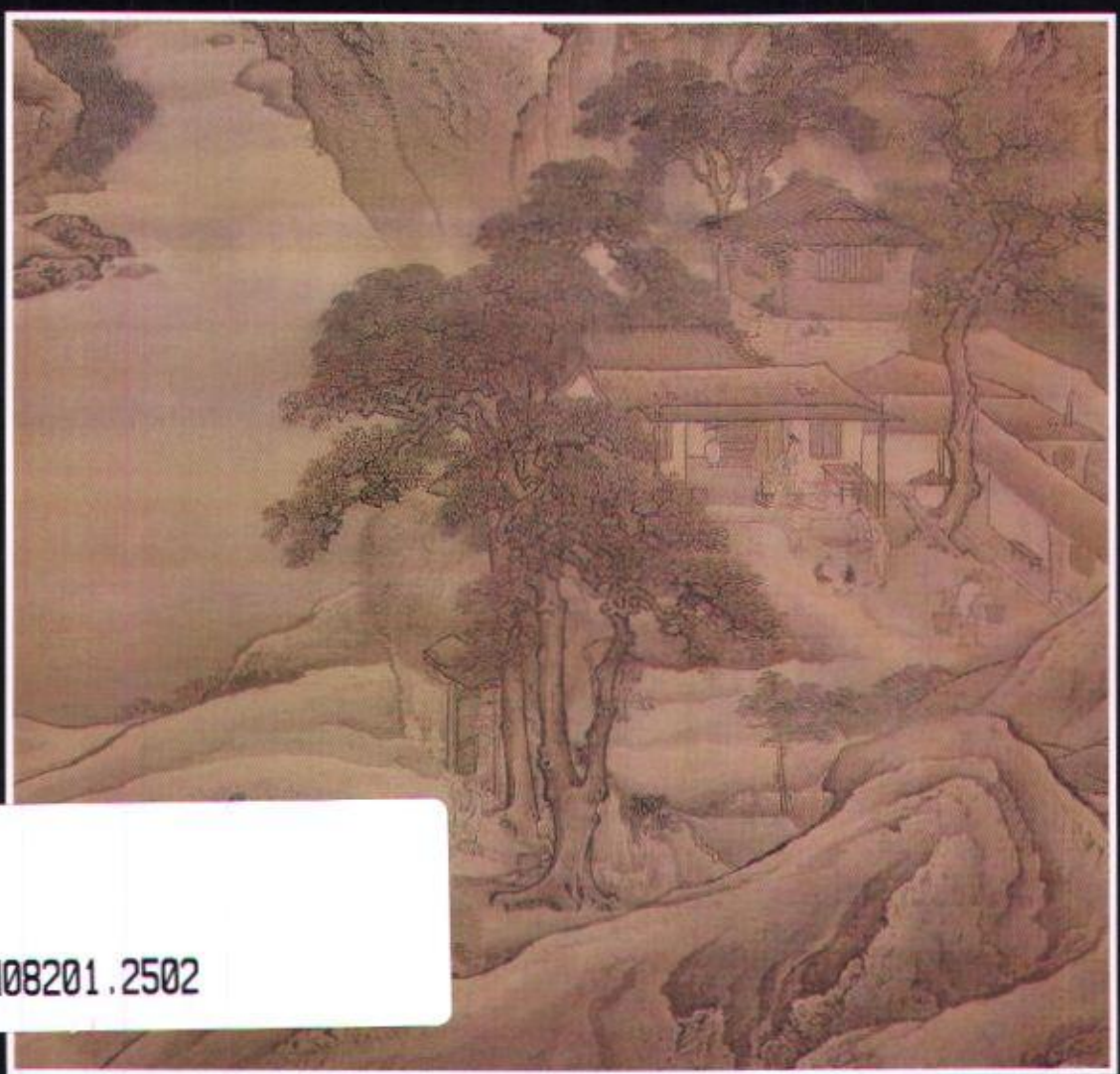
Yiching Song

"New" Seed in "Old" China

Impact of CIMMYT Collaborative Programme on Maize Breeding in South-western China



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Wageningen

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NWO 201, 2502

Propositions

People are the base of a state, while food is the life of people, therefore agriculture, especially food production, is the base for the base. *(This thesis).*

Farmers in poor marginal areas in SW China are women. *(This thesis).*

Local women farmers are capable of maintaining OPVs and landraces without external assistance. *(This thesis).*

Farmers know their farming systems and their needs better than anyone else. *(This thesis).*

Facilitation is the emergent key role for scientists in participatory plant breeding. *(Reflection on the impact of the Programme and the great potential role of CIMMYT in reaching the poor and women in marginal areas. This thesis).*

Food security in China is partially dependent on capturing the surplus productivity of small-holder farmers. *(This thesis).*

Food security in China is increasingly a question of natural resource conservation and regeneration. *(This thesis and reflection on the big flooding in China this year).*

Heaven has its seasons, earth has its balance and people have their agreeableness. (Chinese proverb).

When growing grain, one must cultivate at least five varieties to prevent calamity. (Chinese farming idiom).

Fish and fishing: Teach people how to fishing instead of giving them a fish. *(Chinese idiom).*

If you don't want to end up where you are going, you have to change your direction. *(Chinese proverb).*

Research is a process of participation and sharing. *(Reflection on undertaking this PhD research).*

These propositions are included in the thesis entitled "New" Seed in "Old" China: Impact of CIMMYT Collaborative Programme on Maize Breeding in South-western China.

Yiching Song

Wageningen, October 14, 1998.

"New" Seed in "Old" China

Impact of CIMMYT Collaborative Programme on Maize Breeding in South-Western China

Yiching Song

Proefschrift
ter verkrijging van de graad van doctor
op gezag van de rector magnificus
van de Landbouwuniversiteit Wageningen
dr. C.M. Karssen
in het openbaar te verdedigen
op woensdag 14 oktober 1998
des namiddags te vier uur in de Aula

CIP-DATA KONKINKLIJKE BIBLIOTHEEK, DEN HAAG

Yiching Song

"New" Seed in "Old" China: impact of CIMMYT
Collaborative Programme on maize breeding in
South-Western China / Yiching Song
Thesis Wageningen. - With summary in Dutch
ISBN 90-5485-968-7
Subject heading: agricultural development; China / agricultural research and extension;
China / food security; impact; maize.
English Editing: Janice Jiggins
Cover design: Charlie Chen

To Charlie, my dear partner

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Quotes from interviewees and from personal communications are also in *italics,* but are not acknowledges. This is to preserve the guarantee of anonymity given to respondents.

1 **mu** is one-fifteenth of a hectare and approximately 665 square metres.
1 **yuan** is approximately equal to $ US 012.

Acknowledgement

This study is indebted to a wide range of supporters who have contributed to it from different areas and various aspects. So I can say that the book is the result of collective effort and joint contribution

First of all, this book would not have been possible without the financial assistance of the CIMMYT Maize Programme. The author is very grateful to CIMMYT as well as to all the CIMMYT staff involved in the PhD Research Programme for their various contributions to the completion of this endeavour and, in particular, to Drs. Richard Wedderburn, Gilberto Hernandez, Carlos de Leon and Surinder K. Vasal, for their sincere support and encouragement through out the whole process. Special thanks go to John Woolston and M. Allmand who have gave me timely support with literature and other information from CIMMYT and ISNAR libraries.

Secondly, anyone reading this book will notice that its writing has been guided by the efforts of my two supervisors, Prof. Niels Röling and Prof. Paul Richards, and my potential, but great, supervisor Prof. Janice Jiggins. It was Niels who has been a major influence on my career and on me, personally. He has encouraged and supported me from the very beginning of the study when I was still in the midst of the puzzle. His contribution was of immense benefit for me in the design, organisation and elaboration of the whole process of the research. Paul has contributed tremendously to deepen the research and improve the quality of the book. His sharp mind and challenging insights assisted me to better think through the complex and intertwined issues emerging out of the study. Janice has made a considerable contribution to the research. Her gender sensitive approaches and sharp ideas have been extremely helpful in guiding the research and analysing the gender issues which emerged in the feminisation of agriculture in China in its current transition period. She also performed a magnificent job editing the book for me. In all, my deep thanks go to the three Professors for their constructive and guiding advice and sincere help.

I similarly thank the colleagues and staff of the Department of Communication and Innovation Studies and Group for Technology and Agrarian Development (TAO), in Wageningen Agricultural University for all their administrative support and academic help in the past four years during my research. Special thanks go to Prof. Van Woerkum and Prof. Van den Ban and Joke Janssen, Mieke Peters and Sjoukje Atema for all their helps and concern during my study in the Department.

Guided by the social constructivist view that the structure of natural science, in this case plant breeding, partly shapes and interacts with poverty and development, I have, as a social scientist, felt it highly necessary to explore and learn about the natural sciences concerned with maize and plant breeding. In this learning process, I have received great support and help from many natural scientists in various institutions, e.g., CIMMYT, CAAS, CPRO-DLO. Hereby, I would like to express my sincere thanks to all of them and, in particular, to Dr. Oene Dolstra, senior plant geneticist and maize breeder in CPRO-DLO the Netherlands, Dr.

Richard Wedderburn, a senior maize breeder and deputy director of CIMMYT Maize Programme, Dr. Zhang Shihuang, a leading maize breeder in CAAS, Dr. Yang Huaquan, a senior maize breeder and director of Guangxi Maize Institute in China, for their sincere help and advice. However, none of them will be responsible for my interpretation, views or errors.

I am indebted to the professionals and farmers of the three South-western provinces with whom I worked about two years in the field, especially those in Guangxi province. I am very grateful to Mr. Lu Dinghui, deputy director of Guangxi Agricultural Department, Dr. Yang Huaquan, director of Guangxi Maize Institute, Mr. Tong Qianjing, Deputy director of Guangxi General Extension Station, Mr. Qing Shenlin, director of Guangxi Seed Company, and all their staff for their support and contribution to the success of the field activities.

I owe much to the farmers, especially women farmers, from whom I benefited the most during the learning process and they thought me a lot. I really have had a life changing experience with them. I thank them very much for their trust and great support in hosting me and allowing me share their livelihood and insight. Special thanks go to farmers in Zhichen, Geyang and Wenteng Villages, in particular, to Lang Lijuan, Wei Binsheng, Lin Xoulin and Wei Mingning. The farmers gave me a lot help and concern during my stay and work with them. I owe them so much and the only thing I can do to pay back is to commit myself to the activities for the improvement of their status during the rest of my life.

I am grateful to my women friends. Lisa Stearns is the first one I want to thank for her great help through her participation in my field work, her editing part of this book and her unfailing encouragement. I also want to give my thanks to the friends in the Chinese Society of Women Studies (CSWS) in the United States and, in particular, Xu Wu and Zhou Jiping. Among my women friends, Xu Li has given me a lot concrete help and support for both my research and personal life. I was particularly empowered by working and discussing with them and their ideas have sharpened my gender sensitiveness in the study.

My close friend Gigi Manicad and her husband Jan Van Vegchel have gave me much help by providing me a home away from home and made my study abroad become easier. My sincere thanks and best wishes go to them and their lovely daughter, Suskia. A number of Chinese friends have also provided unfailing support and help to me, I thank them all and in particularly Huang Reiqing, Cheng Yi, Chen Jian, Zhang Xiaoyong, Wang Yihuan, and Ye Jingzhong.

Special mention must be made of Charlie, my dear partner, who has supported and encouraged me all the time and his love made me go on and finish this research. Charlie has given me tremendous support by not only sharing my life but also my research through participating in my field work, being my first reader, and designing the cover of the book, etc. His sharp mind and deep understanding of Chinese society have also contributed to the study through our discussion. We have experienced and shared the arduous times and exciting times together during the research.

Finally, because they have been the most important, my deep thanks go to my family members and, in particular, to my beloved parents; Song Jiyue and Zhao Guixiang and my son, Tao Tao. They have been always a tower of strength and support for me. My parents have helped me greatly in taking care of my son, and Tao Tao, my beloved son and a brave boy, has travelled alone between China and the Netherlands to visit and support his mother since he was eight years old. They have endured all the hardship and overcome all the difficulties of family separation during my study in the Netherlands. Without their sacrifices this book would not have been possible.

Acronyms and Abbreviations

AKS	Agricultural Knowledge System
CAAS	Chinese Academy of Agricultural Sciences
CGIAR	Consultative Group on International Agricultural Research. The CGIAR comprises sixteen international agricultural research centres located in various countries around the world
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CPRO	Centre for Plant Breeding and Reproduction Research
DLO	Netherlands Agricultural Research Department
FAO	Food and Agricultural Organization of the United Nations
FPR	Farmer Participatory Research
FSR	Farming System Research
GA	Gender Analysis
GDP	Gross domestic product
GR	Green Revolution
IARC	International Agricultural Research Centre
IFPRI	International Food Policy Research Institute
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
MoA	Ministry of Agriculture
MV	Modern Variety
NARS	National Agricultural Research System
NGO	Non-governmental Organization
OPV	Open-pollen variety
PRA	Participatory rural appraisal
PTD	Participatory technology development
PPB	Participatory plant breeding
RAAKS	Rapid Appraisal of Agricultural Knowledge Systems
R&D	Research and Development
RRA	Rapid Rural Appraisal
SSM	Soft System Methodology
SSTC	State Science and Technology Commission (China)
TOT	Transfer of Technology
TAO	Group for Technology and Agrarian Development in Wageningen Agricultural University
UNDP	United Nations Development Programme
WAU	Wageningen Agricultural University

Chapter 1

Scope of the Study

1.1. Introduction

The Chinese can be proud to say that China can feed 22% of the world's population with only 7% of the world's arable land. China's success in achieving self-sufficiency in food production in recent decades is remarkable in both Chinese and world history. However, past success does not necessarily guarantee future achievement. China's future ability to feed itself has recently provoked great concern in China and the world started with the projection given by Lester Brown[1].

A review of how China tackled food security in the aftermath of the famine associated with the Great Leap Forwards in the later 1950s can be helpful for formulating appropriate approaches for dealing with the relevant issues for today and tomorrow. It is revealed by some studies that the keys to the success were agricultural research, modern technologies, and farmers' initiatives and incentives to use and improve new technologies based on their own individual farming systems (Lin, 1998; Fan and Pardey, 1997). How to tap the potential of these key factors to achieve food security based on a sustainable and equitable agriculture development in China becomes the main concern of the present study. This book will examine some of the ways food security issues have been addressed in modern China. In particular, it will focus on the so-called Green Revolution approach. This is the idea that there can be major gains in food security through dissemination of scale-neutral fertiliser-responsive improved food grain cultivars (in China predominantly rice, wheat and maize) adaptable to a range of physical and organizational production contexts. The thesis focuses on the case of maize in China. CIMMYT has been the major global centre for maize research, and entered into a collaborative programme with the Chinese NARS in the late 1970s. The present book attempts a broad policy-oriented review of the impact of the CIMMYT Collaborative Programme in Southwest China over the past 15 years, and an assessment of current developments and future prospects.

The book comprises eight chapters. This first chapter provides a general introduction to the scope and context of the study. It moves, after introducing the main structure of the book, step by step from more general to specific issues, ending with the formulation of research problems, objectives and some central research questions.

Chapter 2 starts with review and exploration of relevant theoretical approaches and perspectives on technology development and transfer. Multiple perspectives and approaches are needed to deal with different aspects of the complex and interrelated research issues. Therefore, chapter 2 ends with a description and discussion of the comprehensive and complementary approach chosen to guide the study.

[1] Brown estimates that China will become a massive importer of grain, estimating that China's import deficit would reach 369 million tons in the year 2030, nearly double the current world's grain exports, which he thinks will drain world supplies, force grain prices up, and deny other low-income countries' access to the world grain market. Brown's projection aroused much public concern and awareness of these issues in China and throughout the World (Alexandratos, 1996)

Chapter 3 lays out the research approaches and methodologies used in the study. The research organisation and procedures are presented.

Chapters 4, 5, 6, and 7 present the empirical results of the study. Chapter 4 provides a general presentation of maize technology development. Based on the idea that to understand maize research it is necessary to understand the plant itself, the chapter starts with the origin, evolution and domestication of maize and then goes into a description of the basic genetic resources and principles of scientific breeding and the physical features of MVs. Differences between formal breeding and farmer breeding are discussed with reference to CIMMYT, Chinese NARS and two cases of farmer breeding at the village level.

Chapter 5 is a systematic study of the Programme's technology design, development and diffusion process. Actor networks and actors are mapped out and identified for further in-depth study. The chapter surveys the macro-level impact of the Programme.

Based on the finding revealed by the macro-level study that environmental variation is the main factor affecting the adoption and impact at farming level, Chapters 6 and 7 present the results of an in-depth comparative case study of two distinct areas using both qualitative and quantitative methods. Chapter 6 investigates the two contrasting farming systems in qualitative comparison. Chapter 7 presents the results of a formal questionnaire survey of 200 farmers selected randomly from the two distinct case study areas.

Finally, chapter 8 draws conclusions based on the main theoretical and practical findings, and ends with some discussion of policy implication for both CIMMYT and Chinese government.

1.2. Green Revolution and Alternatives

1.2.1. Crop breeding and Green Revolution

Systematic plant improvement involving production of cross-bred varieties dates from the 19th century. In the normal case plant breeders make crosses which they then stabilize over several selection cycles. For self-pollination crops such as rice and wheat their results are largely stable varieties from which farmers can continue to plant seed more or less indefinitely, through some segregationary renew.

Hybrid breeding[1] dates from the beginning of the 20th century and started with the hybridization of maize, which was developed in the USA by G.H.Shall, E.M.East and

[1] Hybrid and hybridization, here after means F1 hybrids (not just crosses of lines) which result from breeders' exploitation of hybrid vigour/heterosis by mating of distinct inbred lines (cf. F1 hybrid in chapter 4).

D.F.Jones (Liu, 1991). The hybrid vigour of the new varieties relieved the depression of yields experienced in local open-pollinated varieties (OPVs) as a result of forced inbreeding, especially in non-self-pollinating crops such as maize and sorghum. Although hybrids of maize for farmers were not available until the 1930s, they have spread rapidly in the United States (Ryan and Gross, 1948; Mendras, 1970), and were extended across large parts of Central America, Europe, East Africa and part of Asia after 1950 (Mendras, 1970, Liu, 1991).

The Green Revolution yield-increasing genetic innovations that are commonly considered are the use of dwarfing genes in wheat and rice, hybridisation in maize, and in the special case of China, hybridisation in rice (Heisey, 1994). Since the middle 1960s, semi-dwarf rice and wheat have been developed in Asia and Mexico have spread to large parts of Asia and Latin America. In the beginning, these varieties greatly out-yielded farmers' selections, especially. In some cases yield doubled or trebled. The adoption of semi-dwarf varieties by farmers in better-favoured environments of South Asia and SE Asia was dramatic during the period from the mid 1960s until early 1970s. The great leap in productivity was called the "Green Revolution".

The yield increase of the three main grain crops, mainly maize, rice and wheat, was surprisingly great and rapid world-wide. It has been estimated that from the beginning of this century the maize yield-per-acre has increased between 7 to 8 times, while those of wheat and rice has increased about 4 and 3 times respectively (Lin, 1995). This happened mainly after the wide introduction of high yielding modern varieties (MVs). The modern varieties of the main grain crops, developed through plant genetics, currently add at least 50 millions tons each year to Third World grain output (FAO, 1989). However, the rapid rise of the commercialisation of maize is even more dramatic. From the 1950s up until the 1970s, the world's total maize yield increased 25%, while the increase of maize trade was 40%. Up until 1980 the total amount of maize commercially purchased, either hybrids or improved OPVs, was more than 80 million tons, reaching a record in history (Brennan, 1992). It is not surprising that the biggest producer and exporter of maize is USA. In 1990 its total maize export was 53 million tons, about 75% of the world's total maize export that year (CIMMYT, 1991/1992).

The Green Revolution, initiated in the newly independent tropical and subtropical countries in the South and followed the growing concern about the hunger there toward the end of 1950s, was proposed to help the poor to increase their access to food. The obvious solution to the general need to alleviate poverty and hunger was to increase per capita food production and the 'normal way' of increasing agricultural production was seen to be through the introduction of modern technologies. Plant breeders focused their research on the three main staple food grain crops. Increasing the productivity of these staple food crops through plant breeding became the main task for scientists at international and, to some extent, national levels. In China since 1950, the target crops of the state's agriculture research and extension have been the above mentioned main

food crops. China achieved an outstanding success (among developing countries) in getting spectacular yield growth rates in all three crops.

The scientists' perception of the Green Revolution then was that, without political upheaval, modern varieties (MVs) could produce 'revolutionary' improvements in the well being of many of the world's poor (Lipton, 1989). It was assumed that growing more food at less risk and lower cost would help the poor. Scientists widely accepted that the widespread introduction of technically appropriate and profitable MVs would help the poor everywhere.

On balance, the Green Revolution was a success at meeting its primary objective of increasing crop yield and augmenting aggregate food supplies. The general impact of MVs on the South was impressive. Between one-third and one-half of the rice growing areas in the developing world are planted with MVs. However, in Africa and part of South Asia, the adoption of improved rice is quite limited. While in parts of Latin America and in the marginal and remote areas of Asia, farmers grow few or no hybrids. The adoption of F1 hybrid maize in most of the tropic and sub-tropic developing countries and regions is limited. A great deal of research revealed that for the less-favoured environments and the poorest farmers, the release of the MVs has not sufficed to improve people's socio-economic position and their access to food to the extent expected (Lipton, 1989; Conway and Barbier, 1988; Jiggins, 1986).

1.2.2. Second generation and other problems

Some studies (Lipton, 1971, 1975, 1983, 1985,1989; Jiggins, 1986; Conway, 1988, 1994;) pointed out that the people who benefited the least from MVs are small and poor farmers, especially women, in remote and marginal rain fed areas. They were, more or less, marginalized by rapid technology development.

By reference to Cochrane's (1958) 'agricultural treadmill' and Rogers' (1971, 1983, 1995) famous diffusion model it is possible to describe the marginalizing process as follows: many small firms each produce the same product, no one can control the price and each tries to do its best against the given price. The increase of productivity of all firms lowers the price of the product, benefiting consumers only. The first few bigger and earlier adopters of a new efficiency innovation capture a windfall profit, because prices are still determined by the inefficiency of the majority. The diffusion of innovation curve starts with a few earlier adopters, then spreads among later adopters and followers. This diffusion and innovation process, together with market forces, automatically squeeze the later adopters and inefficient farmers. Then these marginalized farmers become the labour force for other development (Röling, 1997). Furthermore, the characteristics of the MVs which are mainly uniform materials designed to adapt to a wide range of areas for environmentally favoured, intensive farming systems might partially contribute to the marginalizing process. This is especially true with maize, because the original materials and the institutional framework

design for the development and distribution of hybrid maize in developing countries are mainly based on the USA model with its large scale, mechanised and monoculture maize cropping system. Accordingly, therefore, it can be argued that small resource-poor farmers, cultivating varied rainfed environments, might not benefit from the uniform MVs to the same extent as better-endowed farmers in more favoured environments.

