CIMMYT

Maize in Vietnam

Production Systems, Constraints, and Research Priorities

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CIMMYT® (www.cimmyt.org) is an internationally funded, not-for-profit organization that conducts research and training related to maize and wheat throughout the developing world. Drawing on strong science and effective partnerships, CIMMYT works to create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources. Financial support for CIMMYT's work comes from many sources, including the members of the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org), national governments, foundations, development banks, and other public and private agencies.

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Abstract: This is one of a series of seven in-depth country studies on maize production systems in Asia, funded by the International Maize and Wheat Improvement Center (CIMMYT) and the International Fund for Agricultural Development (IFAD). It is part of a project designed to promote sustainable intensification of maize production systems while ensuring equitable income growth and improved food security, especially for poor households that depend on maize. This study characterized the social and biophysical maize production environment of Thailand; examined its response to increasing maize demand; determined constraints to future productivity growth; investigated the potential environmental consequences, and examined the options available for promoting sustainable growth in maize production. Maize is the second most important food crop in Vietnam after rice. It is the substitute staple in periods of rice shortage, especially for people in rural areas and mountainous regions. Maize is also the primary source of feed for Vietnam's poultry and livestock industry, and is therefore an important source of income for many farmers. Maize production has risen sharply since 1990, when the Vietnamese government began to strongly support and promote maize hybrid technology. Vietnamese farmers have widely adopted higher-yielding hybrid maize varieties. This was a timely response to Vietnam's growing livestock and poultry industry, which in turn generates an increasing demand for more maize to use as feed. Rapid economic growth and accelerated urbanization are expected to create an even higher demand for maize in Vietnam. This trend will lead to the intensification of current maize production systems, with more land being shifted to maize production, particularly in marginal areas. Vietnam's challenge is to provide more maize for an expanding market, while preserving the natural resource base and the environment through careful agricultural planning. Effective policy design and implementation must be based on comprehensive, accurate data on the current state of maize-based farming systems.

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Acknowledgments

This manuscript reports on the results of the rapid rural appraisal (RRA) and participatory rural appraisal (PRA) surveys conducted in 19 villages across 13 provinces of Vietnam from January to July 2001. It also includes discussions from the National Maize Research and Development Priority-Setting Workshop, held at the Victory Hotel, Ho Chi Minh City, on 14-16 January 2002, and from the Fifth Annual Workshop of the Asian Maize Socio-Economic Working Group held in Bangkok, Thailand, on 1-4 August 2002.

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1. Introduction

1.1 Background

Vietnam has a population of 80 million people, with nearly 80% living in rural areas. Agriculture employs nearly 67% of the total labor force. This sector experienced dramatic reforms in the last 20 years, as Vietnam shifted from a centrally planned to a state regulated market-oriented economy. Agriculture changed from a cooperative and state farm production system, to a system based predominantly on production by individual farmers. The household became the basic unit of agricultural production, with the farmers deciding which crops to grow based on market signals. This change in agriculture production, along with institutional and policy reforms, made Vietnam one of the top three rice exporting countries in the world in 1989 and 1996. Other perennial crops, such as rubber, coffee, tea, mulberry, and maize, have also shown production increases.

Maize is the second most important food crop in Vietnam, next to rice. It is the substitute staple in periods of rice shortage, especially for people in the rural areas and mountainous regions. Maize is also the primary source of feed for Vietnam's poultry and livestock industry, and is therefore an important source of income for many farmers.

Maize production has risen sharply since 1990, when only 431,800 ha were planted to maize, yielding an average of 1.6 t/ha for a total production of 671,000 t. Since then, the government has strongly supported maize hybrid technology and the resultant hybrid maize varieties have been widely adopted by farmers. In addition, the livestock and poultry industry has grown, creating a need for more maize to use as feed. From 1990 to 1999, total maize production increased by 161%. The total area planted to maize by 1999 was 659,100 ha yielding an average of 2.5 t/ha (Vietnam Statistical Yearbook, 2001). This dramatic change in maize demand and production has made a significant positive economic contribution to many rural areas of Vietnam.

Rapid economic growth and accelerated urbanization in the country are expected to create an even higher demand for maize. This trend will lead to an intensification of current maize production systems, with more land being devoted to maize cultivation, particularly in the marginal uplands. The increasing commercialization and intensification of maize production in these upland areas could have negative environmental consequences. Vietnam's challenge is to provide more maize for an expanding market, while preserving the natural resource base and the environment through careful agricultural planning. Effective policy design and implementation must be based on comprehensive and accurate data on the current state of upland maize-based farming systems.

Given the problem of resource degradation and the high level of poverty in the uplands of Vietnam, this study focused specifically on the upland maize production systems in the country. The goal was to clarify the probable response of upland areas to the future growth in demand for maize by determining the constraints to future productivity growth, and the potential environmental consequences, and by collecting information about the options available for promoting sustainable improvements in maize production.

This study is part of a project designed to promote sustainable intensification of maize production systems while ensuring equitable income growth and improved food security for poor households that depend on maize. The project was funded by the International Fund for Agricultural Development (IFAD) and implemented under the direct supervision of the CIMMYT Economics Program. The project has been implemented in seven countries – China, India, Indonesia, Nepal, the Philippines, Thailand, and Vietnam.

1.2 Objective

The study aimed to help research and development efforts better meet requirements for increasing productivity of the maize sector in the country. The specific objectives of the study were to:

- Gather detailed information for identifying and analyzing major characteristics of different maize production systems by agro-ecological zones and geographical regions in Vietnam, with special emphasis on upland maize production systems;
- Identify constraints that limit maize production in those zones and regions;
- Identify priority constraints and solutions to alleviate those constraints in order to help the maize sector better target its research and development efforts; and
- Make recommendations for maize research and development policies that will promote maize production in each agro-ecological zone/ geographical region in the country.

1.3 Methodology

Detailed data on upland maize production systems in Vietnam were collected using a two-stage fieldwork strategy designed by CIMMYT, that includes a rapid rural appraisal (RRA) in the first stage and participatory rural appraisal (PRA) in the second stage of fieldwork. The RRA surveys were conducted in both commercial and semi-commercial maize production systems in the upland and lowland maize areas of all eight major agro-ecological zones in the country (Table 1).

The provinces chosen for the RRA fieldwork were selected for the importance of maize and maize farming in the communities, and for their agro-ecological representation. Villages within the provinces were selected for their dominant maize production systems, accessibility status, and the extent of maize cultivating area. The RRA study was done in 19 villages selected as survey sites across the major agro-ecologies of the country for their differing socioeconomic conditions (Table 1).

For the RRA work, a general RRA questionnaire prepared by CIMMYT was pre-tested and revised to fit Vietnam's specific maize production conditions,

Table 1. Main characteristics of the surveyed villages, Vietnam, 2001.

Agroecology	Village (Province)	Production orientation	Maize varieties reported	Maize seasons	% land irrigated with communal irrigation systems	Road conditions	Distance to market (km)	No. of house-holds	Popu-lation
Northern Upland	Yen Dong (Vinh Phuc)	Upland Semi-commercial	OPV, Hybrid	WS	60	Good	3	315	1755
	Ban Hoa (Son La)	Upland Commercial	Local, Hybrid	SA	0	Fair	20	173	1038
	Pache (Son La)	Upland Commercial	Hybrid	SA	0	Fair	7	28	140
	Phong Quang (Ha Giang)	Upland Semi-commercial	Local, OPV, Hybrid	SS, SA	0	Poor	10	312	1560
	Dong Xuan (Bac Giang)	Upland Self-sufficient	Local, Hybrid	SS, WS, AW	30	Good	2	1600	7360
	Thanh Van (Phu Tho)	Upland Semi-commercial	Hybrid	SS, WS	62	Good	3	1300	5561
Northern Lowland	Dong Thap (Ha Tay)	Lowland Commercial	Hybrid	SS, WS	80	Good	2	467	2420
Central Highland-Central Coast Upland	Bai Tranh (Thanh Hoa)	Upland Semi-commercial	Local, OPV	SS, SA	0	Poor	5	108	436
	Ating (Quang Nam)	Upland Semi-commercial	Local, OPV, Hybrid	SA, WS	0	Fair	25	338	1928
	Kado (Lam Dong)	Upland Semi-commercial	Local, OPV, Hybrid	SA	5	Fair	6	1437	8191
	Pro' (Lam Dong)	Upland Semi-commercial	Local, Hybrid	SA, AW	10	Fair	6	779	4455
	Cour Knia (Dak Lak)	Upland Commercial	Local, Hybrid	SA, AW	20	Relatively good	7	2400	11827
Central Highland-Central Coast Lowland	Ea Bar (Dak Lak)	Upland Commercial	Local, OPV, Hybrid	SA, AW	17	Fair to poor	5	3505	18583
	Nhan Hoa (Gia Lai)	Upland Commercial	Local, Hybrid	SA, WS	10	Relatively good	4	1744	10167
	Quang Truong (Thanh Hoa)	Lowland Semi-commercial	Hybrid	WS	60	Good	4	951	5230
	Dien Phuoc (Quang Nam)	Lowland Commercial	Local, Hybrid	SA, WS	70	Relatively good	3	2850	12269
	Dai Quang (Quang Nam)	Lowland Commercial	Local, OPV, Hybrid	SS, WS	15	Fair	4	2606	14895
Southeast-Mekong Delta Upland	Cay Gao (Dong Nai)	Upland Commercial	Local, OPV, Hybrid	SS, SA, AW	0	Poor	4	1606	9078
Southeast-Mekong Delta Lowland	Phu Tam (Soc Trang)	Lowland Semi-commercial	Local, OPV	SS	100	Relatively good	3	2800	15960

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

Notes: OPV= Open pollinated variety, SS= Spring-summer, SA= Summer-autumn, AW= Autumn-winter, WS= Winter-spring.

especially in terms of agro-ecological zones, seasons, and land use or type. The questionnaire was used in an "open-ended" manner, meaning interview questions were used as guides rather than as fixed questions, to better allow the researchers and respondents maximum flexibility in communicating about maize production systems under survey.

A multi-disciplinary team conducted the RRA surveys that covered both farm and village levels. Secondary information at the village level was collected through interviews with village leaders. The interview covered information on the site's physical environment (e.g. annual rainfall, mean temperature, land use, etc.); biological environment (e.g. maize-based cropping systems and mean cropping intensity by season, area planted to local/traditional maize, improved open pollinated varieties (OPVs), and hybrids by season); and institutional environment (particularly land tenure system). Farm-level socioeconomic information was collected through farmer group interviews. Two groups of 10 household representatives with different socioeconomic status and gender were interviewed in each of the study sites. Some village-level secondary information was also collected from the offices of village and district People's Committees.

The PRA was conducted in a subset of the RRA sites to gather more qualitative than quantitative information. Based on information collected from the RRA surveys, four upland maize-producing villages located in different ecological zones were selected for conducting PRA surveys. The goal of the PRA was to collect detailed information from farmer group discussions on the socioeconomic, agro-ecological and environmental, and technological and marketing aspects of maize production systems. For PRA work, a common list of open-ended questions was used to help the research team better facilitate farmer group discussions. The RRA survey was conducted in January-May, 2001, and the PRA survey was conducted in May-July, 2001.

Information collected from the RRA fieldwork was first analyzed and summarized by village and by ecological zone. Results were presented during the national workshop on identifying priority constraints for maize research and development that were attended by senior maize research scientists from agricultural research institutions and universities, representatives from provincial extension centers and district People's Committees, and CIMMYT scientists. The National Maize R&D Priority Setting Workshop in Vietnam was conducted at the Victory Hotel, Ho Chi Minh City, on January 14-16, 2002.

As suggested by workshop participants, maize production agro-ecologies were further redefined into six agro-ecological regions that capture both the upland and lowland production environments in three major geographical regions of the country—the north (covering the northeast, northwest, and Red River Delta), the central highland and central coast uplands and lowlands, and the southeast region and Mekong Delta. Data were later summarized for these maize production agro-ecologies.

Major characteristics of maize production systems and constraints gathered from the RRA/PRA field surveys were used for the identification of priority constraints and the setting of research and development agenda for the maize sector in Vietnam. The methodology used for identifying priority constraints for maize research and development is presented in a later section of this report.

1.4 Limitations

The initial selection of the eight survey sites based on ecological zones was changed to six major agro-ecologies, which meant the survey villages were no longer equally distributed among the redefined agro-ecologies. As the study focuses specifically on upland maize production systems in the country, a larger number of survey sites were selected for upland agro-ecologies than for lowland agro-ecologies. This potentially means that not all important maize production characteristics of lowland agro-ecologies were fully researched. The study mainly uses information collected from the RRA/PRA farmer-group surveys, with limited information from individual farms, hence setting a limitation for more robust statistical analysis.

2. Maize Agro-ecologies in Vietnam

2.1 General Topography

Vietnam is a humid tropical country in Southeast Asia, with a total land area of 331,700 km^2 and a long coastline of 3,260 km. Although over 70% of the country is less than 500 meters above sea level (masl), three quarters of the country's total land area consists of mountains and hills. The terrain is highly varied and tends to slope down towards the sea in the east. It is low and flat in the Red River Delta in the north and in the Mekong River Delta in the south. The northeast and northwest region of the country is hilly and mountainous. The country's highest mountain peak, Fanxipang Mountain, is 3,143 masl, and is in the northwestern area of the country. Agricultural cultivation on high sloping land is greatly vulnerable to soil erosion, and flooding frequently occurs in the deltas, particularly in the Mekong Delta.

About 28% of the total land area of the country is agricultural land and 35% is forestland. Agricultural land is concentrated in the southeast, central highlands, northeast and north central coast regions, as well as in the Mekong and Red River deltas. Forested areas include the northeast, central coast, southeast and central highland regions. Plains cover about 25% of the country's total land area.

Although rice is the primary crop of Vietnam and is grown mostly in the deltas, rice-cultivating areas can be found in all parts of the country. The north of Vietnam as well as large parts of the southeast and central highland areas of the country are planted to perennial and non-rice crops. The southeast region and central highland regions have the largest areas planted to perennial crops (333.3 ha and 799.3 ha, respectively) such as rubber, coffee, tea, cashew nut, and black pepper, and about 327.9 ha of the Mekong Delta are planted with perennial crops, mainly fruit trees (Vietnam Statistical Yearbook 2001). In general, the climatic and soil conditions in Vietnam are favorable for the development of a diverse agriculture.

Maize is the second most important food crop after rice, and is cultivated in diverse environments. Upland rainfed maize areas are found mainly in the northeast, northwest, central highlands and southeast regions. Large areas of irrigated lowland maize are concentrated in the Red River Delta and north central coast, and only a small area of the Mekong Delta is planted to maize.

2.2 General Characteristics of Maize Production Agro-ecologies

At the beginning of the study, the research team identified eight ecological zones to be used for the identification of RRA and PRA survey sites. These zones were the northwest, northeast, Red River Delta, north central coast, south central coast, central highland, southeast, and the Mekong River Delta (Tran Hong Uy, 1988). As these eight ecological zones are relatively broad and do not fully capture the upland and lowland maize production environments, participants of the national workshop on identifying priority constraints for maize research and development suggested a further redefinition of these ecological zones based on the three major geographical regions as explained earlier (Figure 1). Following are the six maize production agro-ecologies identified and used in the survey:

- The northern lowlands (NL);
- The northern uplands (NU);
- The central highland-central coast lowlands (CHCCL);
- The central highland-central coast uplands (CHCCU);
- The southeast-Mekong Delta lowlands, (SEMDL); and
- The southeast-Mekong Delta uplands (SEMDU).

These agro-ecological distinctions serve as a framework for the identification of priority maize production constraints within the country. The major characteristics of these major maize agro-ecological regions are presented below.

2.2.1 Northern upland

This agro-ecological zone provides most of Vietnam's maize production. It is located mainly in the northwest and northeast regions of the country. The northwest region is primarily highland and mountainous with elevation ranging from 700 to more than 2,000 masl. The northeast region has both mountainous and midland areas with average elevations from 400 to 500 masl. The transportation system is poorly developed making it difficult to transport products to local markets or to other regions. Due to the steep sloping topography, soil erosion is a major constraint to agricultural cultivation. Maize is mainly cultivated in rainfed conditions, but irrigated maize is also found in areas having good access to irrigation systems. In the northwest, there is mainly one maize crop per year, whereas two maize crops are common in the northeast region. Most Vietnamese maize is grown in these northern upland regions, where both commercial and semi-commercial production systems exist. Maize plays an important role in farm household economy as food and animal feed and in providing farm income. The average farm size is about 1.5 ha.

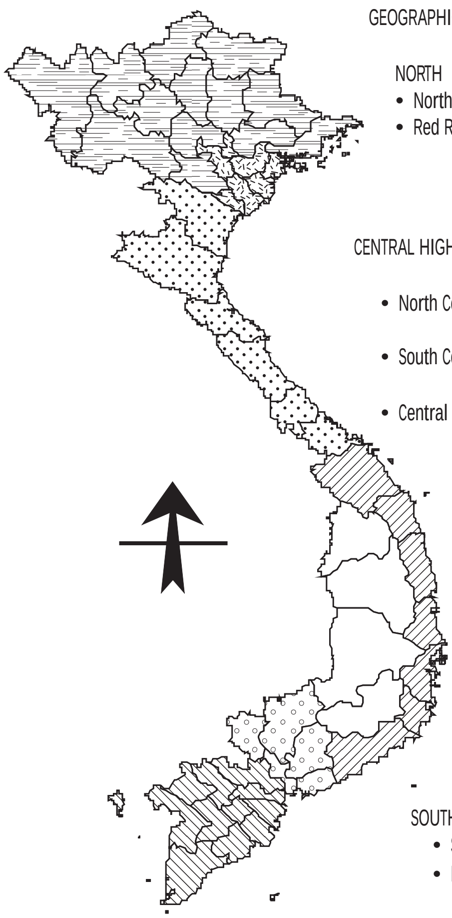


Figure 1. Map of Vietnam. Geographical regions where RRA and PRA surveys were conducted.

