

Agro-ecology	Per capita income (US$)	Per capita PPP income (US$)
Eastern midhill	106	892
Central and western midhill	185	1553
Mid-western and far-western midhill	112	935
Terai/Inner-terai	135	1131
Highhill	109	911

Note: PPP= Purchasing power parity
Source: Nepal Human Development Report (1998)

Table 11: Poverty levels of sample households.

Agro-ecology	Number of Households				
	Above poverty [a]		Below poverty [b]		Total
	Number	(%)	Number	(%)	Number
Eastern midhills	1,369	0.20	5,627	0.80	6,996
Central and western midhills	6,850	0.33	13,892	0.67	20,742
Mid-western and far-western midhills	2,594	0.15	14,255	0.85	16,849
Terai/Inner-terai	26,389	0.33	53,319	0.67	79,708
Highhills	9,302	0.28	23,590	0.72	32,892

Notes: [a]Households that are able to save some amount after being food sufficient from their own production and other sources of family income in a year.
[b]Households with food sufficiency of less than 12 months from their own production and other sources of family income in a year.
Source: Computed based on Poverty Situation Analysis of Nepal (1998).

22. Per capita income in rupee in 1996 converted to US dollar by applying average annual exchange rate of Rs 54.2 per US dollar.

Maize Production Trends and Systems

Maize Production Trends

Maize production increased in Nepal from 1,121,856 tons in 1988/89 to 1,367,340 tons in 1997/98, recording an average annual growth rate of 1.84%. Of this total growth in production, about 0.71% was attributed to an expansion in area and 1.13% to an increase in yield. The yield increase was less than the population growth rate (2.3%) during the same period. Among the maize production agro-ecologies, the eastern midhills recorded the largest production growth (3.68% per annum). Most (2.01%) of this growth, however, came from area expansion and only 1.67% from yield growth (Table 12).

As the population growth during the past decade remained at 2.3% per annum, the increase in maize production was not enough to improve the food security situation of the Nepalese people. The increased use of maize in animal and poultry feed during the period further deteriorated the food situation. Hence, per capita availability of food grains decreased from 189 kg in 1995/96 to 184 kg in 1997/98. At the same time the contribution of maize in total food grains decreased from 24% in 1995/96 to 23% in 1997/98 (Table 13).

Table 12: Area, production, and yield of maize.

	Agro-ecology	Crop years				Growth rates (% per annum)
		1988/89	1991/92	1994/95	1997/98	
Area ('000 ha)						
1	Eastern mid-hill	112	112	124	128	2.01
2	Central & Western mid-hill	312	311	310	320	0.29
3	Mid-western & far-western mid-hill	112	112	109	111	-0.24
4	Terai/Inner-terai	161	161	169	176	1.11
5	High-hill	58	58	60	64	0.93
Total maize area in Nepal		755	754	771	799	0.71
Production ('000 ton)						
1	Eastern mid-hill	158	164	198	219	3.68
2	Central & Western mid-hill	464	497	510	529	1.03
3	Mid-western & far-western mid-hill	147	165	176	181	1.30
4	Terai/Inner-terai	272	292	324	338	2.24
5	High-hill	81	87	95	100	2.14
Total maize production in Nepal		1,122	1,205	1,302	1,367	1.84
Yield (ton/ha)						
1	Eastern mid-hill	1.41	1.47	1.60	1.71	1.67
2	Central & Western mid-hill	1.49	1.59	1.64	1.65	0.74
3	Mid-western & far-western mid-hill	1.31	1.47	1.62	1.63	1.54
4	Terai/Inner-terai	1.69	1.82	1.92	1.92	1.13
5	High-hill	1.39	1.50	1.58	1.57	1.21
Average yield of maize in Nepal		1.49	1.60	1.69	1.71	1.13

Source: Computed from the data published by National Planning Commission Secretariat (1994) and Central Bureau of Statistics (1999).

Table 13: Food availability and requirement.

	Agro-ecology	Population (000)	Edible Food Available (000 ton)			Requirement (000 ton)	Balance (000 ton)
			Maize	Others	Total	(000 ton)	(000 ton)
	1995/96						
1	Eastern mid-hill	1,538	166 (46)	193 (54)	360	309	51
2	Central & western mid-hill	5,633	408 (45)	493 (55)	900	1,132	-232
3	Mid-western & far-western mid-hill	2,032	111 (35)	203 (65)	314	408	-94
4	Terai/Inner-terai	9,974	185 (9)	1,975 (91)	2,160	1,805	355
5	High-hill	1,536	60 (33)	119 (67)	179	293	-114
Total		20,712	930 (24)	2,984 (76)	3,914	3,948	-34
	1996/97						
1	Eastern mid-hill	1,622	153 (46)	180 (54)	333	326	7
2	Central & western mid-hill	5,859	382 (43)	513 (57)	895	1,178	-283
3	Mid-western & far-western mid-hill	2,140	119 (37)	202 (63)	321	430	-110
4	Terai/Inner-terai	10,140	176 (8)	2,068 (92)	2,244	1,835	409
5	High-hill	1,624	65 (36)	115 (64)	180	310	-130
Total		21,384	895 (23)	3,078 (77)	3,973	4,079	-107
	1997/98						
1	Eastern mid-hill	1,656	166 (48)	183 (52)	349	333	16
2	Central & western mid-hill	5,995	400 (43)	540 (57)	940	1,205	-265
3	Mid-western & far-western mid-hill	2,185	124 (36)	221 (64)	345	439	-94
4	Terai/Inner-terai	10,412	182 (8)	2,012 (92)	2,194	1,885	310
5	High-hill	1,656	68 (34)	130 (66)	198	316	-118
Total		21,905	941 (23)	3,087 (77)	4,027	4,178	-151

Note: Figures in the parentheses indicate percentage contribution in total edible food-grains.
Source: Marketing Development Division, DOA (1997, 1998 and 1999)

Maize Production Systems

The field survey showed that there are enormous diversities in the way maize is cultivated among different maize production environments in terms of timing of crop establishment, inputs and input levels, varieties preferred, crop rotation, and crop management practices. Major elements of maize production systems are discussed in the following sections.

Major Farm Enterprises

Maize is grown in almost all *Bari* land and paddy in all *Khet* land in the midhills during the summer, irrespective of location. Relayed millet (with maize) is the second major summer crop in the uplands of the eastern, central, and western midhills. Almost 82% of the upland in the mid-western/far-western midhills is planted to wheat or barley during the winter, while this practice is less common in the eastern to western midhills. Compared to the hills, agriculture in the terai is more oriented toward commercial farming, especially for maize. Other crops grown by farmers in the survey VDCs are dealt with separately in later sections.

Livestock is an integral part of the farming system in Nepal. Some 61% to 88% of all households kept cattle, 41% to 60% kept buffalo, 37% to 53% kept goat, 5% to 24% kept pigs, and 47% to 70% kept poultry during the survey year (Table 14). While buffaloes are kept for milk, cattle are kept for draft power and religious purposes. Goats, sheep, poultry and pig are normally kept for income generation.

Crops and Cropping Patterns

As mentioned earlier, maize is the single most important crop in the hills of Nepal in terms of production and consumption. Maize is cultivated in almost all *Bari* land during the summer season. Other major food crops grown in *Bari* land are: finger millet, wheat, barley, legumes, oilseeds, and potato. Rice is grown in all *Khet* land in the summer. Other crops grown in *Khet* land include wheat, legumes (mostly black gram, horse gram), oilseeds (mostly mustard), and potato.

Table 14: Livestock ownership and average number of livestock per household.

	Agro-Ecology	Cattle		Buffalo		Goat/Sheep		Pig		Poultry	
		% of HH that Own	No. per HH	% of HH that Own	No. per HH	% of HH that Own	No. per HH	% of HH that Own	No. per HH	% of HH that Own	No. per HH
1	Eastern mid-hill	-	3.27	-	1.37	-	3.27	-	1.33	-	6.33
2	Central and Western mid-hill	61.25	2.96	-	1.50	-	4.09	-	-	-	5.67
3	M-west and Far-western mid-hill	88.33	3.19	60.50	1.55	52.88	4.30	6.00	1.50	47.50	3.33
4	Terai/Inner-terai	76.25	4.63	41.25	2.25	37.50	5.13	23.75	4.00	70.00	6.75
5	High-hill	-	2.54	-	1.44	-	3.91	5.00	0.70	-	6.73

Note: HH= Household

Sugarcane, spices (ginger, garlic, and turmeric), vegetables, fruits, and large cardamom are cultivated in some pockets for home consumption and commercial purposes. Cultivation of upland rice in *Bari* land was reported in all midhills agro-ecologies, but on a very limited scale.

Two crops are grown per year in most *Bari* land of the midhills and the valleys. The main crop is maize. Millet is the second most important crop in the eastern to western midhills and decreases in importance as one goes further west. It was cultivated in only about 2% of the upland in the Baitadi district, for example. Millet is either broadcasted as a single crop during July/August after harvesting maize or transplanted in standing maize field near the tasseling of maize as a relay crop.

Winter crops are more common in the western than in eastern hills. While winter crops are grown in 10% of the *Bari* land, in the eastern midhills they are grown in about 91% of *Bari* land in the mid and far-western midhills.

Wheat is cultivated in all study districts. The proportion of cultivated land under wheat/barley was about 5% in the eastern midhills, while it was as high as 81% in the mid-western and far-western midhills. More winter rain enables more successful cultivation of wheat/barley in this agro-ecology. In many cases mustard and lentils are mixed with wheat. This practice is more common in *Khet* land than in *Bari* land and more common in the western than eastern midhills. The proportion of wheat and mustard or lentils in this mix cropping system is estimated to be 4 :1.

Generally, soybean is intercropped with maize in every agro-ecology in the hills. This practice is more important in the mid-western and far-western midhills, as most maize is intercropped with soybean there. Similarly, some peas and beans are intercropped with maize in the hills. Large cardamom, tea, and broom grasses are major cash crops in the eastern midhills. Vegetables, fruits, and spices (ginger, turmeric, and garlic) are cultivated in specific areas in the terai and midhills for consumption and commercial purposes. Sugarcane and jute are the major cash crops grown in the terai.

All *khet* land is planted to rice as a summer crop in the midhills. No intercropping is practiced with rice although legumes are commonly planted on bunds. Wheat is the most important crop grown in the *Khet* land in the winter. Other crops are lentils and rapeseed. The cultivation of winter crops in *Khet* lands depends heavily on the availability of irrigation.

Early (spring) rice is cultivated in the terai and valleys, wherever irrigation exists. Similarly, a rice-maize (winter) system exists in the eastern and central terai. Wheat is cultivated as a winter crop in all terai districts. Crops grown in *Khet* lands in the terai include oil seeds, potato, lentil, jute, pigeon pea, and chickpea.

A single crop of maize per annum and rotation of maize and barley in alternate years were reported in some surveyed sites in the highhills. Intercropping of potato with maize is another common cropping pattern. In the higher altitudes of this agro-ecology, three crops per two years — maize-wheat-millet is also practiced.