Three main points are raised by relevant researchers to support the argument and explain the limited uptake. *In the first place*, poor farmers have limited access to resources such as credit, marketing information, transport, etc. Furthermore, the cultivation environment in rainfed areas is risky and variable, e.g., rain may come or not come. Sometimes the farmer's investment/input would result in nothing. Farmers in such risky areas are normally too poor to run the risk of adopting MVs, if their adoption means further investment and more input. As a result, poor farmers in less favoured rain-fed remote areas seldom adopt MVs, especially hybrids. *In the second place,* the reduced income from agriculture (resulting from increase of food production and falling prices of food) in these areas sharply increased the out-migration of men, leading to a virtual 'feminization' of agriculture. Women who were left behind in agriculture, were overburdened with low or non-profit agricultural activities as unpaid labourers within the household. There were fewer opportunities for women-headed households to adopt MVs owing to their limited access to resources and services (Jiggins, 1986; Ashby, 1985). *In the third place,* hybridisation with homozygosity can rapidly improve crop yields, and give resistance to pests and diseases, in the short run, but reduces crop diversity. The rapid decrease of crop genetic and species diversity brought about by the spread of uniform MVs over time has increased the incidence of pest, disease and weed problems, owing to the narrow genetic base of the early introductions (though the genetic base of MVs has increased somewhat in more recent years, as scientists have become more aware of the problem). It is argued that this may potentially damage poor farmers' livelihoods, by largely reducing their crop selections and increasing their risk.

However, small poor farmers, mainly women, comprise the majority of the poverty population in resource poor areas. Agricultural innovation and diffusion of new technologies are important factors in developing countries' quest for food security. Maize is often grown in less-favoured areas because better land is reserved for high-value crops and usually diets in these areas are based primarily on maize. In order to attack poverty and hunger, it is critical to direct agricultural research to cover these marginal areas and poor populations.

These consideration give rise to questions such as: To what extent do farmers, especially poor farmers and women, do or do not benefit from the introduced MVs? What are the reasons and causes? What are the appropriate technologies needed by them?

In this study, I am going to look at the problems in one area of China and focus on MVs of maize and their impact, especially their impact on farmers (both men and women)

in subsistence agriculture in marginal and remote areas. This will be done through an impact study of a CIMMYT Collaborative Programme on maize breeding in Southwest China, where about 6 million poor farmers, for generations have cultivated and lived on maize in remote rocky mountain areas.

1.3. Food security in China

1.3.1. Food security and food self-sufficiency

China is a big country with limited arable land, only one tenth of its land is cultivable, yet it has a huge population. The total arable land is about 95.3 millions ha (statistics of 1994), one fifteenth of the world's total arable land. The population is more than 1.2 billion, about one fourth of the world's total. The crop land per person is 0.08 ha, one of the smallest ratios in the world. It is only one quarter of that of the world's average of 0.32 ha. Assuring food security for a huge population is a long-existing and fundamental challenge confronting Chinese farmers and governments.

China, as a traditional agricultural country, has long relied on its agricultural sector for the livelihoods of its people. A popular traditional idea is that 'People are the base of a state, while food is the life of people, therefore agriculture, especially food production, is the base for the base'. This ideology originates from 'Fajia', a school of thought dominant in the Spring and Autumn and Warring States Period 770-221 BC, and represented forces of reformism then. This basic 'Fajia' thought, combined with the 'Rujia' and 'Daujia' schools has served as a main guiding ideology throughout the whole subsequent history of development in China (Li, 1996).

The idea of food security by food self-sufficiency is deeply rooted in this country at national and household levels. In most of its history, China could feed its relatively huge population from its limited arable land. This reflects the deep rooted-ness of the idea of food-self-sufficiency among its people, mainly farmers, who have cultivated in subsistence agriculture with traditionally intensive and meticulous ways of farming.

After the establishment of the People's Republic of China in 1949 the government adopted a heavy industry oriented development strategy in order to have rapid development. This was followed by a series of urban biased policies, e.g. the low wage policy with inexpensive food and other necessities such as clothing, housing, and medical care, which are actually subsidised by the agricultural sector. The government instituted a food rationing system in urban areas in 1953. Meanwhile, in order to secure a low-priced supply of food for urban rationing, a low-price, compulsory grain procurement policy was imposed in rural areas (Lin, 1998), which is still partially maintained today.

In addition the "Hukou", the registration system[1] imposed in 1958 prevented the rural people from migrating to the urban areas. Agriculture was, in fact, treated as a supporting sector and farmers' labour was used to subsidise industrial development by the government.

Believing that collective form of production was an effective way to ensure easy control and mass mobilize rural labour, the government encouraged the replacement of the traditional independent family farm firstly by Collective Groups and then by People's Communes, by compulsion, in the late 1950s. The Communal movement together with the ambitious Great Leap Forwards movement led to a profound agricultural crisis between 1959 to 1961, and grain output was reduced by 15% in 1959 and 16% in 1960 and 1961. This immediately resulted in an astonishing famine countrywide which caused 30 million deaths (Aston et al. 1984) this made the government more realistic. Immediately afterwards the government gave priority to agriculture in it development strategy. Since then, Chinese leaders have considered food grain as a special or 'strategic' aspect of the security in the country; therefore, food grain production has been a priority in agriculture. With the goal of food self-sufficiency, Mao took food production as the 'key link' in agricultural development.

Government policy started to emphasise modern inputs in terms of modern varieties (mainly hybrids), fertilizer and irrigation. The most noteworthy change was the establishment of an agricultural research and extension systems for modern varieties (Lin, 1998). The development and distribution of MVs of the three main staples, i.e., rice, wheat and maize, has been their core task and the first priority for the systems from the very beginning. Plant breeders focused their research on the three staple crops, and made efforts to create high yielding MVs through plant breeding. The main task of extensionists is to transfer or 'extend' (literally 'push and enlarge' in Chinese) MVs through the government system (Ministry of Agriculture System). The efforts of public research and extension together with the farmers' initiative and incentive contributed greatly to a rapid growth in food grain production and productivity afterwards.

The achievement is impressive. Up till 1993, more than 54% of the total rice growing area was planted with hybrids (APAARE, IRRI, 1994). The area planted with hybrid maize is over 80% of the total maize area (Peng, Chen, 1993). Hybrid wheat is about 20% of the total wheat growing area (Li, 1996, p:155). The total grain output has increased three times from 164 million tons in 1952 to 490 million tons in 1996; as a result, per capita grain availability increased from 285 kg to 400 kg in the same period (Lin, 1998).

[1] "hukou" , household registration book, can be divided into two distinct categories, urban 'hukou' and rural 'hukou'. Without an urban 'hukou' a farmer can not legally reside and work in urban areas enjoying the subsidised ration systems there. It is one of the most important measures by the state in the control of rural-urban migration and the compulsory urban-rural separation was quite significant for the government's efficient control of labour, allocation of subsidies and other economic means (cf. Household Registration Regulation 1958).

Fan and Pardey (1977), in a study directly measuring the contribution of research to production, found that 20% of the growth in agriculture output from 1965 to 1993 was attributable to research-induced technology change. The modern varieties (MVs), contributed significantly to the increase of productivity of food grain crops, especially in the first Green Revolution period in 1960s and 1970s in China. A study by Perkins and Yusuf, estimated that increased inputs of chemical fertilizer and improved plant varieties, dubbed the 'biological package', accounted for at least half China's agricultural growth in the mid-60s through to the early 1980s (World Bank, 1994).

Since the beginning of 1980s, China has begun to reform its economic and institutional systems and is experiencing a socio-economic transition period, from a planned economy towards a more market-oriented economy. New policies have been introduced and great change has occurred in the social and economic context over the past 15 years. The changes that directly relate to the present research are two important ones; the rural reform started at the end of 1970s and the commercialization of public research and extension systems in the 1990s.

The most important elements of the rural reform included the change from the collective form of production, the People's Commune, to the household responsibility system, and the liberalization of agricultural prices, except for grain and cotton (Lin, 1997). The rural institutional reform released a great deal of initiative and incentive on farmers in agricultural production. Farmers have more space for their own decisions in the management of land and labour, cultivating on individual household-based farms. The period from 1979 to 1984 had seen the largest annual growth rate in total grain output and per capita grain output (China Statistic Yearbook 1995). However, since 1984, the annual growth of grain output has declined significantly, which has drawn attention from researchers at home and abroad. The argument given by Lin and Li, (1995) is in line with the present author's finding below that the main causes of the poor performance in grain production result mainly from continuous government intervention in grain production and marketing. Although the government liberalised the marketing and prices of most of the agricultural inputs and outputs. It still maintains government fixed procurement prices for grain and cotton at lower levels than market prices. So grain production became less profitable than non-food cash crop production and non-agricultural activities. It has been found by some studies that farmers in both environmentally favoured and harsh areas do not have much incentive to grow food grain crops. A great number of rural labourers shifted from agriculture and looked for new opportunities in the non-agricultural sector, in either rural or urban areas. This migration has been driven by the existence of rural surplus labour and partly by the lower returns to agriculture, especially food crops.

The commercialisation of the public research and extension systems was part of the overall market-oriented reform. The government reduced its financial appropriation for most of the public institutions and encouraged them to commercialise their technologies and expertise, using part of the proceeds to subsidize their research and part for the

welfare of their staff. As a result, the public agricultural research and extension systems have become more profit-driven than farmer-driven. In our case, this means a bias towards profitable maize hybrids and a neglect of unprofitable OPVs. Even so the income from commercialized activities was far from sufficient to compensate for the reduction in financial appropriation (Scott et al., 1997). Moreover market competition among institutions has brought some conflicts and confusion which adversely affected the interest of farmers (evidence will be given in the empirical chapters 4, 5, 6, 7).

1.3.2. Food security and poverty

Food security is a complex and widely debated issue. Access to food, availability of food, and entitlement to food, and the risks related to access, availability and entitlement, are the essential determinants of food security. Poverty is a major determinant of chronic food insecurity; the poor do not have adequate means to gain access to food in the quantities needed for a healthy life (IFPRI, 1992). Therefore, I agree that food security should not only focus on food availability but also on causes of food poverty too, i.e., constraints to the entitlement of the poor to food in specific settings for specific populations. This is because food availability does not necessarily equate with food security for all.

In order to alleviate poverty and improve household food security, a range of dimensions have to be considered, such as the characteristics of a country's food security problem, the nature of the food insecure population, resource availability and institutional capabilities, social restrictions on entitlement, and so on (IFPRI, 1992). A comprehensive assessment of the inter-related national and household food security problems and an evaluation of the public and private capability to deal with these problems at different levels, are essential for policy-making.

Lester Brown (1994) in his book, *"Who will feed China? Wake-up call for a small planet"*, points a gloomy and shocking picture of China's food problem in the next century and the threat this posed to the whole world. Brown's main argument is as follows: If countries become densely populated before they industrialise, they inevitably suffer a heavy loss of crop land. With rapid industrialisation, the loss of cropland quickly overrides the rise in land productivity. Meanwhile, industrialisation raises incomes; which means more consumption of livestock products and more demand for grain. Brown used present trend data on China, i.e., the rapid reduction of crop land, degradation of natural resources, slower growth in food grain production and productivity, and increasing growth of population and per capita income, to support his argument. He predicted that China would become a massive importer of grain, estimating that China's import deficit would reach 369 million tons in the year 2030, nearly double the current world's grain exports.

The prediction itself is too pessimistic and unrealistic, in the sense that part of the underlying analysis and data are based on western standards and models which are not in line with the real situation in China. Moreover, the prediction can hardly claim the

status of a true forecast, as uncertainty of the outcome increases overtime when addressing complex dynamic problems such as this. However, the study did provide a 'wake up call' or 'reminding call' to Chinese people as well as to the government. More attention subsequently has been given to food production and food insecurity poverty issues by the government and researchers.

The rural economy in China has experienced a rapid growth and diversification since the early 1980s. In the coastal and developed areas, agriculture has largely commercialised and industrialised. However, in environmentally less-favoured areas, mainly the South-Western and North-Western provinces, a great number of farmers still rely on subsistence agriculture for their livelihoods, and, in the poor remote mountainous areas, thousands of farmers still depend on shifting cultivation of maize.

There are about 80 million people who still live under the poverty line, and they comprise the majority of the food insecure population. They are mainly farmers in poor remote areas and the majority of them are women. These poor women farmers, who are left behind in agriculture by male out-migration, are the main food producers and managers at the household level. However, they have the least access to food and they are the poorest of the poor. These facts are often lost sight of in the rapid growth of the economy at the macro-level and in the aggregate statistics indicating that per capita income for China as a whole is increasing sharply. The latest UNDP data indicate that 11% of China's population, representing approximately 130 million people, earns less than $ 1 per day, equal to nearly half the number of people in this "poorest of the poor" income category found in all of sub-Saharan Africa. This large group of poor people are mainly resident in less favoured and remote rural areas, and are, more or less, marginalized by rapid economic development.

Furthermore, when we discuss food production and security, with special respect to the rural poor, the issues of environment and biodiversity conservation should be also addressed. It is argued by some researchers that poverty and environment degradation are closely linked, often in a self-perpetuating negative spiral in which poverty accelerates environmental degradation, which in turn results in, or exacerbates, poverty (Rosegrand et al, 1995). Continuing to neglect these less-favoured, vulnerable areas where many of the poor live will make degradation worse and perpetuate poverty.

The present research will address the issues and problems of food security both at national and farmers' household level by analysing the capabilities of public research and farmers' indigenous knowledge to deal with these problems at different levels.

1.3.3. Two different scenarios

The food issue has drawn a lot of attention from researchers, activists and policy makers in China from different fields. Many discussions and studies have been carried

out on this problem in search of appropriate strategies and solutions. Two major scenarios have emerged from the research and discussion. Their main ideas are presented here for testing.

The two different scenarios for increasing food grain production and ensure food security in China raised by Chinese researchers and policy makers are as follows:

The first is based on science-oriented thinking, which represents the main-stream, focusing on the public sector. It takes the conventional agricultural development approach: in order to feed a rapidly increasing population on a limited land base the obvious solution is to increase land productivity. The accepted way to improve land productivity is to raise the yield of the three staple food crops that occupy most of the cropland through the introduction of MVs. Policy makers and some scientists are still convinced by the impressive achievement of the Green Revolution in China. There is still a high hope that plant breeding, especially breeding with the new tools of biotechnology, will bring another 'great leap' in food grain productivity. The development of the technology and its transfer will, no doubt, take place, through the government system of agricultural research and extension, which has contributed greatly to the past achievement.

The second scenario is more based on farmers' potential and their needs and interests. Some researches (e.g. Li, 1996 and Deng, 1995) have shown that the most important motive for the majority of Chinese farmers to plant food grain crop now is to have enough for their own consumption. Farmers are not motivated to produce more food grain than for their own need, leading to a rapid decrease in the grain area harvested in the last decade, especially the last five years. Between 1990 and 1994, the grain area harvested dropped from 90.8 million ha to 85.7 million ha. This decline of 5.6 percent in four years, combined with a population growth of 59 million (4.9 percent), reduced the grain harvested area per person by a striking 10.5 percent (Brown, 1995). This is a startling decrease, especially for a country with such a huge population as China. There are four main distinct trends associated with the rapid decrease of the grain harvested area. The first is the conversion of crop land to non-farm uses, the second is the abandonment of cropland, the third is a decline in the multiple cropping index, and the final trend identified is the shift of land use by farmers from grain to more profitable crops, such as fruits and vegetables. The reasons for these trends are complex and differ according to a range of factors for different kinds of farmer in different regions (Lin and Deng, 1995, Zhang, 1996).

These researchers cited above argued that food problems can not be solved only by the introduction of modern technologies, which will result in nothing if farmers do not adopt them. The questions raised by them are; why do farmers not want to grow more food grain crops? Why did some farmers not adopt MVs ? What are the true needs and interests of farmers as food producers and consumers? They emphasize that now our

central concern should be to find out appropriate ways to promote farmers' motivation and to explore their potential by considering their own interests.

With reference to the general purpose of the present study, I am going to test the claims of the two scenarios of food production by comparing the two agricultural technology development systems, the top-down formal system and the farmers' indigenous system, through the CIMMYT Programme impact study. The main focus of the present research is agricultural technology design, development and diffusion in food production, with special reference to maize. Maize, as food and feed, plays a significant and special role in food security, both at farmers' household level and national level.

1.4. Maize in China

1.4.1. Maize development and its changing role as food and feed

China now is the second largest maize producer in the world next to the USA. In 1991, the total maize growing area reached 21.6 m. ha with an average yield of 4.56 tons/ha and a total yield of 93.4 m tons/year. China had 15.9% of the world's total maize area, 19.5% of its production and 122.9% of the world average yield (FAO, 1991).

Land productivity of maize has increased dramatically in the last four decades in China. Total production increased 623%, from 12.9 m tons in 1949 to 93.4 m tons in 1991, but the area under maize cultivation increased by 96% only. It is believed that this achievement can be mainly attributed to the wide adoption of hybrids and the increased use of chemical inputs. It has been stated by the government that the area planted with hybrids is over 80% of the total maize growing area, the highest percent of hybrid area among the three staple food crops.

Maize is a traditional food crop. However, in this century, especially after the introduction of hybridisation of maize in the 1930s, maize has been increasingly used as a feed and fodder crop for development of animal husbandry. Since the 1980s about two-third of the maize produced in the world is used for feed, mainly in the developed world. (FAO, 1986). Meanwhile maize is still an important staple food for poor people in some developing countries.

In China, rice, wheat and maize have long been the three traditional main food crops. Each of these three grains accounts for roughly 100 million tons of the 340 million tons annual grain harvested. However, rice and wheat are now the two national staples, with rice dominating in the South and wheat in the North. Maize used to be staple food in the North-East, South-West and some of the hilly areas of the North and South. It is now increasingly used as feed. About 70% of the maize harvest now is used as feed (Dong, 1995). Some maize is still consumed as staple food by people in the poor, remote

rainfed mountain areas. There is a saying in the Southwest that maize is a poor people's crop, a symbol of poverty (recorded in Guangxi maize area 1997 by the author).

1.4.2. Distribution of maize and the two distinct maize areas

Maize now is produced in China in a territory stretching from the Northern plain area and passing through North China down to the hilly-mountain region of the South-West. It is inadequate to use the familiar American term 'corn belt' for the Chinese situation (Li, 1988), since maize is grown in China in a wide variety of non-homogenous environments covering nearly 30 degrees of latitude.

Five maize regions are delineated and designated in geographical terms i.e., the Northeast, the North, the South-West, the North-West and the South-East. Actually the last two regions only make up 8% of the total area, while the first three regions are the leading maize regions, which cover about 92% of the total maize growing area in 12 provinces in China.

The three leading maize regions:

The three leading maize production regions form a broad diagonal area from North-Eastern China to the South-Western provinces, passing through a large corridor in North China (cf. Map 1-1).

Region 1, the North-Eastern region, includes three of the four provinces; Heilongjiang, Jilin, Liaoning, lying north of 40 degrees north latitude, which covers 28% of the nation's maize area. In two, Jilin and Liaoning, a greater proportion of the cultivated land (60-65%) is devoted to maize than to any other crop. Being similar to the Corn Belt of the USA in soil types and climatic conditions, those two provinces give high yields of maize and sorghum. Since wheat does not grow well there, maize has been the first ranked crop for many years.

Region 2, the North China region, lies between 40 and 33 degrees latitude in the northern part of China and spreads out along the Yellow, Hai and Huai River valleys. It includes 5 provinces; Hebei, Shangdong, Shanxi, Henan and Shanxi, and has a total of 7.9 million ha of maize, covering 41.5% of the total maize area. In this region, maize and wheat are the two main food crops.

Region 3. About 22.5% of the nation's maize is grown in region 3, known as the South-Western region. It has 4.52 million ha of maize crop, which can be found on hills and mountains ranging from 250 to 3000 m in altitude. Because of the low fertility of the red soils, many rainy or foggy days, and various socio-economic difficulties, the yield of maize in this region is much lower than the national average.

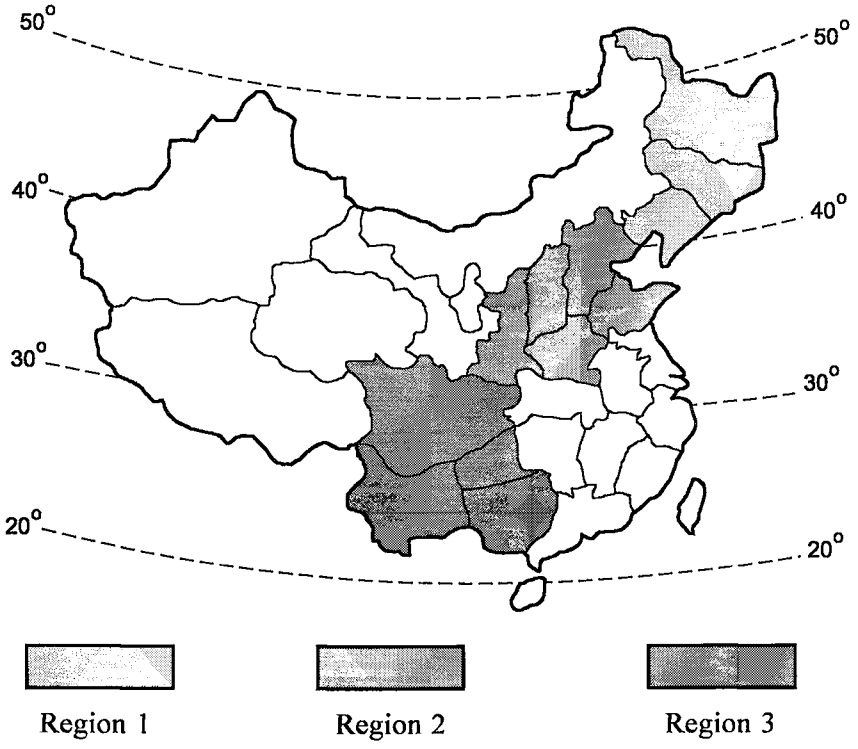

Figure 1-1: The three leading maize regions in China

Two distinct maize growing areas:

The maize growing area can be divided into two main distinct parts, i.e., the Northern plain and the South-West. The South-West can be considered as a specific maize region, while the Northern plain, mainly the Northeast and the North, is the main maize growing area in China now. The two regions vary from each other distinctively in natural environment, and in socio-economic and cultural contexts. The Northern plain is located in a temperate zone, while the South-West has a tropical and sub-tropical climate. The North is a central plains region. The South-West is a remote mountain area inhabited mainly by minority peoples (cf. Figure 1-2).

The motivation to cultivate maize and ways of cultivation are rather different in the two regions, too. The maize produced in the North area is now mainly for feed and export; less than 5% is for human consumption. But, maize in the South-West is the staple food for the survival of thousands of poor farmers, with 96% of the maize harvests used as food in the South-Western three provinces, Guangxi, Yunan and Guizhou

(CIMMYT 1986). At present there are still 25 million people there living under the poverty line (World Bank, 1995) and they are mainly maize growers and direct consumers in the mountainous remote areas (cf. chapter 5). The Northern area has a more favoured, irrigated environment, while the maize growing area in the South-West largely covers the karst mountain regions, which constitute typical rain-fed risky areas. Given this great riskiness in the Southwest it is not surprising that the adoption of hybrids in the North is more than 95%, while that in the Southwest is only about 45% (National Statistic Year Book, 1992).

As a result, the yield varies greatly in the two regions. In Liaoning province of the north region, for instance, the average yield reached 6.11 t/ha in 1984, the highest yield on record. During the same year in the mountainous provinces of the South-West region, i.e. Yunan and Guangxi, the average yields were 2.8 t/ha and 1.9 t/ha respectively (cf. Table 1-1 for the comparison of the Southwest three provinces to the total nation).