2.2.2 Northern lowland

This ecology is located mainly in the Red River Delta, the second largest rice-producing area of the country. These areas have well-developed irrigation systems and irrigated maize is common. Maize is usually planted in two seasons, the winter-spring and the spring-summer crop seasons. The winter-spring maize planted after two rice crops is the major maize-based cropping system in this agro-ecological zone. In most rural areas, farmers have good access to the market. Therefore even with small average farm sizes of about 0.3 ha, farmers produce maize commercially (usually for animal feed) in this agro-ecological zone, and income from cultivated maize is an important source of household income.

2.2.3 Central highlands—central coast upland

This ecology is found at elevations of 400-1500 masl, and is predominant in the central highland area, but also includes upland maize-producing areas of the central coast. The topology is relatively flat and is characterized by vast plains and meadows in the central highland areas, but is high sloping in the upland areas of the central coast and in Lam Dong province, where the risk of soil erosion is high. The infrastructure in most places is still underdeveloped. Soil and climatic conditions in this agro-ecological zone are very favorable for perennial crops such as coffee, rubber, and black pepper as well as annual crops like maize, beans, and cotton. This agro-ecological zone has the third largest maize growing area of the country, after the northern upland and the southeast-Mekong Delta upland agro-ecological zones. On the average, farmers have a relatively large farm size of about 1.3 ha but rural poverty is still very high. The common maize-based cropping systems are either a rainfed maize-beans crop, or one upland maize crop. Both commercial and semi-commercial maize production systems are found in this agro-ecological zone. One single maize crop planted in the summer-autumn crop season is usually found in semi-commercial maize production systems in areas with sloping topography and little access to markets. In the past, maize was an important food crop for most ethnic farmers, but easy access to cheap rice grown in other areas has reduced the importance of maize as food.

2.2.4 Central highlands—central coast lowland

This agro-ecological zone is located in the central coast lowlands, where commercial irrigated maize is the major maize production system. The dominant maize-based cropping pattern is winter-spring maize grown after two successive rice crops on very small farms averaging 0.3 ha. Maize is also planted in rotation with beans, tobacco, or sweet potato. Flooding and storms often negatively affect agricultural production during the rainy season, and rural poverty is remarkable in this area.

2.2.5 Southeast region—Mekong Delta upland

This agro-ecological region is located in the southeast region of Vietnam, between the Mekong Delta and the central highlands. Elevation varies from 100-200 masl. Topography ranges from medium to high sloping land in some areas, and elevation ranges from 100-200 masl. Seasonal flooding from rivers and streams during the rainy season, and drought during the dry season are two constraints to agricultural production in this area.

Rainfed maize is grown twice, in the summer-autumn and autumn-winter seasons. The common maize-based cropping pattern is maize-maize, although maize is also planted in rotation with beans and tobacco. This agro-ecological zone has the second largest area planted to maize in the country. Most maize areas in this region are planted for commercial production, as the relatively good road system and close proximity to a major feed processing center facilitate this. The average farm size is about 1.0 ha, and income from selling maize makes up a large share of total farm income.

2.2.6 Southeast region—Mekong Delta lowland

This agro-ecological zone includes the predominantly flat wetlands of the Mekong Delta. Little maize is grown here as compared to other agro-ecological zones of the country, but some maize is grown in the winter-spring dry season after two successive rice crops. Commercial irrigated hybrid maize varieties are grown in An Giang province. In other provinces, maize farmers mainly cultivate improved open-pollinated varieties (OPVs) and the local/traditional glutinous maize. This region has relatively large farms that average about 1.3 ha, with maize contributing little to the total farm income.

2.3 Biophysical Environment

2.3.1 Climate

The climate varies substantially between regions of the country, from temperate to subtropical in the north, and tropical in the south. The northern part of the country is affected by the northeast monsoon wind that makes the climate hot and rainy from May to October, and cold and sunny from November to April. The rainiest months are in the summer from May to September, but rainy days are also frequent in the winter months from January to March. The temperature is low in winter (15ºC) and high in summer (29ºC), with an annual average of 23°C. In the northwest area, the rainy season is from April to September with the highest rainfall in June and July, contributing to an annual rainfall of 1400 to 2000 mm. In the northeast, winter is cold and dry while heavy rain and storm damage may occur in the summer from June to August in the coastal provinces. The average temperature is 22.6ºC in Ha Giang province. Annual rainfall is 1400 mm in Lang Son province and 2300 mm in Ha Giang province. The annual average temperature is 23.4ºC in the Red River Delta, with a range from 16ºC in January to 28.8ºC in June and July. Annual rainfall is about 1800 mm with most of the rainfall concentrated in the period from May to October.

The southern part of the country has a tropical climate with hot weather in all months of the year. The annual average temperature is around 27ºC, with slight fluctuations throughout the year from 25ºC to 29ºC. There are two distinct seasons - a rainy season from May to October and a dry season from November to April. The rainy season in the southern part of the country begins about a month later than in the northern part of the country, with similar rainfall amounts. The southwest monsoon winds from May to November come across the Indian Ocean bringing an average annual rainfall of 1900-2000 mm to most of the southeast-Mekong Delta lowlands, and about 2200 mm to the higher elevations of the southeast-Mekong Delta uplands.

The central coast lowlands are affected by the western dry wind from Laos from April to June. In the central coastal region total rainfall is high, but unevenly distributed with very heavy rainfall from September to November and a long dry season of seven or eight months. From September to January, the northeast monsoon coming through the China Sea brings very high rainfall to the central coast highland region, which suffers from severe flooding and typhoon damage during the rainy season from September through November. This region also experiences extreme climate variation due to the 400-1500 masl elevation range. Annual average temperature varies from 21.4°C in Lien Khuong (Lam Dong) to 23.5°C in Buon Me Thuot (Dak Lak). Rainfall varies from 1757 mm in Lam Dong to 2396 mm in Pleiku (Gia Lai), with 70% of annual rain falling from May to October. The dry season, from November to April brings cold, dry, windy weather.

2.3.2 Soil types

During the PRA surveys, farmers were asked to describe and classify the type of soil of the land that they plant with maize. Farmers classified the soil based on soil texture and color, and also identified the advantages and different problems of each soil type. Red basal soil for example is largely found in the central highland-central coast upland and in the southeast-Mekong Delta upland agro-ecologies. The soil has good texture and drainage, deep cultivation depth, and is therefore easy to prepare for cultivation. Farmers consider this to be fertile soil good for the cultivation of annual crops like maize, beans, and groundnut, as well as for perennial crops like coffee, rubber, black pepper, and fruit trees. It is however susceptible to erosion, and soil nutrients are easily leached out, causing loss of both topsoil layer and soil fertility. Soil erosion control and soil fertility management are important for maintaining the productivity of this soil type.

Diverse soil types can be found across the six major maize agro-ecologies in the country (Table 2). Common soil types in the northern uplands are humic gray soil (humic acrisols), red-yellow humic soil (humic ferrasols), gray soil (ferralic acrisols), alluvium soil (eutric fluvisols) and new alluvial soil (dystric fluvisols) along rivers and creeks, and brown-red soil on limestone (luric calcisols). Alluvium soil (eutric fluvisols) is the most common soil type in the Red River Delta of the northern lowland agro-ecological zone. The central highland-central coast uplands have large areas with red basal soil (rhodic ferrasols) from basalt weathering. Other soil types found include degraded basal soil (ferric ferrasols), humic gray soils (humic acrisols) in the valleys, new alluvial soils (dystric fluvisols) along the rivers and large streams and some gray soils (haplic acrisols), stony black soils (lithic luvisols), black soil (humic gleysols), red-yellow soils (xanthic ferrasols), and red-brown soils (rhodic ferrasols). In the central highland-central coast lowlands, major soil types include alluvium (eutric fluvisols), sandy clay (gleyic acrisols), and sandy soils (haplic arenosols). Major soil types in the southeast region uplands are gray soils (haplic acrisols), reddish brown soils (rhodic ferrasols), red-yellow soil (xanthic ferrasols), stony black soils (lithic luvisols). Black soil (humic gleysols), new alluvial soils (dystric fluvisols) along river and large streams, low-humic clay soil (haplic acrisols) and swampy soil (staglic gleysols) in the valleys are also found there. Alluvium soil (eutric fluvisols) is the major soil type in Mekong Delta, but there are also large areas of acid sulfate soil (thionic fluvivols) and saline soils (salic fluvisols).

Based on the advantages and disadvantages of each soil type, farmers make crop management choices such as type of crop to plant, type and level of fertilizer application, and control of soil erosion and soil fertility issues (Table 2). Recognizing and understanding farmers' classification of their soils can help researchers and extension workers more effectively communicate and disseminate maize technologies.

2.4 Institutional Environment

2.4.1 Line agencies

The national ministries have their equivalent departments at the provincial level; however, the provincial People's Committee stipulates the tasks and responsibilities of these departments. The Ministry of Agriculture and Rural Development (MARD) supervises the professional extension system under the central level of the Division of Agricultural and Forestry Extension. MARD disseminates extension services to all provinces and most districts. At the village level, there is a cadre responsible for the agriculture sector but the responsibility for agricultural extension rests with the provincial extension center run by MARD. These extension centers transfer technology to the farmers by providing training in crop production, plant protection, animal husbandry, etc.

The extension system is highly centralized, is entirely dependent on the national budget for its funding, and operates from the national to the local level. Inadequate funding limits the service areas and the number of activities the system can provide to the farmers. There are too few extension workers, who are paid little, have poor working conditions, and have little incentive to perform their services well. Extension activities do not effectively address the real problems of the farmers.

Table 2. Soil types in the six major maize agro-ecologies, Vietnam, 2001.

Soil type (farmer's classification)	Soil type (technical equivalents)	Maize agro-ecology where found						Advantages	Disadvantages
		NU	NL	CHCCU	CHCCL	SEMDU	SEMDL		
Red basal soil	Rhodic Ferrasols			√		√		High fertility, good drainage, deep cultivation depth, easy for land preparation, good for various annual and perennial crops	The soil is susceptible to erosion, nutrient loss
Degraded basal soil	Ferric Ferrasols			√					Loss of fertile surface soil layer, surface is hard, poor soil structure, difficult land preparation, low yield, requires high fertilizer inputs
Sandy soil	Haplic Arenosols				√			Easy for land preparation, good drainage	Low fertility, need additional inputs, poor water-holding capacity, low yield
Sandy clay soil	Gleyic Acrisols				√			Good drainage, easy plowing in rainy season, good water access, good for rice, vegetables	Low fertility, low moisture content, hard during dry season, difficult land preparation, low yield
Black soil (humic clay)	Humic Gleysols			√		√		High fertility, good for rice field	Becomes sticky in rainy season, hardens and cracks in dry season, difficult land preparation
Low-humic clay soil	Haplic Acrisols					√		Good water-holding capacity	Low fertility, become waterlogged in heavy rain, difficult land preparation, low yield, requires high fertilizer inputs
Swampy soil	Stagnic Gleysols					√		High humus and moisture content, light texture, good for paddy rice	Become waterlogged in heavy rain, difficult land preparation, need to use potassium, phosphorus to improve soil fertility
Gray soils	Haplic Acrisols/ Ferralic Acrisols	√		√		√		Good drainage, deep cultivation depth, suitable for perennial crops with deep roots	Low to medium fertility, dry and easily eroded
Red-brown soil	Rhodic Ferrasols	√				√		Deep cultivation depth, good soil fertility, suitable for various crops	Susceptible to erosion and nutrient loss
Red/brown soil (on limestone)	Luric Calcisols	√						Deep cultivation depth, good soil fertility, suitable for various crops	Susceptible to erosion and nutrient loss
Red-yellow soil	Xanthic Ferrasols			√		√		Medium fertility, suitable for annual crops	Need additional inputs to obtain high yield, difficult land preparation in dry season
Alluvium soil	Eutric Fluvisols	√	√		√		√	Well-drained, fertile, rich in organic matter, suitable for rice, other annual crops	
New alluvial soils (along rivers,streams)	Dystric Fluvisols	√		√		√		Easy for land preparation, good for rice, maize, other annual crops	Drought in dry season, flooding in rainy season
Humic gray soils	Humic Acrisols	√		√				High fertility, good water holding capacity, easy for land preparation, good for rice field	Poor in phosphorus
Red-yellow humic soil	Humic Ferrasols	√						Relatively high fertility, suitable for perennial crops	Usually found in sloping land therefore difficult land preparation, low pH, susceptible to erosion
Stony black soil	Lithic Luvisols			√		√		High fertility, good drainage, good for various annual crops (maize, tobacco, beans), perennial crops (in area with deep cultivation depth)	Difficult land preparation mechanical land preparation not possible , shallow cultivation depth, water shortage
Acid sulfate soil	Thionic Fluvivols						√	Easy for land preparation, could be planted with rice, pineapple, other annual crops	Low pH, low soil fertility, need irrigation water for reducing acidity
Saline soils	Salic Fluvisols						√	Easy for land preparation, under good irrigation condition could be planted with rice and other non-rice annual crops	High salinity, dry, low soil fertility. Need fresh water for irrigation and fertilizer inputs to obtain high yield

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.
NU – northern upland; NL – northern lowland; CHCCU – central highland-central coast upland; CHCCL – central highland-central coast lowland; SEMDU – southeast region-Mekong Delta upland; SEMDL – southeast region-Mekong Delta lowland.

2.4.2 Cooperative and user groups

Agricultural cooperatives are operating in some of the surveyed villages but most provide only limited services that include helping farmers procure credit or inputs, and the collection of irrigation fees and land taxes. Input supply organization was once an important activity of the agricultural cooperatives, but nowadays farm inputs are readily and cheaply available through private traders.

However, cooperatives still play a relatively significant role in agricultural production in some villages of the central coast, as in Dien Phuoc and Dai Quang of Quang Nam province. These cooperatives organize irrigation, plan and organize collective mechanical land preparation and seeding, help farmers gain access to formal credit, and work with extension workers to disseminate technical information through farmer training.

Farmers associations and other social organizations like the women's association are present in all villages but have limited activities. Their activities may include supporting farmers in organizing training in crop or animal production, or helping poor farmers access formal credit sources. In some villages, farmers also form their own interest groups like a water user group for irrigation management or a small farmer's credit group.

2.4.3 Sources of inputs

In all surveyed villages, most inputs in maize production were supplied to farmers through the private trade system. The availability of inputs like fertilizer was good in most villages, except for the remote villages of the northern uplands and the central highlands-central coast uplands that were hard to access by road. While the major source of organic fertilizer comes from animal production at the farm, some villagers in the central highlands-central coast uplands bought manure from traders for high value crops like coffee and black pepper. Most farmers are aware that organic fertilizer is good for maize cultivation and for improving soil fertility, but few had enough manure on their farm or in other accessible places, to use for their maize crops.

The supply of improved OPV and hybrid maize seed comes from various sources, including extension services; the government marketing and distribution network at the provincial, district and some village levels; private companies; and local agricultural input wholesalers and retailers. In some areas, farmers have the additional option to obtain seed from farmers' associations, extension clubs, and local agricultural officers.

2.4.4 Credit institutions

Farmers need appropriate agricultural technologies, but they also need access to credit to buy them. Today, rural credit is indispensable for farmers if they are to increase agricultural production and their family's income. The most important credit source reported by farmers is the Vietnam Bank of Agriculture (VBA), established to provide short and medium term credit to rural public institutions, as well as farmers and the emerging private sector. A subsidized interest rate arm of this bank is the Vietnam Bank for the Poor (VBP), established in 1995 to offer subsidized credit to poor households, including poor farmer households. The VBP credit is administered through the People's Committees as the 'Hunger Eradication and Poverty Alleviation Scheme'. The main office of the VBA is in each province center with district branches.

Many farmers, however, reported having difficulties meeting the requirements (land use rights or collateral) demanded by the VBA for getting loans. Others reported being afraid of having no ability to pay back the loan. Information generated from farmer group discussions revealed that lack of credit for investment in agricultural production was one of the major constraints in agricultural production for poor farmers. Lack of credit and access to it seriously constrains resource-poor and collateral-less farm households from expanding their production, while larger and wealthier farmers are usually in a position to finance their own activities or have easy access to formal credit sources. The credit demand of maize farmers has only been partially met by the VBA.

When farmers cannot access formal credit, they borrow from private lenders, relatives, friends, other farmers, the women's associations, peasant associations or farmers' credit groups. Farmers, however, have to pay a relatively high interest rate when borrowing from private moneylenders or local traders, and can usually access only insufficient amounts from associations.

2.4.5 Prices of inputs and outputs

Major inputs purchased by farmers are hybrid and improved OPV seed, chemical fertilizers, and pesticides. For local maize, farmers usually keep their own seed at home. Few farmers also buy small quantities of local/traditional and improved OPV seed at local markets. These seeds cost the lowest ranging from 1700 VN Dong to 2500 VN Dong per kg (US$ 0.12-0.18/kg) (Table 3). Farmers, however, have to pay much higher price for hybrid seed, about 7 to 19 times that of local and improved OPV varieties. For the same type of hybrid seed, the price did not vary much among agro-ecologies. There are, however, significant price differences across various types of hybrids. The seed price of LVN 10, a single-cross hybrid planted by most farmers, is relatively lower than that of other hybrids such as DK 888 and those from Cargill and Bioseed seed companies. Across agro-ecologies, the price of LVN 10 seed ranged from 1800 VN Dong to 19000 VN Dong/kg (US$ 0.13-1.36/kg). Seed of Cargill hybrids registered the highest prices from 34000 VN Dong to 37000 Dong/kg (US$ 2.43-2.64/kg).

The prices of fertilizer did not vary much among ecologies, but were expectedly higher in remote upland areas with poor market access. In subsistence and semi-commercial production areas, the use of exchange labor is common among farmers. More hired labor is used in commercial maize production areas, particularly for labor-intensive activities such as land preparation, weeding, and harvesting. Hired labor is usually paid in cash, and the wage rate for hired labor did not vary much across regions. On the average, however, wage rate for men was higher than that for women, primarily because men are hired for more difficult activities such as land preparation, pesticide application, and transportation of inputs and produce, while women were hired for less difficult activities such as weeding and harvesting.