The average cropping intensity for *Bari* land is estimated to be 169% in the highhills, 175% to 200% in the midhills and almost 200% in the terai. Similarly, average cropping intensity for the *Khet* land is estimated at 196% to 254% in mid-hill agro-ecologies, 178% and 216% for the *Khet* lands in highhills and terai agro-ecologies, respectively (Table 15).

Table 15: Distribution of major cropping patterns and cropping intensities.

	Eastern midhills	Central and western midhills	Mid and far-western midhills	Terai/ Inner-terai	Highhills
	Percentage of cultivated area (%)				
Bari land					
Maize+millet[a]	25	51	2		32
Maize+millet-wheat/barley[a]		22	1		10
Maize-millet		1			13
Maize-wheat/barley[a]	5	10	80	7	30
Maize-pulses/oilseeds	5	10	10	68	3
Maize+potato	40				1
Maize-others		3	3	25	7
Maize-fallow	25		2		14
Others		3	2		
Average Cropping Intensity[b]	*175*	*200*	*194*	*200*	*169*
Khet land					
Rice-rice-wheat/oilseed		7		2	
Rice-maize	75	23		31	
Rice- wheat/oilseed-maize		45		9	15
Rice-potato-maize		6		7	7
Rice-wheat/oilseed		9	79	24	34
Rice-others	25	3	17	25	
Rice-fallow		6	4	1	44
Average Cropping Intensity[b]	*200*	*254*	*196*	*216*	*178*

Note: [a]Intercropping of soybeans with maize is common in these systems.
[b]Average cropping intensity was calculated by dividing the sum of the area grown to various crops during the year by the total cultivated area.

Crop Rotation and Calendar

A limited amount of *Bari* land in the central and western midhills is planted with upland rice in the summer. Similarly, some *Bari* land (less than 2%) in the central to far-western midhills is planted with potato as a mono-crop in the summer. Maize in the midhills is cultivated in the rest of the *Bari* land in the summer either as a mono crop or with millet, potato or upland rice as a relay crop.

There are strong differences in the importance of relay cropping among agro-ecologies. Relay cropping millet with maize is practiced on about 25% of *Bari* land in the eastern midhills. It increases to 73% in the central and western midhills and begins declining to about 3% in the mid-western and far-western midhills. Similarly, maize-millet relay cropping is practiced in 42% of *Bari* land in the highhills (Table 15).

Spring maize is planted in three-fourths of the *Khet* land in the eastern midhills. This amount decreases as one moves from east to west up to Baglung (western development region). No maize is reported in *Khet* land in the hills west of Baglung. Among the terai districts, both spring and winter maize are reported in the eastern and central development regions but no maize is cultivated in the *Khet* land of the terai in the mid-western and far-western development regions.

Depending upon the altitude and the time of the pre-monsoon rainfall, maize is sowed in *Bari* land in the midhills between the second week of March and the second week of April. It is sown about a month earlier in *Khet* land where rice is established in July after the maize harvest. Summer maize in the terai is sowed a month later than the midhills. Winter and spring maize are also sowed in the terai with irrigation during October and February, respectively. In the highhills, maize is sowed as early as March, but because of low temperatures there it matures later than in the midhills. A crop calendar for the different agro-ecologies is presented in Figure 1. The time of establishment and harvest might differ up to one month depending on the variety grown.

Soil Management

Soil erosion is one of the major abiotic problems facing farmers in upland slopes in the hills. Though all farmers interviewed said that erosion is a major problem, they lacked knowledge of scientific methods of checking soil erosion. Several cases of landslides were also observed in the study sites.

Terracing and building drains along the safer side of plots are traditional practices adopted by farmers to conserve the topsoil in the hills. Furrows are often made along the side wall of the field so no water falls directly onto the fields. Some farmers in the far-western midhills, where ginger is inter-cropped with maize, practice mulching after crop establishment. No other techniques are adopted to prevent soil erosion.

Application of FYM is the most important soil fertility management practice farmers use. This is more important in remote hills where fertilizer use is restricted by availability and high price. Farmers expend considerable effort to increase FYM by collecting grass or dry leaves from the forest and composting it with dung. Ash and other residues are also used as manure. Mulching and burning of dry leaves is practiced in limited areas near the forest to improve soil fertility.

In the terai and accessible valleys where access to markets permits them to cultivate commercial crops, farmers use fertilizer such as DAP, urea and muriate of potash to improve soil fertility in addition to FYM.

Maize Varieties Farmers Prefer

Several socioeconomic, cultural, and environmental factors contribute to the selection of maize varieties. The most important among them is the use of maize. People in the east and west prepare their food differently. In the eastern, central, and western hills, maize is prepared as *Bhaat* (grits cooked much the same way as rice) or *Dhindo* (porridge). In the mid-western and far-western hills maize is prepared as *Roti* (home made bread) and people prefer a soft and floury maize grain. In the terai and accessible areas of the midhills, market demand and price determines the selection of a variety. As most of the maize produced in the terai is sold for use in the feed industry, higher yielding varieties, which produce good quality grits, are preferred irrespective of color and texture.

Other reasons that influence a farmer's choice of variety are the level of productivity, maturity period, harvesting time[23] , quality and quantity of foliage and the belief that a certain variety produces a minimum quantity despite adverse weather. Local maize varieties planted by farmers and their advantages and disadvantages are presented in Table 16.

Compared to the hills, there are very few traditional varieties grown in the terai. They include *Tinpankhe*, *Sathiya* and *Murali* and are being cultivated exclusively for home consumption with their fodder used for livestock feed.

Farmers were also asked to rank characteristics in terms of importance. In all agro-ecologies, high yield was reported to be most important by all respondants while there were differences among respondents with regards to other characteristics (Figure 2). In the terai, high yield and medium plant height were the most important characteristics and yellow color of secondary importance.

23. In food deficit locality people prefer to cultivate early variety maize in part of their land.

Figure 1: Maize crop calendar.

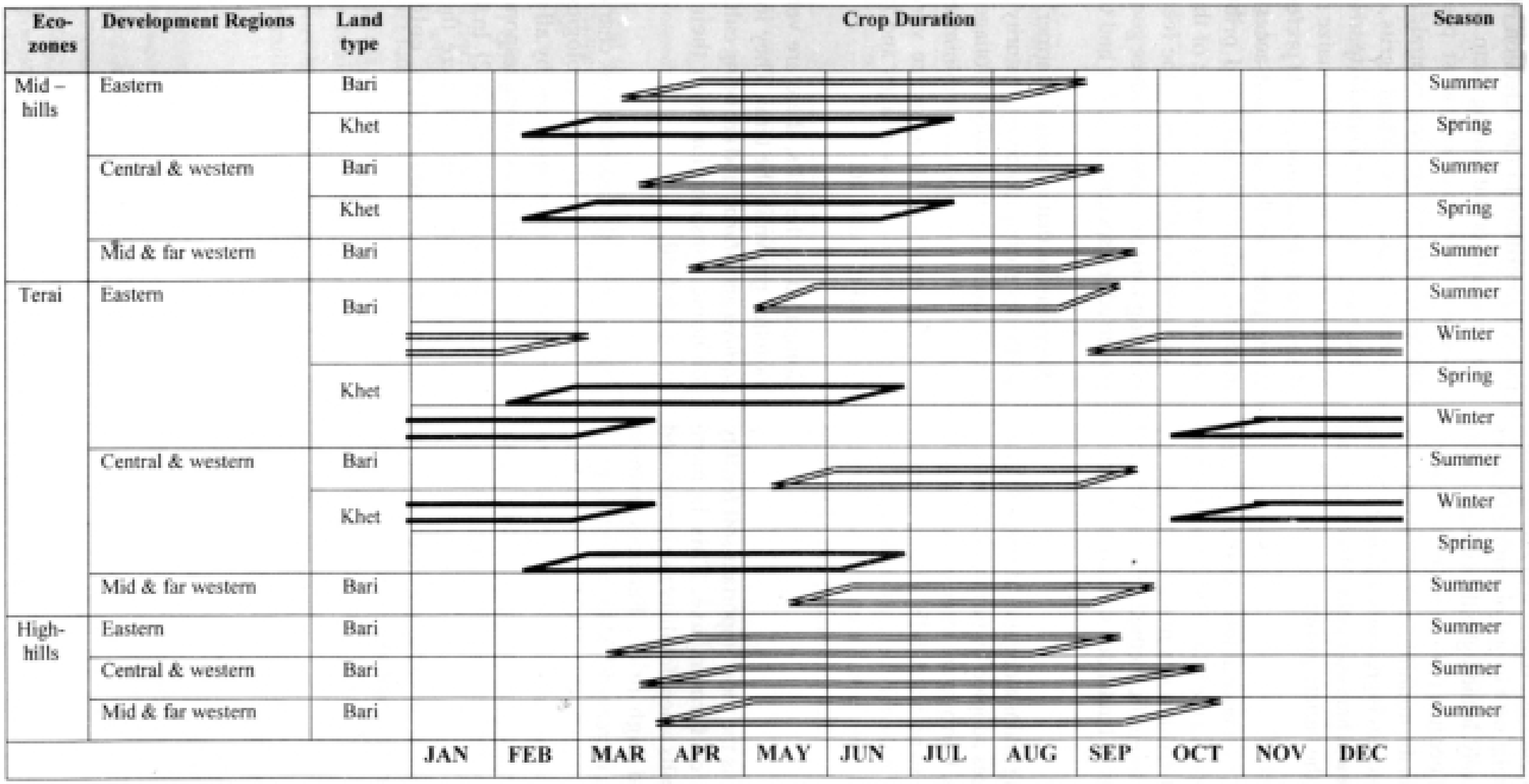
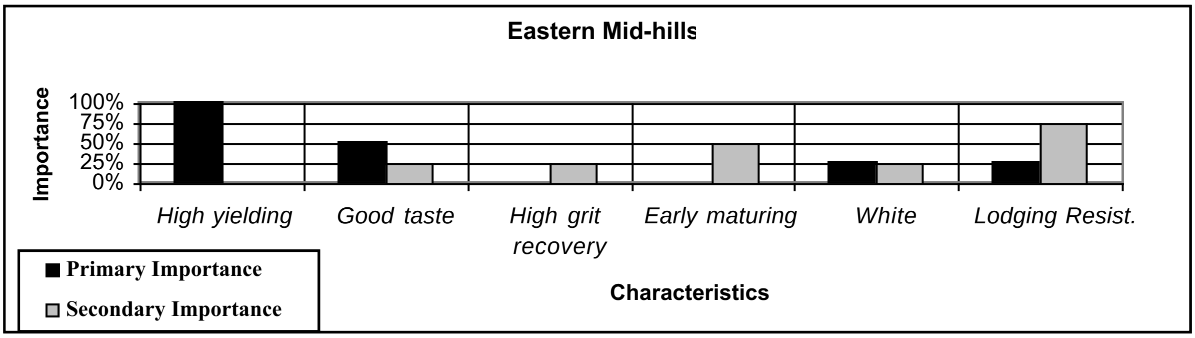


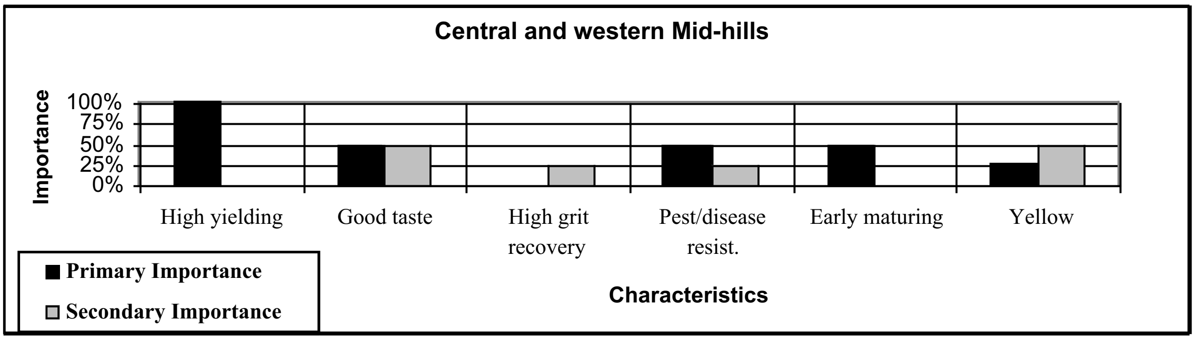
Table 16: Local maize varieties grown in the hills.