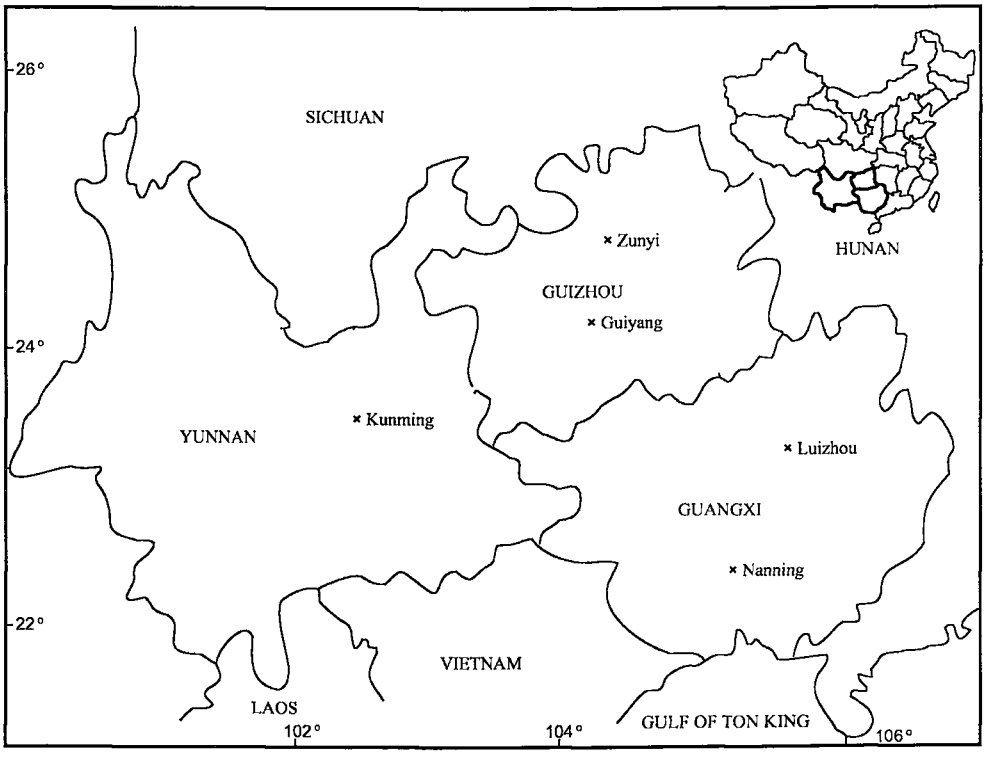

Figure 1-2: Location of the three South-Western provinces, the research area

Table 1-1: Maize production in the three south-western provinces and the total country

Items: / Region:	Area of total arable land (million ha)	(%)	Total maize area (million ha)	(%)	Total Production (million ton)	(%)	Average yield (ton/ha)	Hybrid area/ Total maize area (%)
Southwest provinces	7.3	7.6%	2.1	10%	5.8	5.9%	2.7	45%
Total China	94.9	100%	21.4	100%	97	100%	4.5	83%

Source: Compiled by the Author from Chinese Statistical Year Book 1994

Considering the general purpose of the study the three South-Western provinces were selected as the research area for the present study.

1.4.3. The importance of maize for the poor in the Southwest[1]

The CIMMYT Programme covers three provinces, Guangxi, Yunan and Guizhou in the South-Western border of China, with a population of about 97 million and 45.5 million hectares of arable land. The rural population comprises 85.6% of its total population (National Statistic Year Book 1994).

The low-elevation karst ranges and karst plateaux comprise a large part of the region. Much of the area is high plateau with hilly land and rather poor soils. Fertile soils cover only about 10% of the area while the hilly eroded soil covers 50-70%, and poor and highland soil are 20-30% (Peng & Chen, 1993). This region has been considered a remote and mountainous area in history and remains so today. Many minority peoples have been gathering and living there for generations. In history, this area was called 'man huang di', meaning a waste and desert area, normally used to exile prisoners.

Poverty

The region contains 149 poor counties, (i.e. nationally designated poor counties under the 8-7 Plan[2]), and about 25 million poor people, or nearly one third of China's remaining absolute poor, mainly residing in the remote upland areas of the three provinces. More than half of these absolute poor are ethnic minority people. For instance, in Guangxi province, the minority people comprise more than 90% of the poor population.(World Bank, 1995). These minority peoples have cultivated and lived on maize in the isolated,

[1] South-West in the study hereon refers to the CIMMYT Programme area, including three provinces, Guangxi, Yunan and Guizhou.

[2] Newly issued National Seven-Year (1994-2000) Plan for Poverty Reduction (8-7 Plan), through which the government's poverty reduction strategy has been further defined and substantially updated.

remote rocky mountain area for generations. As in many other tropical mountain areas, these minority peoples used slash and burn cultivation for maize production. The traditional way of cultivation is still maintained and practised as an integral part of the local life style and farming system in some areas.

The incidence of rural poverty here is about six times the national average. Average rural per-capita income and grain production in the three provinces, especially the remote upland areas, are also substantially less than the national average (World Bank, 1995). These areas are the major target areas for poverty alleviation programmes of the Chinese Government as well as the international community.

Maize production

Maize, with its versatile nature and adaptability to difficult growing condition, is an important traditional food crop (See Chapter 4) and is the second most important food crop (next only to rice) in the three provinces. For the remote mountainous areas, maize is the main staple food for the rural poor, who depend basically on maize for their survival. In 1985, when CIMMYT began to participate intensively in the maize breeding work in this area, 96% of the maize produced there was for human consumption (CIMMYT 1990).

The maize area of the three Southwest provinces occupies 2.1 m ha (10% of China maize area), with a total production of 5.767 m t (5.9% of China's maize production), and a mean yield of only 2.771 t/ha. The adoption of hybrids in its total maize growing area is only about 45%. (National Statistics Year Book 1994). Non-hybrid maize varieties, with yields averaging only about 2 tons per ha, occupy 60 to 90 percent of the maize growing area in those rainfed mountainous regions. Thus, in comparison with the country as a whole, the area planted with maize in the three southern provinces is large, but of low productivity.

The three South-Western provinces, the original maize growing area in China (cf. chapter 4), have not been able to parallel the rapid increase of maize production and productivity in the North. They have been left behind by rapid technology development. It is believed by some Chinese scientists and policy makers that the major reason for this is the lower adoption of hybrids resulting from lower fertiliser availability together with some climatic factors, poor soil and poor cultural practices (Peng and Chen, 1993).

With the general objective of increasing maize production and productivity and the reduction of hunger and poverty in this area, CIMMYT started a Collaborative Programme for high yielding maize breeding in the early 1980s. An impact study of this on-going Programme is the main task and general purpose of the present study.

1.5. CIMMYT Collaborative Maize Programme in South-Western China

1.5.1. The initiative and starting

After the resumption of diplomatic relations between the USA and China, the first USA delegation, headed by former President Nixon, visited China in 1973. Dr. Norman Borlaug, former director of CIMMYT's Wheat Programme, came along as a delegate and when he visited the Chinese Academy of Agricultural Science (CAAS), he promised to provide some improved maize and wheat varieties and germplasm for China. This initiated the collaboration between CIMMYT and China in maize and wheat breeding. In 1977, Professor Li Jingxuong , a well-known maize breeder and former director of the Maize Program in the Chinese Academy of Agricultural Sciences (CAAS), was invited to visit CIMMYT. During the visit, several entries were requested and brought back to China. These materials were later tested in farm trials in the Southwest (Guangxi first and then Yunan and Guizhou), taking into consideration of the similarities in the latitude and tropical and subtropical climate between South-Western China and Mexico, where the headquarters of CIMMYT is located. The test results indicated that several entries had a good adaptation and showed good yield potential in the local context.

Given that the major research mandate of CIMMYT is to breed and improve varieties of maize and wheat for tropical and subtropical areas in the developing countries in the South, in short, breeding for the poor, CIMMYT and the Chinese Academy of Agricultural Science (CAAS) agreed to start a collaborative high yielding maize breeding program in the three provinces, Guangxi, Yunan and Guizhou, of South-Western China in 1980. In 1983, the first CIMMYT delegation, headed by Dr. Norman Borlaug, visited CAAS in Beijing and the three provinces in the South-West. The collaboration became more intense and actively implemented from 1985 onwards, after the establishment of CIMMYT's Asia Maize Programme in Bangkok, in 1985. Since then, CIMMYT provides germplasm every year directly to the Maize Institutes in the three provinces. CIMMYT breeders come two times a year to the provinces and some Chinese breeders have visited and trained in CIMMYT.

1.5.2. Major components

The major components of the Programme are:

- Provision and transfer of some tropical and sub-tropical maize germplasm from CIMMYT to China to enlarge the local genetic background resources for improving maize breeding.

- Co-operative international trials with some specific plant breeding objectives, like drought-resistance, disease resistance and etc., in the local contexts.

- Personnel training, i.e., CIMMYT helps China to train some promising young researchers in the headquarters of CIMMYT in Mexico and also gives some training courses and seminars in China to provide technical training for, and open up discussion with, local researchers and extensionists.

- Consultancies from CIMMYT scientists to advise and assist the national and provincial research efforts in maize breeding.

Three provincial Agricultural Academies (parent institutions of the Maize Institutes) are directly involved in this programme, i.e., the Academies of Guangxi, Yunan and Guizhao in the Southwest of China.

1.5.3. General Objective

The general objective of the Programme is poverty/hunger alleviation by increasing maize productivity and production in the South-West China, where maize is an important subsistence grain crop (as explained).

1.6. Formulation of the research problem, Objectives and Relevance

1.6.1. Research problem

How to tackle food security in China is an issue of both national and international significance. The political and socio-economic environment in China has changed rapidly recently. In order to achieve food security under the new circumstances with a more sustainable and equitable development base, appropriate approaches and measures to tap the potential of the key factors, agricultural research, modern technology, and farmers' initiatives and incentives are all crucial and significant factors.

Since the early 1960s the Chinese government has adopted a F1 hybrid approach, which is implemented totally through its public research and extension systems, in food production to ensure national food security. China (unlike some other countries in the developing world) has made a major success of F1 hybrid maize, and even a unique success of F1 hybrid rice during its Green Revolution period. This is mainly attributable to the centrally planned economic system characteristic of socialist economies which is known for its ability to mobilise resources for specific projects (Lin, 1998). It is widely accepted that China developed a strong national state run research and extension systems for the development and distribution of MVs.

However, due to the reform and introduction of market economy, the former conditions and contexts are rapidly changing; increasing market economy, decentralisation of central power and privatisation of public systems. Then, the central

issue confronting us is how food security should be tackled under current circumstances? What should be the degree of emphasis on F 1 hybrids under these new circumstances?

Maize plays a special and significant role in food security and poverty alleviation due to the fact that, contrasting with its utilization for feed in industrial countries and relatively developed areas, it is still directly consumed as food by millions of the poor in less favourable tropical and sub-tropical areas. In China, nearly two-thirds of the maize area is temperate in environment (the Northern plain) with the remaining area subtropical to tropical in its growing environment (the Southwest). So the main maize growing areas are in the Northern plain with a climate and production environment similar to the U.S. Corn Belt. It is here that the public centred effort in hybrid maize development and distribution has focused. Most of the hybrids used in the Northern plain are based on U.S. dent germplasm (Li, 1988; Timothy, Harvey and Dowswell, 1988). Use of F1 hybrid maize in the poorer, hilly sub-tropical and tropical SW China are not so high as in the temperate Northern plain. In the SW, maize is still a human subsistence crop and not mainly for feed as in the North.

CIMMYT started its collaboration with Chinese NARS in maize breeding in the Southwest in the late 1970s. CIMMYT traditionally focuses on OPVs and the tropic and subtropics. As CIMMYT's mandate is to help the poor in the tropical and sub-tropical developing countries and it believes that OPVs are better for poor farmers in environmentally and economically unfavourable areas due to the genetic characters of OPVs and hybrids and the characteristics of poor farmers and their farming systems (cf. chapter 4).

This means that from the outset there has been some tension between China's commitment to F 1 hybrids and CIMMYT's commitment to OPVs. One of the tasks below is to trace how this difference of orientation has played out on the ground. In fact this leads us to the **central research problem** of this book: in order to tap the potential of agriculture technology and farmers' initiative and incentives in maize production to achieve food security, should the government continue to follow the predominant F1 hybrid approach via public systems, or should it start to open up alternative approaches with a multiple focus such as (for example) a combination of the F1 hybrid approach with CIMMYT's OPV approach and an institutional combining public system seed research and distribution with farmer-led local approaches to seed selection and distribution.

Through the impact study my research looks at CIMMYT and Chinese government impact on both macro and micro-levels and farmers responses and strategies towards different varieties in two distinct regions, -a favourable and a less favourable one- and then reflects on the technology design and development process to address relevant technical and institutional issues in order to highlight this central research problem.

1.6.2. Research objectives

Two general purposes of the study

The *first* general purpose of the study is to provide feedback to CIMMYT and Chinese NARS on the level of adoption and impact of the improved maize varieties bred out through collective efforts. The *second* general purpose is to examine the impact on farmers, particularly the poor and women, specifically to generate information better to "reach the un-reached" in the future.

Research objectives

1. to evaluate the impact of CIMMYT derived technologies in terms of their adoption by farmers (yield, surface, type of technology adopted). This includes farmers' assessment of the technologies, the way they apply them, their sources of information, their access to inputs, and the market of the produce at the local level.

2. to study how the technologies were developed, the institutional contexts within which this happened, the objectives and perspectives of the scientists and officials involved. The focus of part of the study is on analysis of the principal institutional and organisational factors influencing the design, development and diffusion of the technologies.

3. to identify the actors in the networks involved in the process of agricultural technology development and diffusion and examine ways for better linkage, integration and interaction between IARCs, NARS and the farmers' informal system, between formal science and indigenous science, and to find ways to tie into farmers' indigenous livelihood processes.

General research questions

Based on the above objectives, three sets of general research questions are formulated as follows:

- What influence does the Programme have on food production and on the food security in Southwest China? What is its impact on resource-poor farmers, and women farmers in particular?

- How are the technologies constructed by society? What are the global network and national network and how do these networks connect to the local networks at village and farmers' household levels? What are the roles of the networks at different levels in the process of technology design, development and diffusion process?

- What is the role of indigenous knowledge in the adoption and reconstruction of the scientific technologies and what is important in local agricultural development? How can this knowledge, and farmers themselves, be involved in the technology development process?

In the study some practical questions also need to be answered:

- How many and what kinds of improved germplasm came from CIMMYT?
- How many varieties and what kinds of varieties have been released, based on CIMMYT genetic material, by the three provincial breeding programmes?
- How many farmers and what kinds of farmer have adopted these new varieties?
- What has been the general impact on production of these new varieties (yield, surface etc., and the change over the last 15 years)?
- What is the situation regarding the use of external inputs, and outputs, of the MVs?
- How did farmers get the information and knowledge on the technology, i.e., through what means did they learn about and obtain the new varieties and relevant training?
- What is the distinction between environmentally favoured areas, and the mountainous rainfed areas in the adoption of these new varieties?
- What are the differences among types of farmers(poor/rich//women/men) in adoption, i.e., types of varieties, ways of improving and reshaping of these MVs and reasons for these differences?
- What are the differences among farmers (different types of farmers), researchers (at different levels) and extensionists in evaluating these varieties?
- What are resource poor farmers' (women and men) ideas about good and ideal maize varieties?
- Do farmers still keep local varieties, why and how?
- How do scientific varieties and the local ones compare?

1.6.3. Relevance of the study

The present study is an attempt to understand key factors in food security by addressing "second generation" problems in the South, i.e., food security and poverty, and the

capability of public agricultural knowledge systems, and of farmers' efforts to develop their own farming systems. Impact study of CIMMYT's Collaborative Programme provides an unique opportunity to conduct a comprehensive assessment of these interrelated issues and evaluate the capacity of the public system and the farmers' systems.

Multiple perspectives and indicators have been adopted to study the impact of CIMMYT-related technology at both the macro and micro-levels in terms of the general increase of yield and coverage at the provincial levels and the farmers' response and strategies with respect to the technology at the household level. Subsequently, the institutional context for technology development and distribution, as well as the farmers' indigenous knowledge development practices are analysed and reflected upon from a perspective influenced by the literature on the social construction of technology (the constructivist perspective-see below), in order to reveal the processes through which technology and innovation are shaped by social action. It is hoped that, theoretically, the study will contribute to the existing body of knowledge relating to the "social construction of technology".

The Programme started in the late 1970s and has paralleled the economic reform in China. It is expected that the impact study herein reported will generate valuable insights into the future options and prospects for China's agricultural research system. I hoped that the impact study will provide Chinese policy-makers with useful information in formatting more durable and comprehensive policies addressing food security as well as poverty reduction and natural resource conservation issues, and help them to tackle difficult institutional reform and restructuring issues.

Furthermore as CIMMYT has long been searching for ways to improve the performance of National Agricultural Research Systems (NARS), it is hoped that some valuable insights can be drawn from the present study to improve CIMMYT's effective collaboration and partnership with Chinese NARS and other partner countries.

Chapter 2

Exploratory Perspectives and Tools

2.1. Introduction

This chapter provides a theoretical review and exploration. Four major sections are included. First of all, in this introduction section, the key concepts used, such as evaluation and impact are clarified. The second section presents a general overview and analysis of the main approaches to agricultural development, conventional policy models and emerging challenges and approaches. In the third section, the main theoretical perspectives, including the social construction of technology, the actor-oriented approach, and Agricultural and Knowledge Systems (AKS), are explored and elaborated using a constructivist perspective. The last section is a synthesis of the above mentioned perspectives in order to explore which part of each perspective will fit and will be used in the different areas and stages of the research.

First of all some conceptual clarification is necessary for the definition of evaluation and evaluation area, standards and criteria. Questions arise like; What is evaluation? Why is evaluation needed? How to do it and what are the criteria? These are major questions facing every evaluator. They have increasingly drawn attention in the social sciences. Various perspectives have emerged with different definitions and approaches to evaluation. The following paragraphs are intended to discuss and answer these questions and clarify the key concepts of relevance to the present study.

The conventional approach to evaluation is represented by Ralph Tyler (1950). It emphasises goals and objectives; evaluation is seen as the process of determining the extent to which the stated goal and objectives of a programme are being attained. Conventional approaches view evaluation as a kind of tool for effective control and management.

Utilisation-focused evaluation emphasises the utility of evaluation (Patton, 1986). Patton defines evaluation as:

> *"the systematic collection of information about the activities, characteristics, and outcomes of programs for use by specific people to reduce uncertainties, improve effectiveness, and make decisions with regard to what those programs are doing and affecting"* (p.14).

This broad definition emphasises the collection of data that are meant to be used for programme improvement and decision making. According to Patton's empirical approach, program evaluation means using reasonably valid and reliable data to assess what is happening in a programme and the programme's effects on the people it is intended to serve (Patton, 1991).

Evaluation in the sense outlined by Patton has been widely used as an instrument for checking the Transfer of Technology (TOT) model of extension. The approach is underpinned by the assumption of positivist realism. In contrast, Norman Long (1989), from a sociologist's view, emphasises that

> "*evaluation must be analysed in the first place as a mechanism inter-linking different interventions through time, secondly, as an important factor in the systematic production of ideologies legitimating the role of intervening agencies and thus also the implied power relations between these agencies and target groups*" (p. 45).

He views the evaluation process itself as a complex phenomenon, serving as a mechanism and guardian for intervening agencies. Guba and Lincoln, in their book 'Fouth Generation Evaluation' (1989), from a constructivist point of view, emphasise the constructivist nature of evaluation and the subjective role of evaluators as partners with stakeholders in formulating the questions, and in giving meaning and assessing outcomes. They see evaluation as negotiation and as a participatory process. The evaluation data have neither special status nor legitimation; they represent simply another construction to be considered in the move towards consensus (Guba and Lincoln, 1989). Their formulation provides a theoretical base for participatory evaluation.

Social constructivism and participatory evaluation are the main guides and tools used in the present study. All the planned interventions are seen as socially constructed by the actors, shaped by their own interests, and all involved in struggling, negotiating and communicating to reach their own goals. The power relations between different actors and their networks at different levels in the Programme are important factors to understand in the technology construction process.

According to Patton, evaluation differs from research in that the former is aimed at action or utilisation, while the goal of the latter is a search for truth (Patton, 1986). Then what is the relationship between the two? A discussion of this will definitely bring us to the 'famous discussion' of the relationship between truth and practice, thus I will not repeat it extensively. What I would like to argue is that there is no clear-cut distinction between an evaluation and research. One serves as a base for the other and both support each other. A good evaluation, in terms of constructive and convincing, should be a combination of the two.

Therefore, the role I would like to play in the study is not only that of evaluator but of researcher as well, for I do not only want to know *what* and *which* about the project's impact but also *why* things occurred like that and *how* they can be improved. Then, my major research problem becomes how to define and measure impact. That is, what kinds of impacts: only the impact which technology has on society or also the social impact on the generation of technology? On this point I appreciate the view point that we are required to address a reality made up not of "society and technology" as separate spheres, but of socio-technological complexes (Latour, 1992). Therefore the society-technology interface and the interaction between different social actors in the technology construction process become the main research area in the evaluation.

I came to realise the nature and appropriateness of technology are not only determined by technology itself or any other factor alone; instead they are "constructed" when all the factors, from social, political as well as scientific dimensions, are taken together. The constructive nature of science determines that technology is a social construction process instead of an end-product of knowledge accumulation. Therefore, for deeper understanding of a result, it is quite significant to study its construction process (Richards, 1995).

In the present research I do not only want to study the result of the technology, by only looking at the adoption by farmers, and the Programme's impact only in the sense of the area covered, the increase of production and productivity, as most evaluations of agricultural technology projects have done before. I want to conduct also a further in-depth-study of the whole technology construction process, including the initiative to start the Programme, and the technology selection, design, development and diffusion, in order to assess the impact both at the macro and micro levels using multiple indicators.

In this way the evaluation itself provides a concrete case for the study of technology construction processes. It serves as linking framework for looking at the technology itself and its linkages to other factors and the interactions among different actors at different levels in the whole technology construction process.

Due to the fact that my main task is evaluation of the Programme, the study is not in the first place, intended to contribute to theoretical development. Practically what I am going to do, is to carry out field research with explicit initial theoretical perspectives, which are thought relevant and helpful for the research, in order to get an overview of a complex phenomenon. Thus, review of the theoretical literature is necessary for identifying relevant and helpful perspectives and approaches, but elaborating the theoretic framework itself is not among my objectives.

2.2. Agricultural Development Paradigms

2.2.1. The Conventional agricultural development policy model

The conventional agricultural development policy model has long dominated and guided agricultural development in both developed and developing countries. It decides the nature of investment, the institutional design and management decisions. According to Röling (1996 and 1997), the conventional agricultural development policy model is based on three mutually supporting and interlocking theoretical perspectives:

- Cochrane's (1958) 'agricultural treadmill';
- the diffusion of innovations (Rogers, 1961, 1995) and
- the linear model of technology transfer.

The following sections present brief descriptions and explanations of the three perspectives respectively and their relevance to the present study in the context of China.

2.2.1.1. The agricultural treadmill

The Agricultural treadmill perspective provides the economic underpinning. According to Cochrane the treadmill works as follows;

1. many small firms each produce the same product;
2. no single firm can control the price;
3. each firm tries to do so as much as possible against the given price;
4. an increase in productivity of all firms lowers the price to the consumer;
5. the first firm to use a new efficiency enhancing innovation captures a windfall profit, because prices are still determined by the efficiency of the majority;
6. others soon copy, slowly the price decreases;
7. those who have not adopted yet see their incomes drop; they have to follow and innovate;
8. in the tail, farmers are marginalised and drop out; their resources are taken up by those who capture windfall profits. In that sense, the process feeds on itself.