Compared to those in the lowland agro-ecologies, the prices of seed, chemical fertilizers, and pesticides were higher in the upland agro-ecologies due to higher transportation and other marketing costs. The rental rate for tractor power is also higher for more difficult working conditions in upland agro-ecologies than for lowland agro-ecologies. Farmers in irrigated areas of lowland agro-ecologies mainly pay irrigation fee. Land tax is another fixed cost that farmers have to pay. It is specified based on soil quality and is higher for the northern lowlands, southeast-Mekong Delta lowland, and central highland-central coast uplands as compared to other agro-ecologies.

Across agro-ecologies, the prices of maize grain do not vary much, and those in the lowlands are only slightly higher than those in upland agro-ecologies. Farm gate prices of maize grain ranged from 1300 VN Dong/kg to 2000 VN Dong/kg (US$ 0.09-0.14/kg) while average price at nearest market ranged from 1900 VN Dong to 2500 VN Dong/kg (US$ 0.14-0.18/kg) (Table 3). Grain prices of local/traditional varieties are slightly higher than those of hybrids but prices were the same for hybrid maize genotypes.

Table 3. Average prices of farm inputs and outputs, Vietnam, 2001.

	Major maize agro-ecologies					
Inputs	Northern Uplands	Northern Lowlands	Central Highlands-Central Coast Uplands	Central Highlands-Central Coast Lowlands	Southeast-Mekong Delta Uplands	Southeast-Mekong Delta Lowlands
Fertilizer (VND/kg)						
Urea	2300	2000	2100	2000	2200	2000
NPK	2600	2500	2600	2500	2500	2500
Phosphorus	1200	950	1250	900	1200	1000
Potassium	2300	2100	2300	2400	2200	2000
Maize seed (VND/kg)						
Local	1700	2000	2000	2000	2500	2500
OPV	2000				3500	2500
Hybrids: - VN10	19500	1800	18500	18000	18000	19000
- DK888	30000	29000	29000	29000	28000	
- Cargill			34000	37000	35000	
- Biocide	33000	33000	33000		32000	
Labor (VND/person/day)						
Men	20000	25000	25000	25000	25000	25000
Women	18000	20000	20000	20000	20000	20000
Pesticides (VND/liter)						
Bazudin	60000	21000	64000	22000	25000	20000
Bassa	195000	170000	195000	180000	190000	165000
Power rental						
Tractor-plowing (VND/ha)	160000	120000	120000	100000	130000	120000
Animal (VND/day)	32000	35000	37000	35000	37000	35000
Irrigation fee (VND/ha)		375000		300000		375000
Land rent (VND/ha)	360000	475000	435000	360000	37500	555000
Maize grain (VND/kg)						
Farm gate price	1300	1700	1400	1900	1400	2000
Nearest market price	2000	2200	1950	2100	1900	2500

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.
US$ 1.00 = 14,000 Vietnamese dong.

2.5 Infrastructure

Economic development in the rural areas of Vietnam depends on a number of critical infrastructure components, such as credit facilities, communication systems, and marketing facilities. A good rural infrastructure system plays a critical role in enhancing commercialization and modernization in the agricultural sector in general, and in increasing maize productivity growth in particular. Most upland agro-ecologies have only a poor and undeveloped infrastructure to support maize farmers.

2.5.1 Accessibility status

In general, the northern uplands, particularly in the mountainous areas of the northwest, have much poorer road systems than the other upland areas in the country. In villages where vehicle access is difficult, farmers use horses and cattle for transporting inputs and farm products. The roads of the northeast are better but still underdeveloped. Most upland villages in the survey have road systems connecting them to the district and province centers, which were built up in the last decade to facilitate the exchange of goods and inputs within the region. The local road systems within the village, however, are still poorly developed, making the transportation of inputs and farm produce difficult. The accessibility status (road conditions) of the surveyed villages is presented in Table 1.

Compared to the northern uplands, the central highland-central coast has a much better road system, but the upland villages of the central coast still have poor road access. Relatively good transportation systems are found in the southeast-Mekong Delta upland agro-ecologies, perhaps due to feed processing centers located near commercial maize growing areas. Table 4 presents the percentage of villages having vehicle access, by agro-ecological region.

Table 4. Percentage of villages having vehicle access, Vietnam, 2001.

Agro-ecology	Villages with vehicle access (%)
Northern Uplands	67.8
Northern Lowlands	99.6
Central Highland-Central Coast Uplands	90.1
Central Highland-Central Coast Lowlands	88.0
Southeast-Mekong Delta Uplands	96.4
Southeast-Mekong Delta Lowlands	66.1

Source: Computed using secondary data from Vietnam Statistical Yearbook, 2002.

The lowland areas of the Red River and the central coast usually have good transportation systems. The provinces of the Mekong River Delta located near Ho Chi Minh City also have good transport, but other Delta provinces have no well-developed road system and most transport of goods is done by waterway.

2.5.2 Markets and marketing practices

Most of the lowland villages surveyed have their own local markets. The average distance from farm to local market varies slightly among lowland villages, ranging from 2 - 4 km. In contrast, the average distance from farm to local market varied widely among the surveyed villages in the upland agro-ecologies. Farmers in the remote villages in the northern uplands and in the upland areas of the central coast have to walk a very long distance of 10 - 25 km to get to the nearest market (Table 1). Farmers in Phu Tam village in Soc Trang province of the Mekong Delta reported that they wanted to grow hybrid maize but would have difficulty selling their product, as the maize feed processing center is too far away, and no local marketing system exists. An efficient marketing system for maize for the feed processing industry is an important factor affecting the adoption of hybrid maize, and its absence in Soc Trang province severely limited production.

In most villages, the tractor is normally used for the transportation of large loads, while motorbikes are used for transporting small amounts of farm inputs and produce to and from the local market. Boats are an important means of transportation in the canals of the Mekong Delta. In remote villages of the northern uplands, local farmers have to transport farm produce and inputs to and from market manually or using horses and ox-cart. In most villages surveyed, however, farmers could buy farm inputs from warehouses or stores located near the main road of the village.

With a relatively large quantity of maize, farmers in most villages reported that they could sell their produce to local traders and collectors right at the farm gate. In commercial maize areas of the southeast region and the central highlands, farmers having a substantial yield prefer to sell fresh shelled maize to local traders right on the field at harvest. This marketing practice is more popular in the rainy season as farmers do not have sufficient drying and storage facilities. In villages with good road access, local traditional and improved OPV maize that is grown for fresh home consumption is sold at the farm gate to local traders who harvest and transport it.

Most farmers use local marketing channels operated by private traders. In commercial maize-producing areas, the marketing system also involves small village-based collectors and also commission agents, middlemen, and independent traders. There is intense competition among them to get the most farm produce to maximize their capital output.

2.5.3 Irrigation facilities

Irrigated maize is mainly grown in the lowland ecosystems where tubewells and communal irrigation cover more than 60% of the total arable land in the villages under survey (Table 1). There is well-developed irrigation infrastructure in the surveyed villages of the northern lowland and the southeast-Mekong Delta lowland agro-ecologies. In most upland villages, more than 60% of the total agriculture land is rainfed, with communal irrigation systems present primarily to supply water for rice production. Groundwater irrigation is widespread in the central highlands, but is mostly used for high value crops like coffee and black pepper. Overuse of groundwater on a large scale for coffee irrigation can threaten the groundwater resources.

2.5.4 Processing and post-harvest facilities

The majority of small farmers throughout the country shell their maize manually. However, in the commercial maize growing areas of the southeast region and the central highlands, the corn-shelling machine, recently introduced to farmers to reduce labor costs, has become popular. Large maize farmers usually hire the corn-shelling machine to reduce labor and time, especially when the crop is harvested under unfavorable weather conditions. In some commercial maize areas of the southern central coast, farmers also commonly use a small electric shelling device.

Few drying facilities exist at the farm level in most upland villages in the survey, and there are no large storage facilities at the village level. Farmers usually dry their maize under the sun, using flat cement floors or roads, drying baskets, or on top of plastic sheets. Sun-dried maize grains are stored in plastic sacks at home. A limited number of power-operated drying facilities are available, mainly in large commercial maize areas and to serve local traders during rainy season. While there are a number of existing multipurpose mills in all surveyed villages, only a few farmers in semi-commercial villages practice corn grinding, mainly for farm animal feed. Commercial maize farmers also report that they do not store maize for long periods due to high storage losses due to weevils.

2.6 Socioeconomic Characteristics

2.6.1 Households and ethnicity

The number of households varied widely among the villages in the survey. The villages of the lowland agro-ecologies had from 1,420 to 15,960 households (Table 1). Very high numbers of households were recorded in the surveyed villages in the central highland, ranging from 10,167 to 18,583 households. In other upland villages, the total number of households per village varied from 140 to 8,191. On the other hand, the average household size did not vary much across agro-ecologies, ranging from 5.2 to 5.9 members per household.

There are 54 different ethnic groups in Vietnam. The Kinh people account for nearly 90% of Vietnam's total population. Major ethnic minority groups include Tay, Thai, Muong, H'Mong, Dao and Khmer, most of whom live in the upland areas of the country. The vast majority of all households in the northern lowlands and the central highland-central coast lowlands and a smaller majority of the households in the southeast-Mekong Delta lowland agro-ecologies are Kinhs. The second and third largest ethnic groups are the Khmer and Vietnamese Chinese, with little representation from the other ethnic groups in the surveyed villages.

A diversified ethnic composition was reported in the upland villages of the northern upland, the central highlands and central coast uplands, and the southeast-Mekong Delta upland agro-ecologies. On the average, Kinh people comprised 43% to 55% of the total households in the surveyed villages (Table 5). In the northern upland, the major ethnic minority groups are Tay and Thai, followed by the Muong, Hoa, Nung, and H'mong. In the villages of the central highland-central coast upland, the ethnic minority groups include Bana, Chill, Churu, Ktu, Ede, Giarai, Muong, Hoa, K'ho, Tay, Man, Nung, and Thai. The ethnic composition in many areas of this agro-ecological zone has changed as large

Table 5. Ethnic composition of population in survey sites, Vietnam, 2001.

	Percentage of total households	
Agro-ecology	Kinh	Other ethnic groups
Northern Uplands	43	57
Northern Lowlands	100	0
Central Highland-Central Coast Uplands	53	46
Central Highland-Central Coast Lowlands	100	0
Southeast-Mekong Delta Uplands	55	45
Southeast-Mekong Delta Lowlands	54	46

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.
Note: Other ethnic groups include Tay, Thai, Muong, Man, Nung, Hoa, Giao, Tho, H'mong, Bana, Chill, Churu, Ktu, Ede, Giarai, and K'ho.

numbers of people of the Muong, Hoa, K'ho, Tay, Man, Nung, and Thai ethnic minority groups have migrated from the northern provinces over the last few decades. In the surveyed villages of the southeast-Mekong Delta upland, there is a relatively large number of Vietnamese Chinese ethnic minority groups. Other ethnic minority groups are Nung, Tay, Giao, and Tho.

2.6.2 Farmer classification

Farmer-respondents in the upland agro-ecologies were asked to classify maize farmers in their respective villages as an exercise in wealth ranking. They first chose to classify maize farmers by the size of their farm, then by availability of cash for farm investment, level of technical knowledge, and a few more minor considerations (Table 6).

Farm size that ultimately defined each farmer group varied substantially in each village, and reflected or indicated some or all of the following farmer characteristics:

- Ability to produce enough food for the family;
- Ability to produce surplus to sell for income;
- Ability to sustain a variety of crops on his farmland;
- Ability to adopt farm mechanization (tractor);
- Access to credit; and
- Level of education or training that allows them to understand and adapt new farming technologies.

The second most important criterion of farmer classification was either availability of cash for farm investment (as stated by farmers in the northern uplands and the central highland-central coast upland agro-ecologies), or level of farmer's technical knowledge (as stated by farmers in the southeast-Mekong Delta upland agro-ecological zone). Farmer-respondents characterized farmers with adequate capital as those having enough credit or personal capital to pay at least 95% of the annual investment in crop and animal production. This allows them to invest intensively in farming, to use advanced technology and to buy adequate levels of inputs such as seed, fertilizer and hired labor. Farmers without access to formal credit must practice non-intensive agriculture or borrow money from informal sources.

The level of a farmer's technical knowledge is used either as the second or third criterion for farmer classification. Farmer respondents identified other farmers as having good technical knowledge based on their level of education and training, their ease of access to technical advice, and technical understanding of wise farming practices. Farmers rated as having little technical knowledge were identified by their low level of educational or training as well as poor farming practices that result in lower income status.

Other classification criteria used by farmers include level of commercial farming, major source of farm income, ownership of farm machinery and draft animals, and farmer age.

Respondents also pointed out the negative aspects of different characteristics of maize farmers:

- Poor or medium farmers may have food security in that they can raise enough to feed their family, but have no crops to sell for cash to satisfy other family needs;
- Owners of draft animals get animal labor and organic fertilizer, but must have feed for the animals and manpower to use them;

Table 6. Classification of farmers in the surveyed villages, Vietnam, 2001.

Upland agro-ecology	First criterion (farm size)	Second criterion	Other criteria
North	· Large · Medium · Small	· Adequate cash for farm investment · Lack of cash for farm investment	· Technical knowledge · Level of commercial farming · Ownership of machinery, draft animals · Age of farmers
Central Highlands- Central Coast	· Large · Medium · Small	· Adequate cash for farm investment · Lack of cash for farm investment	· Technical knowledge · Level of commercial farming · Source of major farm income · Ownership of machinery, draft animals · Age of farmers
Southeast-Mekong Delta	· Large · Medium · Small	· Having good technical knowledge · Having poor technical knowledge	· Availability of cash for farming · Level of commercial farming · Source of major farm income · Ownership of machinery, draft animals · Age of farmers

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

- Large or rich farmers may not have enough in-house (i.e. family) labor to work the farm;
- Commercial farmers can earn a high cash income, but it is dependent entirely on a market where prices can fluctuate up or down;
- Machine owners can harvest and plant on time, but also have associated manpower and maintenance costs;
- Younger farmers usually have fewer assets and less capital than older farmers, but they have more energy, strength, and willingness to learn and adopt new technologies.

The PRA survey of farmer classifications revealed that farmers within any community are very diversified as to their land, educational attainment, credit, and technological assets. Understanding these differences is important to the successful design and implementation of development interventions.

2.6.3 Literacy and level of education

The distribution of population by literacy and education level across agro-ecologies is shown in Table 7. The majority of the surveyed population has attended or completed elementary school. More people surveyed in the lowland agro-ecologies have attended or completed secondary school or university than in the upland agro-ecologies, with a low of 19.9% in the northern uplands to a high of 56.3% in the central highland-central coast lowland region. Remote upland villages populated predominantly by ethnic minorities had the lowest educational levels. Illiteracy was higher in these villages than in the general population. For example, in the central highland-central coast uplands, illiteracy in such villages as Ating village in Quang Nam province, Cour Knia village in Dak Lak province and Kado and Pro' village in Lam Dong province, ranged from 8% to 20% of the total population. However, illiteracy was low in most other surveyed villages with a maximum of only 5% of the population.

Table 7. Distribution of population by literacy and education levels in surveyed villages, Vietnam, 2001.

Agro-ecology	Illiterate (%)	Elementary (%)	High-school (%)	University (%)
Northern Uplands	1.7	79.4	16.6	3.3
Northern Lowlands	0.0	56.5	35.0	8.5
Central Highland-Central Coast Uplands	8.6	62.1	28.7	0.6
Central Highland-Central Coast Lowlands	0.0	43.7	45.8	10.5
Southeast-Mekong Delta Uplands	5.0	54.0	40.0	1.0
Southeast-Mekong Delta Lowlands	5.0	55.0	35.0	5.0

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

2.6.4 Landholdings and tenure systems

Across all agro-ecologies in the country, the average farm size in the lowland is much smaller than that of the uplands, except for the southeast-Mekong Delta lowland where the average farm size is relatively large (Table 8). Very small farm size of about 0.3 ha was recorded in the northern lowland and the central highland-central coast lowland. Among the upland villages under survey, average farm size also varied widely. The lowest average farm size of 0.28 ha was recorded for Thanh Van village in Phu Tho province and the highest average farm size of about 3.5 ha in Pache villages of Son La province. All commercial maize-producing villages in the uplands have an average farm size of more than 1.0 ha. The farm size also varied among local farmers within one village. Some have farms too small to produce enough food or generate enough income for the family. In all surveyed villages, most of the land cultivated by farmers is family owned, and there are few landless farmers overall.

While most farmers in the lowland agro-ecologies have been provided the red book (land use certification) for the land they own, many farmers in the upland agro-ecologies still do not have legal land use privileges for cultivating the land they do, particularly farmers in villages located near forest areas. These farmers cannot access formal credit sources and have little incentive to invest in land that is not theirs.

Table 8. Distribution of income by sources in surveyed villages, Vietnam, 2001.

Agro-ecology	House-hold size	Farm size (ha)	Percentage of total household income: Maize sale	Other agricultural income	Non-agricultural income
Northern Uplands	5.9	1.5	32.7	60.0	7.3
Northern Lowlands	5.2	0.3	14.5	47.0	38.5
Central Highland-Central Coast Uplands	5.7	1.3	16.6	73.3	10.1
Central Highland-Central Coast Lowlands	5.2	0.3	14.2	54.5	31.3
Southeast-Mekong Delta Uplands	5.7	1.0	22.0	76.0	2.0
Southeast-Mekong Delta Lowlands	5.7	1.3	0.5	79.5	20.0

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

2.6.5 Level of income and poverty

Agriculture is the most important source of income in all surveyed villages, although the contribution of maize to farm income varied widely among agro-ecologies, ranging from 0.5% to 32.7% of the total farm income, and making up less than 40% of total farm income across all surveyed villages (Table 8). The sale of maize made a higher contribution to farm income in the upland agro-ecologies compared to that of the lowland agro-ecologies. Upland maize farmers however have less non-farm income than do farmers in the lowlands. In the maize growing villages located near big cities like Hanoi and Ho Chi Minh City, there are opportunities for young villagers to find a job in the city and to send a portion of their income back to the villages.

A high level of poverty still exists in rural areas, although Vietnam on the whole has experienced relatively high economic growth in recent years. Approximately 16% of the total population is very poor, with the highest levels of poverty (19.7-23.3%) recorded in 1999 in the northern upland and in the upland and lowland areas of the central highlands-central coast (Table 9).