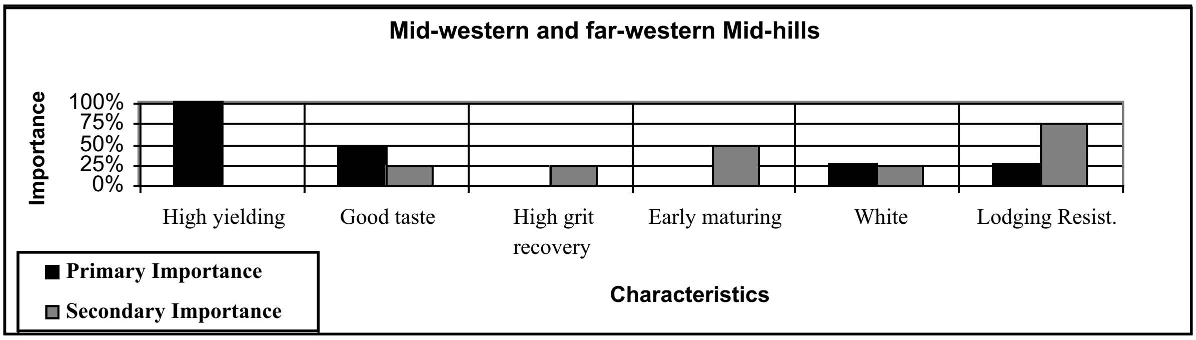
Varieties	Advantage	Disadvantage	Adoption	Trend
Eastern midhills				
Seto Chepti (White)	Tasty white grits High yielding and high grits recovery	Tall plant – lodging Not good for roasting/popping	High	Constant
Pahelo (Yellow)	Good taste as roasted or popped Late planting possible	No pleasant taste/look of cooked grits Low yield in general	Low	Decreasing
Kalo (Black)	Good taste as roasted or popped Good for late planting (after wheat)	No pleasant look as cooked grits Low yield	Medium	Constant
Kukhure (Mixed)	Good for early/late planting Good taste as roasted/popped	Low yield Damage by wild animal (early)	Very low	Constant
Central and western Midhills				
Local Pahelo (Yellow)	Drought resistent Good fodder for livestock Early maturing	Small ear and kernel size, low yield Poor taste High storage loss due to weevil	High	Decreasing
Seto Chepte (White)	Early maturing Good taste Easy to grind	Low grit recovery Lodging	Low	Decreasing
Murali (Yellow)	Good for roasting/popping	Small kernel size- low yield Not good for grits	Very Low	Decreasing
Mid-western and far-western midhills				
Thulo (Large White)	High yield High flour recovery Good taste	Needs more manure/fertilizer Lodging Matures later than Nano	Medium	Constant
Nano (Small White)	Early maturing (food shortage time) Easy to grind and good taste	Small kernel size- low yield Low flour recovery	High	Constant
Maradi (Yellow)	Good for popping	Very low yield	Very low	Decreasing
Highhills				
Thulo Seto (Large White)	Good Yield Good for porridge and bread	Not good for local drinks preparation Damage by wild animals (late)	Medium	Constant
Nano/Sano Seto (Small White)	Suitable for higher altitude Good for porridge and bread	Not good for local drinks preparation Low yield	High	Constant
Sherpa (Large Yellow)	More grain per ear- High yield High flour recovery and good taste Suitable for red soils in higher altitude More fodder for animals	Lodging Poor drought resistance Not good for popping Declining yield	High	Decreasing
Sano Pahelo (Small Yellow)	Good for roasting/popping Suitable for sandy soils in mid-hills	Low yield Poor drought resistance	Low	Decreasing

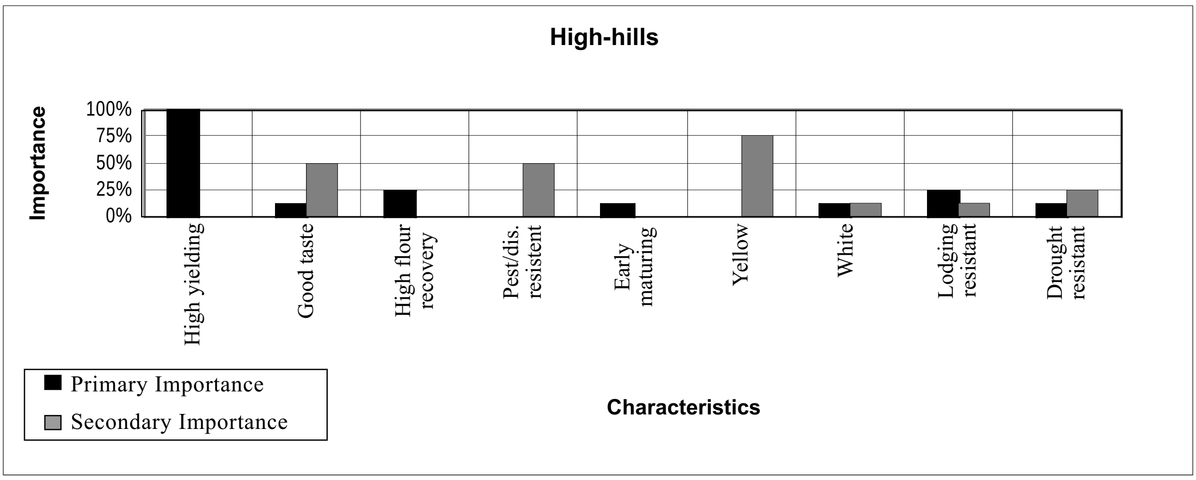
Note on adoption level: < 25% of households cultivating the variety is defined as very low; 25-50% as low; 50-75% as medium; and > 75% as high level of adoption.

Figure 2: Demand of maize characteristics in the hills.









Farmers' preference for characteristics also varied from place to place depending upon different cropping systems, practices, and the length of the maize growing season. As for future maize varieties, farmers emphasized short and strong stalked plant types that do not lodge, drought resistance, early maturing, and higher yielding. A summary of desirable maize varietal characteristics for the different cropping systems is presented in Table 17.

Table 17: Desirable varietal characteristics for different maize production systems in the hills.

Maize Systems	Eastern to western Hills	Mid-western and far-western hills
Sole crop maize under sequential system	• Full season variety (120-150 day maturity) • High yielding, disease and insect resistance, good husk cover • White and yellow colour kernel • Dense foliage and prolific • Plant height medium to short, • Resistant to lodging	• Full season (110- 140 day maturity) • High yielding, disease and insect resistance, good husk cover • White colour kernel • Dense foliage, • Plant height medium to short, • Resistant to lodging
Maize for relay or intercropping system	• Medium to short maturity (90-130 day maturity) • Sparse foliage • Lower leaf senescence and tolerance to defoliation and detopping • Plant height medium • Resistant to lodging	• Because relay millet is not practiced in the mid and far-western dry zone, the introduction of different types of beans, cowpea and vegetables and spices (garlic, ginger and turmeric) should be explored
Maize for *Khet* land	• Short duration variety (< 100 day maturity) • Dense foliage, • Plant height-medium • Resistant to lodging	• Short duration variety (< 100 day maturity) • Dense foliage, • Plant height-medium • Resistant to lodging

Source: Rajbhandari, 2000.

sowing. In-situ manuring (called *Thala Rakhne*) by animals during the off season is also reported in the highhills.

There are two distinct methods of maize planting: dropping the seed in the plough mark or broadcasting before plowing. The first method is more popular, but needs additional manpower. A few farmers in the eastern hills also reported dibbling[24] a method which is useful while sowing maize in fields where potato is already established.

Land Preparation and Crop Management

In the midhills, land preparation begins after the first rains in March/April. In the highhills it starts in February. In most cases, land is plowed twice using oxen followed by de-cloding before sowing maize (if the land was fallow in winter). In the mid-western and far-western midhills where a winter crop is cultivated in almost 90% of the land, a single plowing followed by de-cloding is practiced. Some farmers also do a second plowing before sowing to mix manure into the soil and also to make the soil more suitable for the crop. In smaller plots and narrow corners, where plowing is difficult, manual digging is done.

Transporting farmyard manure is started before land preparation and continues through to sowing as the activity is carried out during leisure times (between farming activities). The manure carried to the field is piled and spread after the first plowing or one or two days before

The first weeding is done about a month after sowing and the second weeding about 50-60 days after sowing. Millet is transplanted into a developed maize during the second weeding. A few farmers indicated that they placed a teaspoon of urea around each plant during the second weeding. This practice is more frequent on land near the homestead.

No major differences are observed in maize cultivation practices between *Bari* and *Khet* lands. In *Khet* land, it is cultivated as spring maize and a higher proportion of improved maize varieties are used. Winter maize is cultivated in *Khet* land in the terai and foothills using improved OPV and hybrid seed. Additionally, unlike *Bari* land, *Khet* land maize is irrigated twice. While some of

24. Making a small hole with a stick, dropping maize seed into the hole and covering with soil.

the stover of the main maize season from *Bari* land is used for compost, all stover produced in *Khet* land is used for fodder, as maize in *Khet* land is harvested during the dry season when fodder supply from other sources is low. In both *Khet* and *Bari* land, all maize stover is removed and not incorporated into the soil.