Owing to its efficiency-driven nature, the treadmill perspective is very attractive for policy makers. As explained by Röling (1997), "all you need to do is to maintain a regular flow of technical innovations to the small group of innovators who have learned that one has to stay ahead of the peak if one wants to make money in farming. Diffusion processes, propelled by the market, will do the rest. The treadmill automatically gets rid of inefficient farmers and releases labour for other development. Efficiency gains are passed on to the consumers, reducing consumer prices. Thus consumers can spend their money on products other than food. And all this happens mainly as a result of a relatively small public investment in research and extension to create a regular flow of innovations" (Röling, 1997, p.4).

The treadmill model is reinforced by theoretical and empirical work on the diffusion of innovation, work which has been a dominant influence on thinking and practice.

2.2.1.2. The diffusion of innovation

In the early days of extension science, extension scientists were primarily interested in issues relating to diffusion of innovations, and the prospects of particular media and methods of getting certain message and/or technological packages across (Havelock, 1969; Rogers, 1983, 1995). The questions they asked were mainly: "How do we get the message across?" and "how does a new idea spread among people through communication?", then, "what's the impact of the innovation"?

The basic ideas are: first of all, science is the source of innovation and research leading to the development of innovation. Secondly, extension is a 'delivery mechanism' through

which innovation reaches farmers. Then, finally innovation diffuses from earlier adopters to later adopters "automatically" through natural social process of communication and innovation. As one can see, it is quite a linear way of thinking, laid out as a sequential process. It assumes that the innovation comes from outside, farmers are adopters, and the innovation is normally a good and progressive technology, and that diffusion is an autonomous process, "which take place while one sleeps". The innovation and diffusion theorists, like Rogers, view technology as a social given, an exogenous variable, and then just trace the impact of innovations as they spread through society (Richards and Diemer, 1996).

According to Rogers' famous diffusion curve, the process starts with few earlier adopters, then increases rapidly when the innovation spreads among those later adopters who consider the innovation to be beneficial. This idea of diffusion processes has greatly supported, and is consistent with, the treadmill model.

2.2.1.3. Transfer of Technology (TOT)

The basic idea underlying the conventional scientific paradigm and its TOT model rests on an epistemology of realist-positivism. Its central elements, characterised as the conventional approach by Röling (1996), are presented in Box 2-1.

Box 2-1: Elements of realist-positivism

- Reality exists independently of the human observer;
- Scientific research allows us to acquire true knowledge about the nature of that reality (laws of nature);
- Scientists discover the truth, they lift the veil and unravel nature's secrets. In this way they expose the naked truth.
- The aim of research is to contribute to the stock of knowledge;
- Scientific research is the source of innovation;
- Technology is applied science.

Source: Niels Röling, 1996

These are the main characteristics of a realist-positivist interpretation of the nature of knowledge, which underpins all the conventional approaches and the linear model of technology transfer. The two major representatives of the conventional model are modernisation and structural dependency. Although these are theoretically and ideologically opposed, they have in common that they generalise a linear model of socio-economic development and accord analytical priority to the role of exogenous factors in promoting changes (Long, 1977).

The core concern of realist-positivist thinking is science. Science has been able to expose the "Law of nature", and to use those laws to predict events, and to provide

unambiguous guidance for relevant technical interventions. With an 'instrumental rationality', conventional scientific approaches are goal-seeking and problem-solving. The problems themselves are seen to be unambiguous; as Peter Medawar said, 'science is the art of the soluble!'

Knowledge is interpreted as the accumulation of scientific discoveries and technical inventions. Thus, the aim of research is to contribute to the stock of knowledge. Technology development and diffusion in this view is seen to occur through a linear model, in which science is considered the growth point of knowledge and the source of innovation. Technology is considered applied science, extension as a mechanism for delivering scientific results to users. Users are seen as just passive receptors. It is a linear and sequential process in which innovation is 'end-of-pipe' product of the sequential process (Röling and Jiggins 1996).

The TOT (Transfer of Technology) model underpins the design of agricultural research institutions and the design of technologies in the developing as well as developed nations. The institutions comprising the TOT Model in practice were seen to 'institutionally calibrate the science-practice continuum' (Lionberger and Chang, 1970).

It is admitted that the TOT approach has played an important role in the rapid development of agriculture in industrial and some developing countries. The policies derived from it have brought an unprecedented increase in agricultural productivity and meanwhile led to a sharp reduction in the number of agricultural labourers. However, within any one country the TOT model has played also a negative role, in different periods and different situations, and for particular categories of farmers. The following section will describe how the Collaborative Programme matched with the Chinese government's central control, top-down linear system and the TOT model and the challenges confronting the public system at the present stage.

2.2.1.4. TOT in China, past and present

The TOT model has been playing a predominant role in agricultural research, extension and management in China. This top-own linear approach underpins the design of the government institutions and dominates policy making in agricultural research and extension.

The top-down linear agricultural knowledge system (including CAAS and MoA) is adapted well to the state's need and interest, and serves its predominant goal i.e., national food security. The TOT approach played a successful role in technology generation and transfer in the collective period, especially for the development and dissemination of the Green Revolution technology package i.e., hybrid rice, wheat and maize, together with modern inputs, e.g., chemical fertiliser and pesticides. The national average cereal yields increased nearly four times from 1.4 t/h in the 1960s to 4.4.t/h in the 1980s.

In the period of the highly centrally controlled and planned economy, the state controlled the price and market of agricultural inputs and outputs and even the mobility of rural labour force was restricted and controlled by the state. In this way the state could mobilise a large group of scientists to work exclusively on hybrid technology for food crops, could transfer an army of farmers to build up irrigation systems, and shift a large number of enterprises to produce chemical fertilizers. TOT was used as an efficient approach by the central power to achieve the success of the Green Revolution in China.

After the introduction of a market-oriented economy and the "Household Responsibility System" in agricultural production, the production unit changed from the collective to the household. Farmers became decision makers on their own land rather than only a labourer for the state and acquired relatively more freedom to develop their own options. Meanwhile, with the increase in market economic activities accompanied by the process of decentralisation and privatisation, some conflicts between public and private institutions and contradictions between farmer's and state's goals and interests, began to emerge.

As the whole social climate and context have changed, the TOT approach, which is still underpinning and driving the public agricultural knowledge systems and policy making, has increasingly began to appear insufficient or even to constrain thinking for the development and diffusion of effective agrarian innovations under the new circumstances.

The introduction and integration of new approaches and thinking are necessary to help the system to develop more flexibility, to involve the interests and participation of farmers and other relevant social actors in search of a common goal. The present impact study is intended to draw out implications for policy making and the institutional reconstruction of the public knowledge system in agriculture development.

2.2.2. Emerging challenges and approaches

The above three perspectives i.e., the agricultural treadmill, the diffusion of innovation and TOT, together with a phenomenal advance in applied agricultural science, have provided a highly inter-connected and mutually reinforcing theoretical basis for the long existing and powerful conventional agricultural policy model (Röling, 1997).

This is the model that has informed agricultural policy making in most industrial countries and has brought a great increase in agricultural productivity, although leading to a sharp reduction in the number of agricultural labourers. However, the situation in many developing countries is different. The innovation of technology packages has proceeded at an uneven pace, in some cases with virtually no adoption. It was found that the technology offered is often not meeting farmers' needs, especially resource-poor farmers and women cultivating in complex, diversified environments.

It is realised that the social context and conditions in most of the developing countries are not 'good enough' to facilitate rapid market-propelled diffusion. And there is an increasing recognition that efforts have to be made to break-away from the narrow focus only on interactions between researchers to extension agents, and extension agents to their clients. Instead, ways need to be found to involve multiple actors in the technology development and diffusion process. It has been argued by some researchers that the linear model describes only one way in which innovation can take place in circumstances which are difficult to control. Innovation in their view can, on the whole, best be seen as the resultant of complex and highly diverse interaction and interplay among varying sets of actors (Engel, 1995, Paine, 1997, Röling and Wagemakers, 1998). Innovation is social constructed rather than socially given, and in the social construction process, many actors are involved. It is not an external or exogenous input but a construction and negotiation process.

Röling (1991), and many others like Chambers and Jiggins (1987), have criticised the TOT model for not paying much attention to feedback paths or to the anticipation of technology needs (feedforwards). It also does not consider farmers as experimenters and technology developers but rather situates them as passive receptors and users. The model of a widely disseminated but uniform technology package denies that transformation of technology continues even while it spreads among farmers. Thus, the TOT model prevents researchers and extensionists from linking into these transformation processes so as to help develop and adapt different technologies and techniques for different circumstances (Reijntjes, 1992).

Although the TOT model is still a powerful and dominant model of innovation, which drives most of the decisions in agricultural research and extension and their institutional and organizational arrangements, it has been increasingly questioned and challenged in the last two decades. Some new or supplementary approaches have emerged. In the context of the present research several relevant approaches and methods are presented in the following sections.

2.2.2.1. Farming System Research and Participatory Approaches

Development of farming system based research perspective

The conventional agricultural development model and linear technology transfer has long been demonstrated to have limited application to the needs of resource-poor farmers. In the past two decades a great deal of effort have been given to improving the capacity of formal agricultural research to meet the priority needs of farmers, especially those of resource-poor farmers operating in complex, diverse and changeable environments. Farming System Research (FSR) and participatory approaches are two outcomes of these efforts.

Farming system research in its modern form started in the late 1960s and early 1970s; conceptually it was good and convincing in its simplicity and internal consistency. The

perspective of FSR was widely accepted. International Agricultural Research Centres (the IARC), like CIMMYT and IRRI, together with National Research Organizations (NAO), research institutes, universities and international donor agencies like FAO, have worked hard to contribute their own experience to the development and implementation of Farming System Research approaches. In the process, FSR has become increasingly 'participatory'. The expansion of this development has been so broad, there are now various different FSR and participatory research approaches, such as On Farm Research (OFR), Farming System Development (FSD), Participatory Technology Development (PTD), Participatory Action Research (PAR), Rapid Appraisal of Agriculture Knowledge System (RAAKS) etc. These methodologies can be roughly divided into two broad categories based on their basic concepts of "farming system" and scope and ways of analysis. Some draw on "hard system" thinking and others are closer to "soft system" thinking. Those with a hard system thinking bias focus more on the technical parts and deal mainly with cropping systems design; for them FSR is logical set of research procedures, the aim of which is to systematically understand farmers' conditions and develop and test innovations that can help them to improve the productivity of a component in practice in the context of the farm as a system. On the other hand, those with a soft system thinking bias take people as their centre of analysis and question the roles people play in shaping their own farming systems, which include crop-farm-household-social and production elements in dynamic interaction. The tools of research informed by soft systems thinking are systemic. In short, the essential distinction between the hard system thinking and the soft system thinking is that the former is **for** farmers, while the later is **with** farmers. Actually the development of FSR and the participatory process is still being argued. The following sections will briefly present FSR and PTD in terms of their relevance to the present research.

2.2.2.2. On-Farm Research by CIMMYT (OFR)

1) Basic Ideas of OFR

On-farm research could be considered as the location-specific variant of FSR. It was initiated by CIMMYT in the early 1970s, when it became obvious that the adoption of high yielding wheat and maize varieties, and improved management practices, was proceeding at an uneven pace; in some cases the recommended innovations were not adopted by farmers at all. A series of studies sponsored by CIMMYT established the finding that new technologies are adopted only when they are consistent with the agroecological and socio-economic circumstances of farmers (CIMMYT, 1986). The conclusion was drawn that adoption of new technology is mostly a question of assuring that recommendations fit farmers' conditions.

Realising the fact that the conventional process of technology generation was limited and inefficient with respect to difficult and variable farming systems, CIMMYT's OFR activity concentrates on strengthening the research process in order to generates more cost-effective, more efficient recommendations and technologies which would be widely used by farmers.

Four elements were considered by CIMMYT critical to efficient OFR. The first was careful identification of the farmer clients for whom recommendations were to be derived. The concept of recommendation domain was adopted, based on identifying farmers whose circumstances are similar enough according to the agro-ecological zones they are in, that they will be eligible for the same recommendation. The concept of recommendation domain enables researchers efficiently to direct their programs towards specific farmers and well-defined research goals. The second element was to recognise how interactions--biological and economic--influence farmer responses to alternative technologies. As the majority of low resource farmers in developing countries make decisions about technology in very complex environments, consideration of complexity is necessary. The third element is the importance of involving both biological and social scientists in the research process. The last element is the advantage of carrying out much of the research on the farms of representative clients and under their circumstances. These four elements are considered as the core of the On Farm Research approach by CIMMYT.

The procedures of OFR includes five stages which are presented in Box 2-2:

Box 2-2: The five stages of the procedures of On-farm research:

1. Diagnosis: review of secondary data, informal and formal survey.
2. Planning: selection of priorities for research and design of on-farm experiments.
3. Experimentation: conduct experiments in farmers' field to formulate improved technologies under farmers' conditions.
4. Assessment: agronomic, statistical and economic analysis of experimental results in order to derive recommendations.
5. Recommendation: Demonstrate improved technologies to farmers.

source: CIMMYT, 1986

CIMMYT takes OFR to be a kind of systems research (CIMMYT 1986). However, in contrast to other systems-based research, OFR takes a restricted view of the farming system focusing on one or two enterprises (e.g., wheat, or maize-bean intercrop) while recognising competitive and complementary relationships with other activities (CIMMYT, 1986). CIMMYT sees its role in OFR as one of providing guidance in research procedures and training--along with germplasm and technical information--to its clients, the national agricultural research services (NARS). NARS are positioned as responsible for developing technologies for farmers which raise the productivity of resources committed to maize and wheat (CIMMYT 1986).

2). OFR: Assessment, critiques and relevance to the current study

As stated above, OFR represents an improvement or adjustment in relation to the TOT model in the sense that it gives more scope for consideration of farmers' production conditions and tries to improve and strengthen the research process by involving more actors rather than breeders. It raises the probability of formulating more useful and practical improvements in technology generation. Another quite significant step taken by CIMMYT in OFR is its "decentralisation" of research, down to the national level. Thus formerly isolated national research facilities have more-or-less been connected to the global information generated by international agricultural research.

However, owing to its limited concepts of the farming system, and of social science as mainly economics, it remains focused on limited goals, i.e., productivity and economic efficiency. By pushing outside the system boundary all other social aspects and factors in the technology generation process, it has missed or under-valued the significance of other dimensions of the whole knowledge system. Other social actors besides biologists and economists are overlooked or ignored by OFR. Further, also in some other FSR approaches, a major weakness of OFR is that it has limited itself to hard system thinking, which focuses mainly on designing improvements in external forces instead of the internal factors and processes of local farming system, the farmers themselves, and the interaction and interface between the external and internal.

It was stated earlier that CIMMYT itself does not develop technologies directly for farmers. CIMMYT's role in OFR is to prove the efficiency and the effectiveness of research procedures (or methodology) and provide training to the NARS, which plays the crucial role in OFR implementation. However, CIMMYT scientists always try to participate in on farm research with national programme scientists. The work is considered as part of a conscious strategy of national programme improvement. CIMMYT has been assisting numbers of NARS scientists to use OFR methodology and its procedures in selected countries in Africa, Latin America and Asia. The experience gained through work with the NARS provides the materials for continuing refinement of OFR. The NARS, in turn, modify the methodology better to fit their specific needs. As a result, some new ideas and methods have emerged.

Based on the present author's own research and observation, OFR methodology has not been introduced to the Collaborative Programme in South-Western China. This is mainly due to two factors; the first is the specific situation of the Chinese NARS, which typically are top down, centrally controlled systems, which find it difficult to accept new ideas and approaches. The second reason lies in CIMMYT's strategy of leaving NARS options open.

In the present study, a Farming System Research approach, with a combination of soft systems thinking and hard systems thinking, has been used as a key research tool in the farm level impact study, especially in the two in-depth comparative case studies. Some of the OFR procedures were also adopted and tested in the field study. It is intended

that a number of implications and methods will be drawn, to modify and improve OFR methodology to the Chinese context.

The variant of Farming System Research adopted in this study takes a constructivist perspective in that scientists are seen as capable of developing knowledge for people, but also of being able to help people at different levels of social aggregation to develop knowledge themselves in the knowledge construction process.

Constructivist thinking, in certain degree, has stimulated the emergence of some participatory research approaches and methodology in agricultural research.

2.2.2.3. Participatory Technology Development (PTD)

Farmer participatory approaches differ from the conventional research models in that farmers are not treated as passive receivers, but as active partners, although the form and degree of farmer participation is still debated. It is a quite significant departure from conventional thinking, and, it is claimed, substantially improves the knowledge process.

Pretty (1994) defines participatory inquiry as

> *'a structured methodology based on principles of multiple perspectives, group inquiry, context specificity and flexibility that uses systematic methods to bring about changes in problem situations that the people in these situations see as improvements'(p.42).*

Participatory approaches increasingly are used in agricultural research. Scientists are beginning to learn how to cooperate with farmers, especially in applied technology and farm management. Participatory Technology Development *(PTD)* is one of the outcomes, which is highly relevant to the present research.

The concept of Participatory Technology Development defined by Engel and Jiggins (1986) is:

> *activities aimed at, or resulting in a change of the existing technology in a direction considered desirable by the different utilizers of that technology (in our case mainly farmers) and which are carried out by networks in which the utilizers of the technology play an active role. It is the practical process of bringing together the knowledge and research capacity of the local farming communities with that of the commercial and scientific institutions in an interactive ways.*
>
> *It involves activities in which local producers and traders work together with external actors in the identification, generation, testing, application and diffusion*

of new technology and practices. Participatory Technology Development therefore seeks to strengthen the existing experimental capacity of farmers and will sustain on-going local management in the processes of innovation.

PTD incorporates participatory methods into technology development process and focuses on working *with* farmers rather than *for* farmers. It is an user oriented and demand-driven approach and focuses on farmers' needs, their capability and their indigenous knowledge. It can be used to identify and address the diversity of needs by various regions and different farmers and stimulate and mobilize farmers to do their own research with their indigenous knowledge and networks.

2.2.2.4. Participatory Plant Breeding and Gender Analysis

Participatory Plant Breeding (PPB) is a field-specific application of PTD. Institutional formal breeding appears to have failed to adequately meet the varying needs and requirements of farmers cultivating in complex and difficult farming systems. Decentralization and farmer-involvement may better be able to meet the requirements of the 'environment' in a broad sense (Hardon, 1995).

The incorporation of participatory methods into formal plant breeding began in the mid-1980s when farmers were invited to become involved in the evaluation of pre-release materials. Through such participatory research experience it was found that there existed a large gap between farmers' and breeders' criteria for acceptability and selection of new plant types. This finding stimulated plant breeders to introduce farmer participation at still earlier stages in applied research. The results so far have proved effective and well acceptable by breeders as well as farmers. Some breeders perceive participatory methods as comparable to biotechnology techniques in terms of their potential for opening up new frontiers in breeding (Kornegay et al., 1996; Ceccarelli et al., 1995; Zimmermann, 1996; Hardon, 1995; Iglesias and Hernandez, 1994). While the form and degree of farmers' participation or involvement is still debated, PPB has drawn increasing interest and become a central theme of international research and development programmes by NGOs, NARS, and the CGIAR.

The CGIAR has increasingly seen the participation of farmers, particularly women, as vital to technology development. In 1996, CIAT, CIMMYT, ICARDA, and IRRI, in collaboration with the CGIAR Gender Analysis Programme, initiated a System-wide Programme in Participatory Research and Gender Analysis (Green, 1998). The key role that women play in agriculture and food security in developing countries cannot be sufficiently emphasized. Women account for more than half of the labour required to produce the food in Asia, and about three fourth of the labour in Africa (CGIAR, 1997).

In most farming systems, especially small and difficult farming systems, women are fully responsible for post-harvest operations, seed selection and storage and food

processing activities. Quite often, women are plant breeders as they are good at and keen on domesticating wild species and selecting new germplasm. Furthermore, in most developing countries women are increasingly playing a main role in farm management owing to increasing male migration in search of non-farm employment (Jiggins, 1998). However, these facts are not widely accepted and women's significant role in agricultural technology development is also not fully recognized by policy makers or by scientists.

With the economic development and transition in most developing countries poor rural women, as household keepers and farm managers, in small and difficult farming systems, are forming an increasing proportion of the very poor. Therefore the participation of poor rural women in the process of technology development is very critical in terms of household food security, poverty alleviation and biodiversity conservation.

Most ongoing research projects have not been incorporating gender aspects into their work and not much effort has been placed on studying women's expertise, their different criteria and their specific needs for technology development (CGIAR, 1996).

In the author's point of view, more empirical studies of different country cases, to reveal women's significant roles and their specific needs in different circumstances, are necessary to develop and institutionalise methods for enhancing women's participation in technology development. In the context of the study some of the issues of relevance to China will be presented in the following section.

2.2.2.5. Feminisation of agriculture in China and its relevance to the study

China now is experiencing two transitions: from a central command economy to a market based economy and from a rural, agricultural society to an urban, industrial one. Major economic and social transformations are occurring which are changing the structure of agriculture and households. Under the two transitions, male out-migration from agriculture is generating what is known as the feminisation of agriculture (Jiggins, 1998).

In his book "The Vanishing Peasant; Innovation and Change in French Agriculture" (1970), Henri Mendras stated:

> *"all agrarian civilisations have assigned a high value to the land, believing it could not be compared with other possessions" (p.46).* He quotes Redfield's idea that *"--it is characteristic of peasants the world over to attribute a sentimental and mystical value to the land."*

However, Chinese peasants at the present stage are, more or less, an exception to this conclusion. They have today a rational and economic view of the land rather than a sentimental one. This is mainly because land has not totally belonged to farmers themselves since the early 1950s. Furthermore there is a huge gap and differentiation

between agriculture and industry, and between urban and rural sectors, which have resulted from an extreme industrial-biased policy orientation in China in its earlier stage of urbanisation (Gao, 1993, 1992; Song, 1993; Meng, 1992). So when there is a possibility and the freedom to transfer to industry and cities, farmers do not hesitate to do so. However, in the Chinese historical reality and context, the most common strategy adopted by farmers in adapting to the changes, is "Yijia Lianzhi" (one family with two systems), which means one spouse migrates to non-farming employment while another stays with agriculture. In this way, land and agriculture can serve as a kind of insurance and retreat for farmers and their households.

Although different types of migration are occurring in different areas (see chapter 6 for details), yet, in any type, the majority of migrants are men rather than women (Gao, 1993, Song, 1993). This male migration model in China is determined by two major factors. First is the traditional patriarchal and patrilineal ideology in society, the household, and even in women themselves, which always maintains women in an inferior status to men in terms of resources, opportunity allocation and other aspects. The second important factor is the current structure and status of rural households, as shaped by the rural economy and society itself. In China it is very difficult for a whole rural family to migrate either from a rural area to an urban area or from agriculture to industry at the present time, because it is almost impossible for a rural migrant to get a permanent residence permit (Hukou in Chinese, cf. footnote 2 in chapter 1). That means that the majority of rural migrants have to become temporary labourers in cities. Therefore, someone has to be left behind to cultivate the contracted land and take care of the family. Home and land in the rural area are considered as a kind of permanent insurance and retreat for adventurers in cities and industries.