2.6.6 Maize utilization

Maize has become a major element of people's diets and the preferred substitute for rice during periods of rice shortage, especially for ethnic minorities in the northern upland and the central highland-central coast upland. Most maize, however, is grown not for human consumption, but for animal feed as the livestock and poultry production industry in the country has rapidly expanded. The proportion of total maize production used as human food is also negatively impacted by the availability of cheap rice.

Across the agro-ecologies, the average proportion of maize sold to the market is high, ranging from 40% to 97% of the total maize production (Table 10). Most of the maize kept for home consumption is used for farm animals, mainly for raising pigs and poultry. The proportion of maize used for farm animals is relatively high in central highland-central coast lowland and the northern upland and lowland agro-ecologies, ranging from 28.5% to 60% of the total production, which corresponds to the larger numbers of pigs and poultry raised by farmers in these agro-ecologies.

On the average, around 13% and 10% of the total production of maize is used for human consumption in the central highland-central coast upland and in the southeast-Mekong Delta lowland agro-ecological zones, respectively. In all other agro-ecologies, less than 10% of total maize production is used for human consumption. However, in villages with a high proportion of ethnic minorities, more maize is allocated for home than in other villages, as 40% of the maize yield was allocated for human consumption in Phong Quang village (Ha Giang province), 35% being allocated in Ating village (Quang Nam Province), and 30% in Kado village (Lam Dong Province). Maize used for human consumption is mainly local/traditional varieties. In all surveyed villages, the proportion of maize kept for seed was very small.

Table 9. Rural poverty situation in Vietnam, 1999.

Agro-ecology	Rural population ('000)	Rural poverty (%)	Number of rural poor ('000)	Share of total rural poor (%)
Northern Uplands	9,268	19.8	1,832	0.22
Northern Lowlands	13,516	8.7	1,169	0.14
Central Highland-Central Coast Uplands	5,714	23.3	1,332	0.16
Central Highland-Central Coast Lowlands	10,866	19.7	2,140	0.25
Southeast-Mekong Delta Uplands	5,743	7.4	427	0.05
Southeast-Mekong Delta Lowlands	13,409	11.7	1,574	0.19

Source: Computed using poverty data for 1999 in *Population and Socioeconomic Statistics Data 1975-2001*, General Statistics Office, 2002.

Table 10. Utilization of locally produced maize as % of total production, Vietnam, 2001.

Agro-ecology	Sold to market (%)	Home consumption (%)			
		Total	Human consumption	Animal feed	Seed
Northern Uplands	62.2	37.8	9.0	28.5	0.3
Northern Lowlands	40.0	60.0	0.0	60.0	0.0
Central Highland-Central Coast Uplands	73.3	26.7	13.1	13.5	0.1
Central Highland-Central Coast Lowlands	70.0	30.0	0.7	29.1	0.2
Southeast-Mekong Delta Uplands	97.0	3.0	1.0	2.0	0.0
Southeast-Mekong Delta Lowlands	89.0	11.0	10.0	0.0	1.0

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

3. Maize Production Trends and Systems

3.1 Maize Production Trends

In the period from 1961 to 1980, the area planted to maize increased from 260,200 ha to 389,600 ha. Maize varieties used were mostly local cultivars, synthetics, and composite. A few imported hybrid maize varieties were planted in a very small area, and these yielded a low average of about 1.1 t/ha. From 1980 to 1992, maize area increased to 478,000 ha and the wide adoption of improved open pollinated varieties increased average yield from 1.1 t/ha in 1980 to 1.56 t/ha in 1992 (Tran Hong Uy 1998).

Since 1991 the government has strongly supported the introduction of hybrid maize throughout the country. Hybrid seed production increased domestically as did hybrid seed importation, and hybrid maize varieties were widely adopted by farmers to replace low yielding local/traditional and open pollinated varieties. Hence in 2000, area planted to maize was an impressive 730,200 ha and yield averaged at 2.75 t/ha (Table 11). Currently, large commercial maize areas are concentrated in the upland agro-ecologies, namely the northern upland, southeast-Mekong Delta upland, and central highland-central coast upland. In the southeast-Mekong Delta lowland agro-ecology, there is only a small area of maize.

Table 11. Area, production and yield of maize, Vietnam, 1995-2000.

	Crop years					
Agro-ecology	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Area ('000 ha)						
Northern Uplands	214	249	244	250	268	287
Northern Lowlands	95	89	114	105	103	93
Central Highland-Central Coast Uplands	65	61	90	90	97	111
Central Highland-Central Coast Lowlands	67	75	82	81	94	97
Southeast-Mekong Delta Uplands	95	121	115	107	112	123
Southeast-Mekong Delta Lowlands	20	21	18	17	18	19
Total maize area	**557**	**615**	**663**	**650**	**692**	**730**
Production ('000 t)						
Northern Uplands	340	469	467	497	553	653
Northern Lowlands	249	267	349	306	320	280
Central Highland-Central Coast Uplands	142	153	256	261	281	380
Central Highland-Central Coast Lowlands	117	150	178	177	215	239
Southeast-Mekong Delta Uplands	245	411	345	317	336	402
Southeast-Mekong Delta Lowlands	84	91	55	54	48	52
Total maize production	**1177**	**1541**	**1651**	**1612**	**1753**	**2006**
Yield (t / ha)						
Northern Upland	1.59	1.80	1.86	1.95	2.05	2.28
Northern Lowland	2.70	3.00	3.17	3.08	3.20	3.11
Central Highland-Central Coast Uplands	1.91	2.70	2.68	2.85	2.84	3.65
Central Highland-Central Coast Lowlands	1.71	1.90	2.09	2.06	2.07	2.48
Southeast-Mekong Delta Uplands	2.69	3.40	3.17	3.10	3.13	3.34
Southeast-Mekong Delta Lowlands	4.16	4.40	3.12	3.16	2.72	2.73
Average yield	**2.11**	**2.50**	**2.49**	**2.48**	**2.53**	**2.75**

Source: Computed using secondary data from Statistical Yearbook, 2001 and Statistical Data of Vietnam Agriculture, Forestry and Fisheries 1975-2000.

Major factors contributing to the rapid increase in hybrid maize area in Vietnam include the improvement of market access and commercialization of the upland systems, increasing demand of maize for animal feed, strong support from the government (particularly through policies supporting research and extension activities to expand hybrid maize production) and technical and financial support from international organizations such as FAO and CIMMYT.

The increase in maize production and yield varied among agro-ecologies. From 1995 to 2000, maize area increased in all upland agro-ecologies but decreased in lowland agro-ecologies, except in the central highland-central coast lowland, due to the competition for land by other cash crops. In the southeast-Mekong Delta lowland agro-ecology, not only maize area but also average maize yield declined due to the unfavorable market outlet for feed maize. However, in all other agro-ecologies, maize yield increased over this period, mainly due to the adoption of hybrid maize varieties. The average yield is relatively high in the northern lowland, the central highland-central coast upland, and the southeast-Mekong Delta, ranging from 3.11 t/ha to 3.65 t/ha.

3.2 Maize Production Systems

3.2.1 Major farm enterprises

In all the surveyed villages, agricultural production is the major occupation of local farmers, and most farm investment is concentrated on crop production. Although animal husbandry is an also important farm enterprise, the level of animal production and its importance to farm income varied across surveyed villages. The average number of animals by type raised per household in each agro-ecology is reported in Table 12. In addition to providing meat, cattle and buffalo are used as draft animals for land preparation and transportation. The number of swine and poultry per household was reported to be high in the northern upland and lowland and central highland-central coast lowland as compared to other agro-ecologies in the country. While inland fisheries is a well-developed farm enterprise in many villages of the southeast-Mekong Delta lowland agro-ecology, there is little fish cultivation in lands devoted to maize.

There are few non-farm work opportunities in the upland areas. Buying and selling activities and local service businesses are mainly concentrated in and near local markets or along the main road of the village. In upland villages located close to large forest areas, forest protection and harvesting of forest products are important livelihood activities for resource-poor farmers.

3.2.2 Maize cropping patterns and calendar

There is diversity in the numbers and types of crops grown across agro-ecologies. In the upland agro-ecologies, maize is the second most important food crop after rice, and rice is cultivated in one or two crops per year. Cassava, sweet potato, beans, tea, and fruit trees are other major crops grown by farmers in the northern upland. Important crops grown in the central highland-central coast upland and the southeast-Mekong Delta upland are cassava, beans, groundnut, tobacco, sugar cane, cotton, coffee, rubber, cashew, and black pepper.

In the lowland agro-ecologies, maize is also the second most important food crop after rice, except for the southeast-Mekong Delta lowland. In most places irrigated rice is cultivated in two to three crops per year, and other important crops grown include sweet potato, beans and groundnut in the northern lowland; sweet potato, groundnut, sugarcane, and cassava in the central highland-central coast lowland; and sweet potato, vegetable, and fruit trees in the southeast-Mekong Delta lowland.

Cropping calendars and cropping patterns differ across agro-ecological zones, reflecting variations in environmental conditions like soil, topography, irrigation, drainage, rainfall and other climatic characteristics. Farmers in the northern upland agro-ecology can grow three crops of maize, with the spring-summer maize crop planted in January/February and harvested in May; the summer-autumn crop planted in April/May and harvested in August; and a large area of maize is planted in September/October and harvested in January; (Table 13). The autumn-winter maize sown by the end of July or early August and

Table 12. Average number of livestock per household in surveyed villages, Vietnam, 2001.

Agro-ecology	Buffalo or cattle (heads)	Swine (heads)	Poultry (heads)	Fish (water area, m^2)	Goat (heads)
Northern Uplands	2.1	4.1	34.8	6.7	0.0
Northern Lowlands	0.7	3.5	25.0	10.0	0.0
Central Highland-Central Coast Uplands	0.8	1.9	7.7	20.8	0.0
Central Highland-Central Coast Lowlands	0.8	3.0	16.7	5.0	0.1
Southeast-Mekong Delta Uplands	0.0	0.6	5.5	0.0	0.0
Southeast-Mekong Delta Lowlands	0.0	1.2	10.0	15.0	0.0

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

harvested in November covers only a small area. In this agro-ecology, the winter-spring maize or in some areas the autumn-winter maize planted after two rice crops is an important cropping pattern covering 45.4% of the total maize area (Table 14). The spring-summer maize as the first crop, followed by two rice crops, also comprises about 17.8% of the maize area. These cropping patterns are mainly concentrated in irrigated areas, particularly in the northeastern provinces near the Red River Delta. A single spring-summer maize crop is more common under rainfed conditions. This cropping pattern covers about 22.1% of the total maize area. The pattern of two continuous maize crops contributes only about 12.6% of the total maize area in the northern upland agro-ecology.

Table 13. Distribution of maize area by crop seasons (% of total maize area), Vietnam, 2001.

Agro-ecology	Spring-summer	Summer-autumn	Autumn-winter	Winter-spring
Northern Upland	19	34	1	47
Northern Lowland	50	0	0	50
Central Highland-Central Coast Upland	3	75	21	1
Central Highland-Central Coast Lowland	7	12	0	81
Southeast-Mekong Delta Upland	0	59	41	0
Southeast-Mekong Delta Lowland	100	0	0	0

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

In the northern lowland agro-ecology, the dominant pattern is one maize crop and two rice crops. Maize is planted either in the winter-spring or spring-summer crop seasons. Winter-spring maize is fitted as the third crop to the cropping pattern of spring rice-early summer rice-winter maize. Winter-spring maize planted in September/October and harvested in January has become a stable cropping pattern in this agro-ecology. Maize-soybean-maize is also a common cropping pattern with two maize crops planted in the spring-summer and winter-spring seasons. Winter-spring maize planted after two rice crops is also the main maize crop in the central highland-central coast lowland agro-ecology covering about 62.6% of the total maize area (Table 14). Winter-spring maize is usually planted in September/October and harvested in January/February, with two maize crops planted under both irrigated and rainfed conditions. This cropping pattern is followed on about 15.9% of the total maize area. Maize is usually planted in the spring-summer season from January to April/May and in the summer-autumn season from May to August/September. Summer-autumn maize is planted after two crops of beans or after one crop of tobacco, beans, or groundnut. The area planted with one maize crop is relatively small, and is confined mainly to rainfed ecosystems. Figure 2 presents the crop calendar for the different maize agro-ecologies in Vietnam.

In the central highlands-central coast upland agro-ecology, maize is cultivated mainly in the summer-autumn and autumn-winter seasons, with summer-autumn maize (the major maize crop) planted in April-

Table 14. Distribution of major cropping patterns (% of total maize area), Vietnam, 2001.

Cropping patterns	Northern Upland	Northern Lowland	Central Highland-Central Coast Upland	Central Highland-Central Coast Lowland	Southeast-Mekong Delta Upland	Southeast-Mekong Delta Lowland
Maize-rice-rice	17.8	0.0	0.0	0.0	0.0	100.0
Rice-rice-maize	45.4	67.0	0.0	62.6	0.0	0.0
Maize-soybean-maize	1.1	33.0	0.0	0.0	0.0	0.0
Maize	22.1	0.0	31.5	3.0	0.0	0.0
Maize-beans (intercropping with coffee)	0.0	0.0	4.3	0.0	2.0	0.0
Maize-maize-watermelon	0.0	0.0	0.0	0.0	2.9	0.0
Maize-maize	12.6	0.0	8.7	15.9	70.0	0.0
Maize-beans	0.0	0.0	16.4	0.0	20.0	0.0
Maize-sesame	0.0	0.0	0.0	2.9	0.0	0.0
Maize-cotton	0.0	0.0	10.9	0.0	0.0	0.0
Maize-maize-maize	1.1	0.0	0.0	0.3	0.1	0.0
Groundnut-maize	0.0	0.0	0.0	4.5	0.0	0.0
Beans-maize	0.0	0.0	26.4	7.9	5.0	0.0
Maize-maize+beans	0.0	0.0	0.2	0.0	0.0	0.0
Upland rice-maize	0.0	0.0	0.2	0.0	0.0	0.0
Maize-maize+upland rice	0.0	0.0	1.4	0.0	0.0	0.0
Beans-beans-maize	0.0	0.0	0.0	1.5	0.0	0.0
Tobacco+chili-maize	0.0	0.0	0.0	1.5	0.0	0.0

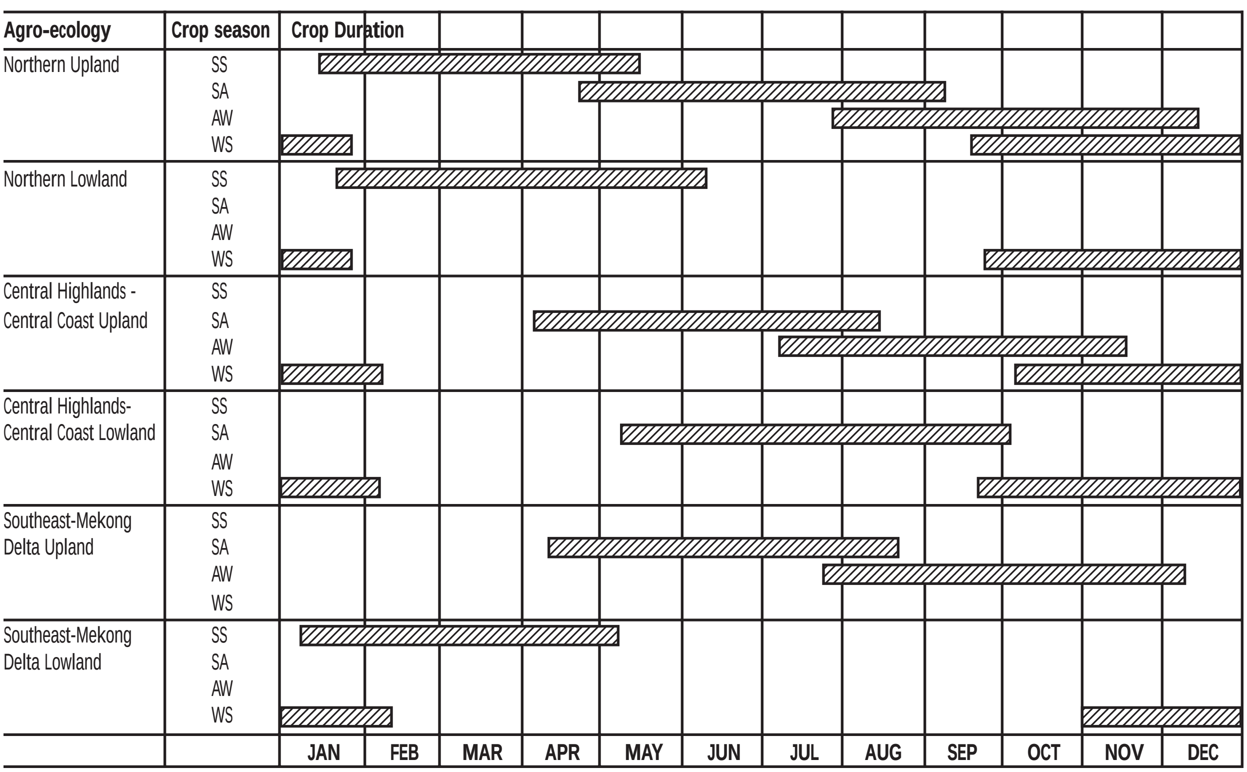
Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

May and harvested in July-August. Autumn-winter maize is planted in July-August and harvested in October-November. In many rainfed upland areas of this agro-ecology, there is usually a single monocrop maize planted in the summer-autumn crop season, contributing about 31.5% of the total maize area (Table 14). A single summer-autumn maize crop is usually planted in semi-commercial maize production areas with sloping topography and more difficult access to market. The maize-maize pattern planted in the summer-autumn and autumn contributes to 8.7% of the maize cultivated area. In many areas, farmers intercrop maize with beans or groundnuts, or they replace the second maize crop with beans to maintain soil fertility. Upland farmers commonly grow summer-autumn maize as the first crop, followed by a crop of beans or cotton. In coffee producing areas of the central highland, maize and beans are also intercropped with coffee. Another common cropping pattern is one autumn-winter maize crop planted after beans. In some sloping lands, there is also a small area planted with autumn-winter maize after an upland rice crop. The normal winter-spring maize is planted in December-January and harvested in April, but some areas planted spring-summer maize in January-February and harvested in May.