Level of Input Use

Seed, fertilizers, and manure are the major inputs used by farmers in the study sites. Seed rate is as high as 60 kg per ha in the eastern midhills. This is to ensure that enough plants develop despite possible low germination rates and pest problems. In other parts of the mid-hills it ranges from 25 to 34 kg/ha and is 35 kg/ha in the high-hills. In the central and western midhills, 95 kg urea per ha is applied. The average use of fertilizer in the eastern midhills is 90 kg/ha comprised of 57 kg urea, 30 kg DAP and 3 kg Potash, whereas 36 kg/ha fertilizer is used in the mid-western and far-western midhills. In the terai, where adoption of improved technology is higher than the hills, 84 kg/ha urea, 62 kg/ha DAP and 32 kg/ha potash is used. Despite poor access, farmers in the highhills reported using 37 kg fertilizer per ha in maize fields on average (Table 18).

Table 18: Average level of input use in maize cultivation

	Agro-ecology	Material inputs						Labour inputs			
		Seed	Urea	DAP	Potash	PPC	FYM	Human			Animal
		(kg/ ha)	(kg/ ha)	(kg/ ha)	(kg/ ha)	(kg/ ha)	(ton/ ha)	(day/ha)	Male (%)	Female (%)	(pairday/ha)
1	Eastern mid-hill	60	57	30	3	0	11	267	48	52	-
2	Central & western mid-hill	34	95	0	0	0	22	295	38	62	10
3	Mid-western &far-western mid-hill	25	20	14	2	0	15	154	40	60	14
4	Terai/Inner-terai	25	84	62	32	2	9	124	47	53	-
5	High-hill	35	30	7	0	0	15	251	45	55	35

Labour use rates were as high as 295 mandays per ha in the central and western midhills[25] and as low as 154 mandays per ha in the mid-western and far-western midhills[26]. If all the labour used is valued at market wage rates, returns to maize production would be less than the costs of inputs and labour in some cases. However, 90% of this labour is provided by the family and through exchange labor, making the real wage rate of family labour lower than the market rate. In all surveyed sites, more females were involved in maize cultivation than males. Generally, less human labor is involved in maize cultivation per unit of area in the terai than in the hills (Table 18). Labour use rates are more uniform among the study sites in the terai.

Yields and Yield Gap

There was large variation in maize productivity ranging from a minimum of 0.36 t/ha to a maximum of 5.13 t/ha in the different agro-ecologies within the midhills. The average yield of local maize in the mid-hill agro-ecologies was reported to be from 1.35 t/ha to 2.36 t/ha and that of improved OPV's to be from 1.35 to 2.95 t/ha. Yields were better in the western than eastern parts of the midhills. Yields of hybrid maize in the midhills ranged from 3.80 t/ha to 5.06 t/ha with an average yield of 4.43 t/ha. Productivity of local and improved maize was lower, but productivity of hybrid maize was higher in the terai than in the midhills and highhills. The average yield of improved OPV maize in the midhills and highhills was 18% and 20% higher than local maize. The average yield of hybrid maize was recorded at 4.43 t/ha, about 90% higher than improved OPVs.

The yield of local maize in the terai ranged from 0.20 t/ha to 2.00 t/ha and that of improved OPVs from 1.35 t/ha to 2.83 t/ha. Similarly, the yield of hybrid maize ranged from 4.75 t/ha to 7.50 t/ha. The average yield of an improved OPV was about 57% higher and that of a hybrid 300% higher than local maize in the terai as a whole (Table 19).

25. One of the reasons is labourers work for only 4-5 hours a day in the midhills and highhills of the central development region compared to 8 hours in other areas.
26. One of the reasons is that only one plowing and less labour for decloding is required in the area where a winter crop is cultivated.

Table 19 : Maize yields by variety.

	Agro-ecology	Local Maize			Improved OPV Maize			Hybrid Maize		
		Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
1	Eastern mid-hill	2.21	1.13	1.35	4.42	0.36	1.35	-	-	-
2	Central &western mid-hill	2.69	1.49	2.2	2.99	2.22	2.7	5.06	3.80	4.43
3	Mid-west &far-western mid-hill	5.13	0.78	2.36	4.43	1.73	2.95			
4	Terai/Inner-terai	2.00	0.20	1.34	2.83	1.35	2.10	7.50	4.75	5.45
5	High-hill	2.83	0.89	1.84	2.83	1.10	2.22	-	-	-

Note: Max= Maximum, Min= Minimum, Ave= Average.

Maize yields differ significantly among districts, villages, and even among plots within a village. Poor soil fertility was cited by all farmers as the major factor for the yield gap. Other reasons were the quantity and pattern of rainfall, time of crop establishment, quality of seed, level of input use, availability of irrigation, and diseases and pest infestations.

Post-harvest Practices

Maize is harvested at maturity and stalks are removed to allow for the development of relay crops such as millet. Cobs are separated by size and quality (appearance). Small cobs with poor appearance are dehusked and sun-dried for 3-4 days on the floor and then shelled by hand or with a stick. Grains are kept loosely if they are going to be consumed shortly or placed in some kind of containers for longer term storage.

Large and good cobs are tied in bunches (4-6 cobs) and sun-dried for 4-5 days. After drying, these bunches are piled in specially prepared open-air storage structures, called *Thankro*, S*uli or Luta*. Special care is taken in preparing these stores to make them water[27] and rodent proof[28]. The maize is removed from these stores in December or later, shelled and stored in bamboo baskets or wooden stores. Farmers in general do not use chemicals to protect grains from storage pests.

Maize cobs are also hung on ropes inside the house or on verandahs by tying the sheaths together (in *Jhuttas*). This method of drying/storage is economical, provided that it can be protected from rodents and rain. Farmers also store maize by hanging them with ropes above the kitchen or keeping them in specially prepared bamboo/ wooden structures.

Other maize storage structures found in the country are *Kuniu* (wooden platform usually in uppermost floor of the house), *Dehari* (indoor structure made from a mixture of mud, straw pieces, and dung), *Bhakari* (interwoven split bamboo), bamboo baskets, earthen pots, timber bins, and metal bins. The choice of storage structure depends upon the form (whether the maize is dehusked or shelled), quantity, and duration of storage.

No open stores are used to store maize in the terai. Harvested cobs are cleaned and pilled in a shed, mostly inside a house or a store, until they have enough time to shell them. Shelled grains are then stored in a *Bhakari* made of bamboo and wood or in a *Dehari*, an earthen store. Farmers here also rarely use storage chemicals.

The major problem with postharvest handling is the difficulty of drying maize. The summer maize harvesting season coincides with the late monsoon when cobs have a relatively high moisture content (23- 28%). Ideally maize should be dried to 13-14% (K.C. Ganesh 2000) before being stored. Farmers have neither the knowledge nor equipment to measure maize moisture content and simply dry the maize for 4-5 days before storing. However, because of humid rainy days during and immediately after harvest, the maize is usually not dry enough to be safely stored.

Some farmers said they select seeds for planting the following season while storing the harvest by selecting good cobs, sun-drying them, and storing them separately. However, most farmers in the hills select seeds when shelling or sowing. Seed grains are taken (hand-shelled) from the middle of the cob so that big and uniform sized grains could be obtained. If seeds are selected during harvest or shelling (December-January), they are stored with ash, *Timur* (*Xanthozylum alatum*) seeds, *Titepati* (*Artemisia vulagaris*) leaves or millet grains to prevent attack from storage pests. In the mid-western hills kerosene use was also reported to control storage pests.

27. Some straw is tied on top of the stored cobs.
28. A spiky structure made of iron or tin placed around the poles just below the stored maize to prevent rodent access.

Maize Production Constraints

Several problems that impact maize production were identified during the transact-walk, field observations, and discussions with farmers, extension workers, local knowledgeable persons, and VDC officials. Across all agro-ecologies, farmers frequently mentioned the lack of quality seed as the single most important factor affecting maize productivity. Lack of knowledge of improved production practices was also mentioned, particularly in more remote areas. Other major threats that were mentioned were maize field and storage pests and diseases. Problems that were identified are grouped into biotic and abiotic constraints, institutional constraints, and other constraints.

Biotic and Abiotic Constraints

Diseases and Pests in Maize Fields and Stores

Smut (*Sphacelotheca reiliana*) and turcicum blight (*Helminthosporium turcicum*) in the eastern and mid-western/far-western midhills and highhills; ear rot in the central/western and mid-western/far-western midhills; stalk rot in the mid-western/far-western midhills, terai, and highhills; and downy mildew (*Perona sclerospora spp.*) and leaf firing in the terai were important diseases mentioned by farmers. Banded leaf and Sheath blight (*Rhizoctonia solani*) was increasing in severity and prevalence in all environments. Turcicum Leaf Blight is ubiquitous in hill environments and can cause severe losses if the variety does not have good genetic resistance.

White grubs (*Phyllophaga spp.* and *Cyclocephala spp.*), stem borers (*Chilo partellus*), and termites (*Microtermes spp. and Macrotermes spp.*) were major maize field insects in all agro-ecologies. Army worms (*Spodoptera spp.*) and cutworms (*Agrotis spp.* and other species) were also major problems in all agro-ecologies except the eastern midhills. Blister beetle was a major problem in the central/western and mid-western/far-western midhills and the terai, and field cricket was a major problem in the eastern and mid-western/far-western midhills and highhills. Aphid (*Rhopilosiphum*

Table 20: Major diseases and pests in maize fields and stores.

Disease/pest	Type	Occurs during	Agro-ecologies				
			Eastern mid-hills	Central/western mid-hills	Mid/far-western mid-hills	Terai	High-hills
Aphid	Insect	Flowering stage	√				
Army worm	Insect	Mostly vegetative stage		√	√	√	√
Turcicum blight	Disease	Flowering stage	√		√		√
Blister beetle	Insect	Grain filling stage		√	√	√	
Cut worm	Insect	Emergence		√	√	√	√
Downy mildew	Disease	Early vegetative stage				√	
Ear rot	Disease	Cob formation		√	√	√	
Field cricket	Insect	Emergence	√		√		√
Grasshopper	Insect	Knee high stage		√			√
Leaf firing	Disease	Flowering stage					√
Locust	Insect	Any time					√
Monkey	Animal	Pre-harvest & Store			√		
Moth	Insect	Store	√	√	√	√	√
Porcupine	Animal	Pre-harvest & Store			√		
Rat/mouse	Rodent	Pre-harvest & Store	√	√	√	√	√
Red ant	Insect	Emergence & Pre-harvesting			√		
Smut	Disease	Late flowering stage	√		√		√
Stalk rot	Disease	Flowering stage			√	√	√
Stem borer	Insect	Knee high stage	√	√	√	√	√
Tassel beetle	Insect	Tasseling stage	√				
Termite	Insect	Flowering stage	√	√	√	√	√
Weevil	Insect	Store	√	√	√	√	√
White grub	Insect	Emergence	√	√	√	√	√

spp.), locust, red ant, and tassel beetle were also reported by farmers (Table 20). White grubs were more localized than stem borers and seem to favoer sandier soils. Stem borers can be particularly problematic in spring and summer plantings when temperatures and insect reproduction rates are high. Insects in general tend to be less problematic in highhills than in other agro-ecologies.