These social and economic factors together have shaped the transformation and reconstruction of the patterns of obligation in the household, i.e., from "the men till and the women weave" to "the women till and the men work in industry". In my point of view, it is a kind of reprint of the traditional model of the gender division of labour, which follows the same principle of a patriarchal social estate i.e., "men control the outside world, women the inner". The only difference is that women's 'inner world' is extending to agriculture, which is considered an inferior profession, but also a valuable retreat for farmers.

The new patterns in the gender division of obligation have led to a feminisation of agriculture all over the country. In the research area, women comprise more than 85 percent of the actual agricultural labour force (cf. chapters 6 and 7 for the relevant qualitative and quantitative findings). Women's predominant role in agriculture, especially in subsistence food production, is vital to food security both at national and household levels. Therefore, integrating gender concerns and analysis, and enhancing the participation of poor rural women in the process of technology development, is central, not optional, in addressing the issues of food security, poverty alleviation and biodiversity conservation.

PPB and gender analysis are important approaches guiding the study. The main concern in using PPB and gender analysis in the study is the attempt to develop a two-way communication approach i.e., a twin track approach to combine formal breeding systems with farmer-breeding by stimulating communication and interaction between the two systems among the different actors at different levels. The informal sector needs to know more about the complex ways of biotechnology, while the formal system needs to know more about the complexity of poor farmers' farming systems and their livelihood.

2.3. Integration of Science and Society with a constructivist perspective

2.3.1. Social construction of technology

2.3.1.1. Basic ideas of this perspective

Conventionally, technical innovation is considered as the result of a linear process by which science is applied in practice. However, a lot of research have shown that technical innovation is better understood as the result of interaction among different social actors with different conflicts and complementary contributions. And the indigenous knowledge of local people is increasingly realised to be an important contribution. An increasing number of researchers argue that technology development and innovation is a social shaping and transforming process, and a participatory, collective learning process, not a linear process (Röling, 1995). We have to enlarge and broaden our ways of thinking and a constructivist perspective allows us to do so.

The central philosophical notion behind the constructivist perspective is the idea that, as Berger and Luckmann (1967) would have it own sense, reality is socially constructed. Röling has interpreted this as meaning "groups of people, through discourse, develop an inter-subjective system of concept, beliefs, theory and practices that they consider to be reality. Based on their intention and experience, people construct reality creatively with their own language, labour and technology"(1996, p.40). As they differ in intention and experience, different people construct reality in different ways. People keep changing their reality during the course of time in order to adjust to changing circumstances. Thus, actually reality is man-made and shaped by the factors in society.

When Mary Douglas suggested that *"reality is a social construction"*, she refers to the practice, social negotiation, shared understandings and so on involved in forging cooperative action (Douglas, 1992). Thus, as "reality" changes in response to social change/adjustment, so reality is understood through social knowledge and action.

The main concern of the social construction of technology perspective is to understand how a technology emerges; thus, the social climate and context of the development of

technology in its construction process become an important research focus, and the relationship of the technology and society is the first question to answer (Richards, 1996).

2.3.1.2. Agricultural technology and society

There is a large literature on technology development and diffusion, and lot of studies have showed us in what ways technology is a form of social construction (Richards and Ruivenkamp 1994, Latour 1987, Leeuwis 1993 and etc.). The design and development of technology are influenced and shaped by society. It has been argued that there is no pure science and pure technology. Especially in research and applied technologies directed to solving problems in developing countries, we should not ignore cultural differences in technology development and diffusion processes (Richards, 1996).

There have long been debates about the relationship between technology and society. The arguments can be catalogued into two major sets: socio-technological "separated" and socio-technological "integrated". Those in former group mainly view technology and society separately; for them, technology is considered as an exogenous variable. Their major concerns are *"how do material processes work? and what impact does technology have on society?"* (Richards, 1996). Such "separated" thinking inhabits almost all the conventional scientific approaches to technology development. A typical one is the approach of neo-classical economists to technology innovation. It considers that supply and demand for new technology to be analytically discrete, and that technological advance is "induced" by independent social forces manifest in the market place (Cochrane 1958; Hayamy and Ruttan, 1971, 1978). They believe that innovation is propelled and induced by market forces. Other technology diffusion and impact theorists (e.g., Rogers, 1995) similarly have a "separated" view of technology and society. They view technology as a social given, an exogenous variable, and then, "trace the impact of innovations as they spread through society, logging the changes wrought in, e.g., institutional values and organizational forms, as these adjust to the presence of a new technical element" (Richards, 1996 p.2). Such a 'separated' standpoint has dominated almost all the conventional scientific approaches.

The "integrated" approach, in contrast, considers technology and society as a complete whole, each implicated in the other. This "hybrid thinking" about science and society, initiated by a physicist, Niels Bohr, breaks down the "conventional" distinction between nature and culture. The ideas of "socio-technological complexes" (Latour, 1992), and the focus on "hybridity" as the never-ending inter breeding of the two, view technology as an integral element within the process of social change, rather than claiming that technology itself causes social change. Richards and Ruivenkamp (in the Group for Technology and Agrarian Development in Wageningen Agricultural University) have advanced the idea of agrarian technologies as social-technical hybrids (1996). It is assumed that the development of agricultural technology is a process of social construction. Social shaping of technology is a necessary condition for effective design

of innovations. It denies either science or society as a role as the determinant force for social development, but sees the integration of the two in socio-technological complexes as close to reality. The assumption is that:

> *"social-technical innovation is a venture in the elaboration of a life world, jointly constructed by technicians and farmers. This new life world is a product of the interactive agency of farmers and technicians, and their joint reflexive monitoring of each other. Whatever the relative power and authorities of the two sets of parties, the weaker party (almost certainly, in developing countries, the farmers) have an inviolable veto right; farmers can simply walk away from the 'best laid plans' of technocrats if these fail to resonate in their lives"*(Richards and Diemer, 1996 p. 24).

Distinct life styles and social worlds are imbued with different values, and value conflicts are unavoidable, so innovation is part of the process of socio-technical 'world-making' (Goodman, 1992). This world-making is jointly processed by representatives of distinct social worlds. Thus, facts, practice, social negotiation, and shared understanding are necessarily involved in the knowledge constructing process.

Hybrid thinking concerns not only the technology itself but a focus on the climate and context of the development of technology. A significant question posed by hybrid thinking is: *"what balance between managerial intervention and mechanical manipulation best sustains the generation of healthy technology?"* The integrated standpoint is increasingly conspicuous on the ground, especially in the fields of technical practice applied to the problems of developing countries.

This thinking is linked to an important analytical concept, i.e., actor networks. Research based on this concept, which itself derived from constructivism, has shown that science has impact in society, not on the basis of its causal generalisations, but by scientists and others actively creating situations in which science can be applied. These situations are maintained by networks of actors (Law and Callon 1992; Fujimura, 1992).

An actor-network is defined as: the structure and operation of an actor-world; an interrelated set of entities that have been successfully translated or enrolled by an actor who is, thereby, able to borrow their force and speak or act on their behalf or with their support. The entities may be seen as forming a network of simplified points whose simplicity is maintained by virtue of the fact that they are juxtaposed with others. The actor who speaks or acts with the support of these others also forms a part of the network. Hence the term actor-network, for the actor is both the net-work and a point therein. It should also be noted that each point entity enrolled in an actor net-work depends on its capacity to "translate" or subsume other actor-networks, a simplified entity that is nevertheless also a network in its own right. Law and Callon (1989) suggest, therefore, that to "map" the actor-networks that come together in any technology project is a

significant step towards understanding the technical design process and its outcomes. This offers scope for what is termed "interpretative flexibility", that is, design modification resulting from an understanding and ability creatively to manage the tension between different actors, and their, at times, divergent sense of what is needed and what can be achieved (Richards, 1996).

2.3.1.3. Relevance to the study

Given the close and interrelated "kinship" between technology and society, research on technology development should not only focus on technology itself, but also on the social forces in technology development and study the dynamic interaction between 'internal' and 'external' factors in the knowledge construction process.

The social construction of technology perspective has allowed me to look at CIMMYT/China Collaborative Programme in a new way. From a broad constructivist view, the impact study not only focuses on the technology itself but also on the dynamic social forces and contexts within which it has been "constructing".

The actor network approach is used to map out the actor networks of the Programme, encompassing the global network and local networks, scientists' networks and farmers' networks in various types at different levels, in the technology design, development and diffusion process. Then, the different intentions, priorities, criteria and methods used among different actors in different social groups in the technology constructing process are analysed to reveal how the different networks are formulated based on their own interests and needs, shaped by their own social contexts and circumstances.

2.3.2. Agricultural Knowledge System(AKS) and Actor-oriented Perspective

2.3.2.1 The basic theoretical insights of AKS

AKS is a perspective that lets people look at complex events, relations and processes systematically and to build a representation of these in order to understand reality. Röling and Jiggins (1998) define the Agriculture Knowledge System as:

> *"a soft systems approach for looking at the interaction among the (institutional) actors operating in a ' theatre of agricultural innovation'. Innovation emerges from this interaction, and is no longer seen, as was customary in the 'transfer of technology perspective', as the end-of-pipe product of a sequential process.*
> *`The knowledge system perspective looks at the institutional actors, within the arbitrary boundary of what can be considered as the theatre of innovation, as potentially forming a soft system. A soft system is a social construct in the sense that it does not 'exist' One can not, therefore, say that*

> *such actors as research, extension and farmers are a system. In all likelihood, they are not, in that there is no synergy among their potentially complementary contributions to innovative performance. But by looking at them as potentially forming a soft system, one begins to explore the possibilities of facilitating their collaboration and hence the possibilities to enhancing their synergy and innovative performance "(pp. 304-305).*

The AKS, as a soft system, essentially includes a "human factor", which can not be modelled in a predictive sense, but must by its very nature be interactively constructed and negotiated (Röling and Jiggins, 1997).

Soft System Methodology (SSM) is a problem-solving approach developed from systems engineering, a so called hard system approach. Systems engineering failed to deal with the ever-changing and complex situation in real society. In hard system thinking, social systems are assumed to be goal-seeking systems (Checkland 1985: 759). Organizations are primarily considered as systems that can and should be engineered or optimised in a rational manner towards a previously defined goal. As pointed out by Checkland (1985:759) *"problem solving is a search for an end we already know to be desirable"*. Soft Systems views "human activity as systems", such as organizations, as complex wholes, in which people have different world views and therefore, have different interpretations of the purpose of the system, the problems existing, the goals to be achieved, and the boundaries of the system itself. Therefore, Soft System thinking is an approach to improving or managing a situation considered problematic. Managing here is interpreted as a process of achieving organised action, aiming at reaching agreement and consensus on purpose, problems, goals and boundaries.

The AKS is soft system thinking applied to agricultural knowledge management processes. The actual composition of the knowledge system depends upon the set of actors relevant to a given situation. The judgement about the actors is dependent on the assessment of the potential role of each actor in creating the "mix" of conditions for sustainable innovation (Röling, 1994). The boundaries of the system are not 'fixed' but tied into their objectives. The actors in the AKS depend on reaching a shared perspective or an agreement among the set of actors. An AKS is therefore bound to vary with the functions or purposes these actors have in mind for the system to perform.

AKS focusses on actors (individuals and institutions) and links and interaction between them (Röling and Engel 1990). These actors are expected to make up an "articulated whole in which the contributions of each adds to the contributions of the others"(Röling, 1994), and then, their synergy, their active differentiation, articulation, integration, linkage and co-ordination will all contribute to innovation (Röling, 1994).

Actors in an AKS can be individual persons (e.g., researchers, extensionists, government officials, farmers etc.), and institutions, (e.g., research institutions, extension services,

financial institutions, government organizations, NGOs etc.). It is further pointed out by Röling that from the AKS perspective all the actors are considered elements of a soft system. Systems thinking allows people to focus on practical things instead of only stopping at the theoretical level. The AKS, perspective, then, is to be seen as a practical tool for reaching consensus on problems and goals within the boundaries of human activity systems.

The AKS has been constructed as a tool to create and deliberately form a way to analyse the interaction of actors and explore the possibilities of facilitating their collaboration and hence, as a means for trying to improve knowledge processes and stimulate the emergence of "innovative performance". Its goal is consensus, defined as agreement on action, and collaboration. Hence, communicative rationality becomes a quite significant path towards achieving system goals.

The AKS assumes that the more information is exchanged among the actors of a system, the better the chances are that the actors will have similar perceptions of what agriculture development is, and should be (problems, potentials, purposes etc.). And when homogenous perceptions (or as we may put it, boundary objectives) emerge, the mutual understanding among actors will be increased and thereby actors will be more willing to collaborate in activities which improve the functioning of the system as a whole.

There are in brief three assumptions underlying AKS, as outlined by Engel (1995). The first is that knowledge processes are socially constructed, and that is why actors are trying to influence and manage them. The second one is that communication is a form of social interaction. Such communicative interaction is realised by each of the participants in bringing his or her own world views, interest, concerns and objectives. The third central assumption of the AKS perspective is that innovation is the desired outcome of a knowledge system (Röling 1992). AKS thus is a constructivist formulation for looking at the interactions of different actors, and their interface in various dimensions in order to analyse how to create conditions for change through the social process of collective learning, negotiation and shared understanding and then to reach a common decision.

As a kind of soft system tool, AKS has drawn on some elements of Checkland's Soft System Methodology to develop a participatory methodology for applying the AKS to the actual world, i.e., the Rapid Appraisal of Agricultural Knowledge Systems (RAAKS). RAAKS is a participatory methodology for applying the AKS perspective to real situations. RAAKS has been designed to support actors in an AKS to gain a better understanding of the processes affecting social and technological innovation in which they are involved in. RAAKS facilitates the participatory analysis of interaction among actors so that problems, constraints and opportunities for improvement can be identified.

RAAKS uses different tools or "windows" as its creators Engel and Salomon (1997) prefer to call them, to achieve an integral analysis and transparent problem definition.

So far 15 windows have been identified by the creators of RAAKS. Some important issues addressed in RAAKS are: forms of cooperation between actors, actors' objectives, conflicts, shared interests, integration and coordination of activities, relevant knowledge and information networks, and the division of tasks. RAAKS methodology seeks actively to involve relevant actors in the analysis of a problem situation. It facilitates a process of identification of constraints and opportunities for further cooperation among actors to address the issues through concrete actions and project intervention. RAAKS provides a framework for developing a collective definition of a problem situation and for identifying problems which hinder the successful performance of the social actors in an AKS (cf. chapter 3 for the details of RAAKS methodology used in the study).

2.3.2.2. Actor-Oriented perspective.

The actor-oriented perspective takes as a starting point of analysis the concepts of social actor and human agency. Social actors may be individuals or groups of individuals or even institutions such as businesses, political parties and churches, providing they have the capacity to reach decisions and act accordingly. Thus the actor-oriented perspective defines a social actor as any social entities to whom the power of agency can meaningfully be attributed (Long, 1992). According to Long:

> *"the notion of agency attributes to the individual actor the capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion-----. Agency- which we recognise when particular actions make a difference to a pre-existing state of affairs or course of events - is composed of social relations and can only become effective through them."* (1992, pp.22-23)

Long's emphasis that agency is composed of social relations, however, it is not an equivalent to decision-making capacity. An effective agency should also comprise organisation capacity to manipulate social relations and the ability to "enrol" others into the agent's project (Long, 1992). Thus, the social actor is a social construction rather than just an individual human being. It is at this point that actor-oriented approach is quit essentialism and moves towards constructivist thinking.

While focusing on the analysis of interface encounters, Long also addresses the importance of linkages and discontinuities in different social systems when studying the relationship between actors at different social levels. Interface has been defined by Long as (1989 a:10):

> *" the critical point of intersection or linkage between different social systems or level of social order, where structure discontinuities, based upon differences of normative values and social interest, are most likely to be found. The concept also implies some kind of face to face encounter between individuals or social units representing different interests and backed by different resources".*

Interface analysis in the agrarian context often occurs when government or other external organizations intervene in an attempt to further rural development or to control a particular territory. As Long (1984) has stated interventions enter a particular social order, interact with existing social phenomenon, transfer them and are themselves transformed.

One of the perspectives which the actor-oriented research has provided has been labelled by Leeuwis (1993) the 'deconstruction of planned intervention'. Many actor-oriented case studies have been carried out which focus on the processes and daily practices of planned intervention in agriculture. These case studies show how the different actors involved in 'planned' intervention are actively strategizing and negotiating the outcomes of development projects. These studies lay bare the true nature of project plans, that sharply contrast with the views of those who believe that such plans are a relatively efficient and unproblematic means to achieve certain previously defined goals and outcomes (Leeuwis 1993). As Long and Van der Ploeg (1989:228) theoretically conclude:

> *"the concept of intervention needs deconstructing so that we recognise it for what it fundamentally is, namely, an ongoing, socially-constructed and negotiated process, not simply the execution of an already-specified plan or action with expected outcomes". Meanwhile, Crehan and Von Oppen (1988:133) state: "a development project should be seen not simply in terms of its goals and their achievement or non-achievement, but rather as a social event, an arena of struggle between different groups with different interests".*

Any planned intervention or project is an on-going process, which consists of a continuous flow of different social life and relations among actors based on their own experience; it involves a complex set of social practices and struggles. In this "intermingling" of different flows of events driven by different interests and goals based on differing values, intervention itself emerges as a socially constructed and negotiated process. The concept that intervention is an on-going socially constructed and negotiated process instead of the implementation of a plan with fixed goals has broadened our view of planned intervention and project implementation from the linear thinking to a constructivist perspective.

2.3.3.3. Combination of AKS and Actor-oriented perspectives in relation to the study

In the CIMMYT/China Collaborative Programme, there are many actors i.e., farmers, scientists, maize breeders and institutions in various actor-networks at different levels, involved in the technology design, development and diffusion process. Thus, from an AKS perspective, these actors can be considered as potentially forming an integrated, functioning organism, a soft system, a social construct.

According to Jones (1990), the notion of a "system" is a useful framework for considering, analysing and evaluating most forms of human action. It also provides a

basis for proposing alternatives to existing patterns of activities. In this social sense, a system is a conceptual construct, each particular system consists of a structure of components (or element) which are interlinked in various ways. Beyond the boundaries of any defined system lies its environment. To use system theory is to apply a holistic approach to a relevant and complete defined whole and the activities in it, for general system theory is a broad model used to examine all kinds of systems (Du Brin et al., 1989).

As a soft system perspective, AKS cannot avoid sharing some common conceptual and practical problems with Checkland's soft system approach, which have been pointed out by many other authors before (Van Woerkum 1990, Leeuwis 1993). I will not repeat these extensively here. My focus is only the weaknesses relevant to the present impact study. First, power issues and how power relations affect the knowledge processes that take place in interactions within the system, have not been fully clarified by AKS, yet power is a crucial factor in the analysis of the interaction and conflicts among different actors. The Collaborative Programme of CIMMYT is a planned intervention operating in a centrally controlled social context. It would be too narrow and optimistic to ignore the power relations in analysing the technology constructing process.

Based on the literature study and field utilisation of AKS, I have to say that AKS can be used more as a useful diagnostic, descriptive and general analysis framework rather than as an in-depth analytical tool. AKS itself is not sufficient to stand alone in forming the theoretical framework for my evaluation and research.

However, the constructivist view and communicative rationality embedded in AKS make it possible to combine it with the complementary actor-oriented perspective. As described earlier, the actor-oriented perspective focuses on social actors and human agency in analysing the interaction, conflicts, power issues and so on among people and institutions as "actors". Case study is used as an efficient research tool by actor-oriented theorists to trace daily practice in planned interventions in agriculture to reveal the true nature of the social construction process of intervention. In this sense, the actor oriented approach is an useful tool for the present impact study and evaluation. However, in its over-emphasis on personal interests and individuals struggling to realise their own goal, the actor-oriented perspective ignores the possibility of actors to communicate and develop a collective interest in collaboration to solve a common problem. It is more useful as a theoretical tool rather than as a practical tool to stimulate collaborative activities and joint forces and the participation of different actors, one of the main goals of the present evaluation.

For the present study, the actor-oriented perspective is more or less a useful perspective for the in-depth case study, revealing the life world of different actors and the daily practices of planned intervention. However, a systematic analytical framework more at the macro level is still quite necessary for the whole study. Furthermore, the

actor-oriented approach is more useful in phenomena description and explanation than in guiding policy making at practical level. However, research on agriculture technology, at least as far as the present study is concerned, can not afford to stop only at the level of explanation. AKS, as action-oriented perspective, is more focused on utilization and decision making. Therefore, Agricultural Knowledge System analysis and the Actor-oriented perspective would make an efficient combination to guide the study.

2.4. Synthesis with focus on action: towards a comprehensive and complementary approach

Based on the literature overview and study of the main perspectives described above, I found that these perspectives and approaches have some similarities and differences and each of them has its strength and weakness. In the following table a comparative outline is presented of the four major perspectives to show their overlaps and differences, their strengths and weakness, as revealed in the literature study (cf. table 2-1).

The conventional policy model with its TOT approach, as the dominant model, uses hard system thinking to emphasise external factors. It considers science and innovation as social givens and policy-making as based on electoral politics and expertise. The three alternative perspectives, besides TOT approach, used in the study are all soft-system-oriented, focusing on the internal factors and social actors instead of only the external factors. They all are based on, or are at least moving towards, the epistemology of constructivism. They consider innovation and technology as social construction rather than as social givens. So they have a lot in common in their concepts of truth, goals etc. Furthermore, they are still in an on-going process of improving themselves, consistent with constructivist thinking. However, as they are originally from different ideologies, and with differing rationality, so their target aspects are different and this why I have used them all in a complementary manner in the research.

As I stated earlier, in the evaluation and impact study I intend to do not just a general and macro-level impact measurement of a single goal and criterion, but rather a comprehensive impact study both at macro and micro levels with multiple criteria. Reflection on the technology construction process is the main concern of the study, in order to understand the impact of the programme. In confronting the multiple realities in the Programme's complex situation, i.e., conflicts in institutional, technical and social-political aspects and the different objectives of various social actors at different levels, no single perspective is able to address all aspects of the "puzzle". A pluralistic/multiple components approach is needed to capture and analyse the intercrossed and intertwined technological, institutional and socio-economic aspects. Based on the literature study, I strongly feel that each of the perspectives described may serve as sub-set of the other and in all they are supporting and supplementary of each other. As a whole they compose a comprehensive analytical and theoretical framework to guide the study.

Table 2-1. Comparative outline of the four perspectives

	Conventional policy model and TOT	AKS perspective	Actor-oriented approach	Social construction of technology and actor networks
epistemology:	realist positivism	moving from realist positivism to constructivism	moving from essentialism to constructivism	constructivism and hybrid thinking about nature and society
rationality:	instrumental rationality	communicative rationality	strategic rationality	from strategic to communicative rationality
concept of truth:	law of nature, generalisable and universal	multiple perspectives, diversity	complex, diversity	multiple, diversity
nature of treatment:	top-down planned intervention	participatory, collective learning and communication	struggle, strategizing and negotiating	collaboration and cooperation
goals:	to control with unambiguous and implicit goals	multiple goals by different stake-holders	multiple and conflicting goals by actors from different life worlds and social level with different values and interests	multiple goals, often in conflict with each other, actors from different networks at different levels
target aspect:	thing, external factors	thing and person, external and internal factors	person and internal factors, their interaction with and response to external factors	technology and society, person and thing
role of science:	dominant role	partner in the social construction of reality	scientists and farmers achieving influence through actor networks	is socially construed and constructed
innovation:	result or end product of linear process, innovation is considered as social given	result of interaction among different actors with complementary contribution	result of struggling and interaction in the socially constructed and negotiated process	result of social construction
policy:	based on electoral politics and expertise, policy is taken as given	based on collective learning and communication	arises from exercise of agency by actors with varying degree of power	arises from interaction among actors of different networks at different levels

Source: compiled by the author, 1997

TOT and diffusion of innovation approaches can describe and study the general impact of the Programme, i.e., adoption, production and productivity, etc. However, as it was argued earlier that these are not all the impacts that should be assessed. Other indicators of agricultural development like sustainability, equity and stability, would be ignored by TOT. The other three perspectives, the Social Construction of Technology, the Agricultural Knowledge System and the Actor-oriented Approach, are needed to address the multiple realities and diversified situation, such as the impact on the poor and women, institutional constraints, social contexts etc.