In the southeast-Mekong Delta upland agro-ecology, two rainfed maize crops (summer-autumn and autumn-winter) are common, covering about 70% of the total maize cultivated area. Summer-autumn maize, the major crop is planted in April to early May, and harvested in July to early August, and autumn-winter maize is planted at the end of July to early August and harvested at end of October to early November. Many farmers also plant maize and beans in rotation to maintain soil fertility.

In the southeast-Mekong Delta lowland agro-ecology, one winter-spring or spring-summer maize crop planted after two rice crops is the dominant maize-based cropping pattern. A maize crop is planted on land with relatively high elevation either in November and harvested in January-February or in January and harvested in April. Commercial irrigated maize, mainly hybrid varieties, is cultivated in An Giang province, but semi-commercial maize production systems with OPV and local glutinous maize varieties are common in other provinces.

Figure 2. Maize crop calendar, Vietnam, 2001.



Note: SS= Spring-summer, SA= Summer-autumn, AW= Autumn-winter, WS= Winter-spring.

3.2.3 Soil management

Among the upland villages surveyed, soil erosion and fertility deficiency are major constraints to increasing maize productivity. Under sloping soil conditions with high rainfall, the risk of soil erosion is high in most upland villages of the northern upland and the central highlands-central coast upland agro-ecologies. The level of soil depletion varies across surveyed sites depending on cropping intensity, topography, soil characteristics, and rainfall. A very high level of soil fertility loss was reported in upland villages where ethnic minority peoples cultivate maize in a slash and burn cultivation system on sloping land. In Ating village (Quang Nam province), farmers reported that maize yield declines rapidly after cultivating for two or three years on cleared forestland without chemical fertilizer inputs. In some areas, farmers report that high soil erosion has led to irreversible land productivity damage.

Farmer-respondents nevertheless opined that different measures to control soil erosion and losses in soil fertility could be adopted. To maintain or improve soil fertility, some farmers replace the second maize crop with a legume crop such as green beans, soybean, or groundnut, and others intercropped maize with legume crops. Farmers also use organic fertilizer and lime to improve soil fertility, but many farmers also reported that more chemical fertilizers are needed to increase soil fertility.

For soil erosion control, farmers discussed such available options as planting pineapple, banana, or other crops or bushes around field boundaries; using contour lines during land preparation; or intercropping maize with perennial crops such as coffee or fruit trees. They also mentioned that reducing land preparation and weeding on steep sloping lands would reduce soil erosion. Only a few farmers, however, apply soil erosion control measures, and farmers reported that under sloping land conditions, the return of investment in soil erosion control is low. In the central highland-central coast upland and the southeast-Mekong Delta upland agro-ecologies, farmers did not use organic fertilizers to improve soil fertility because these were not available even for higher value crops such as coffee and black pepper. Proper soil management is, therefore, an important factor for stabilizing maize yields under upland conditions.

One common method practiced by ethnic farmers in the uplands was to let the land lie fallow for a certain period. Farmers return to cultivate the rested land when natural vegetation is recovered. In the past, many ethnic farmers in the central highland, the southeast region, and in mountainous areas of northern provinces, and the southern central coast region also used this method of recovering soil fertility, but increasing population pressures now make this practice unfeasible for most upland areas. Government policy does not allow shifting cultivation, although ethnic people in Ating village of Quang Nam province practice it anyway. Some ethnic farmers in Lam Dong province also practice shifting cultivation, but under higher population pressure and limited land resources, the fallow period becomes too short, leading to faster soil degradation.

3.2.4 Maize varieties grown and farmer preferences

Until 1991-1992, maize farmers planted mostly improved OPVs and local varieties. The rapid expansion of area planted to hybrid maize was attributed to the research, development, and promotion of hybrid maize in the late 1990s. In commercial maize-producing villages, hybrid maize replaced old OPV cultivars and traditional maize varieties and made up 89% of the total maize grown. Popular maize varieties planted by farmers include LVN 10, DK 888, DK 999, LVN 20, and hybrids released by private companies such as Pacific, Bioseed, and Cargill. The variety planted most widely is LVN 10 due to its good field performance and relatively cheap seed compared to other hybrids. Farmers in many areas also like DK 888 for its high yield potential, but its seed price is restrictive. Farmers did not adopt Bioseed and Pacific hybrid maize varieties because the price of seed is a major constraint.

Sweet corn, an improved OPV with good eating quality, was adopted by farmers in Soc Trang province of the Mekong Delta and in some villages in the southeast region for producing fresh maize for cooking and selling to local markets. In many commercial and in semi-commercial maize-producing areas, the area planted with traditional and OPV maize varieties has declined significantly since the introduction of hybrid maize in early 1990s. In Soc Trang province, the introduction of hybrid maize was not successful due to poor access to feed processing centers and an underdeveloped marketing system to sell maize for animal feed.

In most areas, seed availability and market conditions are significant determinants of hybrid maize adoption. Where there is good availability of hybrid seed and easy access to markets, farmers with large land areas are the first to adopt hybrid maize. Under less favorable market access, such as in Phu Tam and Ating villages, the proportion of land planted to hybrid varieties is small. Output price of local varieties relative to that of modern varieties does not seem to be an important factor affecting farmers' adoption of hybrid maize.

During the survey, upland farmers were asked to rank characteristics of maize varieties by importance (Table 15), and all respondents considered high yield to be the most important. Other important characteristics include early maturity, insect resistance, firm (hard) stalks, and large ears. Early maturity is a particularly important factor for farmers in the northern upland agro-ecology for avoiding drought at the end of the crop season. Firm stalks are important for areas with relatively strong wind such as in the northern upland and the central highland-central coast upland agro-ecologies. Large ears are considered by farmers to be an indicator of high yield and therefore valued, and drought resistance is a characteristic considered to be important as well. On the other hand, grain color and eating quality are not deemed to be very important characteristics because most farmers cultivate maize to sell for animal feed.

3.2.5 Land preparation and crop management practices

Land preparation practices for upland maize cultivation vary greatly depending on rainfall patterns and soil conditions. Land preparation is intensive in commercial maize-producing villages in the northern and the central highland-central coast upland agro-ecologies, that are accessible by road, have flat or medium sloping topography, and soil that can support mechanized preparation. In most other upland areas, however, land preparation is done primarily by hand with some animal power, and is the only option for farmers in upland villages with unfavorable field conditions such as high sloping or rocky land. In some remote areas of the central highland-central coast upland agro-ecology like in Ating village (Quang Nam province) and Kado village (Lam Dong province), shifting cultivation is still practiced by ethnic peoples, and land preparation begins with slashing and burning forest, bush or grassland before the onset of the monsoon rains, and is continued with hand tools. In contrast to upland agro-ecologies, land preparation in the lowland agro-ecologies is done with either animal or machine power.

Table 15. Desirable varietal characteristics for different maize production systems, Vietnam, 2001 (% of farmers in favor).

Characteristic	Northern Upland	Central Coast-Central Highlands Upland	Southeastern-Mekong River Delta Upland
High yield	100	100	100
Drought resistant	65	68	58
Ability to grow on less fertile soil and still give some yield with low inputs	45	40	25
Short-duration / early maturing	75	65	70
Insect resistant	70	60	65
Disease resistant	35	40	42
Good grain color	14	6	15
Good eating quality, sticky	35	20	12
Firm (hard) stem	70	80	60
More number of ears per plant	65	60	63
Large corn cob	75	70	62

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

Maize seeds are most commonly sown in the plow marks or in holes and covered with soil. The first maize crop is planted at the beginning of the rainy season in the rainfed ecologies, and the time of the year depends entirely on the advent of the first rains. In areas with two succeeding crops, early planting assures more available water for the second crop, but also puts it at more risk of early drought or unstable rainfall at the beginning of the rainy season. Crops planted late may suffer yield loss from pests among other constraints. In the upland rainfed villages with steep sloping fields, farmers sow maize seed in small holes made with a stick or small hoe. Alternatively, maize is also grown as transplanted seedlings under irrigated systems, in the northern upland, northern lowland, and the central highland-central coast lowland agro-ecologies.

Weeding in maize fields is done manually two or three times per season, and is consistent across all surveyed villages. All weeding is done by hand, and no herbicide was applied anywhere. The first weeding is done 15-20 days after maize seed germination, the second after 25-30 days and the third after 45-50 days. Fertilizer application is usually done first before sowing the seed, and then during weeding.

Irrigation is not common in the upland maize growing areas, as most maize is rainfed, and any available irrigation is applied to maize growing near home gardens. On the other hand, maize grown under irrigated conditions in the lowland and northern upland agro-ecologies was irrigated several times (up to 30 times) per crop season.

With the adoption of hybrid maize, farmers reported an increase in pesticide use to combat major maize pests and diseases—stem borer, maize ear borer, maize bug, grasshopper, field rats, blight, and root and stalk rot. However, pesticide use by many farmers was inefficient since the level of insect and disease infestation was reported to be low to medium. Farmers growing maize commercially commonly use chemical pesticides, but subsistence farmers report not using them for local/traditional maize, nor for hybrid maize varieties. Integrated pest management (IPM) was not reported at all in most of the surveyed villages.

The shift from OPVs and local/traditional varieties to hybrids brought changes to crop management practices for maize farmers, as:

- Much higher fertilizer use was reported;
- The adoption of mechanical land preparation became more location-specific; and
- Labor-saving post-harvest technology such as the use of shelling machines became widely adopted, particularly among large maize farmers.

In contrast, the adoption of modern maize varieties did not alter crop establishment, irrigation and harvesting methods nor increase the amount of family or hired labor for pre-harvesting activities.

3.2.6 Labor and material input use

The amount of seed used by maize farmers did not differ much across ecologies, ranging from 17 kg/ha in the southeast-Mekong Delta upland areas to 24 kg/ha in the northern upland areas. Farmers in the northern lowland agro-ecology used the most seed at 27 kg/ha. However, the amount of chemical fertilizer used varied widely across agro-ecologies, with the highest level of 810 kg/ha reported in the northern lowland agro-ecology and the least of 242 kg/ha reported in the central highlands-central coast upland agro-ecology (Table 16). In all surveyed villages, farmers applied more fertilizer to hybrid maize than to OPV or local varieties, and more fertilizer to maize grown on flat lands than on the marginal sloping or hilly lands. In most upland villages surveyed, the amount of chemical fertilizer used for local maize varieties was reported to be very low, and ethnic minority farmers in remote upland villages such as in Ating village (Quang Nam province) do not use chemical fertilizers at all.

The average amount of each type of chemical fertilizer used by farmers (urea, NPK, phosphorus, potassium, ammonium sulfate) varied widely across agro-ecologies. This variation is partly explained by differences in specific soil conditions, but also reflects the different levels of farmers' understanding of the basic nutrient requirements of the maize plant. A relatively high level of nitrogen fertilizer use was recorded in both upland and lowland agro-ecologies of the north and the southeast-Mekong Delta regions, but tremendous quantity variation was reported among farmers from the same village. This indicates that improving farmers' technical knowledge, particularly on timing, type and quantity of fertilizer application, is essential to increasing the efficiency of fertilizer use and the overall yield performance of maize in the country.

In general, the use of organic fertilizer is more common among farmers in the lowland than among those in the upland agro-ecologies. While maize farmers in most villages in the northern upland and lowland agro-ecologies applied 4.7-8.1 t/ha of manure, no organic fertilizer was used for maize cultivation in all villages in the upland agro-ecologies of the central highlands-central coast and the southeast-Mekong Delta (Table 16). In the latter regions, farmers tend to use organic fertilizers only on high value crops like rice, vegetables, coffee or black pepper. The use of organic fertilizers also requires high labor input and high transportation costs, while chemical/inorganic fertilizers are readily available in the market and easier to transport and apply.

On average, maize production in Vietnam used a total of 170-243 person-days/ha with little difference between commercial and semi-commercial maize production. The use of male and female labor is also relatively equal, as male and female laborers participate in almost all production activities in most villages. Land preparation, fertilizer and pesticides application, and

Table 16. Average level of input use in maize cultivation in surveyed villages, Vietnam, 2001.

Agro-ecology	Seed (kg/ha)	Chemical fertilizer Total (kg/ha)	Urea (kg/ha)	NPK (kg/ha)	DAP (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Ammonium sulfate (kg/ha)	Manure (kg/ha)	Pesticides (kg/ha)	Labor (person-days/ha)
Northern Upland	24	604	216	177	0	155	57	0	4750	25	181
Northern Lowland	27	810	270	0	0	405	135	0	8100	270	243
Central Highland-Central Coast Upland	22	242	66	86	0	31	46	13	0	1	188
Central Highland-Central Coast Lowland	21	516	74	260	70	90	22	0	2000	62	195
Southeast-Mekong Delta Upland	17	725	250	150	0	207	100	18	0	4	170
Southeast-Mekong Delta Lowland	18	714	214	143	0	179	178	0	893	14	178

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

transportation of inputs and produce tend to be done by the men, while more female labor is used for weeding, sowing, shelling and drying maize grain.

3.2.7 Yields and yield gap

All the villages surveyed reported that hybrid maize varieties give a much higher yield than do traditional and OPV varieties. On average, local/traditional varieties yielded low ranging from 1.2 t/ha in the southeast-Mekong Delta upland to 2.5 t/ha in the southeast-Mekong Delta lowland (under irrigated conditions in Phu Tam village, Soc Trang province). The average yield of OPVs was higher in the same agro-ecologies at 1.5-3.5 t /ha. As expected, hybrids yielded the highest at about 3.5-5.0 t/ha, with the highest average yield recorded in the central highlands-central coast lowland (Table 17). Some surveyed villages in the central highlands-central coast upland such as Nhan Hoa village (Gia Lai province) and Pache village (Thanh Hoa province) recorded very high average maize yields of 6.0 t/ha and 7.5 t /ha, respectively.

Yield varied widely among farmers in each village, particularly for hybrid varieties, as well as between surveyed villages, and across maize production agro-ecologies. For hybrid maize varieties, yields are frequently lower than the potential yield levels, making it important to understand why many farmers are unable to achieve the full potential of the new maize technology. The identification of the reasons for the gap between yield and the yield potential in the farmer's environment, and the yield gaps between poor-practice and best-practice farmers, would provide valuable information to researchers on the efficacy of their technologies under farm conditions.

During the RRA survey, farmers were asked to describe what they felt were the causes of the clear yield differences among them. They broke the causes down into two categories—those relating to environmental conditions not under farmers' control, and those under farmers' control, as defined by his ability and willingness to achieve the yield potential on his farm. According to farmers, a part of the yield gap could be explained by different factors in maize cultivating environments, such as soil fertility, topography, rainfall, irrigation/drainage conditions, and weed, insect and disease constraints. The differences in maize yield were also attributed to differences in fertilizer/pesticide application, planting time, seed quality, crop management practices, and farmer knowledge of cultivation techniques. Interestingly, no farmer reported that lack of fertilizer available in the local market was limiting maize production.

3.2.8 Post-harvest practices

In all villages in the survey, maize is harvested by hand. After harvesting, farmers either transport the produce to the farmhouse, or they shell the maize immediately in the field. Maize is shelled either by hand or by hired shelling machine. Maize is commonly shelled by hand across the northern provinces. In the southern provinces, the recent introduction of maize shelling machines to commercial maize areas has made mechanical shelling popular. It enables farmers to sell their maize right after harvesting, as well as reduce shelling labor costs. Mechanized shelling is also popular in the commercial maize areas of the southeast and central highland regions, especially when the crop is harvested in unfavorable weather. Farmers growing local/traditional or improved OPVs for local consumption usually sell fresh maize on the field or directly after harvesting. After shelling on the field, maize grain is sold to traders who transport maize to drying facilities and sell it to feed companies, or farmers transport the produce to their house and sell it after sun-drying. In most villages in the survey, maize is sun-dried, and no farmer reported having access to drying facilities.

Table 17. Maize yield by variety (kg/ha), Vietnam, 2001.

	Local maize			Improved OPV			Hybrid		
Agro-ecology	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Northern Upland	5000	1000	2300	4000	1800	2500	10000	2000	4760
Northern Lowland	-	-	-	-	-	-	5200	2700	3750
Central Highland-Central Coast Upland	3000	500	1454	4000	900	2100	9000	1200	3460
Central Highland-Central Coast Lowland	3000	900	1700	4000	1000	2900	8500	2500	5000
Southeast-Mekong Delta Upland	2500	800	1233	2500	1000	1500	8000	2000	4250
Southeast-Mekong Delta Lowland	3500	1200	2500	2000	5000	3500	-	-	-

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.
Note: Max= Maximum, Min= Minimum, Avg= Average.

Most farmer-respondents did not store their maize to wait for higher grain prices, as they cannot afford the potential storage losses. In commercial maize production areas, maize grain can be stored from a few weeks to three months, whereas maize for home consumption might be stored for up to six months. The extent of storage loss varied among farmers depending on how farmers dried their maize, the quality of their storage facility, and the duration of storage. Farmers who stored maize for longer than six months reportedly lost as high as 90% to rats and weevils. On the other hand, only 2-10% loss was reported by farmers who stored their grain for short periods (Table 18).

Farmers harvesting grain from local/traditional varieties and OPVs reported selecting large and good-looking ears to store as seed for the next season. The ears were sun-dried, bunched and stored inside the house in plastic bags or wooden boxes, and no chemicals were applied to protect them in storage. Ethnic minority people hang harvested maize ears selected for seed in their kitchens to store for the next season, protecting the ears from pest attack.

Table 18. Losses due to major diseases and pests in maize fields and in storage (% of total production), Vietnam, 2001.