Weevils (*Sitophilus* spp.) and Angoumois grain moth (*Sitotroga cerealella*) were major problems in stored grain. In all survey sites the extent of damage to maize grain depended on the duration of storage. In the terai and other accessible areas where maize is stored for longer periods, pest damage was as high as 50%. However, it is not clear how extensive post-harvest losses are in the midhills and highhills as most maize is consumed within six months of harvest and pest development is relatively slow during the cooler winter months.

Soil Fertility and Crop Management

Soil fertility was one of the most serious constraints to maize production in all survey sites. Due to a number of socio-economic factors, the primary input into maintaining and improving soil fertility is manure/compost. Farmers complained that they do not have access to adequate quantities of manure/compost because of diminishing access to quality fodder for their animals. Compost quality was extremely variable, as many farmers have not adopted improved compost management practices.

In comparatively accessible areas, fertilizer is used to supplement manure/compost. However, only urea is used and there is concern that other nutrients, particularly phosphorous, are now limiting as organic inputs are generally poor sources of P. Soil erosion results in significant losses in productive topsoil as most fields are sloped and rainfall during the monsoon can be intense.

Traditional planting and weeding practices are labour intensive and the labour shortage (more adult males leaving the village for off-farm work and children attending schools) makes it difficult to control weeds effectively. As weed growth is slower in high hills, weed competition is less of a constraint in this agro-ecology. Lodging is a common problem of currently used genotypes. Less research has been carried out on the maize-wheat system (mainly in the mid-western/far-western hills) compared to the maize-millet relay system. Therefore, specific recommendations for management of inputs that optimize this cropping system are generally not available. There has also been little adoption of modern varieties in this particular agro-ecology.

Although fertilizer is readily available and commonly used in most areas of the *terai,* problems of micronutrient deficiencies have been noted and current practices do not address this problem. High temperatures during flowering in spring maize and drought are stresses that are occasionally problematic in this agro-ecology.

Institutional Constraints

Although the DADO has offices in the district headquarters and satellite offices at the service center/ sub-center level, it has not been able to provide sufficient services to farmers, especially in remote hills. One of the problems is the relatively large area each extension personnel has to serve. Many farmers in remote areas did not know the Junior Technicians/Junior Technical Assistants deputed to their area. Only a few farmers in some VDCs reported NGOs as sources of technology. However, NGOs were more inclined toward social awareness campaigns and production of cash crops such as vegetables and fruits. The majority of farmers rely on progressive farmers for information about new technologies. The case is similar with the supply of inputs and credit.

Information Constraints

Lack of information is most acute for farmers in the highhills and remote areas of the midhills. Many farmers in these areas did not know which improved varieties are suitable for their farms and where to obtain them. While they did sometimes find seeds bearing the names of improved varieties, these varieties often failed to produce as much as local varieties, resulting in indifference on the part of farmers towards adopting improved varieties. Lack of knowledge of improved crop management practices including spacing, fertilization, and choice of variety are other problems.

Farmers, in many instances, could not identify insect pests, diseases, and nutritional deficiencies in their crops and had no knowledge of pesticides that could be used for their control. In most locations improved technology[29] was beyond the reach of the farming community because of their unavailability and high price.

While only a few farmers used fertilizers in their maize fields, those using them did not use them in a balanced way. It was also found that in some cases farmers used urea exclusively and other cases applied it to the surface without covering it with soil.

Input Supply Constraints

The problems associated with availability of quality maize seeds differ between agro-ecologies. In the eastern to

29. Mainly improved seed, fertilizer, and plant protection chemicals.

western midhills farmers often complained that improved maize varieties of their choice is not available. While the DADO distributes some seeds through minikits and for demonstration plots, this amount is negligible when compared to the need. In the mid-western and far-western midhills and highhills, farmers complained that available improved varieties are not suitable to their environment and taste.

With the withdrawal of the AIC from active involvement in supplying seed, there is currently no public or private institution marketing certified seed of newly released OPVs in large quantities. Some hybrid maize seeds were imported from India by private traders and sold in accessible areas, but the price was three times higher than an improved OPV. Some farmer groups have become active in producing maize seed, especially in the central midhills and terai, but the quantity they supply is small compared to demand. Most of the seed that these farmer groups produce is channeled through the DADO and small-scale seed sellers, rather than through an organized system.

The AIC has not been able to supply sufficient inputs (seed and fertilizers) in the hills for three reasons: remoteness of the area; lack of awareness and demand of modern inputs; and lack of purchasing capacity of the farmers. The price of fertilizers has also gone up drastically as a result of the government's recent withdrawal of its subsidy. In the absence of a stable government policy and the underdeveloped market, the private sector has been skeptical about getting into the input business. Farmers also complained that fertilizers supplied by private traders (mainly imported from India) were of poor quality and that there was no quality control in the districts.

Other Constraints

In the mid-western and far-western regions, people eat maize bread and porridge only and are unaware of other maize dishes. Further, existing processing tools, namely grinding stones and local water mills, are designed to grind softer local maize and cannot grind the harder grains of some improved maize varieties.

Because of the underdeveloped marketing system, poor market infrastructure, and shortage of inputs, excess maize production is not easily disposed of at an attractive price. This has indirectly slowed the pace of adoption of new technologies.

Population pressure and declining productivity has pushed farmers toward increased use of marginal/steep lands for maize cultivation. This practice has caused soil erosion especially along newly opened road corridors.

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Priority Constraints for Research

Methodology for Identifying Priority Constraints

The constraints identified during the field survey were summarized and presented in the Third Planning Meeting of HMRP[30] discussed earlier. This meeting was attended by senior NARC scientists engaged in maize development in different parts of the country. Senior CIMMYT scientists facilitated the discussions directed at establishing priorities. After a general discussion on the constraints, the participants were divided into four working groups[31] to further validate and elaborate the constraints in light of the importance of the problem, yield gain should the particular constraint be alleviated and the probability of finding a solution to the constraint. The working groups presented their findings in the panel session, which were further discussed, validated and finalized (Annex-2).

Table 21: Priority ranking of major biophysical and institutional maize production constraints.

Agro-ecology	Constraints	Ranks based on			
		Efficiency	Poverty	Subsistence	Combined
CW Midhills	Lack of high-yielding varieties	1	1	1	1
CW Midhills	Lack of impr. variety for relay cropping	2	2	2	2
CW Midhills	Declining soil fertility	3	3	3	3
Terai	Lack of hybrid varieties	4	4	7	4
CW Midhills	Low plant population	5	5	4	5
CW Midhills	Weeds	7	7	5	6
Terai	Drought	6	6	10	7
CW Midhills	Stemborers	9	9	6	8
Terai	Inadequate crop management technologies	8	8	13	9
CW Midhills	Soil erosion	11	11	8	10
CW Midhills	Ear rot	12	12	9	11
Terai	Lack of seed supply	10	10	14	12
Terai	Inadequate post-harvest technologies	13	13	16	13
CW Midhills	Turcicum blight	15	15	11	14
CW Midhills	White grub	16	16	12	15
Terai	Stemborers	14	14	17	16
CW Midhills	Soil acidity	17	17	15	17
Eastern Midhills	Labour shortage for first weeding	18	18	18	18
Eastern Midhills	Lack of variety for maize/millet compatibility	19	19	19	19
Eastern Midhills	Lack of improvement in local implements	20	20	20	20
Eastern Midhills	Declining soil fertility	21	21	21	21
MFWMidhills	No alternative variety option	22	22	22	22
Eastern Midhills	Turcicum leaf blight	23	23	23	23
Eastern Midhills	Loose husk cover	24	24	24	24
Eastern Midhills	Storage grain loss (due to pests)	25	25	25	25

Note: 1 is the highest priority and 25 the lowest priority.
CW= Central and Western, MFW= Mid-western and Far-western.

30. The first two days of the Planning Meeting were devoted to setting the priorities for maize R&D work in Nepal.
31. One group each was assigned the responsibility to look into details on (i) eastern highhills and midhills, (ii) central and western highhills and midhills, (iii) mid-western and far-western high hills and mid hills and (iv) terai/inner terai maize production domains.

Efficiency indices of the specific constraints were estimated as a product of the importance of the constraint; yield gains associated with the constraint alleviation; total production of maize in specific agro-ecologies; probability of finding a solution to the constraint; and adoption history (percentage of farmers that have adopted the new technology).

As the primary objective of increased maize production is to ensure food security and reduce poverty incidence, future programs have to be designed to achieve this objective. The poverty index was therefore developed as an additional indicator to set priorities for maize research. This index was derived as a product of the efficiency index and proportion of households living below the poverty line[32] in each agro-ecology. Further, a subsistence index was calculated as the product of the efficiency index and the proportion of farmers in each agro-ecology who produce food primarily to meet subsistence needs. Finally the combined index was calculated by adding the products of 0.50 X efficiency index, 0.30 X poverty index and 0.20 X subsistence index.

Priority Constraints

Based on the efficiency, poverty, subsistence, and combined indices, 25 constraints across all agro-ecologies were established. These constraints are more or less similar in ranking regardless of which index is applied (Table 21). The priority problems for each agro-ecology are discussed in the following paragraphs.

Eastern midhills (Agro-ecology-1)

This ecology suffers from labour shortage for maize cultivation, especially for the first weeding. Lack of a compatible maize variety that allows growth of relayed millet is the second most important problem here. Lack of improved implements, declining soil fertility and loose husk cover (which makes the maize ears susceptible to field and storage pests) are other problems.

Even though farmers complained that several diseases and pests such as stalk rot, ear rot, stem borers, field cricket, white grubs, and turcicum leaf blight damage their maize, only turcicum leaf blight was among the 25 priority constraints.

Central and western midhills (Agro-ecology-2)

Lack of high yielding variety (HYV) was the main constraint for this agro-ecology. As in the eastern midhills, lack of a suitable variety for relay cropping is the second priority constraint followed by declining soil fertility. Low plant population (often caused by drought after planting), excessive rain and weeds, insect damage, soil erosion, and increasing soil acidity are other problems.

Among the diseases and pests reported by farmers, ear rot and turcicum blight were identified as major diseases and stem borers and white grubs as major insects.

Mid-western and far-western midhills (Agro-ecology-3)

Though several constraints were mentioned by farmers in this domain, only the lack of alternative HYV to suit this environment fell within the 25 priority constraints that were identified. Farmers did not accept improved OPVs released by the NMRP as they matured later than traditional varieties. Early maturity is an important characteristic in the area as maize is planted a month later than the eastern part of Nepal and harvesting must be done in time to prepare land for winter crops (wheat/barley).

Terai, inner-terai, and foothills (Agro-ecology-4)

The warmer temperatures and better irrigation facilities in the terai/inner terai agro-ecology offer a suitable environment for maize cultivation, especially winter/spring maize. Many farmers use hybrid seed. However, most hybrid seeds are imported and the unsystematic approach to importation of hybrid seeds is a setback to maize production in the terai. Drought is another major constraint, especially in spring maize. Inadequate crop management technologies, lack of regular seed supply mechanisms, and inadequate post harvest technologies are other priority constraints. Stemborer is a major pest problem in this agro-ecology (Table 22).