Chapter 3

Research Methodologies and Methods

3.1. Introduction

This chapter deals with research methodology and methods with which the research objectives were pursued. Special attention is given to methodological issues related to technology development programme evaluation and impact assessment. In agreement with the perspectives and concepts discussed in chapter 2, a pluralistic approach to methodology, consisting of exploratory qualitative methods and quantitative formal survey methods, was needed for capture and analysis of the intertwined complex dimensions. In the following sections the main methodologies used are presented and then methods of data collection and analysis, selection of case study areas and reasons for doing so, as well as the organisation of the field study, are described. The role of the researcher and her experience doing social science research in China is discussed.

3.2. Main Methodologies in Research

There are two general methodological orientations of the study:

- To evaluate the development and diffusion of improved germplasm and to clarify its impact with respect to the poor, the environment and gender, and to analyse the factors that affect adoption, including policy and institutional constraints.

- To develop an assessment of impacts, in such a manner that the highly diverse circumstances, and their reflection in scores, can be taken into account. The investigation of impact must reflect an awareness of the synergy of international and national research and all the actors in the networks, including farmers, the most important actors.

The use of participatory techniques and methods in data collection and analysis allowed the evaluation and impact assessment to be done from the perspective of all actors, including farmers. The research explored what was happening and led to the uncovering of multiple realities. The research process is intended to improve the learning and understanding of all actors involved in the programme at different levels and draw conclusions for further action, rather than only to measure progress against objectives.

Participatory methodologies, such as Participatory Rural Appraisal (PRA), Rapid Appraisal for Agricultural Knowledge Systems (RAAKS) and Participatory Monitoring Evaluation and etc., are important methodologies guiding the research. They allow relevant actors, stakeholders, and the researcher to express themselves in an interactive and multidimensional manner. They help explore the ways messages can be conveyed and interpreted locally and offered opportunities for the researcher to share the life worlds

of stakeholders through data collection and analytic processes for mutual learning and understanding.

3.2.1. Participatory evaluation

The conventional way of evaluation typically is a matter of collecting data on what has been realised, and comparing these with what has been planned, as formulated in the objectives. The results are then compared with the costs (personal, material, organizational etc.) (Abma, 1993). *Evaluation* generally is defined as a systematic process that attempts to assess as objectively as possible the relevance, effectiveness and impact of a project in the context of the project's objectives (FAO, 1985). Thus, the conventional evaluation is a kind of tool for control and effective management based on a "top-down" policy-driven approach (Groot, Stuijt and Boon, 1995). But as argued in Chapter 2, it is being increasingly realized that an evaluation of a social activity requires more than a comparison between empirical data and programme objectives through counting and measuring. It has very much to do with the different perspectives, values and interests of the different actors in a development programme, which results in different interpretations and perceptions of different impacts on various actors (Patton, 1986; Guba and Lincoln, 1989; Long, 1989; Groot et al, 1995). Participatory evaluation stresses the process of learning and interaction among actors based on the acceptance of the multiple perspectives of the different stakeholders. It takes the different values, knowledge, skills and interests of the actors as a starting point for negotiation in order to decide on sustainable development (Groot et al, 1995). In the present research the spirit and some methods of participatory evaluation approach, focusing on utilization and action, was followed.

3.2.2. RAAKS

In the context of the research, RAAKS, as a participatory methodology for applying the AKS perspective to a real situation (see chapter 2), is one of the main analytical tools used. RAAKS focuses on interaction among the actors, and the aim is to share knowledge and information for improving the performance of the social organisation of innovation (Engel and Salomon, 1997). RAAKS consists of three different phases: a) defining the problem, b). analysing constraints and opportunities, and c) strategy/action planning. Each phase includes different windows/tools for analysing different cases in various circumstances.

The importance of RAAKS in the present evaluation arises from its systematic and flexible analysis, which is a significant strength for the systematic study of the whole technology design, development and diffusion process. It helps to map out the actor networks and involve the actors such as breeders, extensionists, seed companies, policy makers and farmers in the learning and analytical process. The windows/tools of the RAAKS methodology which are most relevant to the present research are: actor analysis,

knowledge network analysis, integration analysis, coordination analysis, and communication analysis. The actor analysis aims to analyse the reasons behind certain types of action by individuals, to determine what intention they had, and what room there might be for change of behaviour. Knowledge network analysis focuses on the analysis of the whole knowledge network of the Programme, including formal and informal networks operating at different levels. It helps to explore what types of knowledge and innovation is important for farmers in different circumstances. Integration and coordination analysis stresses the interaction of actors in the networks and reveals how the relationship between different actors and their interactions shaped the multiple realities in the innovation process. Communication analysis questions whether the actors understand each other and find ways to reach synergy through a learning and communication process. In short, RAAKS is used as analytical tool for the research and learning tool for all actors around the Programme.

3.3. Case study and comparative approaches

Based on the definition of a case study as a research *strategy or approach* by Robert K. Yin, a more concrete definition of case study is given by Yin (Yin, 1981) as follows; A case study is an empirical inquiry that:

- investigates a contemporary phenomenon within its real-life context; when
- the boundaries between phenomenon and context are not clearly evident; and in which
- multiple sources of evidence are used.

Can a case study be used for evaluation? From the point of view of constructivism, it is believed that the most useful format for reporting the reality of social construction in the field is the case study (Guba and Lincoln, 1989). If constructions are developed on the basis of experience, a most effective way to change them is to provide new or additional experience. That experience need not, however, be direct; it may well be vicarious. As Stake (1986) stated that *" the role of the evaluator can be to provide narrative accounts that provide vicarious experience."* (p.20) Therefore the case study report is considered an ideal form for evaluation (Zeller, 1987). Based on the above ideas and approaches and considering the specific situation of the evaluation and research I am doing, the case study is chosen as one of the most important research strategies in evaluation.

The comparison between cases helps to capture additional data, to reveal the characteristics and differences between cases, and to explore the specific social, institutional and environmental constraints that affect the adoption of innovation, in different circumstances. The comparative analysis of different cases is adopted as a supplementary method. In the context of present research three cases are chosen. A comparative in-depth study of two representative cases with different environments and

farming systems is carried out in order to know farmers' responses and strategies with respect to the technologies, and to reveal the relevant institutional promoters of and constraints to meeting farmers' real needs in different contexts. The comparison was done in both qualitative and quantitative research phases and the research procedure and findings are presented in chapters 6 and 7 respectively.

The third in-depth case study, of Guangxi Maize Research Institute, was carried out in order to assess the technology design and development process. A comparison of two knowledge networks, the formal network and farmers' informal network, was carried out to show the gaps and differences, and to identify the synergy that could emerge through mutual learning and communication.

3.3.1 Reasons for a comparison between two areas

Normally, comparative study of technology adoption and impact is done between types of farmer, i.e., big-scale commercialised farmers, small subsistence farmers etc. However, the present study is executed through a comparison of two contrasting areas. This is mainly because of the specific situation in China, which is described as follows. In the first place, it is difficult to develop a typology of maize farmers according to their land holding, as land was equally distributed on a household basis in the Rural Reform of 1978. According to internationally acceptable standards, almost all farmers in China are small scale and there are hardly any large-scale farmers. Instead, obvious typology of maize farming systems results from agro-ecological environments and socio-economic factors. In the second place, geographical variation is one of the major characteristics differentiating farmers and maize farming systems in the Southwest in particular, and in China in general. The variety of natural environments has contributed to a differentiated and unstable regional rural development.

There is an increasing spatial differentiation since the 1980 reforms. As a result of the gradual decentralisation of central power, there is more flexibility and opportunities for the development of regional and private economies. More and more industries and private enterprises and businesses have been emerging in rural areas, mainly in the economically booming areas and in relatively developed regions close to cities which have easy access to transportation, communication, and markets. These environmentally and economically favoured areas have experienced a rapid increase in rural and agricultural specialisation, industrialisation and commercialisation. Meanwhile, the remote mountain areas, the so-called economically lagging regions, lack the resources for such development. Farmers there are following an other strategy, that is, labour mobility, searching new opportunities in urban areas or other developed rural areas. These changes have significantly affected and reshaped the agriculture and farming systems in terms of crops cultivated, varieties used, investment, household dynamics and gender division of labour. Therefore, a comparative study of two representative cases of the two major types of maize farming systems in the two areas is significant: such a comparison enables the researcher to find out farmers' different responses and strategies

with respect to maize technology to clarify the specific needs and interests of farmers in different areas, and to identify the opportunities and constraints for them to fulfil these needs in the context of rapid macro-social change brought about by out-migration.

3.3.2. Selection of comparative study cases

The selection of case study sites basically depends on two main criteria. Firstly it is based CIMMYT's agro-ecological zoning of maize production regions in developing countries (CIMMYT, 1988). However, as the majority of the maize growing areas in the Southwest belongs to the category: 'Low land tropics', it does not make much sense to identify and select study sites by ecology alone in Southwest China. Therefore, a second criterion has to be introduced, i.e., the cultivation environment and maize farming systems. Here the selection was mainly based on the local insight drawn from interviews and discussion with farmers, local agricultural professionals, and breeders. The selection of case study sites is a result of collective effort through a process of dialogue.

Two basic criteria for selection

1. *Agro-ecological zone*: according to the classification of maize production regions in developing countries used by CIMMYT Maize Programme (1988), there are 13 maize production regions identified by ecology in the South-Western China. Within them 8 are lowland tropics (LT), 2 are subtropics (ST) and the remaining 3 belong to the transitional zone (TZ). Considering that most of the maize grows in the lowland tropical and transition areas in the Southwest, the two cases study sites were both selected from the lowland tropic zone.

2. *Maize farming system:* according to the local wisdom, maize in the Southwest is mainly grown in two distinct types of farming system as follows:
    - Less-favoured mountainous rainfed areas, inhabited mostly by minority peoples; maize is mainly for human consumption.

    - Relatively flat and developed irrigated areas, which are environmentally favoured and economically developed; today, maize is largely used as feed.

Two major maize-growing counties (locally, counties are designated as rice growing or maize growing, according to the importance and growing area of the two major food crops), in Guangxi provinces have been selected, i.e., Duan and Wuming. Duan county represents the poor, remote mountain areas, where maize is produced mainly as subsistence food. Wuming county represents the relatively flat and rich areas. Maize is now mainly used as animal feed. The two counties approximately represent the two major maize farming systems in the Southwest China. Although the maize producing areas in the three South-Western provinces are quite varied in natural conditions, management and other socio-economic factors, they can be roughly categorised into the above mentioned two types of maize farming systems.

Further, two representative villages and some farming households were selected (see chapter 6 for the ways of selection) respectively from the two counties for further participatory observation and in-depth study based on sharing the daily life and farming activities with farmers. The case studies provided an insight into the environmental and social/political factors that affected the choices of farmers and influenced the farming systems. The studies revealed the existence of an informal network of technology development and diffusion operating at farmers' indigenous level.

3.4. Methods used

The following are the main methods and techniques used in the research. They could be grouped into four, as follows.

Participant observation

Participant observation is an useful and important method applied through three phases of the whole field research. It allows the observer to share the life activities and sentiments of people and his/her role reflects the social process of living in society (Bruyn, 1966). In the present research, participant observation allowed direct observation and experience of the maize breeding activities and farming practices in different environments and of the different life worlds of breeders and farmers. Sharing day-to-day activities and social events with farmers, scientific breeders, and other professionals helped the author to understand the "rationality' of what and why the farmers and breeders do and why they think in different ways. It helped to share and know the process of social construction of technology at both the formal professional level and farmers' informal indigenous level.

Informal surveys with PRA techniques

Informal surveys here encompass various qualitative methods and PRA techniques of data collection including unstructured and semi-structured interviews, group discussion, free chatting and dialogue, drawing and game playing, etc. Informal surveys with PRA techniques are a flexible, iterative approach that uses dialogue and other techniques to communicate with farmers, researchers, programme managers, policy makers, etc., to gather information and insight in what is happening in the Programme. Owing to its rigorous yet, informal and flexible characters, such surveys can effectively stimulate the participation of actors in communication and learning processes more than other formal methods. More over, the involvement of the decision makers and the programme executing personnel in the evaluation process provided them a good opportunity to understand the social reality of the Programme region and farmers' life worlds (see section 3.5.1. for more detail). Informal surveys with PRA techniques were used as the most important tool in the field research during the qualitative and exploratory phases.

Formal Questionnaire Surveys

A questionnaire survey has the advantage of being an established scientific method; it can obtain standardised information from a number of respondents on a set of predetermined questions. However, for an evaluation of a research programme questionnaire surveys have, quite often, tended to be costly and time-consuming and have not produced the expected results (Horton and et al, 1993). Therefore, in the context of the present research, the questionnaire survey was chosen only as a supplementary method in order to validate and support the findings of the qualitative research. In order to insure the efficacy and efficiency of the quantitative study the questionnaire was carefully designed to focus on some key questions. The duration of each interview was limited to about 30 minutes. 200 sample farmers were selected randomly from two contrasting farming systems (for detail see section 3.5.3).

Document analysis

Relevant literature and official documents (e.g., programme documents, Annual reports, statistical year books) from CIMMYT, Chinese NARS, and relevant research and extension institutions were examined to establish their policies, objectives and strategies for achieving their mission goals. Changes in breeding strategies at CIMMYT and Chinese NARS levels are analysed to see the causes for the changes and how they impacted on the research and technology development and farm level adoption. The main objective was to see the role of policy in the social construction of the technology in the context of the Programme.

3.5. Organisation and Procedure of Field Research

Based on the chosen theoretical framework, research approach and methodology, the field research was carried out at five different levels, i.e. national, provincial, county, village and farmer's household. And it was divided into three separate phases, i.e. exploratory, qualitative and quantitative, with different focuses respectively as follows:

a). The exploratory study phase aimed to map out the knowledge networks in the technology design, development and diffusion process and explore some relevant issues and typical phenomena for further in-depth study. Some general information for the evaluation of the macro level impact was also studied in this phase. Based on the findings and issues of the macro level impact study,

b). *The qualitative study phase* then focused on in-depth research of the relevant issues in selected representative areas and cases in order to assess the micro-level impact of the programme and the differences between various regions and cases.

c). The purpose of the *quantitative study phase* was to further investigate and validate the qualitative findings obtained from the two previous research phases, using a quantitative method.

Different methods and techniques were used in the different phases, although some, such as participant observation, were used in all phases. The following sections present an overview of the three phases and the data collection procedures, methods and techniques used.

3.5.1. Exploratory phase

The first objective of this phase was to develop an overview of the programme by identifying different actors in the networks and their roles in the technology construction process and the Programme's social and natural contexts. The second objective was to get complete and comprehensive information and data concerning the maize breeding activities in the three provinces needed for the general assessment of the macro-level impact of the programme. Then, the third objective was to develop a general idea required for the selection of case study areas according to different factors like, representative of agro-ecological zone, soil type, farming system, socio-economic development, market and transportation etc.

The exploratory phase actually comprised two important research tours which were designed to explore and realize the above mentioned objectives. The procedures and methods used in the tours are as follows:

a). Exploratory research tour to the three provinces

The Co-operative Programme covers three provinces, i.e., Guangxi, Yunan and Guizhou in the South-Western board of China (Guangxi and Yunnan provinces share a border with Vietnam). The Programme area has a total population of about 97 millions and arable land of 45.5 million hectares. (see Chapter 5 for the introduction of the programme area and table 5-1 for the comparison of the Southwest to the total nation). So first of all an exploratory tour or a reconnaissance visit to the three provinces was essential to get some general information about the programme and the social and production contexts in which it has been operating.

The Academies of Agricultural Science and Maize Research Institutes in the three provinces, which are direct co-operative institutions of CIMMYT, had been contacted first and investigated. Some important contact persons of CIMMYT, who are the main policy makers, such as the presidents of the Academies and heads of the Maize Institutes, were identified as key informants for interviewing in order to develop a general idea of the programme and its networks. Then, unstructured and semi-structured interviews were

carried out with the maize breeders in each of the provincial Maize Research Institutes to get data and information for assessing the macro-level impact. Methods such as free chatting and group discussion starting with their interest topics, etc., were used to stimulate the dialogue with and participation of the maize breeders in discussing relevant issues and breeding strategies. Some significant issues and findings emerged during the mutual learning and communication process.

Later on the same methods are used to secure the participation of other individuals and institutions in the Programme network such as agricultural departments, extension stations, and seed companies of the MoA system at the provincial level. Some farmers from different maize growing areas were also interviewed during this period to obtain a general idea of farmers' responses to the Programme.

In total 38 professionals (31 male and 7 female), including policy makers, scientific breeders and government officials, were interviewed during this phase, some of them were interviewed several times. In addition, 30 farmers (22 female and 8 male), were interviewed in various maize growing areas in the three provinces.

b). Exploratory research tour throughout the main maize growing areas in Guangxi province

Based on the information obtained from the previous tour, an exploratory tour to the main maize growing areas in Guangxi province was carried out in order to get some general information concerning adoption and farmers' assessment of the technologies, and to identify cases for in-depth study.

The author conducted this research tour together with Dr. Yang, the director of Guangxi Maize Research Institute, and himself a senior maize breeder, and Mr. Tang, director and senior extensionist of Guangxi General Extension Station. Both of them have been involved in the Programme since the beginning of 1980s. Together with them I visited ten counties. Relatively more effort was given to two counties in order to test their significance and representativeness for the in-depth comparative case study. 60 government professionals (relevant government officials, extensionists, managers of seed companies etc.), and 30 farmers of different types (specialised farmers, small and resource poor farmers, maize seed farmers, etc.), were interviewed.

The main methods used in the exploratory phase were unstructured or semi-structured interviews, participant observation, group discussion and free chatting. The research procedure and findings of the two research tours are presented in chapter 5 in order to provide an overview of the co-operative programme networks and of its macro-level impact.

3.5.2. Qualitative phase

Based on the information, data and observation gained from the exploratory phase, the work of this period mainly dealt with two aspects: a) systematic study of the technology design, development and diffusion process and the adoption, impacts and consequences by studying different institutions and individuals at five different levels, b) in-depth study of some emerging issues and problems in selected representative areas and cases to assess the micro-level impact and the differences between various regions and cases.

When considering the consistency of the policy and institutional environments among practices, it was decided that the qualitative research should focus on one province in order to have a systematic institutional analysis of the technology construction process. Therefore, cases for in-depth study were also selected in this province.

As a result of the exploratory research, Guangxi province was chosen as the research base and the province for systematic study of the knowledge networks of the Programme. Guangxi Academy of Agricultural Science and its Maize Research Institute is the initial co-operator with CIMMYT and starter of the Programme. Furthermore, I had worked in the Academy for 5 years since the beginning of the 1980s and had been directly involved in the starting stage of the Programme. Therefore, factors like familiarity with the contexts and situation, good personal relationship for easy cooperation, etc., were also considered and contributed to the selection of Guangxi.

3.5.2.1. Systematic study at five levels

With the perspective of AKS and its participatory methodology RAAKS, the actor network involved in technology design, development and diffusion was mapped out at five different levels and the key actors were identified by tracing the Programme's TOT model of technology transfer. The five levels and the key actors at each level are given as follows:

1. Provincial level: scientists, maize breeders, extensionists, managers and officials in the Academy of Agricultural Science, the Maize Research Institute, Agricultural Department, Public Seed Company, Seed Station and Agricultural Extension Station.
2. County level: breeders, extensionists and officials in Institutes of agriculture science, public seed companies and the agricultural technology extension stations.
3. Township level: extensionists and officials at the township governments, and agricultural technology extension stations.
4. Village level: village leaders in the village committees and other village organisations.
5. Farmer level: male and female farmers in farmer households.

I have visited in total 30 institutions, 10 counties, 15 townships and 20 villages and interviewed 100 professionals and 200 farmers. Group discussions were organised with professionals and farmers in some cases.

The RAAKS windows such as actor analysis, and integration and coordination analysis, were used to analyse the different intentions and interests of the actors and their relations and interactions, and how these shaped the emergent issues and phenomena. For instance, the conflicting attitudes towards hybrids and OPVs by different actors at different levels, were analysed. The window of communication analysis was used to identify gaps in understanding and to find ways to reach a consensus among actors through a learning process. Based on this systematic analysis, certain typical or representative cases were selected for a further in-depth and comparative study in order to investigate and compare the issues and phenomenon in their real -life contexts so as to reveal the nature of problems and causes of differences.

3.5.2.2. In-depth and comparative case studies

There are actually three cases chosen for in-depth and comparative study of the technology construction process so as to explore the institutional/organisational and environmental factors that constructed the design, development and diffusion of the technology in the formal and informal knowledge systems.

Cases 1 and 2: Duan and Wuming counties

Case 1 and case 2 are farm level case studies focusing on farming household, village and county levels. Two counties, Duan and Wuming, were selected for in-depth comparative case study for the two major maize farming systems involved in the Programme. Duan represents the difficult maize farming system in the poor, remote and rocky mountain maize growing area, which is mainly inhabited by minority people. Maize in this area is mainly for human consumption. Wuming represents the favoured maize farming system in a relatively flat and developed area. Maize there is mainly used as feed for pigs. One village from each county and several households of different types (e.g., female-headed, male-headed, single adult) from each village were selected purposively for participatory study. The author stayed in the farmers' households and shared their daily life activities and sentiments through *"three together"* (This is Mao's slogan which means: live together, eat together and work together with farmers) for most of the qualitative and quantitative study period. The study procedures and main findings of the two comparative case studies are presented in chapter 6 and 7.

Cases 3: Guangxi Maize Research Institute was chosen as the in-depth study case of formal breeding. I stayed in the Maize Institute for eight weeks for participant observation and maize research. By working and doing research together with the maize breeders there I came to know the policies followed, the priority setting and the technology design and development process. The more important achievement is that I began to realize how technology is affected or shaped by social/political and economic factors rather than only technical facts. For example, most of the breeders and policy makers knew OPVs are appropriate varieties for the harsh environments; however, almost all the Institute's effort and resources, if not all, are devoted to hybrid breeding rather than OPVs. It was also found that a difference existed

between breeders and policy maker at different levels in terms of breeding strategy and priority setting. The main findings of the case study is presented in Chapter 5.

3.5.3. Quantitative phase

After the above two phases, a formal quantitative survey was carried out to further investigate and validate the issues and findings gained during the qualitative research, by using quantitative methods.

The concrete objectives of the survey are to:

- study farming systems in the two contrasting environments
- examine the impact of CIMMYT related varieties at the farmer's household level by studying the scale and degree of adoption, and ways and patterns of adoption
- determine farmers' preferences (women and men's different preferences) for different types of maize varieties and identify opportunities and constraints for meeting these needs.
- examine women's role in agriculture in general and in plant breeding and seed selection in particular.
- compare the above indicators and factors in the two different villages and find out different needs and interests in different maize growing areas in terms of natural environments and socio-economic contexts.