	Agro-ecology					
Maize pests	**Northern Upland**	**Northern Lowland**	**Central Highland-Central Coast Upland**	**Central Highland-Central Coast Lowland**	**Southeast-Mekong Delta Upland**	**Southeast-Mekong Delta Lowland**
Field pests						
Stem borer	4.1	2	2.7	3.7	3	2
Maize ear borer	0	0	2.5	2.3	1	2
Cutworm	2	0	0	0	0	0
Maize bug	0.7	5	0.2	0.7	0	0
Field mice	4.2	0	2.9	1	0	0
Blight	1.2	3	1.9	1.2	1	1
Grasshopper	0	0	0	0	3	0
Stalk rot	0	0	0.1	0	2	0
Other pests	0	0	0.7	0.5	0	0
Total	**12.2**	**10**	**11**	**9.4**	**10**	**5**
Storage pests						
Weevils	5.2	2	8	3	3	2
Rodents	2.7	0	2	1	2	0
Total	**7.9**	**2**	**10**	**4**	**5**	**2**

Source: IFAD-CIMMYT-Vietnam RRA/PRA Surveys, 2001.

4. Maize Production Constraints

There is a strong incentive for farmers to intensify their maize production given the increasing demand for maize from the expanding livestock and poultry industry in Vietnam, coupled with the introduction of high-yielding hybrid maize varieties. Indeed, most of the surveyed villages showed an increase in land planted to maize over the last five years. However, in some semi-commercial maize-growing upland areas such as Kado village of Lam Dong province and Ating village of Quang Nam province, the area planted to maize declined due to restrictions on shifting cultivation. In the southeast-Mekong Delta upland and the central highlands-central coast upland areas, some maize farmers have shifted to more profitable crops such as coffee and black pepper. Others, however, shifted from annual crops such as beans or groundnut to maize, particularly when hybrid maize varieties were introduced to these areas. The adoption of hybrid maize varieties increased yields in all agro-ecological regions, although yield variations exist across agro-ecologies and among farmers in the same area. The actual yield obtained by many maize farmers is also still below the potential yield of modern maize varieties.

During the RRA/PRA village surveys, farmers were asked to identify factors that affect maize productivity in their respective areas and to rank them according to importance. The same exercise was conducted with local key informants, extension officers, and government officers at the village, district and provincial levels. The responses of both sets of respondents were later grouped into abiotic, biotic, institutional, and other constraints, as discussed in the following sections.

4.1 Biotic and Abiotic Constraints

Abiotic constraints to increasing maize productivity vary across agro-ecological zones. In the northern upland agro-ecology, the second maize crop is usually affected by drought at the end of the rainy season when rains stop early. In the mountainous and midland areas of this upland agro-ecology, there is a high risk of soil erosion due to steep sloping topography. Other problems include poor soil fertility and irregular rainfall.

Major abiotic constraints for maize production in the southeast-Mekong Delta upland and the central highlands-central coast upland include water shortage and seasonal drought, medium-to-high risk of soil erosion, unstable rainfall patterns, seasonal flooding in some areas, and a medium-to-high risk of soil fertility depletion. The northern part of the central highlands-central coast upland and lowland agro-ecologies is also affected by hot, dry western winds. In many upland villages, farmers reported a trend of declining maize productivity and also observed that the yield gain brought by the introduction of hybrid maize in the early 1990s has been in decline ever since. This decline in hybrid maize yield was reportedly due to the depletion of soil fertility and exhaustion of soil resources, particularly in sloping field conditions.

Flooding is a major problem reported in all lowland agro-ecologies, especially in the Red River and Mekong Deltas as well as in the plains of the central coast. Storms and typhoons affect the northern lowland, the central highland-central coast lowland agro-ecologies, and some areas in the north of the central highlands-central coast upland.

Farmers also reported an upward trend in insect and disease infestation particularly stem borer and blight, although current losses from these pests averaged fairly low at 15% of yield (Table 18). Some farmers reported using more pesticides with the adoption of hybrid maize varieties, yet yield loss due to pests and disease might reach more than 30% of the expected yield level.

4.2 Institutional Constraints

Although services are available in all rural areas, the national agricultural extension system is still highly centralized and does not meet the real demand of local farmers. Only a few local extension workers are available to provide service to a limited number of farmers. In the upland areas, poor transportation and difficult working conditions combined with low salaries lead to ineffective service and lack of motivation of government extension workers. In terms of credit, insecure land tenure, particularly in more remote mountainous areas, makes it difficult for farmers to access formal credit sources. It also does not provide farmers enough incentive for investing in soil erosion control and maintaining and improving soil fertility.

4.3 Information Constraints

In general, maize farmers in commercial maize-producing areas have better access to information than do farmers in semi-commercial upland areas. Farmers learn about new maize varieties through a myriad of sources:

- Extension services;
- Government marketing and distribution networks at the provincial, district, and (sometimes) village levels;
- Farmers' associations and extension clubs;
- Local agricultural officers;
- Fellow farmers;
- Private company marketing ventures;
- Local agricultural input wholesalers and retailers;
- Radio and television, and
- Demonstration trials.

For information on maize cultivation techniques, most farmers appear to rely on their interpersonal network of co-farmers, friends, and relatives. Recognizing the ability of farmer networks to effect information exchange could improve the efficiency of maize technology dissemination.

The extension service system is also an important source of information, even though there are too few extension agents to meet the needs of farmers. In many areas, extension services focus more on the introduction of high-return modern farm technologies that benefit richer farmers than they focus on small, resource-poor farmers.

Other common sources of information on input use and pest management are radio, TV, and local traders. Few farmers listed interest groups or associations or clubs as valuable information sources; however, farmer cooperatives were named as important sources of information on agricultural production and maize cultivation techniques in many villages in the northern provinces and in the southern central coast.

Although commercial farmers have better access to information than do the rest of Vietnam's maize farmers, they still report that the lack of technical knowledge in maize production was a major limiting factor to improving maize cultivation. They particularly cited the need for more information on optimal levels of fertilizer application; management of nutritional deficiencies; nature of insect and disease populations; types of pesticides to use and methods of application; optimal spacing for specific soil conditions, and best maize variety to use.

An even greater information gap exists for maize farmers in the sloping and mountainous regions, and especially for those in remote villages. They report a need for specific information and extension services to help out with cultivation techniques of modern maize seed technology and sustainable maize production in their fragile upland environments.

4.4 Input Supply Constraints

Most inputs in maize production in Vietnam are supplied to farmers through private trade systems. In commercial maize areas, the private trade system for inputs and farm outputs is relatively efficient, and inputs are readily available in villages except in areas having poor road access. In remote mountainous areas in the northern upland and the central highlands-central coast upland agro-ecologies, poor road conditions can increase the cost and limit the availability of inputs like fertilizers, which in turn discourages the application of the recommended quantities. Lack of cash, lack of access to formal credit sources, and high interest rates on loans from informal sources have forced many poor farmers to apply too little fertilizer on hybrid maize varieties resulting in low yield.

Shortage of hired labor as a constraint in maize production was also mentioned by farmers in some villages with large commercial maize areas, particularly those located near Ho Chi Minh City and in the central highland-central coast upland agro-ecology. In these areas, hired labor is more often used for higher value crops like coffee than on maize.

4.5 Other Constraints

Other factors affecting maize productivity growth include:

- Lack of market infrastructure;
- Lack of post-harvest storage and drying facilities;
- Lack of price information and fluctuating input and output prices;
- High input price, particularly chemical fertilizer and hybrid seed;
- Low farm income and lack of capital for farm investment;
- Unreliable quality of maize seed sold by local private traders;
- Lack of short-duration and drought tolerant varieties;
- Undeveloped infrastructure, and
- High production costs and tight crop calendar in the northern lowland agro-ecology.

5. Priority Constraints for Maize Research and Development

5.1 Methodology for Identifying Priority Constraints

The constraints to increasing maize production in Vietnam were identified by farmers during the RRA and PRA fieldwork, and their perspectives provide important input into the country's research and development planning and policy-making process. However, 75 constraints to maize production across all agro-ecologies in Vietnam were identified through this survey, and it is obvious that not all of these constraints can be adequately addressed with the limited resources available. In order to help the maize sector better target its research and development efforts, it was necessary to prioritize these constraints.

The National Maize R&D Priority Setting Workshop in Vietnam was conducted at the Victory Hotel, Ho Chi Minh City, on January 14-16, 2002. Participants included senior maize research scientists from agricultural research institutions and universities, CIMMYT scientists, representatives from provincial extension centers, and district Peoples' Committee members. The first day of the workshop was devoted to the discussion of major constraints to maize production, and to setting priorities for maize research and development work in Vietnam. The second day was spent identifying available and potential research and technology suppliers who could provide the means to alleviate maize production constraints.

The workshop provided good opportunities for linking farmer and researcher perspectives in the maize sector of the country. Constraints identified by the farmers during the RRA/PRA were the starting point of the national prioritization workshop. During the workshop, major characteristics of maize production systems and constraints that had been identified from RRA/PRA field surveys were presented and further validated by workshop participants. CIMMYT scientists then introduced a methodology to use in identifying priority constraints.

For the priority setting work, participants were divided into two working groups—one group working on the northern areas, and the second group on the central coast–central highland and the southeast-Mekong Delta areas. The groups discussed the constraints and ranked each one based on its relative importance to maize production. Participants also estimated possible yield gain if each constraint could be alleviated, and estimated the probability of finding a solution to this specific constraint (Annex 1). Outputs from group discussions were presented in the panel session for further discussion and validation.

Public investment in agriculture in Vietnam aims to achieve a high return per unit investment in research and development, and to alleviate poverty. The process of identifying and assigning priorities to specific constraints in maize production was geared toward these two major objectives through the use of three criteria—efficiency, poverty, and marginality. Based on the results from group discussions, the efficiency, poverty, and marginality indices were computed for each of the constraints.

The efficiency index is used as a criterion for ranking constraints based upon the expected return to research and development efforts, i.e. highest expected production gain due to alleviation of the constraint. The efficiency index of a specific constraint was estimated to be a product of:

- The importance of the constraint (rank multiplier);
- Yield gain associated with constraint alleviation, and total production of maize in specific agro-ecologies;
- Probability of finding a solution to the constraint, and
- Adoption history (percentage of farmers who adopted the new technology in the past).

In this study, the total maize production of each agro-ecology was computed based on the national statistical data for 2000.

The poverty index was used as a prioritization tool that redirects research and development efforts in the maize sector to areas with the highest rural poverty. The poverty index was derived as a product of the efficiency index and proportion of rural households living below the poverty line in each agro-ecology. The proportion of rural poverty in each agro-ecology was computed based on the national statistical data. As there were no detailed data on rural poverty available for the year 2000, statistical data on rural poverty for 1999 were used in this study.

Another index for priority setting is the subsistence index used to target R&D investments in areas with a high proportion of subsistence farmers. This index is computed as the product of efficiency index and the proportion of maize used as food by farm households. However, because maize has lost its importance as food for home consumption in many areas of Vietnam, the proportion of maize used as food was found to be very small in all agro-ecologies, and subsistence index was therefore not included in the analysis.

To consider the problems of the production environment and maize yield variability across maize production agro-ecologies, a marginality index was also included in the analysis. The marginality index was computed as the inverse of the average yield of maize in a specific agro-ecology.

The combined index was then derived as a sum of the weighted efficiency, poverty, and marginality indices. Based on the importance of efficiency and poverty issues and risk factors in the production environment, participants agreed to use a weight of 0.5, 0.3, and 0.2 for the efficiency, poverty, and marginality index, respectively. Hence, the combined index was computed by adding the products of 0.5 * efficiency index, 0.3 * poverty index, and 0.2 * marginality index.

5.2 Priority Constraints

The efficiency, poverty, marginality, and combined indices were used for ranking maize production constraints across maize production agro-ecologies in the country. The most important 25 constraints based on the combined index are listed in Table 19.

Table 19. Top 25 priority ranked major maize production constraints in Vietnam.

			Rank based on			
Region	Production System	Constraint	Efficiency	Poverty	Marginality	Combined
North	UPSC	Lack of knowledge-cultural practices	1	1	1	1
North	UPSC	Lack of investment capital	4	2	2	2
North	UPSC	Lack of suitable varieties	6	3	3	3
North	UPSC	Poor market access and undeveloped transport system	7	4	4	4
North	UPSC	Poor technology transfer system	8	5	5	5
SEMK	UPC	Declining soil fertility	2	30	8	6
SEMK	UPC	Drought	3	31	9	7
North	UPSC	Drought	10	6	6	8
North	UPSC	Undeveloped input supply system	11	7	7	9
CCH	UPC	Lack of info on technology	9	9	15	10
SEMK	UPC	Lack of info on technology	5	33	11	11
CCH	UPC	Inefficient use of fertilizers & pesticides	12	10	18	12
CCH	UPC	Declining soil fertility	14	12	19	13
CCH	UPC	Lack of investment capital	15	14	20	14
North	LWC	Tight cropping calendar	17	18	12	15
SEMK	UPC	Lack of capital	13	37	14	16
North	LWC	High production costs	18	19	13	17
SEMK	UPC	Uneven distribution of knowledge on maize cultivation	16	41	16	18
North	UPSC	Lack of post-harvest facilities	19	8	10	19
CCH	UPC	Drought	21	20	26	20
SEMK	UPC	Lack of market information	20	46	23	21
CCH	UPC	Lack of post-harvest facilities	22	21	27	22
North	UPSC	Sloping land and soil erosion	23	16	17	23
CCH	LWC	Lack of info on technology	24	11	21	24
CCH	LWC	Inefficient fertilizer use	25	13	22	25

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

Notes: 1 is the highest priority and 25 is the lowest priority.
CCH=Central highland-central coast, SEMK= Southeast-Mekong Delta. UPSC=upland semi-commercial maize production, UPC=upland commercial, LWC=lowland commercial.

Of these 25 top priority constraints, 16 are from commercial maize production systems in the north, central coast and highlands, and southeastern region-Mekong River Delta, and nine are from semi-commercial systems all in the northern region. In terms of maize agro-ecology, nine constraints were identified for the northern upland, seven for the central highlands-central coast upland, six for the southeast-Mekong Delta upland agro-ecology, and only four constraints for the lowland agro-ecologies (the northern lowland and the central highlands-central coast lowland). The priority constraints to maize production in each agro-ecology are discussed below.

5.2.1 Northern upland

There are nine priority constraints identified for this agro-ecology (Table 20), with the foremost constraint to improving maize cultivation being lack of technical information, that is, poor technology transfer. Ethnic minority farmers, who are semi-literate and have little access to information, populate the remote villages in this region. A very poor technology transfer system characterized by few human or financial resources, few public extension services, and bad roads limits the amount and quality of technology transfer. Limited experience in working with ethnic farmers and language barriers are also problems that reduce the efficiency of the few existing extension services.

Lack of investment capital is the second most important constraint to maize production, particularly for the poor ethnic minority farmers. Farmers also suffer from too few suitable varieties, specifically high-yielding varieties with short-duration, to fit with their upland soil, climatic, and cropping pattern conditions. An underdeveloped transportation system in this often mountainous or sloping terrain limits the exchange of inputs and farm products from and to the local market or to other regions, and also makes it difficult and costly. Poor market access and the underdeveloped transportation system are therefore important constraints to maize production in this agro-ecology. Other priority constraints to maize production in the northern upland agro-ecology include drought, undeveloped input supply system, lack of post-harvest facilities, and sloping land and soil erosion.

5.2.2 Northern lowland

Only two priority constraints to maize production were identified for the northern lowland agro-ecology, a tight cropping calendar and high production costs. In the northern lowland agro-ecology, particularly in the Red River Delta, there is a large commercial maize area cultivated under irrigated conditions. Maize is usually planted in the winter-spring or spring-summer crop seasons. The winter-spring maize planted in September-October and harvested in January is the

Table 20. Priority problems of maize production across agro-ecologies, Vietnam.

Ecology	Upland	Lowland
North	Lack of knowledge on cultural practices Lack of investment capital Lack of suitable varieties Poor market access and underdeveloped transport system Poor technology transfer system Drought Undeveloped input supply system Lack of post-harvest facilities Sloping land and soil erosion	Tight cropping calendar High production costs
Central Coast-Central Highlands	Lack of info on technology Inefficient use of fertilizers and pesticides Declining soil fertility Lack of investment capital Drought Lack of post-harvest facilities	Lack of info on technology Inefficient fertilizer use
Southeast-Mekong River Delta	Declining soil fertility Drought Lack of info on technology Lack of capital Uneven distribution of knowledge on maize cultivation Lack of market information	

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

third crop after two rice crops. This very tight cropping calendar is the most important constraint in the area, as farmers have only a very short time between the two consecutive crops. High production cost is the second constraint in this agro-ecology, particularly due to high input use such as labor and chemical fertilizer, and very small farm size.

5.2.3 Central highland—central coast upland

There were seven priority constraints identified for this agro-ecology, with the foremost constraint to improving maize cultivation being lack of technical information, that is, poor technology transfer. Inefficient use of fertilizers and pesticides is another important priority constraint associated with this lack of technology awareness. While the risk of soil erosion is not so severe as compared to that in the northern upland agro-ecology, declining soil fertility is another important factor that hinders maize productivity growth in the central highlands-central coast upland. As in the northern upland areas, lack of investment capital, drought, and lack of post-harvest facilities are also priority constraints identified for this upland agro-ecology.

5.2.4 Central highland—central coast lowland

Lack of technical information and inefficient fertilizer use are two priority constraints to maize production in the central highlands-central coast lowland agro-ecology. While farmers in this agro-ecology are also often severely affected by storms, typhoons, and dry and hot western winds, these problems were not considered to be high priority constraints, as there is nothing man can do to change the weather.

5.2.5 Southeast region-Mekong Delta upland

Priority constraints to maize production in this agro-ecology include declining soil fertility, drought, lack of technology understanding, lack of capital, and lack of market information, which are similar to those identified in other upland agro-ecologies. Declining soil fertility (leading to declining maize yields) and exhaustion of soil resources, particularly under sloping field conditions, were identified as the most important constraints for maize production systems in this agro-ecology. In general, there is a relatively good marketing system in this agro-ecology, but the development of more efficient marketing systems is considered to be a major stimulus to maize productivity growth here. Lack of market information is also a major constraint, particularly for farmers in more remote areas of this region.

5.2.6 Southeast region-Mekong Delta lowland

No priority constraint in this agro-ecology appeared in the top 25 priority constraints of the maize sector of the country. This is probably due to the fact that maize production in this agro-ecology contributes only a small proportion to total maize production in the country. Investment in research and development efforts to eliminate constraints in this agro-ecology will have negligible impact on the country as a whole.