Highhills (Agro-ecology-5)

Many of the constraints mentioned in the midhills apply in the highhills. Considering the area affected by and seriousness of the constraints, the lack of HYV is the most important priority constraint. However, none of the constraints mentioned by farmers were among the top 25 priority constraints that were identified because of the smaller quantity of maize produced in this agro-ecology.

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32. See Table 11 for information on population below the poverty line.

Table 22: Priority problems of maize production.

	Eastern Development Region	Western & Central Development Region	Mid & Far- western Development Region
Mid-hills	Labour shortage for 1st weeding; Lack of variety for maize/millet compatibility; Lack of improved local implements; Declining soil fertility; Turcicum leaf blight; Loose husk cover; Storage pests	Lack of HYV; Lack of improved variety for relay cropping; Declining soil fertility; Low plant pop'n; Weeds; Stemborers; Soil erosion; Ear rot; Turcicum blight; White grub; Soil acidity	No alternative variety option
Terai	Lack of hybrid varieties; Drought; Inadequate crop management technologies; Lack of seed supply; Inadequate post-harvest technologies; Stemborers		

An Agenda for Maize Research and Development in Nepal

For greater impact through research, the most pressing constraints that are likely to have a technical solution should be addressed first. Therefore, maize scientists, participating in the third planning meeting of HMRP, were asked to estimate the probability of success in eliminating each of the 25 priority constraints in each agro-ecology, and the probability of farmers adopting the new technology. Based on an index that combined these criteria, research approaches were ranked. The most effective approaches for dealing with identified priority constraints and likelihood index of producing an impact to eliminate the constraints are summarized in Table 23. Annex 3 gives details on probability of success, adoption, and potential suppliers of the technology.

Major findings

The prioritization exercise indicated that top priority should be given to the midhills, where the lack of high yielding OPVs is the main constraint. The high priority given to this constraint may also be associated with the lack of availability of seed of existing released varieties[33]. The exercise did indicate that more emphasis should be placed on developing full-season than early maturing varieties. Although not specified as a solution, community seed delivery programs could also help reduce this constraint.

The problem of *turcicum blight* can effectively be dealt with through a breeding program. Screening for this trait should also be carried out as a standard component of the germplasm development process.

To address the problem of soil fertility decline (mainly caused by continuous mining of soil nutrients and loss of topsoil by erosion), research should include an investigation on reducing the loss of nutrients from farm manure. Additionally, priority should be given to the developments of cropping system that includes legumes. There is also scope for integrated plant nutrient management and improvement in the efficiencies of applied fertilizer nutrients. Soil conservation, soil amendments, and development of soil acidity tolerant varieties can help with soil acidity problems. Land preparation practices such as minimum tillage, improvement of farm implements, improved planting methods, and improved weed management practices can ease the problem of poor crop management and labour shortage in peak periods.

In the terai a concerted effort is needed for the development of hybrids. The production of hybrids in the absence of a viable seed enterprise, however, is a formidable challenge, and must be addressed through policy and/or through non-traditional seed multiplication schemes. The issue of seed multiplication should be addressed before hybrids are formally selected so that there will not be a lag in the provision of seed once the hybrids have been identified.

Recommendations for Future Action

While increased production per unit area is the main objective of R&D, other considerations must be taken into account in setting an agenda for maize R&D in Nepal—the end use of the crop, the cost of production per unit of output, socio-economic factors, the microclimates, accessibility status, tastes/preferences and competing as well as complementary crops grown. From an equity point of view, priority should be given to areas where the majority of poor people reside and where maize is a major staple. At the same time, return to investment is higher where maize is grown as a commercial crop. Considering these climatic, socio-economic, and infrastructural complexities, it is recommended that resources should be allocated in such a way that they address the needs of the different agro-ecologies, if not each micro climatic pocket.

The major areas of concern can be divided into three categories — technology development (including varietal development, cropping systems research, soil fertility research, and pest control research), technology dissemination, and input supply and output marketing.

Varietal Development

Improved varieties should be developed and made available as broadly as possible. Farmers repeatedly stated that they like early maturity, but also made it clear that they are unwilling to accept lower yields associated with this characteristic. Mid to late maturing varieties

33. A list of maize varieties released by NMRP is presented in Annex 4.

Table 23: Research approaches ranked by likelihood of producing an impact on eliminating constraints to maize production.

S.N.	Constraints	Research Approaches	Likelihood Index
Agro-ecology: Hills (mid and high-hills)			
1	Lack of HY OPVs	Development of Full season varieties	0.50
		Development of Early season varieties	0.30
2	Turcicum blight	Breeding for resistant varieties	0.28
		Early planting	0.08
		Fungicide	0.03
		Fertilizer management	0.01
3	Stem Borer	Biotech	0.30
		Breeding for resistant varieties	0.15
		Integrated Pest Management	0.15
		Insecticide	0.08
4	White grubs	Biocontrol	0.15
		Crop management	0.08
		Insecticide/traps	0.08
5	Soil fertility decline	Improved FYM/compost preparation/use	0.40
		Grain-legume Intercropping	0.15
		External fertilization	0.10
		Residue management	0.08
		Improved terrace management	0.08
		Bio fertilizer (direct/indirect)	0.02
		Cover crop introduction	0.00
6	Soil acidity	Soil amendment OM/lime	0.10
		Tolerant varieties	0.05
		Soil conservation	0.01
7	Poor crop management	Weed management (mechanical & chemical)	0.40
		Plant Density	0.40
		Planting method and thinning	0.25
		Farm implement improvement	0.03
		Land preparation (min. tillage)	0.00
Agro-ecology: Terai (Terai and foothills)			
1	Lack of OPVs/hybrids	Summer: OPVs	0.72
		Spring: Early OPV/hybrids	0.72
		Winter: full-season, yellow hybrid	0.63
2	Drought (spring & summer)	Early varieties	0.72
		Tolerant varieties	0.51
3	Seed supply	Private seed sector (policy opt)	0.63
4	Pollen death (due to high temp. in spr.)	Early varieties	0.72
		Temperature tolerant varieties	0.20
5	Crop management	Weed control	0.42
		Fertilizer + irrigation	0.32
6	Stem borer/stalk rots	Chemical control	0.63
		Tolerant varieties	0.16

Note: Higher figures in index column indicate greater likelihood of producing an impact.

should therefore be developed, but in most cases they should not be longer in duration than the currently recommended varieties.

In the eastern to western midhills (agro-ecology-1 and 2), there is sufficient moisture for late maturing genotypes, if the inclusion of millet or other relay crops are not considered. Varieties developed for these ecologies must be resistant to *turcicum blight*, ear rots, stem borers, and white grubs. Both yellow and white coloured genotypes are needed but the grain texture should be flint, as maize is primarily prepared as grits. Although the demand for white grain is greater than yellow grain, yellow grain should be developed especially in more remote areas where vitamin A deficiencies are problematic. Plants should be resistant to lodging but taller plants are desired as stover is used extensively for animal feed and fuel. Resistance to stored grain pests is also desirable. Since maize is often grown in a relay system with millet (in low to mid altitudes) and potato (in higher altitudes), plant characteristics that allow for good relay/intercrop development as well as tolerance to the stripping of lower leaves and detasseling soon after pollen shed are required.

Since maize is primarily used in making *Roti* in the mid-western and far-western midhills (agro-ecology-3), the grain type should be white and floury. Farmers expressed an interest in early maturing varieties even though full season types appear to fit the rainfall pattern in this ecology. One of the reasons farmers mentioned early maturing varieties was the need to prepare land for winter crops (wheat/barley) while there is sufficient moisture in the soil (by the first week of October), though these crops are seeded in November. Early maturing varieties are also required because of the need for food during lean periods. Further follow-up is needed to understand these issues fully and decide on the importance of early maize for this agro-ecology.

Considering farmers' increasing interest in high yielding hybrid varieties, especially in irrigated and accessible areas in the terai/inner-terai and foothills (agro-ecology-4), it is recommended that hybrid maize be developed in the country. At the same time, some regulations are needed on imported hybrid maize seed (until it is produced in the country) so that good quality can be assured. Stem borer and drought resistance varieties are needed particularly for the spring plantings in this ecology. Early varieties are required for areas where maize is grown before rice (i.e. *Khet* land). Early varieties are also required in the *terai/inner-terai* where pollen death due to high temperature is reported in spring maize. At the same time, drought tolerant varieties should be developed. Grain colour should be yellow but grain type (i.e. flint or dent) is not critical. The development of high yielding maize varieties with improved protein quality (Quality Protein Maize) may also be justified particularly if a premium market price for such grains can be obtained.

The most important problem for the highhills (agro-ecology 5) is the lack of suitable HYVs. Given the small area in this agro-ecology, only white grain types should be developed, as that is the colour preferred by most farmers. Resistance to *turcicum* blight is needed and genotypes should not be later than existing released genotypes (i.e. Ganesh- 1).

Cropping System Research

The maize-millet system that dominates the eastern to western midhills (agro-ecology-1 and 2) is ideal for the long rainy period. Maize reaches physiological maturity 4 to 6 weeks before the end of the rains. Millet is transplanted after the flowering of the maize and develops with minimal competition after maize is removed. The exploitation of the available moisture after maize removal is key to intensifying this system. In warmer areas of this ecology where sequential cropping is practiced, new crops should also be tried.

The current practice of transplanting millet is extremely labour-intensive. Management practices that ease labour requirements for transplanting and weeding should be developed. The effect of stripping lower leaves and of over-planting and thinning maize needs to be investigated to determine practices that optimize the overall yield of the system. To reduce the labour requirement for millet transplanting, alternatives to millet should be sought, especially legumes or cash crops. It is also possible to adopt higher yielding long duration maize in areas where land remains fallow after maize. Long duration soybean varieties, which have shown promising results, should also be tried.

In the mid-western and far-western midhills (Agro-ecology-3) where there is significant rainfall during the winter months, research is recommended to determine the optimum varietal combinations of maize and wheat with different maturity lengths. From an analysis of the rainfall data and fallow period between maize and wheat, it would appear that a longer season variety of maize could be grown without compromising the yield of wheat, which is usually planted in November when temperatures are optimum for its growth. Further investigation is required to verify this.

Since maize can be grown in any of the three seasons (summer, winter, and spring) in the terai/inner-terai and foothills (agro-ecology-4), research is required to identify the best crop management practices including appropriate time for specific activities. Time of crop establishment is very important for spring maize, which often suffers from excessive heat and drought. An analysis of weather data might help determine the appropriate time to plant the crop to minimize losses.