The survey time chosen was just after maize harvesting, from the end of September 1996 until March of 1997. Farming households in the two villages, Zhichen and Geyang, formed the survey population from which the sample was selected. In order to ensure representative coverage of farming households, the sampling was fully random, using the farm household files maintained by the village committees. 100 farming households were randomly selected by lot(drawing file numbers out of a small basket) respectively for each village. Two sample populations, totalling 200 households, were selected randomly as respondents.

A questionnaire of three pages (which required about half an hour to complete) was designed in a quantitative, simple and straightforward way. It was formulated on the basis of the exploratory and qualitative phases of field study and focused on key questions. There were four major sections, as follows;

-Profile of the Survey Respondents in the two village
-Farming system, land holding, crop pattern and livestock
-Maize cultivation and varieties used
-Gender division of labour (over three periods of time)

There are in total 72 questions and 288 variables included in the questionnaire(cf. Appendix)

Although it was a formal quantitative survey executed by formal interview and questionnaire, the author also tried in a participatory spirit to create more opportunities for direct dialogue with and participant observation of farmers. So the author did all the interviews herself and took time free chatting with farmers after each interview. This proved quite helpful to obtain both quantitative and qualitative information of good quality.

Data processing and computer analysis:

The computer programme used for data processing and analysis is SPSS (Windows version 6.2.). Two main research steps were adopted in the survey data analysis: the first was descriptive, using the frequencies and means to show counts, percentage and averages of some relevant variables in the two sample villages. Then, a comparison between the two samples was done to show differentiation and significance. The second step was more analytical and explanatory one, in order to explore and reveal the relationship and causality between factors. The procedure and results of analysis and survey findings are presented in Chapter 7.

3.6. Experience of Doing Social Science Research in China

3.6.1. Challenges to make new perspectives acceptable

Doing social science research in China is not a completely new experience for the author. However, research with all these new (in the context of China) concepts, perspectives and methodologies, like social construction of technology, multiple realities, AKS, RAAKS, PTD, PRA etc., was a great challenge because of the long existing centrally controlled top-down bureaucratic system in China. Both government professionals and farmers had the TOT model deep rooted in their minds. Attempts to put the new ideas and methods into practice made both farmers and government professionals sceptical at the beginning.

Some government officials and extensionists thought farmers, especially those poor farmers in remote areas, have so little education and knowledge that extensionists have to provide them modern technologies and new farming practices and to teach them how to improve maize varieties. Some government officials even think bureaucratic intervention and administrative methods must be used to get farmers to accept new things. A lot of effort had to be made to put constructivist ideas and participatory methods into practice. The skills and techniques for communication and learning from each other proved very important. Once mutual understanding had been achieved through communication, the new ideas and methods were understood and accepted much easier. One old farmer commented:

> *"for years we have been told that we have to listen to the government officials and extensionists. They are knowledgeable and know what we*

> *should do for our farming. You are the first one who says that we know our farming system better than any one else and should share knowledge with researchers and extensionists to find solutions to the problems. That's right, we always discuss our problems with other farmers and neighbours and find ways to solve them. There is a Chinese saying that 'three cobblers with their wits combined equal Zhuge Liang, the master mind' ".* (recorded by the author in her field work 1996).

Gradually, through mutual communication and learning, some government officials, breeders and extensionists also admitted that farmers have some indigenous knowledge and local varieties well adapted to their farming systems. And they began to think that working together and sharing knowledge may be helpful and beneficial for both farmers and Government for problem solving.

3.6.2. Relationships and trust building

To do research in China, the first important thing is to build relationships ('Guanxi' in Chinese). Without "Guanxi" it is very difficult to start your research. So first of all I had to find out who are the key actors to start the 'Guanxi' I needed for the research. The head of the Agriculture Department in the Government of Guangxi province was the key person to start with. The provincial Agricultural Department belongs to the MoA system. It is an administrative management system and its institutions cover all levels, from the State to the village. Therefore, to build up relationships and develop my own network in the system is crucial for systematic research at the five different levels. Furthermore, the extension system and seed production and checking system are key actors in the Programme network, and both are subsystems of the MoA (see chapter 5 for CAAS and MoA systems in China). So first of all I tried to get permission for doing field research from the head of the Agricultural Department and tried to get his help to build up 'Guanxi' with key persons in other levels. Through the exploration of Guanxi and development of my own network I had a better understanding of the social forces and context of the Programme and the public system itself.

For farmers, *trust building* is always more important than 'Guanxi' at the beginning of a study. So first of all, participating and sharing farmers' day to day life and farming activities and sentiments are essential to understand them and become one of them. Once mutual trust and respect had been established and you are accepted as one of them, they will share their knowledge with you and discuss all their problems and ideas.

3.7. Conclusion

In concluding this chapter, first I want to emphasise that the research was really a learning process for me and I have benefited the most from living and working together

with farmers. I really had a life change experience in the field with farmers. Then, I would like to argue that the research I was able to undertake, and the level of understanding I have reached, benefited significantly from two other facts. The first is my working experience with the Programme and its main actors in the first half of the 1980s and subsequent continuous contact with them. The second is my own life history as a native from the research area. These two facts provided me unique opportunities to observe and understand the insights and nature of the research problems that would not have been possible for an external researcher.

Chapter 4

Maize Technology Development and Strategies of Formal and Informal Systems

4.1. Introduction

Globally, maize (*Zea mays L*), comes third among food grain crops in terms of production as well as acreage. Maize is known for its versatile nature and tremendous genetic variability enabling it to grow well both under tropical and temperate climates and to adapt to favoured areas as well as difficult environments.

Maize is one of the most versatile of all agricultural products, being employed as human food, livestock feed, and raw ingredient for hundreds of industrial materials. Its characteristics of high energy content, excellent adaptability to difficult environments, and its relative ease of cultivation, storage and processing, have made maize a very important food crop for the poor in the difficult farming systems in remote mountainous rainfed areas. Meanwhile, maize is the world's chief animal feed. The outstanding characteristics of maize: high in energy, low in fibber, and easily digested by most livestock species, make it a suitable cereal grain for use in ruminant and non-ruminant feed diets. Industrialised countries, such as the United States, use their maize crop mainly as feed and depend on it to produce their meat, milk, and eggs (Brown and et al, 1988). Maize grain is also a key industrial raw material used for diverse purposes, including starch, glucose, oil and alcohol production.

Moreover, maize's special genetic characteristics allowed initiation of the hybrid seed industry, which has promoted a rapid development of the feed industry and animal husbandry since the invention of maize hybrid technology in 1915, which diffused rapidly since the 1930s. It is considered that hybrid maize has played a significant and specific role in the transition from traditional agriculture to modern agriculture (Liu; 1991; Zhang; 1995; Mendra, 1970).

The multiple end-uses of maize, its wide adaptability, and other characteristics together make it an attractive crop for industrialised countries and the developing world. In the industrialised societies, maize is bred for mechanised agricultural technologies, highly engineered milling and processing plants, sophisticated marketing strategies, and various consumer tastes and choices. These industrial endeavours are supported by, and are part of, a well-functioning and highly developed infrastructure. However, in the developing countries and unfavourable areas in which sufficient levels of development do not exist, the farmers have played an important role in the evolution and improvement of the kinds of maize being grown. This is particularly true when maize is used for direct human consumption rather than as animal feed or industrial use (Timothy, Harvey and Dowswell, 1988).

This chapter provides a general presentation of maize technology development and strategies in formal and farmers' systems. Based on the idea that to understand maize research it is necessary to understand the plant itself, the chapter starts with the origin, evolution and domestication of maize and then goes into a description of the basic genetic

resources and principles of scientific breeding and the physical features of MVs. Differences between formal breeding and farmer breeding are discussed with reference to CIMMYT, Chinese NARS and two cases of farmer breeding at the village level.

4.2. The History and Development of Maize

4.2.1. The origin and spread of maize

Despite a great deal of research, the origin and spread of maize is a source of much controversy. Most researchers argue (Candolle, 1886; Mangelsdorf, 1974; MacNeish, 1964, Liu, 1991; Zhang, 1995) that the cultivation history of maize can be traced back to about seven thousands years ago, originating among the ancient peoples of Central or Southern America. It is believed that those residing in the highlands of Mexico and Chile, planted maize and potato on terraces and cultivated cassava, tomato, cotton and tobacco in the river valleys, these areas are considered one of the original sites of the ancient cultures and civilisation in America. Maize, the most important food crop, was worshipped. The cultivation and management of maize and especially seed selection was a focus of attention and became important and sacred activities for the ancient American Indian people. This is considered crucial for the maintenance and improvement of maize in it's process of domestication. The cultivation of maize provided a very important base for the development of American Indian culture and civilisation. Since 1492, when Columbus discovered "the New World", maize as the most important crop of the local residents, was recognised by the Europeans for its nutritive value and introduced into Europe, from where it spread rapidly to other parts of the world. Maize, then, became a major staple crop world-wide (Candolle, 1886; Mangelsdorf, 1974; Mannion, 1995; Liu, 1991; Zhang, 1995).

However, some other researchers, represented by Collins (1909) and Anderson (1943, 1954), argue that maize must either have originated in Asia or have been taken there in pre-Columbian times. One of the main evidences adduced to the argument is the discovery in Chinese maize of a peculiar type of endosperm known as "waxy". This kind of waxy maize was unknown as a cultivated variety in the Americas but was widespread in China, Burma, and Philippines (Collins, 1909, 1920). The origin of this kind of waxy maize has also been a matter of debate and controversy. Mangesdorf (1974) attributed the existence of the waxy maize to genetic drift and artificial selection in narrow based populations. He described "people of these areas being familiar with waxy varieties of rice, sorghum, and millet and accustomed to using them for special purposes recognised the waxy character in maize after its introduction into Asia and purposely isolated varieties pure for waxy endosperm" (Mangeisdorf, 1974:143). Meanwhile, Anderson and Stonor argued (1949) that waxy maize is a race, originally grown by hill people in Asia, different from those widely spread along the coastal areas and plains in Asia, and introduced from America. Their argument is supported by some evidence and findings provided by Chinese scholars in the following section.

4.2.2. The origin and initial starting of maize cultivation in South-Western China

There is no evidence of the exact beginning of maize cultivation in China. Some written records of maize cultivation are found in some ancient Chinese regional annals such as the annals of several local regions in the South-Western China under the Tong Dynasty (618-907 AD), and "Annals of Shou Zhao" published in 1511. So it is alleged that maize had been already introduced in China or existed there already before Columbus' discovery of the "New World" (Liu, 1991; Zhang, 1995).

From historical and scientific analysis it is believed by Chinese scholars that there are two sources of maize cultivated in China, i.e., exotic maize and indigenous landraces.

The introduction of exotic maize: there are two possible routes of introduction of exotic maize from the Americas via Europe to China (Zhang, 1995). The first is the Portuguese route, which brought it to Java (or the Philippines); from there maize spread to the South-eastern coastal regions of China and then to the inland. The second possible route was through India, Tibet and then into South-Western China, the putative centre of maize cultivation in China in pre-Columbus times.

The origin of indigenous landrace, waxy maize: of the existence of local landraces of maize in China still no clear and formal record exists. However, there is a great probability that landraces existed in South-Western China long before the introduction of exotic varieties. Two facts have been cited to support this claim (Zhang, 1995). First, in the annals of several local regions in the three South-western provinces i.e., Yunan, Guangxi, and Guizhao, under the Tong Dynasty(618-907 AD), there are records of maize cultivation, with the characteristics of local maize landraces described in detail. Secondly, the landraces described in the Annals are identified as waxy maize varieties with the characteristics of small grains and a good quality of waxy endosperm which fits the local taste. Based on my own observation there are various connections between waxy maize and the traditional local life style of the minority peoples dwelling in this area. These people like waxy types of food. In ancient times almost all of their food crops were "waxy" in character and even now, when a lot of these waxy varieties are replaced by high yielding varieties, they still try to grow some waxy varieties in isolated areas, like vegetable gardens, as quality food for special use, such as festivals, and weddings etc.

The original and initial cultivation area of maize, i.e., the three South-western provinces have a wide variety of local germplasm; the largest genetic record of landraces contains more than 1000 entries (cf. Maize Germplasm Resource in China published in 1988). Some are still in cultivation and a few have been used in maize breeding. However, most are kept in provincial and national gene banks. The common characteristics of the local varieties are small size, waxy grain, and good eating quality. These varieties are normally stress resistant, with cold and drought tolerance, and adaptable to infertile soils; in short they have good adaptability to difficult growing

conditions. They also have high specific combining ability with temperate and tropical maize. However, their yield capacity is rather low.

It has been accepted by some scholars that the sticky maize race is originally from the South-west China (Liu, 1991). Therefore, it is argued by some Chinese scholars that the South-west is not only the initial starting region for maize cultivation in China but also one of the centres of origin and domestication of maize in the world (Cao and Xu, 1987; Liu, 1991; Zhang, 1995).

4.2.3. Shift of the main maize production area from the Southwest to the North

The South-west is commonly accepted as the origin of maize cultivation and development in China. The varieties indigenous to these areas, having small and waxy grains, had spread to the northern plains before the introduction of exotic maize (Cao and Xu, 1987; Liu, 1991). Later, with the introduction of exotic varieties these small and waxy maizes have been gradually and almost fully replaced by high yielding maize (Zhang, 1993; Zhang 1995). The South-west still was the most important maize growing area in China at the beginning of 1950's, but since the end of 1950's and especially after the hybrid campaign in the later 1960s, the centre of maize production moved towards the North and North-east plains (Li Jianxiong, 1988). This shift is mainly due to the wide use of maize and rice hybrids.

The rapid development of hybrid rice gradually resulted in replacement of maize by rice on the relatively flat lands in the South and South-west, whereas the favourable flat area in the North after 1960s were used for maize production, when hybrids better adapted to areas with higher external inputs became available. Maize production developed quite rapidly in the Northern Plains after the 1960s, especially since the 1970s with the rapid development of hybrid breeding in China (Li Jianxiong, 1987, 1988).

4.3. Maize breeding and its genetic resources

4.3.1. Development of hybrid maize

Maize is a monoecious and open-pollinating crop, having separate male and female inflorescences. The male inflorescence, i.e. the tassels, can easily be removed to control pollination. Control of pollination between inbred lines enables the development of commercial maize hybrids, a breeding strategy, which became popular after the discovery of the relevance of hybrid vigour for maize breeding in the USA in 1915 (Ryan and Gross, 1950). Plant breeders exploit the so-called phenomenon of hybrid vigour, or heterosis, by mating of distinct genotypes (inbred lines), and selecting cross combinations with an excellent yielding capacity. Seeds of such combinations, potential hybrid varieties, can be generated indefinitely from inbred lines. Since each hybrid variety is

the result of a unique combination of parent materials, farmers must purchase new seed every cropping season rather than save their own seed from the previous harvest. The commercial potential of hybrid maize was realised and maize became the first crop that can be largely commercialised through F1 hybrid seed production.

Commercial production of F1 hybrid seeds began in the early 1930s in the United States and developed quite rapidly. In 1934 the area of hybrid maize in USA was only about 0.4%, and in 1956 about 98%. This success made the USA the biggest maize producer and exporter in the world both by volume and value.

Following its wide adoption in the USA during the 1940s, hybrid maize spread quickly throughout the developed countries, and also aroused interest in the developing world. However, the results in most developing countries were not good, though there were a few cases of success, such as in Zimbabwe, Kenya and the northern part of China (CIMMYT, 1991), in environmentally favoured areas.

4.3.2. Types of maize variety and their physical features

Maize varieties can be divided roughly into two main categories: Hybrids and OPVs. Hybrids can be subcategorised into four crossing types, and OPVs can be divided into two sub types (see Figure 4-1).

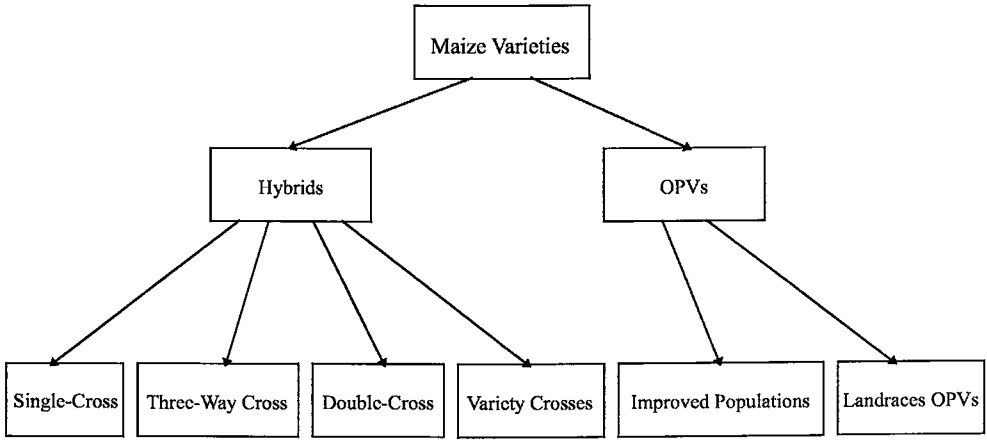

Figure 4-1. Major categories of maize variety

Source: compiled by the author, 1998

OPVs: Improved populations: Population improvement through mass selection is the most basic traditional method of plant improvement. It is the most popular method of breeding used by farmers. It still retains importance by scientists. Since the accelerated development of hybrid breeding by American breeders in the 1930s, it has been gradually realised that the continuation of hybrid breeding unavoidably has resulted in an increasingly narrow genetic base. So in order to enlarge and improve the genetic base of hybrid breeding, breeders now grow hundreds of different lines and varieties together and select through current selection. The output is called an improved population (or breeding population), which has a wider genetic base and relatively broader adaptability and stability. Normally, the improved population may be used as breeding material by breeders for selection of inbred lines for hybrid breeding. However, as it is possible that an improved population outperforms a hybrid in terms of stability and lower external input requirement, and is superior to many landraces in yield potential and other characteristics. With these advantages, improved populations are often popular with farmers in environmentally harsh regions. Farmers in these areas can use improved populations directly.

Landrace: A landrace is a local population with certain characteristics that often include strong local adaptability and local stress tolerance. It typically has lower yield but normally a good quality and other characteristics suited to the local preference. They are an important source of breeding material. Landraces are effectively managed and maintained by farmers.

F1 Hybrid: The scientific base for hybrid seed production is *heterosis* or *hybrid vigour*, which is the tendency for offspring of genetically diverse plants (preferably inbreds) to outperform their parents. Crossing two different parental lines, which contain specific characteristics, results in a genetically uniform offspring (F1 generation), which can combine all these characteristics. Yield potential may be very high. In order to produce hybrids, inbred lines must be developed first by repeated self-pollination of individual plants, finally resulting in fully homozygote plants. The selfed progeny of such a plant is called an inbred line, which is genetically uniform.

On the basis of the ways in which the crossing is made, there are four main types of hybrids, each with different characteristics and which represent different stages of hybrid technology:

Varietal crosses: One OPV is crossed with another OPV, i.e., OPV1'OPV2. This is considered a "conventional" hybrid by breeders. It represents the initial stage of maize hybridisation and has only a modicum of hybrid vigour. But as both parents are OPVs rather than inbred lines, it has a relatively wider genetic base than other types of hybrid.

Top-cross: One single-cross hybrid is crossed with an OPV, i.e., A'OPV. As one of its parents is F 1 hybrid, a top-cross has more hybrid vigour than varietal cross. It is

considered as a modified hybrid by breeders. The cost to produce top-cross seed are less than that of single cross seed due to the fact that the female parent is an OPV. So Top-cross is popular with farmers in less favoured areas.

Double-cross: Inbred lines A'B, inbred lines C'D, followed by crossing the F1 hybrids, i.e., A'B and C'D, then AB'CD. This type requires two generations.

Three-way cross: Inbred line A is crossed to inbred line B, followed by crossing of F1 with another inbred line C, i.e., (A'B)'C, two cycles of crossing. This type of hybrid tends to have less hybrid vigour than a single cross. However, its genetic base is somewhat wider than that of a single cross.

Single cross: Inbred line A is crossed with inbred line B, i.e., A'B. With its 'tremendous' potential of hybrid vigour it is considered by scientific breeders an advanced approach to hybrid breeding and the best type of hybrid. It has high yield potential and it is considered to give rise to high input and high output varieties. Broad adaptability and stability for single crosses in a wide range of environments has become one of the most important goals of scientific maize breeding. However, this is difficult to achieve owing to the narrow genetic base. Moreover, because the parental lines suffer from an inbreeding depression resulting in lower yields of the seed line, single cross hybrid seed is costly to produce.

4.3.3. Hybrid and OPVs; risk, stability and adaptability

Generally speaking, (improved) populations are relatively stable and adaptable to a wider range of environments due to their broad genetic base. Whereas hybrids, especially single crosses, can be very good for certain areas, they tend to be less adaptable. This type of hybrid in particular lacks the buffering capacity of the population to environmental constraints. However, hybrid genotypes adapted to a wide range of climatic conditions can be developed, but it is more easy to develop a stable improved OPV. The mean yield of hybrid over environments, however, is usually higher than that of OPVs (owing to its hybrid vigour). Figure 4-3 shows the general trend that in favoured environments hybrids could yield much higher than OPVs whereas in harsh environments, the yield potential of hybrid is close to OPVs while in some extreme circumstances it could be worse.

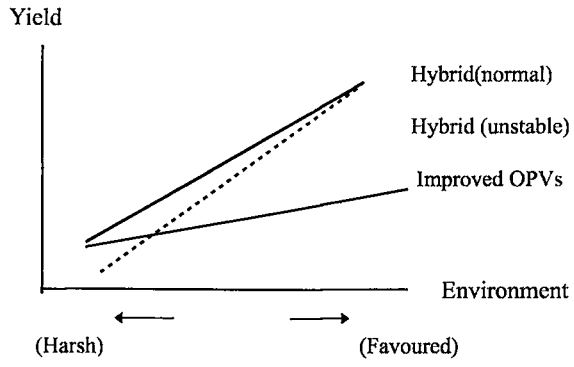

Figure 4-2: Yield potential of hybrid and improved OPVs in different environments

Source: compiled by the author, 1998

In order fully to explore the yield potential of hybrids, farmers may need extra inputs to optimize growing conditions. Farmers in harsh environments normally have few resources and they are risk-vulnerable, whereas the benefits of extra input are relatively small. So they normally avoid the use of technology requiring external inputs. In the case of hybrids, farmers have to make additional investments for seasonal changes of seed and more fertilizer to benefit from the genetic potential. Furthermore, they have to rely on an external formal distribution systems for supplying hybrid seed and have fewer options for self-reliance. That is why poor farmers in harsh environments usually prefer improved OPVs rather than hybrids, which reflects their risk-aversion orientation.

However, mechanical assumptions that hybrids are appropriate for favoured areas and OPVs for the harsh ones is just too simple. Things are more complex and intertwined than this. Some breeders argue that from a breeding point of view, it is possible and necessary to develop a genotype with more stable performance for harsh environments (Mangelsdorf, 1974; Becker and Leon, 1988; Timothy G.R., 1996; Vasal, 1996 pers. com.; Dolstra, 1998 pers. com.). It is noted that a hybrid could show high performance of yield stability and other essential agronomic traits for certain areas and lower stability in others. It is considered that "the basic cause of differences between genotypes in their yield stability is the wide occurrence of genotype-environment interactions (GE-interactions,), i.e., the ranking of genotypes depends on the particular environmental conditions where they are grown"(Becker and Leon, 1988). (The general trend of types of environment and yield stability of hybrid is interpreted and illustrated by the author in Figure 4-4).