6. Agenda for Maize Research and Development in Vietnam

The maize R&D planning process proceeded to identify possible solutions to the top 25 priority constraints identified for the upland and lowland maize production systems. At the national priority-setting workshop, the working groups also estimated the probability of success for each solution to alleviate a specific constraint and the probability that farmers would adopt the solution. The most effective alleviating technologies or processes would have a high probability of success and high probability of being adopted by farmers. For each possible solution, a likelihood index was calculated as the product of the probability of success and the probability of adoption (Table 21). The potential suppliers for each of the solutions were also identified (Annex 2).

Future interventions in the maize sector should focus on those problems addressable by research and development, whose alleviation will bring the most benefits to the largest number of poor people. It is clear that the strongest intervention efforts should be directed to the upland maize production agro-ecologies, and specifically to the northern upland where

Table 21. Approaches ranked by likelihood of producing an impact on alleviating constraints to maize production in Vietnam.

Constraint	Technology / Policy options	Probability of success	Probability of adoption	Likelihood ratio
UPLAND				
Unsustainable cultivation practices	Research on integrated farm resource management	0.8	0.5	0.40
	Promote available sustainable farming systems through extension	0.75	0.5	0.38
	Research on sustainable crop management	0.6	0.4	0.24
	Use organic fertilizer, bio-fertilizer	0.75	0.3	0.23
Lack of investment capital	Easier access to formal credit for poor farmers	0.8	0.6	0.48
	Subsidies for new seed, fertilizer to encourage poor farmers to adopt new/improved technologies, high yield variety	0.55	0.45	0.25
	Encourage farmers to participate in credit groups	0.3	0.2	0.06
Lack of suitable varieties (short-duration and high yield varieties fit with bio-ecological conditions and cropping pattern)	Develop short-duration, high yield varieties.	0.7	0.55	0.39
	Test available short-duration varieties for adoption to local condition	0.7	0.5	0.35
	Introduce available short-duration varieties, and appropriate cropping pattern to farmers	0.75	0.45	0.34
Poor market access and undeveloped transportation system	More investment for rural road systems	0.8	0.6	0.48
	Encourage private sector to become involved in marketing systems in areas with poor market access	0.6	0.5	0.30
	Encourage animal producers to use locally produced products	0.6	0.4	0.24
	Encourage farmers to raise horses, cattle for local transportation in mountainous areas	0.7	0.3	0.21
Poor technology transfer system	Reorient the focus of extension activity to the need of local farmers	0.8	0.7	0.56
	Allocate more resources (budget, personnel) for extension activities, particularly in the uplands	0.8	0.5	0.40
	Human resource development for extension centers	0.7	0.4	0.28
	Strengthening the linkage between research and extension	0.7	0.4	0.28
	Develop demonstration plots, farming models for technology transfer	0.8	0.2	0.16
Decline in soil fertility	Research on integrated soil fertility management (considering biophysical and socioeconomic conditions of resource-poor farmers)	0.8	0.45	0.36
	Dissemination of available soil fertility management techniques, sustainable farming practices	0.7	0.5	0.35
	Accelerate the process of providing land use right to upland farmers (to encourage them invest in soil fertility conservation and management, soil control)	0.7	0.4	0.28

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

Table 21. Approaches ranked by .....cont'd

Constraint	Technology / Policy options	Probability of success	Probability of adoption	Likelihood ratio
	Research on organic fertilizer use and balanced use of chemical fertilizer	0.6	0.4	0.24
	Bio-fertilizer research	0.5	0.4	0.20
	Research on appropriate crop rotation	0.5	0.35	0.18
	Strengthening farmers' knowledge on effects of soil erosion and soil fertility loses, community education,	0.5	0.3	0.15
	Research on intercropping with nitrogen fixing crops	0.4	0.3	0.12
	Improving germplasm adapted to nutrient deficiencies and other edaphic stresses	0.3	0.4	0.12
Drought	Testing available early maturing high yield varieties for local conditions to avoiding drought; cropping systems research.	0.8	0.6	0.48
	Develop early maturing variety to avoid drought	0.65	0.6	0.39
	Introduce available short-duration varieties that are resistant to drought; introduce available farm-level drought management options.	0.7	0.5	0.35
	Develop drought tolerant variety (high yield)	0.4	0.75	0.30
	Crop management research to mitigate drought effects (land preparation, planting time, crop management)	0.6	0.3	0.18
	Improve irrigation system	0.35	0.3	0.11
Undeveloped input supply system	Encourage private sector to become involved in input supply systems in mountainous, remote areas with poor market access (such as credit policy, subsidy for state enterprises, farmers organization or cooperatives involved in input supply system).	0.6	0.6	0.36
	Develop input supply system for areas with poor market access	0.4	0.2	0.08
Inefficient use of fertilizer and pesticides (uplands)	Research to increase efficiency of fertilizer use considering biophysical and socioeconomic conditions in the uplands	0.7	0.6	0.42
	Increase farmer training on IPM, efficient use of fertilizer, pesticides, and integrated crop management	0.7	0.5	0.35
	Pesticide research	0.6	0.4	0.24
	Crop management research	0.7	0.3	0.21
	Research on IPM for maize	0.35	0.3	0.11
	Pest resistant varieties	0.3	0.3	0.09
	Through private sector, provide training and information for local input dealers; encourage them to disseminate the information to farmers	0.4	0.2	0.08
Lack of post-harvest facilities	Research to improve farm level post-harvest facilities, particularly for poor farmers	0.6	0.5	0.30
	Provide incentive to encourage various stakeholders to invest in agriculture processing, post-harvesting facilities (credit support, price policy)	0.5	0.5	0.25
	Research on varieties resistance to post-harvest storage pests	0.3	0.2	0.06
Lack of technical information	Improve extension services for farmers, particularly for remote upland villages (more resource allocation, demand driven extension program, appropriate extension approach)	0.75	0.6	0.45
	More technical information for farmers through mass media and other channels	0.35	0.35	0.12
	Develop extension network	0.6	0.2	0.12
	Community based extension, farmer extension clubs	0.4	0.3	0.12
Lack of market information	Enhance private sector involvement in marketing, exchange of good, products	0.5	0.6	0.30
	Develop government supported market information system	0.6	0.3	0.18
Sloping land and soil erosion	Testing available sustainable cultivation practices and modify for adoption to site specific sloping land conditions	0.75	0.5	0.38
	More extension activities to introduce appropriate soil erosion control measures and cultivation practices for upland farmers.	0.7	0.4	0.28
	Research on sloping land intercropping system, cropping pattern, and crop rotation.	0.6	0.3	0.18
	Research on soil control measures for sloping land	0.5	0.3	0.15
	Research on appropriate land preparation (minimum/reduced tillage), weeding practices for sloping land.	0.5	0.25	0.13
LOWLAND				
Tight crop calendar	Cropping systems research (use available short-duration varieties, appropriate cropping pattern)	0.7	0.4	0.28
	Use short-duration varieties	0.5	0.3	0.15
	Improve land preparation	0.4	0.2	0.08
High production cost	Research to improve efficiency of input use.	0.7	0.5	0.35
	Crop management research	0.5	0.3	0.15
Lack of technical information	Improve extension services for farmers .	0.75	0.55	0.41
	More technical information for farmers through mass media and other channels.	0.7	0.3	0.21
	Develop extension network	0.65	0.3	0.20
	Community based extension, farmers extension clubs	0.4	0.25	0.10
Inefficient use of fertilizer and pesticides	Research to increase efficiency of fertilizer use	0.75	0.6	0.45
	Increase farmer training on IPM, efficient use of fertilizer, pesticides, and integrated crop management	0.75	0.5	0.38
	Pesticide research	0.6	0.45	0.27
	Crop management research	0.7	0.3	0.21
	Research on IPM for maize	0.4	0.4	0.16
	Pest resistant varieties	0.3	0.35	0.11
	Through private sector, provide training and information for local input dealers; encourage them to disseminate the information to farmers	0.3	0.3	0.09

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

there is the largest maize area and a large number of rural poor. A modest effort should be directed to alleviating maize production constraints in the lowland areas, concentrating on the northern lowland and the central highlands-central coast lowland agro-ecologies.

Interventions in the maize sector need also consider the specific climatic, biophysical, and socioeconomic conditions of different maize production systems in the country. These interventions could be grouped into technology research and development (on varieties, cropping systems, soil erosion and soil fertility issues, pest control), technology dissemination, input supply and marketing, and policy development. Most constraints to maize production in Vietnam can best be addressed by a combination of all these.

6.1 Research and Technology Development

Public sector efforts in maize research should address the following constraints to maize production:

- Unsustainable cultivation practices;
- Lack of varieties suitable to specific bio-ecological conditions and farmer-preferred cropping patterns;
- Declining soil fertility;
- Inefficient use of fertilizer and pesticides;
- Soil erosion, and
- Drought.

To effectively alleviate these constraints, both variety development and crop management research need to be implemented in an integrated approach. There is a need for location-specific maize technologies, especially for marginal upland maize production systems and resource-poor farmers. High levels of public sector investment in varietal research and development will help address variety-related maize production constraints in Vietnam. The breeding of short-duration/high-yielding varieties that will resist drought and fit into the tight cropping calendar will aid upland and lowland farmers. Long-term research to develop improved pest resistant germplasm that is adapted to nutrient deficiencies and other stresses is also a priority. Varietal development for resistance to post-harvest storage pests is, however, not very important.

On the other hand, integrated farm resource and crop management research for upland agro-ecologies can focus on making yield levels sustainable, and on reducing the negative environmental consequences of intensification. Cropping systems research that helps generate productivity-enhancing, resource-conserving maize cultivation practices for the marginal upland areas is expected to have high benefits, both short- and long-term. It can for one focus on testing available maize technologies for adoption to specific local conditions. This, together with the development of short-duration varieties, will effectively address the need for suitable varieties that fit the bio-ecological and socioeconomic patterns of the uplands.

The problem of inefficient use of fertilizer is usually due to farmers' lack of technical knowledge as to how and when to apply it. This study discovered, however, that recommendations on the amount and type of fertilizer to use are often made without fully considering the specific local soil and climatic conditions, which can lead to unnecessary expense for the farmers. Increasing the efficiency of fertilizer use would substantially reduce production costs, improve farm income and market competitiveness in the maize sector. Crop management research can therefore provide farmers with correct and appropriate fertilizer application information for different maize production systems. More research is also needed to address the problem of declining soil fertility, possibly through intercropping with nitrogen-fixing crops, the use of organic fertilizers, chemical fertilizers and bio-fertilizers, and adoption of appropriate cropping patterns or crop rotations.

Another important issue in upland maize production systems is how to reduce soil erosion and maintain/improve soil fertility. Cropping systems research can focus on the development and dissemination of integrated soil fertility management technologies appropriate for the biophysical and socioeconomic conditions in these environments. Other research areas directed at this problem include intercropping, cropping patterns, and crop rotations, as well as appropriate land preparation (minimum/reduced tillage) and weeding technologies. The expected positive impacts from soil fertility and soil erosion control research can only be obtained through a long-term commitment to research and extension activities.

Farmers report that losses due to pests are currently not very high. Increasing intensification in most maize production areas could, however, increase pest incidence, which would in turn increase the amount of pest-related production loss. Inefficient use of pesticides was identified as a constraint to maize productivity growth; hence research on integrated pest management (IPM) is needed to provide farmers with new technologies for controlling pests.

Drought is a common problem in most upland areas, and its alleviation requires more testing of available early maturing varieties for adaptation to local conditions, as well as research on related crop management issues. Transplanting maize in the northern lowland agro-ecology is extremely labor intensive. Management practices that ease labor requirements for transplanting and weeding should be developed. Efforts also need to be directed to the development and management of high quality protein maize to increase the value of farm output.

6.2 Technology Dissemination

Most maize-producing areas in Vietnam are widely planted to high-yielding maize varieties, yet many farmers, particularly poor farmers, still have little technological knowledge or only limited access to available improved technologies like efficient crop management practices, soil fertility management techniques, and soil erosion control measures. The improvement of the national extension service system will be critical for improving maize productivity and efficiency by providing sufficient technical information to farmers through training and education.

Agricultural extension services must be redirected to meet the real needs of local farmers, for which a greater investment in personnel and human resource development will be essential. Farmers can become better resource managers if local extension staff are better trained and informed as to the farmers' specific needs and worries, are more responsive, available, and more service-oriented, and are more appropriately rewarded for their services. The promotion of a participatory approach in extension services is crucial for improving the efficiency of local extension services.

Providing farmers with technical information through mass media and the extension network (including the community base and farmer organizations) is a parallel complementary approach to the formal extension service system of the government. The linkages between research and extension should also be strengthened through a closer collaboration among stakeholders such as research institutions, universities, extension systems, and farmer communities.

Understandably, there is a large and diverse demand for extension services across agro-ecologies and locations, but the priority for extension services related to maize production will be to focus on the constraints identified in this study. The extension system ought to provide a wide range of technical information and services covering topics such as sustainable farming systems and resource management practices, available varieties that fit local biophysical and socioeconomic conditions, soil fertility management and soil erosion control techniques, farm-level drought management options, efficient use of fertilizer and pesticides, and integrated crop management.

6.3 Input Supply and Output Marketing

In recent years, increasing feed maize demand in Vietnam has led to increasing commercialization of maize production in the upland agro-ecologies, for which more inputs are purchased and a larger share of farm outputs is marketed. Better marketing infrastructures in the upland areas will support the expected increases in marketable production. Transportation is an essential link in marketing farm produce, and more investment in rural infrastructures in the uplands will be essential. These will also help the poorest of the poor have access to markets, and can encourage the private sector to become more involved in input and output marketing.

It is also important to support farmers with a timely, accurate flow of market price information to help them make the best decisions in the production and marketing of farm produce. Lack of knowledge and information about the market places many small farmers in remote areas at a disadvantage. The lack of market information could be addressed by the development of a government-supported market information system, and by enhancing the marketing and exchange of farm products.

6.4 The Role of Public and Private Sectors

The public sector, including the national agriculture research centers, universities, provincial departments of agriculture and rural development, and extension centers, have long experience in doing research and development activities with OPVs and, in recent years, with hybrid maize varieties. The private sector was allowed to enter the maize industry only in 1990/91 but has since become more active in hybrid maize research, development, and dissemination. In effectively alleviating maize production constraints and realizing the recommendations, it is important to identify the possible roles of the public and private sectors and areas where they could work together to maximize benefits to society.

To alleviate constraints in the maize sector, human resource development in general and farmers' training and education in particular are also critical. Over the last decades, the public sector in Vietnam, through its extension system and university education, significantly contributed to human resource development for the maize sector. The public sector will continue to play a major role in this direction.

Constraint prioritization results imply that future interventions in the maize sector will need to focus on upland maize production agro-ecologies. Many of these upland agro-ecologies, however, have poor market access, making the profit from investment in research and development less attractive to the private sector. For this reason, the public sector will continue to be the more important supplier of research products and technology for farmers in these areas, particularly poor farmers. Public sector efforts in variety development will need to focus more on maize production constraints that the private sector does not address. Major efforts of the public sector in maize research, particularly in crop management research, should address priority constraints such as unsustainable cultivation practices, lack of varieties suitable to specific bio-ecological conditions and farmer-preferred cropping patterns, declining soil fertility, inefficient use of fertilizer and pesticides, soil erosion, and drought.

It is expected that the private sector will be more active in high-potential commercial maize production areas. There is, however, also a need for public sector support to encourage the private sector to be more active in subsistence and semi-commercial maize production areas, particularly in input supply and output marketing, towards the sustainable commercialization of maize production in these areas.

Increasing public and private sector collaboration is particularly important in addressing/alleviating maize production constraints. The public sector would benefit from access to maize technologies developed by the private sector, while the private sector would benefit from the public extension system for disseminating new, improved maize technologies to farmers. Public and private sector collaboration and coordination would help lessen the duplication of R&D efforts, accelerate the delivery of new technologies to maize farmers, and promote the spillover of research results from favorable to less favorable maize production areas. Maize farmers would also benefit from activities of NGOs and mass organization in extension, credit, and community-based resource management activities.

Overall, for effectively alleviating and/or eliminating priority production constraints in the maize sector, there is a real need for an interdisciplinary, integrated and participatory research and development approach that will involve scientists from various disciplines, extension workers, the private sector, NGOs, as well as the farming community.

6.5 Institutional Policies

As a large number of small farmers still face the problem of lack of capital, policies should continue to help poor farmers access formal credit. Short-term seed and fertilizer subsidies should be made available to poor farmers, which will encourage them to adopt new/improved maize technologies to help increase their productivity and farm income. Credit policy should also focus on providing sufficient incentives to encourage various stakeholders (private sector, state enterprises, farmer organizations and cooperatives) to invest in agricultural processing operations like post-harvesting facilities and to become more involved in input and output marketing especially in mountainous and remote areas with poor market access.

There is also an urgent need to grant land use rights especially to upland farmers to encourage them to invest in soil fertility conservation and management techniques, as well as in other sustainable agricultural production technologies. More investment in infrastructure development, particularly the upgrading and development of rural road systems in the uplands, is also needed.

Last but not least, more resources (budget, personnel) for extension activities should be allocated particularly to address the problem of a poor technology transfer system in the uplands. There is a need for a more effective and coordinated linkage between research and extension services, both at the national and local levels, in order to reduce unnecessary competition and duplication of efforts and to improve the cost effectiveness of research and extension activities. Public funding to research and extension should to be linked to their performance.

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8. Annexes

Annex 1. Prioritization of maize production constraints in Vietnam.