Many farmers complained that profits are dwindling as maize grain prices are decreasing, whereas the prices of inputs have increased significantly over the last two years. Because of limited restrictions on the import/export of agricultural products from/to India, prices in Nepal are determined by prices in Indian markets. Therefore, there is little scope of intervention to stabilize maize prices. There is also very little scope of reducing the price of fertilizer, which is one of the important inputs. A feasible way to increase profitability of farmers is through the use of cost effective technology. Research directed towards the development of technologies that improve efficiencies should, therefore, focus on reducing the labour requirement per unit of production. As land preparation and weeding are labour-intensive activities, the development of zero-tillage or minimum tillage practices for maize should be investigated. Research should focus on developing labour saving weed control mechanisms in maize fields.

As the highhills (agro-ecology-5) are not food sufficient, research should concentrate on increasing total production in addition to yield improvement. There is considerable scope to do so by developing alternative cropping systems.

Soil Fertility Research

One of the most logical and feasible solutions to check soil fertility decline in the mid- and highhills is increased use of compost. One of the major constraints mentioned by farmers in this respect was declining fodder caused by reduced access to the forest. Increased fodder cultivation in farmers' fields should, therefore, be initiated. Technological improvement is also needed to improve preparation techniques and management of FYM/ compost. Fertilizer recommendations need to be developed for a range of soil types and compost/manure use scenarios. Similarly, some soils in the hills are acidic. Research on liming and soil conservation is therefore justified in this ecology. Research also should be directed at developing an acid tolerant variety in the future.

In areas where inorganic fertilizer is used, only urea is applied. Data on the requirement of other nutrients are needed. Better recommendations on the combined use of inorganic and organic sources, and an investigation into the role of reduced tillage practices are needed to check soil fertility decline and to mitigate soil erosion. Additionally, research that will enable synchronizing the requirement of nutrients of both maize and other crops with the inputs of organic and inorganic sources of nutrients is needed. There is also a need to explore the role of micronutrients and liming in the production of maize in many intensively cultivated areas of the terai.

Insect Control Research

Given the predominance of stem borers and white grubs in all agro-ecologies, integrated approaches to control these pests need to be developed and/or verified if already available. Post-harvest losses from insects needs serious consideration especially for warmer areas in the terai/ inner-terai and the foothills where maize is stored for longer durations. Better drying and storage facilities are required to protect the grain from pests. At the same time varieties that are genetically resistant to field and storage pest attacks need to be developed.

Technology Dissemination

Farmers often complained that they have difficulty accessing technological information. The present extension system needs to provide technological information more effectively and efficiently. Strong communication and links between researchers, extension workers, and farmers is also needed. The involvement of extension staff, particularly DADO subject matter specialists (SMS) in outreach research activities, joint planning, implementation, monitoring and evaluation is needed. In all the steps of on-farm research, farmers' participation should be sought as far as possible. A complete technology package should be introduced along with improved seeds. In addition to production technology, improved post-harvest practices such as storage, processing, and different maize uses should be included in extension messages.

Adoption of improved technologies is very low in the mid-western and far-western midhills and all of the highhills (agro-ecology-3 and 5) compared to other agro-ecologies. While non-availability of maize varieties for these environments is a major problem, the extension service has failed to disseminate varieties that are available. The situation is worse in remote areas where extension personnel are unwilling to stay. It is strongly recommended that the extension system needs to reorient and make it mandatory that extension personnel spend at least 75% of their time in villages.

Technological information is not a major constraining factor in the terai (agro-ecology-4), as farmers are better exposed to modern technology. However, the situation is not the same for the eastern and western parts and remote villages within the agro-ecology. Because some NGOs are active in relatively accessible area and near the towns, and there are agro-vets who also serve as sources of information, the extension network should dedicate itself to more remote villages.

Input Supply and Output Marketing

Seed is a key input and there is always a shortage of quality seed in the midhills and highhills (agro-ecology-1, 2, 3 and 5). Seed requirements for summer maize cultivation in the midhills and highhills can be fulfilled from winter maize produced in the valleys and terai/inner-terai (agro-ecology-4). Farmers' groups in the area should be utilized for the production of commercial seed. It would be helpful to producers to get a premium price for the maize they produce and at the same time the seed demand of the hill districts could be met. Government policy should favour the establishment of seed enterprises and community based seed supply systems should be tried.

With the withdrawal of AIC from subsidized input delivery, some provisions for input supply are urgently needed. The Nepalese government needs to formulate policies with regards to the private sector involvement in input supply. The present system of a dual policy[34] should be abolished.

An alternative to improve the supply of fertilizer is to mobilize farmers. By organizing farmers into groups they may be able to access short-term loans to purchase inputs. These groups can also facilitate the marketing of surplus. This model has been already tested by some NGOs and found to be effective.

The marketing of produce has been a neglected area in the past and has created a bottleneck in promoting production. Major efforts are needed to develop market infrastructure. As motorable roads now connect many places in the hills, marketing activities can be promoted by developing market centers along these roads. Some training on post harvest handling of grains including grading is also required.

The problem of input supply in the midhills of the mid and far-western development region (agro-ecology-3) and the highhills (agro-ecology-5), where the use of improved seed, fertilizer, and plant protection chemicals are very low, is different from other agro-ecologies. Also no spring maize is cultivated in *Khet* lands of these two agro-ecologies. Therefore, arrangements need to be made to supply maize seeds from the terai. Alternatively, farmers need to be trained and supplied with appropriate technology to minimize storage losses. As the use of fertilizers is very low, the government needs to provide incentives for fertilizer use and assure timely supply.

Policy and Institutional Arrangements

The main responsibility of maize technology generation should be shouldered by NMRP/NARC in association with International Agricultural Research Centers (IARCs) such as CIMMYT. Development of high yielding and resistant varieties for the different agro-ecologies will be the primary responsibility of the NMRP. The NMRP needs to collaborate with agricultural research stations located in different parts of the country, Institute of Agriculture and Animal Sciences (IAAS) and I/NGOs working in similar fields. The private sector, coordinated by the Department of Agriculture (DOA)[35] , should come forward in seed multiplication and dissemination. NMRP should also work closely with the DOA to identify and disseminate improved crop management practices. Details on the research approaches to be adopted and potential suppliers of technology are presented in Annex-3.

The AIC, the government undertaking to trade agricultural inputs, has not completely withdrawn itself from the seed industry nor it has been supplying maize seeds effectively. The private sector is unwilling to enter into maize seed industry because of risks associated with unwarranted and sudden policy shifts of the government. Therefore, public and private sector roles should be clearly defined, and a stable policy needs to be formulated to attract the private sector to the seed industry.

Since farmers reported sales of fake fertilizers, lab-testing of fertilizers before distribution or other quality control mechanisms are needed. One option might be to establish simple laboratories at major entry points to test fertilizers imported into the country and make it mandatory for every consignment to go through the test.

While it is increasingly clear that the demand of hybrid maize seed is growing very fast in the country, especially in the terai (agro-ecology-4), the exact size of the potential market is not known. Equally unknown is the annual quantity of hybrid maize seed imported from India due to its disorganized trade. The government needs to make the necessary formal arrangements to import commercial hybrid seed until it is produced in the country.

34. The private sector and AIC sell fertilizer at prices fixed by the government. Being a government organization, the AIC gets an indirect subsidy which the private sector does not.
35. DOA has District Agricultural Development Offices in all 75 districts under its control.

Seed quality is a sensitive but often neglected area. In the absence of laws and by-laws, the seed act of 1988 is yet to be fully and effectively implemented. The DOA needs to carefully review the problems associated with the seed sector and develop appropriate policy measures.

The government also needs to create an environment to establish maize based industries to replace the large quantity of maize products (corn flakes, oil, starch) being imported into the country. This could be an effective incentive to boost maize production in relatively accessible areas. It is recommended that the DOA coordinate with the Department of Industries and Royal Nepal Academy for Science and Technology and introduce appropriate technology to establish these industries in the country.

●●●

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Annex-1: Major maize production systems relative to altitude and agro-ecology.

Agro-Ecologies	Area under the agro ecologies in hectare	Altitude land type and (optimum maturity duration)	Dominant cropping system	Area under the cropping system in hectares
Highhills *Bariland* maize	64,180 (8%)	>1800 m Bariland (140-180 days)	Sole maize	20,180
			Maize-potato	25,000
			Others systems	19,000
Midhills *Bariland* maize	561,600 (70%)	500-1800 m *Bariland* (120-160 days)	Sole maize -winter crops	161,000
			Maize millet relay	300,600
			Maize+legume-winter crop &others	100,000
Valleys in the hills –*Khetland* Spring maize	25, 000*	< 500 m *Khetland* (irrigated) (90-110 days)	Rice-maize	15,000
			Rice - wheat/ potato-maize and others	10,000
Terai/Inner Terai Summer maize	176,500 (22%)	< 500 m Bariland/Khetland (unirrigated) (110-150 days)	Maize-mustard	120,500
			Rice-maize	20,000
			Rice-maize and others	36,000
Spring maize	30,000[a]	Khetland (irrigated) (90-110 days)	Rice-maize	30,000
Winter maize	60,000[a]	Khetland (irrigated) (120-160 days)	Rice-maize	60,000

Note: [a] Data published by CBS, 1999 does not include winter and spring maize area in the khetland in the terai, inner terai, and foothills.
Source: N.P. Rajbhandari, 2000.

Annex-2: Maize research prioritization for Nepal

Ecological Belt	Development Region	Constraints	Priority Rank	Rank Multiplier	Yield gain associated with constraint alleviation	Probability of success in finding solution to the constraint
High-hills	Central and western	Lack of HYV	1	100	0.40	1.00
High-hills	Central and western	Soil erosion	2	95	0.15	0.60
High-hills	Central and western	Lodging of local variety	3	90	0.15	0.80
High-hills	Central and western	Ear rot	4	85	0.10	0.70
High-hills	Central and western	Weevil	5	80	0.10	0.70
High-hills	Central and western	White grub	6	75	0.03	0.80
High-hills	Central and western	Stemborers	7	70	0.05	0.85
High-hills	Central and western	Soil acidity	8	65	0.05	0.40
High-hills	Eastern	Declining soil fertility	1	100	0.30	0.30
High-hills	Eastern	Unavailable variety for potato+maize system	2	95	0.20	1.00
High-hills	Eastern	Human drudgery	3	90	0.15	0.25
High-hills	Eastern	Lack of technology know-how (husbandry, seed maintenance)	4	85	0.25	1.00
High-hills	Eastern	Turcicum leaf blight	5	80	0.10	0.50
High-hills	Eastern	White grub	6	75	0.25	0.50
High-hills	Eastern	Lack of improved seeds	7	70	0.10	0.60
High-hills	Eastern	Stalk rot	8	65	0.05	0.50
High-hills	Eastern	Stemborers	9	60	0.05	0.60
High-hills	Eastern	Lack of pref variety for taste, color, and grit recovery	10	55	0.05	1.00
High-hills	Eastern	Loose husk cover	11	50	0.05	1.00
High-hills	Eastern	Lodging	12	45	0.10	0.50
High-hills	Eastern	Field cricket	13	40	0.04	0.50
High-hills	Mid and far western	Lack of suitable improved varieties	1	100	0.13	1.00
High-hills	Mid and far western	Seeds not available	2	95	0.10	0.33
High-hills	Mid and far western	Loose husk cover	3	90	0.05	1.00
High-hills	Mid and far western	Soil fertility decline	4	85	0.18	0.16
High-hills	Mid and far western	White grub	5	80	0.05	0.25
High-hills	Mid and far western	Lack of post-harvest technology	6	75	0.10	0.25
High-hills	Mid and far western	Lodging	7	70	0.03	0.25
Midhills	Central and western	Lack of high-yielding varieties	1	100	0.35	0.95
Midhills	Central and western	Lack of improved variety for relay cropping	2	95	0.20	0.90
Midhills	Central and western	Declining soil fertility	3	90	0.40	0.80
Midhills	Central and western	Turcicum blight	4	85	0.10	0.45
Midhills	Central and western	Low plant population	5	80	0.20	0.90
Midhills	Central and western	Weeds	6	75	0.15	0.90
Midhills	Central and western	Soil erosion	7	70	0.15	0.70
Midhills	Central and western	Stemborers	8	65	0.03	0.90
Midhills	Central and western	Ear rot	9	60	0.08	0.85
Midhills	Central and western	White grub	10	55	0.05	0.70
Midhills	Central and western	Soil acidity	11	50	0.05	0.65
Midhills	Eastern	Declining soil fertility	1	100	0.40	0.60
Midhills	Eastern	Labor shortage for first weeding	2	95	0.20	1.00
Midhills	Eastern	Lack of improved seed	3	90	0.18	0.35
Midhills	Eastern	Lack of variety for maize/millet compatibility	4	85	0.20	1.00

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Annex 2 Continued... ... ...

Ecological Belt	Development Region	Constraints	Priority Rank	Rank Multiplier	Yield gain associated with constraint alleviation	Probability of success in finding solution to the constraint
Midhills	Eastern	Lack of improvement in local implements	5	80	0.10	1.00
Midhills	Eastern	White grub	6	75	0.10	0.50
Midhills	Eastern	Lack of technology know-how (husbandry, seed maintenance)	7	70	0.15	0.25
Midhills	Eastern	Storage grain loss (due to moth and weevils)	8	65	0.10	0.75
Midhills	Eastern	Turcicum leaf blight	9	60	0.10	1.00
Midhills	Eastern	Loose husk cover	10	55	0.05	1.00
Midhills	Eastern	Lack of market and good price	11	50		
Midhills	Eastern	Lack of stay-green variety for fodder	12	45	0.05	1.00
Midhills	Eastern	Stalk rot	13	40	0.05	0.75
Midhills	Eastern	Ear rot	14	35	0.05	1.00
Midhills	Eastern	Stemborers	15	30	0.10	0.75
Midhills	Eastern	Silk beetle	16	25	0.04	0.60
Midhills	Eastern	Field cricket	17	20	0.04	0.60
Midhills	Eastern	Aphids	18	15	0.03	0.65
Midhills	Mid and far western	No alternative variety option	1	100	0.10	1.00
Midhills	Mid and far western	Lack of improved seed	2	95	0.13	0.33
Midhills	Mid and far western	Turcicum blight	3	90	0.08	0.50
Midhills	Mid and far western	Soil erosion	4	85	0.18	0.33
Midhills	Mid and far western	Nutrient mining (lack of fertilizer, etc.)	5	80	0.30	0.20
Midhills	Mid and far western	Ear rot	6	75	0.03	0.25
Midhills	Mid and far western	Termite / white grubs	7	70	0.05	0.20
Terai	ALL	Drought	1	100	0.20	0.80
Terai	ALL	Lack of hybrid varieties	2	95	0.28	1.00
Terai	ALL	Lack of seed supply	3	90	0.10	0.70
Terai	ALL	Inadequate crop management technologies	4	85	0.23	0.75
Terai	ALL	Stemborers	5	80	0.09	0.60
Terai	ALL	Inadequate post-harvest technologies	6	75	0.10	0.80

Annex-3: Research approaches ranked by their likelihood of producing an impact on eliminating the major constraints to maize production.

S.N.	Constraints	Research Approaches	Probability of Success[a/]	Probability of Adoption[b/]	Index	Potential Suppliers								
						NMRP/ NARC	CIM MYT	IAA S	I/NG Os	Pvt. Sector	IAR Cs	DOA	DOS C	Others
			(1)	(2)	(1*2)									
Agro-ecology: Hills (mid and high-hills)														
1	Lack of HY OPVs	Development of Full season varieties	1.00	0.50	0.50	√	√	√	√	√				
		Development of Early season varieties	1.00	0.30	0.30	√	√	√	√	√				
2	Turcicum blight	Breeding for resistant varieties	0.70	0.40	0.28	√	√	√	√	√				
		Early planting	0.40	0.20	0.08	√		√	√	√				
		Fungicide	0.50	0.05	0.03	√		√	√	√				
		Fertilizer management	0.10	0.10	0.01	√		√	√	√				
3	Stem Borer	Biotech	0.60	0.50	0.30		√			√				
		Breeding for resistant varieties	0.30	0.50	0.15	√	√	√	√	√				
		Integrated Pest Management	0.50	0.30	0.15	√	√	√	√	√				
		Insecticide	0.80	0.10	0.08	√		√	√	√				
4	White grubs	Biocontrol	0.50	0.30	0.15	√	√							
		Crop management	0.40	0.20	0.08	√		√	√	√				
		Insecticide/traps	0.80	0.10	0.08	√		√	√					
5	Soil fertility decline	Improved FYM/compost preparation use	1.00	0.40	0.40	√			√			√		
		Grain-legume Intercropping	1.00	0.15	0.15	√			√					
		External fertilization	1.00	0.10	0.10	√			√			√		Policy
		Residue management	0.80	0.10	0.08	√			√					
		Improved terrace management	1.00	0.08	0.08	√						√	√	Policy
		Bio fertilizer (direct/indirect)	0.93	0.02	0.02	√			√			√		
		Cover crop introduction	0.15	0.02	0.00	√		√						Universities
6	Soil acidity	Soil amendment om/lime	1.00	0.10	0.10	√						√	√	Policy
		Tolerant varieties	0.90	0.05	0.05	√	√							Universities
		Soil conservation	0.40	0.02	0.01	√							√	Policy

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Annex 3 Continued... ...

S.N.	Constraints	Research Approaches	Probability of Success[a]	Probability of Adoption[b]	Likelihood Index[c]	Potential Suppliers								
						NMRP/ NARC	CIM MYT	IAA S	I/NG Os	Pvt. Sector	IAR Cs	DOA	DOS C	Others
			(1)	(2)	(1*2)									
7	Poor crop management	Weed management (mechanical & chemical)	1.00	0.40	0.40	√	√		√					
		Plant Density	1.00	0.40	0.40	√		√	√					
		Planting method and thinning	1.00	0.25	0.25	√			√					
		Farm implement improvement	0.50	0.05	0.03	√								ATF
		Land preparation (minimum tillage)	0.20	0.02	0.00	√	√							
Agro-ecology: Terai (Terai and foothills)														
1	Lack of OPVs/hybrids	Summer: OPVs	0.80	0.90	0.72	√					√			
		Spring: Early OPV/hybrids	0.80	0.90	0.72	√					√			
		Winter: FS, yellow hybrid	0.70	0.90	0.63	√					√			
2	Drought (spring & summer)	Early varieties	0.80	0.90	0.72	√					√			
		Tolerant varieties	0.60	0.85	0.51	√					√			
3	Seed supply	Private seed sector (policy options)	0.70	0.90	0.63				√	√				AIC
4	Pollen death (due to high temp. in spring)	Early varieties	0.80	0.90	0.72	√					√			
		Temperature tolerant varieties	0.25	0.80	0.20	√					√			
5	Crop management	Weed control	0.70	0.60	0.42				√	√		√		
		Fertilizer + irrigation	0.40	0.80	0.32	√					√			
6	Stem borer/ stalk rots	Chemical control	0.70	0.90	0.63	√					√	√		DADO
		Tolerant varieties	0.20	0.80	0.16	√					√			

Note: Higher figures in the index column indicate most important.

[a] Probability of success in finding a solution to the constraint. A value of 1 indicates 100 % success.

[b] Probability of adoption of the new technology by farmers. A value of 1 indicates adoption by all.

[c] Likelihood index is the product of probability of success and probability of adoption.

NMRP= National Maize Research Program, NARC= Nepal Agricultural Research Council, IAAS= Institute of Agriculture and Animal Sciences, I/NGOs= International/Nongovernmental Organizations, CIMMYT= International Maize and Wheat Improvement Center, DOA= Department of Agriculture, DOSC= Department of Soil Conservation, IARCs= International Agricultural Research Centers, DADO= District Agricultural Development Office, ATF= Agricultural Tools Factory.

Annex-4: Available technology options.

The National Maize Research Program (NMRP) has so far released 15 varieties of improved Open Pollinated Varieties (OPV) of maize. Among them, nine varieties are suitable for cultivation in the *terai, inner-terai* and foothill agro-ecology, four in midhills agro-ecologies and two in highhills agro-ecology. Details of these varieties are presented in Table 22. In addition, eight other varieties are in the pipeline. They are: Arun-4, Manakamana-2, Population-22, Pool-21, B.A.-93, Hill Pool, Pool-15E and Pool-17E. Three of these varieties (Arun-4, Pool-15E and Pool-17E) are targeted for the *terai/inner terai*/foothills and five for the midhills agro-ecologies. None of these varieties are targeted for the highhills (NMRP record).

Nepal's program on hybrid maize development began in 1978 with efforts to develop conventional hybrids through inbreeding plants from well-adapted improved populations. Among the hybrids tested by the research center, 17 were found to be superior to Rampur composite and at par with company hybrids (Adhikari K. 2000). However, no hybrid maize varieties have been released in Nepal.

Improved OPV Maize Varieties Released in Nepal

	Varieties released	Year released	Grain colour	Days to maturity	Potential yield (ton/ha)
***Terai, Inner Terai,* and Foothills**					
	Rampur Yellow	1966	Yellow	105	4.70
	Hetunda Composite	1972	Yellow	115	4.30
	Rampur Composite	1975	Orange	108	4.40
	Sarlahi Seto	1978	White	115	4.10
	Janaki	1978	White	155	6.50
	Arun 2	1982	Yellow	85	2.20
	Rampur 2	1989	Yellow	108	4.00
	Arun 1	1995	White	100	4.00
	Rampur 1	1995	White	115	3.80
Midhills					
1	Khumal Yellow	1966	Yellow	125	4.90
2	Manakamana 1	1986	White	125	4.00
3	Makalu 2	1989	White	145	4.00
4	Ganesh 2	1989	Yellow	165	3.50
Highhills					
1	Kakani Yellow	1966	Orange	195	3.00
2	Ganesh 1	1997	White	175	5.00

Source: Paudyal K.R. and S. Poudel 1999.

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