Region	Production system	Production constraint	Scientist ranking of constraint	Yield gain associated with constraint alleviation (%)	Probability of success in finding solution to the constraint (%)
North	LWC	High production costs	1	12.5	0.60
North	LWC	Tight cropping calendar	2	12.5	0.65
North	LWC	Rat damage	3	5.0	0.40
North	LWC	No available land	4	6.0	0.15
North	LWC	Lack of suitable winter-crop varieties	5	10.0	0.45
North	LWC	Undeveloped irrigation system	6	22.5	0.30
North	LWC	Lack of technology to plant maize on wet soil	7	10.0	0.50
North	LWC	Typhoons and floods	8	6.0	0.15
North	UPSC	Sloping land and soil erosion	1	9.0	0.28
North	UPSC	Lack of knowledge on cultural practices	2	12.5	0.75
North	UPSC	Lack of investment capital	3	17.5	0.55
North	UPSC	Poor market access and undeveloped transport system	4	12.5	0.55
North	UPSC	Lack of suitable varieties	5	20.0	0.55
North	UPSC	Drought	6	25.0	0.55
North	UPSC	Lack of post-harvest facilities	7	12.5	0.50
North	UPSC	Poor technology transfer system	8	15.0	0.70
North	UPSC	Undeveloped input supply system	9	10.0	0.75
North	UPSC	Lack of knowledge on pest management	10	7.5	0.35
North	UPSC	Rat damage	11	5.0	0.23
CCH	LWC	Floods	1	27.5	0.13
CCH	LWC	Typhoons	2	20.5	0.12
CCH	LWC	Western wind	3	14.0	0.12
CCH	LWC	Lack of info on technology	4	20.0	0.52
CCH	LWC	Inefficient fertilizer use	5	27.0	0.52
CCH	LWC	Lack of knowledge on intensive cropping	6	30.0	0.47
CCH	LWC	Lack of investment capital	7	28.5	0.54
CCH	LWC	Lack of short-duration varieties	8	23.2	0.32
CCH	LWC	Lack of post-harvest facilities	9	17.2	0.46
CCH	LWC	Stem borers	10	12.4	0.27
CCH	LWC	Ear borer	11	10.5	0.27
CCH	LWC	Insects	12	8.8	0.31
CCH	LWC	Rats	13	9.5	0.30
CCH	LWC	Blight	14	11.0	0.29
CCH	LWC	Lack of draft power	15	9.2	0.40
CCH	UPC	Drought	1	33.0	0.34
CCH	UPC	Typhoons	2	15.0	0.05
CCH	UPC	Western winds (dry, high temp winds)	3	13.5	0.05
CCH	UPC	Lack of info on technology	4	29.5	0.61
CCH	UPC	Inefficient use of fertilizers & pesticides	5	27.5	0.60

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

Notes: 1 is the highest priority and 25 is the lowest priority..
CCH=Central highland-central coast, SEMK= Southeast-Mekong Delta. UPSC=upland semi-commercial maize production, UPC=upland commercial, LWC=lowland commercial.

Annex 1. Prioritization of .....cont'd

Region	Production system	Production constraint	Scientist ranking of constraint	Yield gain associated with constraint alleviation (%)	Probability of success in finding solution to the constraint (%)
CCH	UPC	Lack of investment capital	6	27.5	0.61
CCH	UPC	Lack of post-harvest facilities	7	18.2	0.54
CCH	UPC	Declining soil fertility	8	23.0	0.75
CCH	UPC	Undeveloped infrastructure	9	14.5	0.28
CCH	UPC	Lack of drought-tolerant varieties	10	25.0	0.41
CCH	UPC	Lack of inputs	11	23.0	0.59
CCH	UPC	Stem borers	12	15.5	0.46
CCH	UPC	Ear borers	13	14.2	0.42
CCH	UPC	Blight	14	14.3	0.43
CCH	UPC	Poor market access	15	16.0	0.37
CCH	UPC	Lack of draft power	16	11.0	0.49
CCH	UPC	Localized flooding	17	11.7	0.15
CCH	UPC	Rats	18	9.4	0.37
SEMK	LWC	Drought	1	21.5	0.65
SEMK	LWC	Floods	2	29.0	0.09
SEMK	LWC	Lack of info on technology	3	25.5	0.53
SEMK	LWC	Lack of market information	4	17.5	0.45
SEMK	LWC	Inefficient use of fertilizers	5	22.0	0.52
SEMK	LWC	Lack of capital	6	22.5	0.55
SEMK	LWC	Lack of post-harvest facilities	7	17.0	0.43
SEMK	LWC	Stem borers	8	8.8	0.36
SEMK	LWC	Ear borers	9	7.1	0.37
SEMK	LWC	Stalk rot	10	7.4	0.39
SEMK	LWC	Blight	11	7.3	0.36
SEMK	LWC	Rats	12	8.8	0.39
SEMK	LWC	Poor soil	13	18.0	0.31
SEMK	UPC	Drought	1	27.5	0.50
SEMK	UPC	Lack of info on technology	2	24.5	0.49
SEMK	UPC	Uneven distribution of knowledge on maize cultivation	3	18.5	0.46
SEMK	UPC	Lack of market information	4	16.5	0.41
SEMK	UPC	Lack of capital	5	23.5	0.51
SEMK	UPC	Declining soil fertility	6	22.5	0.70
SEMK	UPC	Lack of post-harvest facilities	7	14.0	0.33
SEMK	UPC	Stem borers	8	9.5	0.33
SEMK	UPC	Ear borer	9	7.3	0.35
SEMK	UPC	Blight	10	8.1	0.34
SEMK	UPC	Rats	11	8.0	0.29
SEMK	UPC	Lack of draft power	12	9.7	0.42
SEMK	UPC	Lack of labor	13	13.0	0.37
SEMK	UPC	Floods	14	12.0	0.09

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

Notes: 1 is the highest priority and 25 is the lowest priority.
CCH=Central highland-central coast, SEMK= Southeast-Mekong Delta. UPSC=upland semi-commercial maize production, UPC=upland commercial, LWC=lowland commercial.

Annex 2. Solutions ranked by likelihood of producing an impact on alleviating constraints to maize production and potential suppliers of solutions.

Constraint	Solution	Probability of success	Probability of adoption	Likelihood ratio	NMRI / IAS	Univ	CIMMYT	Extension	Policy	Private sector	NGO	Prov DARD	IARC	Mass media
UPLAND														
Lack of knowledge on cultivation practices	Research on integrated farm resource management	0.8	0.5	0.40	X	X	X						X	
	Promote available sustainable farming systems through extension	0.75	0.5	0.38				X						
	Research on sustainable crop management	0.6	0.4	0.24	X	X								
	Farming system research	0.75	0.3	0.23	X	X						X		
Lack of investment capital	Easier access to formal credit for poor farmers	0.8	0.6	0.48					X					
	Subsidies for new seed, fertilizer to encourage poor farmers to adopt new/improved technologies, high yield variety	0.55	0.45	0.25					X					
	Encourage farmers to participate in credit groups	0.3	0.2	0.06							X			
Lack of suitable varieties (short-duration and high yield varieties to fit bio-ecological conditions and cropping patterns)	Develop short-duration, high yielding varieties	0.7	0.55	0.39	X		X							
	Test available short-duration varieties for adoption to local conditions	0.7	0.5	0.35	X							X		
	Introduce available short-duration varieties, appropriate cropping pattern to farmers	0.75	0.45	0.34				X						
Poor market access and undeveloped transportation system	More investment in rural road systems	0.8	0.6	0.48					X					
	Encourage private sector to become involved in marketing systems in areas with poor market access	0.6	0.5	0.30					X	X				
	Encourage animal producers to use locally produced products	0.6	0.4	0.24				X						
	Encourage farmers to raise horses, cattle for local transportation in mountainous areas	0.7	0.3	0.21				X						
Poor technology transfer system	Reorient the focus of extension activity to the need of local farmers	0.8	0.7	0.56				X						
	Allocate more resources (budget, personnel) for extension activities, particularly in the uplands	0.8	0.5	0.40					X			X		
	Human resource development for extension centers	0.7	0.4	0.28				X				X		
	Strengthen the linkage between research and extension	0.7	0.4	0.28	X	X		X		X	X	X		
	Develop demonstration plots, farming models for technology transfer	0.8	0.2	0.16				X						
Declining soil fertility	Research on integrated soil fertility management (considering biophysical and socioeconomic conditions of resource-poor farmers)	0.8	0.45	0.36	X	X								
	Dissemination of available soil fertility management techniques, sustainable farming practices	0.7	0.5	0.35				X						
	Accelerate the process of providing land use right to upland farmers (to encourage them to invest in soil fertility conservation and management, soil control)	0.7	0.4	0.28					X			X		
	Research on organic fertilizer use and balanced use of chemical fertilizer	0.6	0.4	0.24	X	X								

Note: the columns NMRI / IAS through Mass media appear under the heading "Possible suppliers of technology".

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

Note: NMRI= National Maize Research Institute, IAS= Institute for Agriculture Science, Univ= University, Extension= Extension centers, Prov. DARD= Provincial Department of Agriculture and Rural Development, IARC's= International Agricultural Research Centers.

Probability of success: Probability of success in finding a solution to the constraint.

Probability of adoption: Probability of adoption of the new technology by farmers.

Likelihood ratio: Likelihood index is the product of probability of success and probability of adoption.

Annex 2. Solutions ranked by likelihood of ....cont'd

Constraint	Solution	Probability of success	Probability of adoption	Likelihood ratio	Possible suppliers of technology: NMRI / IAS	Univ	CIMMYT	Extension	Policy	Private sector	NGO	Prov DARD	IARC	Mass media
	Bio-fertilizer research	0.5	0.4	0.20	X		X			X			X	
	Research on appropriate crop rotation	0.5	0.35	0.18	X	X								
	Strengthening farmers' knowledge on effects of soil erosion and soil fertility loses, community education	0.5	0.3	0.15				X			X			X
	Research on intercropping with nitrogen fixing crops	0.4	0.3	0.12	X	X							X	
	Improving germplasm adapted to nutrient deficiencies and other edaphic stresses	0.3	0.4	0.12	X		X							
Drought	Testing available early maturing, high yielding varieties for local conditions to avoid drought; cropping systems research	0.8	0.6	0.48	X							X		
	Develop early maturing variety to avoid drought	0.65	0.6	0.39	X		X							
	Introduce available short-duration varieties that are resistant to drought; introduce available farm-level drought management options	0.7	0.5	0.35				X						
	Develop drought tolerant variety (high yield)	0.4	0.75	0.30	X		X							
	Crop management research to mitigate drought effects (land preparation, planting time, crop management)	0.6	0.3	0.18	X		X						X	
	Improve irrigation system	0.35	0.3	0.11					X			X		
Undeveloped input supply system	Encourage private sector to become involved in input supply systems in mountainous, remote areas with poor market access (such as credit policy, subsidy for state enterprises, farmer organizations or cooperatives involved in input supply system)	0.6	0.6	0.36					X					
	Develop input supply system for areas with poor market access	0.4	0.2	0.08					X	X				
Inefficient use of fertilizer and pesticides	Research to increase efficiency of fertilizer use considering biophysical and socioeconomic conditions in the uplands	0.7	0.6	0.42	X	X								
	Increase farmer training on IPM, efficient use of fertilizer, pesticides, and integrated crop management	0.7	0.5	0.35				X						
	Pesticide research	0.6	0.4	0.24						X				
	Crop management research	0.7	0.3	0.21	X	X	X						X	
	Research on IPM for maize	0.35	0.3	0.11	X	X	X						X	
	Pest resistant varieties	0.3	0.3	0.09	X		X							
	Through private sector, provide training and information for local input dealers; encourage them to disseminate the information to farmers	0.4	0.2	0.08					X	X				
Lack of post-harvest facilities	Research to improve farm level post-harvest facilities, particularly for poor farmers	0.6	0.5	0.30	X	X		X						
	Provide incentive to encourage various stakeholders to invest in agriculture processing, post-harvesting facilities (credit support, price policy)	0.5	0.5	0.25					X	X				
	Research on varieties resistant to post-harvest storage pests	0.3	0.2	0.06			X							

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.

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Annex 2. Solutions ranked by likelihood of ....cont'd

Constraint	Solution	Probability of success	Probability of adoption	Likelihood ratio	Possible suppliers of technology: NMRI / IAS	Univ	CIMMYT	Extension	Policy	Private sector	NGO	Prov DARD	IARC	Mass media
Lack of technical information	Improve extension services for farmers, particularly in remote upland villages (more resource allocation, demand driven extension program, appropriate extension approach)	0.75	0.6	0.45				X	X			X		
	More technical information for farmers through mass media and other channels	0.35	0.35	0.12				X			X			X
	Develop extension network	0.6	0.2	0.12				X						
	Community based extension, farmer extension clubs	0.4	0.3	0.12				X			X			
Lack of market information	Enhance private sector involvement in marketing, exchange of goods, products	0.5	0.6	0.30					X	X				
	Develop government-supported market information system	0.6	0.3	0.18						X				X
Sloping land and soil erosion	Test available sustainable cultivation practices and adapt to site specific sloping land conditions	0.75	0.5	0.38	X							X		
	More extension activities to introduce appropriate soil erosion control measures and cultivation practices for upland farmers	0.7	0.4	0.28				X						
	Research on sloping land intercropping system, cropping patterns, and crop rotation	0.6	0.3	0.18	X	X	X						X	
	Research on soil control measures for sloping land	0.5	0.3	0.15	X	X	X						X	
	Research on appropriate land preparation (minimum/reduced tillage), weeding practices for sloping land	0.5	0.25	0.13	X		X						X	
LOWLAND														
Tight crop calendar	Cropping systems research (use available short-duration varieties, appropriate cropping pattern)	0.7	0.4	0.28	X	X								
	Use short-duration varieties	0.5	0.3	0.15	X									
	Improve land preparation	0.4	0.2	0.08	X									
High production costs	Research to improve efficiency of input use	0.7	0.5	0.35	X	X								
	Crop management research	0.5	0.3	0.15	X	X								
Lack of technical information	Improve extension services for farmers	0.75	0.55	0.41				X						
	More technical information for farmers through mass media and other channels	0.7	0.3	0.21							X			X
	Develop extension network	0.65	0.3	0.20				X						
	Community-based extension, farmers extension clubs	0.4	0.25	0.10				X			X			
Inefficient use of fertilizer and pesticides	Research to increase efficiency of fertilizer use	0.75	0.6	0.45	X	X							X	
	Increase farmer training on IPM, efficient use of fertilizer, pesticides, and integrated crop management	0.75	0.5	0.38				X						
	Pesticide research	0.6	0.45	0.27						X				
	Crop management research	0.7	0.3	0.21	X	X							X	
	Research on IPM for maize	0.4	0.4	0.16	X	X	X						X	
	Pest resistant varieties	0.3	0.35	0.11	X		X							
	Through private sector, provide training and information for local input dealers; encourage them to disseminate the information to farmers	0.3	0.3	0.09					X	X				

Source: IFAD-CIMMYT-Vietnam National Maize R&D Priority Setting Workshop 2002.
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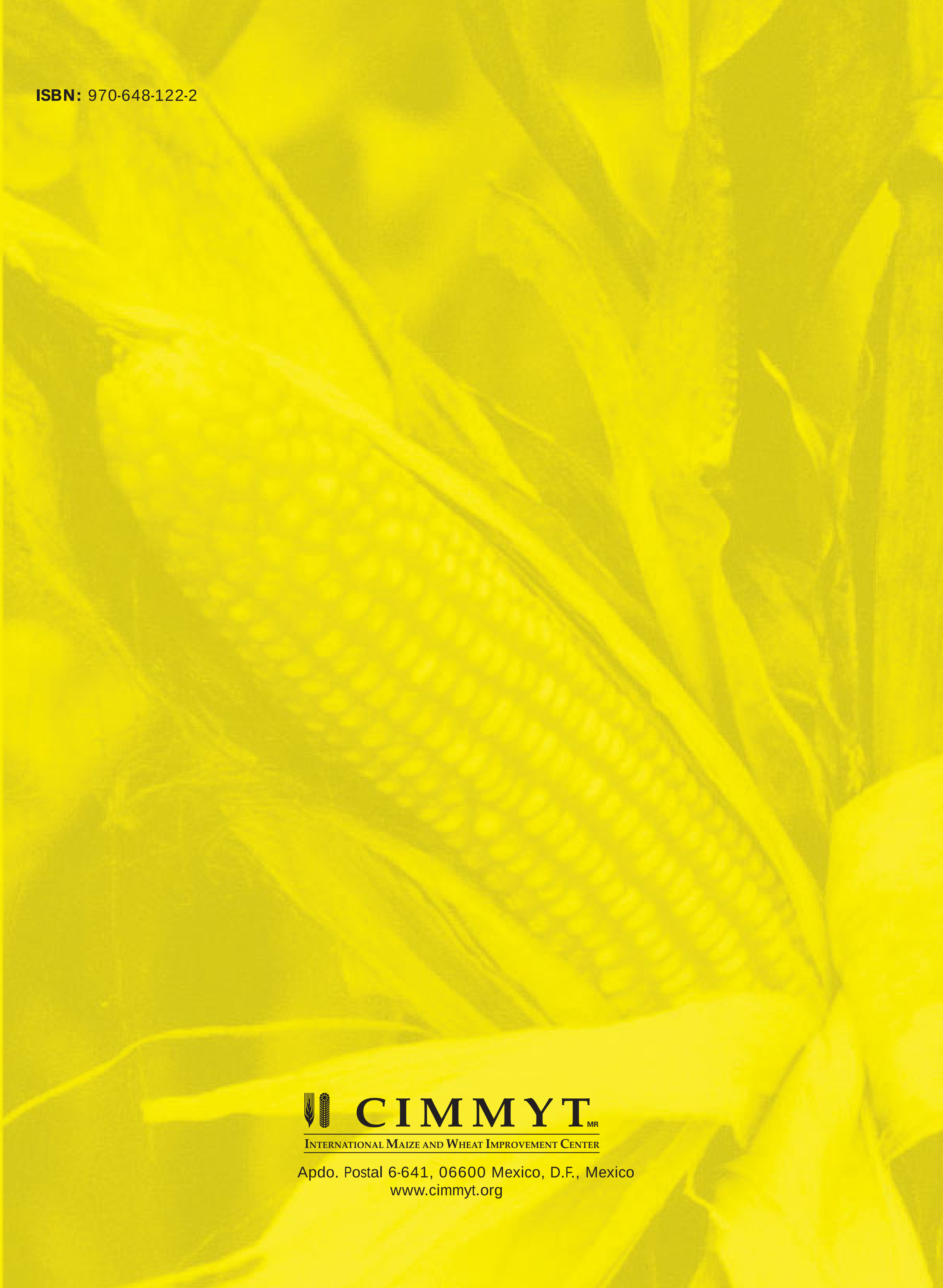

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