So hybrid breeding should target on particular regions rather than search for broad adaptability (Amanor, 1995, Becker and Leon, 1988; Dolstra, 1998 pers. com.). Breeding should be based on knowledge of farming systems and target area. Therefore, it is very important to develop locally appropriate materials. Local breeding and farmers' participation have a very crucial role to play in such a local level breeding strategy.

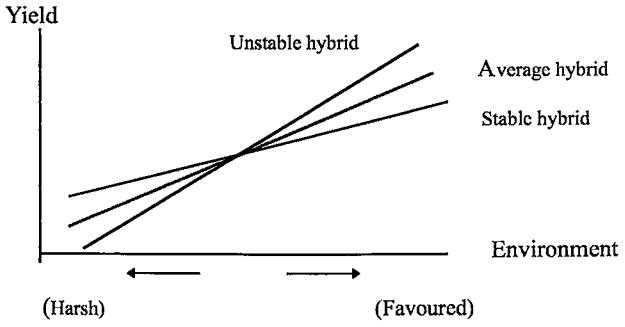

Figure 4-3: General trend of types of environment and stability of hybrid

Source: compiled by the author, 1998

Furthermore, institutional factors are very crucial for the success of a breeding strategy. This is especially true with hybrid maize, because hybrid breeding and seed production is done by external formal seed systems rather than by farmers' own systems. There are many institutional factors which may influence farmers' adoption of hybrids, such as availability of appropriate hybrids and farmers' timely access to them, reliability of seed supply and quality of seeds, seed price and price of other external input inputs and outputs among many others. As stated by Dr. Dolstra (a senior plant geneticist and maize breeder in CPRO-DLO the Netherlands): "If there is no appropriate hybrid breeding infrastructure, including a good variety testing and seed quality testing systems, and a good institutional framework and appropriate policy to support them, it is better for farmers to rely on the well known OPVs which are more stable and reliable and less risky" (Dolstra 1998, pers, com). Farmers realise this better than scientists and this may explain the rejection of F1 hybrid in Zhichen and shift to OPVs in Geyang (discussed later). The rejection of F1 hybrid has been mainly because of the extreme harsh environment and the recommendation of an inappropriate hybrid, whereas the shift to OPVs has been mainly due to poor hybrid seed quality and unreliable seed supply and other institutional reasons (cf. chapter 7).

Based on the general genetic features of the different types of varieties and their implications for farmers in different environments, some questions arise. How do formal and informal breeding systems take advantage of these features? What are the focuses and breeding priorities set by breeders and farmers themselves? The following section will analyse and present the breeding strategies of breeders and farmers. Then, examples of maize breeding activities by CIMMYT, Chinese NARS and two cases of farmer-breeding will be presented to illustrate the differentiation and gaps between the formal and informal systems.

4.4. Breeding strategies and priorities with formal and informal systems

4.4.1. Two knowledge systems of crop improvement

Before the advent of science-based agriculture, plant breeding was strictly a local activity. Farmers selected genotypes according to their own needs and preferences and for adaptation to their own specific environments (Byerlee, 1993). Meanwhile, the scope of scientific plant breeding internationally has become much broader, with a global perspective. One of the fundamental tasks confronting scientific breeding is to develop varieties with a ***broad adaptation***, having high yields across a wide range of climates (CIMMYT, 1991). Given the diverse farming environments and situations at farmers' level, varieties should be buffered to wide environmental variation. This is especially true for maize, which is grown in a great number of distinct geographical environments across developing countries. Besides, socio-economic and cultural variations make it even more difficult to cover a wide range of area with an uniform variety or a type of variety (Lipton, 1989, Byerlee, 1994).

Modern plant breeding and formal agricultural research have focused mainly on high yielding varieties which are adapted mainly to favourable production environments. Little research attention has been given to the development of hybrid varieties to ecologically marginal and diverse environments. Not much attention has even been given to the development of "locally adapted", relatively low yielding OPVs and landraces, which are locally important, especially for the poor and small farmers in harsh and diverse environments (Hardon and de Boef, 1993; Gruire and Manicad, 1998)

A formal research system is limited by its institutional and technical constraints to reach the marginal areas (marginal population, crops, varieties and environments). So farmers' informal systems have a role to play to fill the gaps and match the diversity required by farmers. As a result, two independent knowledge systems of crop improvement continue to operate at different levels in most of the developing countries (Berg et al., 1991). The two systems are typified by Hardon and de Boef (1993) as follows:

- A formal institutional system involving international agricultural research centres (IARCs) and other regional and commodity-oriented centres, national research systems

and private industry, linked to farmers through extension services and marketing in a linear model of technology development and transfer. The emphasis is on maximizing yields and use of external inputs with the main objective of solving macroeconomic and national needs for more food. The focus is on control.

- An informal system at the farm level using and developing crop diversity through local landraces and seed production and distribution at the community level. The major emphasis is on yield stability, risk avoidance and low external input farming. The focus is on adaptive management (cf. chapter 8).

4.4.2. Different goals of formal breeding and farmer breeding

Formal breeding:

Institutional and economic factors determine that formal breeding aims to develop new, widely adaptable varieties which satisfy a narrow set of breeding objectives (Hardon and de Boef, 1993). Quantity (as indicated by yield) has been seen as the most important goal by most formal breeders and breeding for resistance for diseases, pests, lodging, drought are all, more or less, to serve this purpose (Lipton, 1989). Resistance breeding is considered significant in improving yield stability. The main focus of the formal breeding is normally to maximize yield with high external input and to serve the purposes of macroeconomic goals and national needs for more food. As a result, formal plant breeding is tend to be constrained by the single purpose orientation and its specificity and commodity focus to address the diversity of environments and meeting the heterogeneous needs of farmers (Amanor *et al.*, 1993; IPRA, 1995).

Farmer-breeding:

Holistic vs. segmented/specialized: Farmers' goals in breeding frequently are described as more holistic than those of formal breeding (e.g. Amanor *et al.*, 1993). Farmers and their families seldom isolate one aspect of crop performance for selection, such as high yield. This is proved by the present author's own field experience: farmers found it difficult to give only one primary reason for using a variety, quite often they gave several connected reasons as their "primary" reasons. A farmer's selection criterion is holistic in nature, based on a combination and balance of multiple factors related to his/her farming environment and social/cultural and economic context. Through multiple-cropping, and selection of varieties and planting materials, farmers manage diversity at a number of levels and their choices reflect a wide range of criteria (Sperling *et al.*, 1993; Dennis, 1987; Brush *et al.*, 1992). These criteria may include yield stability, biomass production, palatability for animal or human consumption, other quality and culinary traits (Ashby *et al.*, 1995), as well as adaptation to conditions of timing and photoperiod (Bunting and Pickersgill, 1996), storage ability (Teshome, 1997), soil moisture (Richards, 1986), or soil fertility (Bellón and Taylor, 1993), among many others.

The very range of traits sought by farmers is seen as a major causal factor in the varietal diversity observed in farmers' fields (Teshome, 1996; Bellón, 1996, Brush, 1995). As pointed out by Hardon and de Boef (1993), formal plant breeding usually does not consider such a range of traits, partially reflecting the technical and institutional challenges of such a task, but also because the context(s) in which a crop is to be used is often not considered.

Local vs. broad adaptation: Formal breeding, as described above, typically seeks broad adaptation, indirectly hoping that material selected under experimental station conditions will perform well (high yielding) across a range of conditions. However, on the other hand, the scale for which farmer seeks adaptation is more complex and locally biased. Especially in high-stress and variable environments, farmers are searching for stress tolerance and local adaptable materials. For example in Zhichen, an extremely difficult environment, the farmer's main priority in selection was lodging resistance (cf. Zhichen case in chapter 6 and 7). I would argue that direct selection for target environments and local breeding is necessary to meet the heterogeneity of needs.

Adaptive vs. standard approaches: Farmers are continually interacting with the environment and changing as new problems are encountered (Amonor, 1993). They take experimental and adaptive approaches to cope with the changing situation and environments. Therefore, the goals and criteria for selection and breeding vary together with changes of environments and situation through time. The shift from hybrid maize to OPVs in Geyang village, an environmentally favoured area, is a good example of this (cf. Geyang case in Chapters 6 and 7).

4.4.3. Seed production by formal systems and farmers

Traditionally, farmers select and save seed from previous harvests for cultivation. Their indigenous knowledge and skill in on-farm seed selection and saving has accumulated and been enriched by practice through generations. Farmers' indigenous knowledge, methods and skills such as mass and recurrent selection still play a main and significant role in OPV improvement by farmers, as well as by breeders.

It is assumed that farmers have to rely on external supplies of hybrid seed, however, as on-farm seed saving of hybrids is practically impossible without the loss of its superior hybrid vigour. The difficulties to produce on-farm hybrid seed have stimulated the rapid development of the seed industry as mentioned in section 4.3.2. However, commercial seed production efforts are sustained mainly in the more advanced maize growing areas focusing on several widely adaptable hybrids. While, in most developing countries, farmers are cultivating maize in difficult farming systems under heterogeneous conditions. Therefore, an effective seed production system has a crucial role to play in the distribution of MVs, hybrids and improved OPVs, in order to reach different types of farmers, especially the poor and women. A governmental seed sector mandated by

agricultural development needs rather than the requirement to make a profit is needed to play such a role (Timothy, Harvey and Dowswell, 1988). Unfortunately, in a number of developing countries, inadequate profit incentives within public maize sectors have restricted the development of effective seed production and distribution systems (Timothy, Harvey and Dowswell, 1988). This is the case in China after the introduction of market oriented economy and privatization of public institutions. The market force and single minded goal of national food security together have shaped the public seed sector's increasing bias towards hybrid and neglect of OPVs (cf. chapter 5).

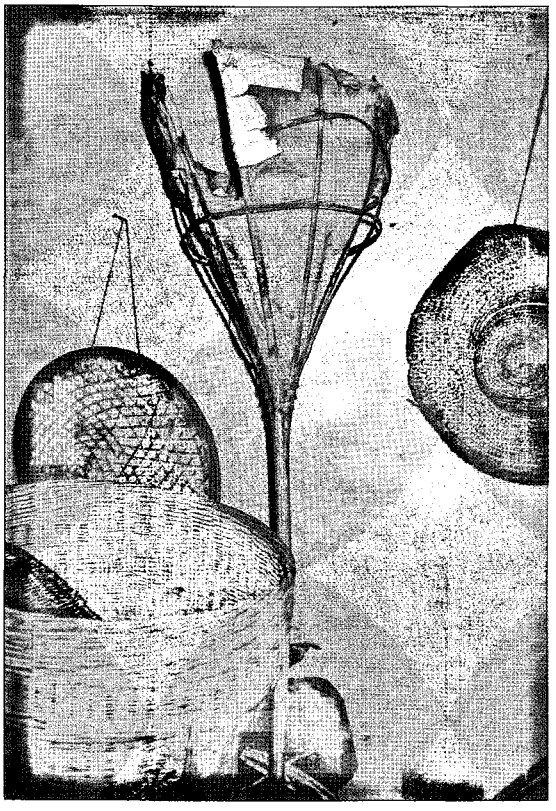

Photo 4-1: Indigenous tool used by farmers in hybrid maize seed production

Based on the author's observation during the present field research, small scale farmers are capable enough to produce hybrid seed (cf. the Pingou case in Guangxi, chapter 5). According to the principle of hybridisation, the key to the successful production of hybrid seed is efficient control of the pollination process. Self-pollination of certain seed line plants must be prevented. This is relatively easy for maize due to its distinctly separate male and female flowers. Either mechanical or manual methods can be used to remove tassels from the seed plants before they are able to shed pollen, and

to collect pollen from male plants for artificial pollination. So efficient control of the pollination process and complete isolation from other varieties are crucial for hybrid seed production, but this can be done by farmers. Therefore, so long as farmers could get parental lines and some scientific instruction from breeders they can produce hybrid seed for themselves. Consequently a suggestion for collaboration between farmers and breeders in maize seed production has emerged (cf. chapter 8 for more discussion). Technically it is possible, although some economic and institutional issues, such as the scale of economy and the forms of collaboration etc., need further research and exploration. There would be certain practical advantages to *in sity* hybrid seed production in remote mountainous areas (e.g. transport/supply bottlenecks; stimulate local company when some farmers become engaged in specialist seed production).

4.5. Hybrid or/and OPVs: Strategies of formal breeding and farmers' breeding

Owing to various institutional reasons and partially resulting from their physical features, maize hybrids and OPVs almost become the symbols of favoured maize farming systems and difficult maize farming systems respectively, although there are some controversies and conflicting ideas about this distinction. This section presents an overview of research priority setting by formal maize breeding, and farmers' breeding, with examples and cases. First, the breeding strategies of CIMMYT are briefly reviewed, and then the overall policy of maize breeding in China and the development of maize technology in the last four decades is presented. Finally a comparative case study of two villages will be used to illustrate the different needs of farmers in different environments and their own effort in breeding to adapt to their heterogeneous farming systems.

4.5.1. CIMMYT, its breeding strategies and methods

The rapid spread of hybrid maize production in the United States during the 1940s was accompanied by the disappearance of indigenous maize varieties. There was a growing realization that the loss of those genetic resources, products of hundreds or thousands years of evolution under domestication, could restrict future maize improvement and deprive us of genes of great potential importance (Timothy, Harvey and Dowswell, 1988). Concern for this situation stimulated the first international concerted effort, by the Mexican Ministry of Agriculture and the Rockefeller Foundation, in native maize germplasm collection and classification, which led to the subsequent identification and development of some outstanding germplasm in Latin America. This event laid the basis for the establishment of CIMMYT and the development of its main research strategy and methods.

Based on its general mission (cf. chapter 5), CIMMYT focuses its research on the tropical and sub-tropical production environments and its Maize Programme traditionally has concentrated on population improvement through recurrent selection.

These approaches are determined by several realities. First, although the U.S. hybrids diffused rapidly in the temperate areas they failed to adapt to the tropical and subtropical harsh growing conditions and environments where the majority of the poor farmers in developing countries live. Second, the diffusion of hybrids was restricted by the 'poor' functioning of hybrid seed production and distribution systems in developing countries and other economic and institutional constraints there. Third, since the mid-1950s, there was growing awareness that the development of synthetic varieties from superior germplasm could serve many less developed areas of the world. Timothy et al (1988) state:

> *"breeding theory and methodology indicated that appreciable improvement in maize could be attained by various recurrent selection schemes. These procedures could be applied to the existing superior germplasm stocks, varieties, racial groups, and composites. Here, the material from each breeding cycle has the potential of being released directly as a variety. This would allow for wide-scale distribution, even from farmer to farmer, without suffering losses in yield or agronomic desirability, and without having a sophisticated seed industry in place. Additionally, the material from each breeding cycle could also serve as an improved source from which to extract inbred lines for hybrid seed production to suit those areas having more advanced agricultural capability" (p.11).*

In the belief that population improvement through recurrent selection is an effective approach for a wide range of source materials which national breeding programmes can use as breeding material for the development of improved varieties and hybrids, or as direct release to farmers, CIMMYT Maize Programme has concentrated most of its efforts on population improvement. These improved populations have contributed greatly to the development of high-yielding open-pollinated varieties(OPVs) and hybrids for farmers in the developing world, especially for the resource-poor farmers in rainfed areas. Moreover it is claimed that these improved populations introduced a substantial amount of useful genetic diversity into national maize research programmes, especially in Asia and Africa, where the genetic base of national breeding programmes had become very narrow (Timothy, Harvey and Dowswell, 1988). The improved populations, on the other hand, are also considered to be a threat to some indigenous maize varieties.

By the early 1970s the majority of maize programme in developing countries focused on the development of high-yielding open-pollinated varieties (OPVs). CIMMYT's main contribution, throughout the 1960s and 1970s, lay in supporting the development of OPVs by supplying improved germplasm.. By the 1980s, CIMMYT had begun to shift its exclusive emphasis on OPVs to hybrids and to support hybrid maize development in developing countries. One important reason for the change was that in a number of developing countries average yields had risen impressively. It was assumed by some CIMMYT breeders that: "as long as yield are below 2.5.t/ha, farmers are highly unlikely to adopt hybrids. But wherever average yields have climbed above that level, crop management and growing conditions are

good enough that many farmers can realize sufficient yield improvement with hybrids to justify the annual purchase of higher priced seed" (CIMMYT, 1991).

Meanwhile, in the last two decades the adoption of hybrids in some developing countries has increased impressively. In 1985, 38% of the maize area in developing countries was planted with hybrids (although this percentage is biased by the large areas in Argentina, Brazil and Northern China). It is to be expected that the proportion of hybrids is even greater now. Some CIMMYT breeders expect that hybrids are going to contribute a great deal to the future of maize cultivation in developing countries (CIMMYT, 1993). Thus, although CIMMYT still directs a large part of its maize resources to the improvement of population and development of new OPVs, added emphasis more recently has been given to the selection of inbred lines and other products for hybrid development (Lopez-Pereira, and Morris. 1994). In 1994, CIMMYT allocated about 20 percent of its Maize Programme fund to hybrids/inbreds, around 15 per cent to development of OPVs, and 34 per cent to population improvement (Lopez-Perera and Morris, 1994).

There are some doubts and conflicting opinions among CIMMYT maize breeders concerning the shift in research policy. The reasons given by those who favour OPV bias are mainly two. The first is that the areas where the yields are high enough for the introduction of hybrids are still quite limited in the developing world. The second reason is that in those more-favoured areas suitable for hybrids, private seed companies can effectively meet the demand for seed, therefore, CIMMYT should pay more attention to these less-favoured areas (CIMMYT, 1991). Others have argued that hybrids could be made adaptable to harsh environments and more research efforts should be given to the development of more stable genotypes and their adaptability to harsh environments. The development of stress tolerant, e.g. drought tolerant and low-N tolerant, maize breeding for difficult farming systems increasingly has become one of the most important research priorities of CIMMYT (CIMMYT, 1996).

In short the research focus of CIMMYT is getting broader in order to meet the wide range of demand in developing countries. As stated by P. Roger Rowe, Deputy Director General of Research, that " *We feel this broad effort is required because of the different situations in our partner countries. .....* ". However, CIMMYT is cautious about its direct involvement in hybrid breeding and follows an indirect strategy by supporting NARSs with the supply of improved germplasm depending on NARS's own interest and requirements. The option (hybrids or OPVs) is left to the NARSs.

4.5.2. Formal breeding in China, its policy orientation and hybrid bias

Policy orientation

As national food security via food self-sufficiency has been the number one goal of the Chinese central government in agriculture, the target crops of public agricultural

research have been food grain crops, mainly the three staples, rice, wheat and maize. Increasing productivity of these crops via hybrid technology has become the main goal for agricultural research. A "hybrid" strategy has become a kind of bible for the policy makers for the achievement of the overall goal, and hybrid breeding has become almost the only target of formal plant breeding in China.

Development of hybrid maize

Hybrid maize breeding started in China as early as the 1930's, when Jin Shangbao first systematically wrote about hybrid technology in a pioneering book on the subject (Jin Shangbao, 1934). After finishing his study in the USA at the end of the 1930s', Mr. Wu Shiaokuai, the god-father of hybrid maize breeding in China, introduced 64 USA hybrids into China. These two events actually opened the history of hybrid maize in China.

Hybrid breeding started with conventional methods, i.e., varietal crosses. However, owing to the civil war and other factors, the hybrids developed were not released to farmers until the early 1950s. Large scale hybrid maize breeding in China started in the 1950s after the establishment of the new government. Similar to the experience of some developed countries, maize improvement has moved progressively through three stages. Each involves a different breeding approach, as follows: (Zhang, 1993)

1. Varietal hybridisation, including population improvement and varietal hybrid breeding.
2. Formation of double-cross and three-way cross hybrids.
3. Development of single-cross hybrids.

Table 4-1: Three stages of maize production in China

Stage	Type of variety	Period	Yield (kg/ha) (mean)	(range)	Average increase per year Kg/ha	%
1	Varietal hybrids & OPVs	1949-60	1329	1337-1406	15.4	1.2
2	Double-cross hybrids	1961-69	1573	1309-1842	66.7	5.1
3	Single-cross hybrids	1970-91	3155	2053-4539	118.4	5.8
Overall		1949-91		1237-4539	78.6	6.4

* The three stages were characterized by the dominant maize breeding approaches which emphasized varietal hybridisation, double cross and single cross hybrids.

Source: Zhang Shi-huang, 1993.

The first attempt to use varietal hybrids in farmers' fields was 'a kind of compromise between divergent genetic disciplines(Li Jingxiong, 1986). That approach was pursued for only a few years until 1956, when the emphasis was shifted to the development of inbred lines for F1 hybrid breeding in a few agricultural universities and research institutes. The hybrid campaign began in the beginning of 1960s, right after the great famine (cf. chapter 1). When the first group of double-cross hybrids was demonstrated in the countryside in Northern China in the early 1960s, farmers were much impressed by the uniform short stature and outstanding yield potential of the new hybrids. Several promising hybrids were released for production in Northern China.

During that period, under the call of Mao, most of the maize scientists and agro-technicians went to rural areas and became 'bare-foot' scientists. They participated in production together with farmers and trained farmers in hybrid seed production and other improved cultivation practices. (It was found in the field by the present author that some of the breeding methods currently used by farmers were learned originally from scientists during that period). The hybrid technology diffused quite rapidly after farmers learned how to produce the seed themselves (Li, 1989). It took only 5 years for the double-cross hybrids to become popular in the North and Northeast China. As a result, the average increase of maize yield was impressive, at 66.7 kg/ha/year. However, in 1966 a nation-wide epidemic of Turcicum Leaf Blight (TLB), which was attributed mainly to the wide diffusion of hybrids with a narrow genetic base (Li, 1989), brought about serious damage to maize production. It took quite a few years for maize breeders to find new approaches to combating the disease.

As it would be more easy to develop two resistant elite lines for hybrid combination than four lines, the maize breeders decided to develop single-cross hybrids instead of double-cross hybrids. An advantage of this type of hybrid was the higher yield potential (Zhang, 1993). By the end of the 1960s, a number of high-yielding, disease resistant single-cross hybrids had been released, which replaced the double-cross hybrids rapidly. Up till 1992 about 90% of the maize area planted with hybrids was under single crosses. During the period from 1970 to 1990, the maize yield increased greatly, i.e. 118.4 kg/ha/year (or by 5.8%). This increase is much higher than the earlier stage of OPVs/variety hybrid and double-cross hybrids era.

It is obvious that formal maize breeding in China has had an overwhelming bias toward hybrids, mainly single cross hybrids. The impressive improvement in yield resulted in the large-scale adoption of hybrids in the northern plains. More than 83% of the total maize area is planted with hybrids (Zhang, 1994), with the Northern plains taking the largest share. Improved OPVs and landraces still continue to play the main role in the South-western provinces especially in the remote mountainous areas. Up till 1994 hybrids only comprised 45% of the total maize grown there (cf. table 1-1 in chapter 1).

Striking contrast between environments led to demand for different breeding material

China is well known for its striking geographic variation. This is reflected at the extreme in the huge differentiation between the two main maize growing regions; the

Northern plains and the South-western mountainous areas, in terms of climate, farming environments, economic and cultural contexts. (cf. chapter 1 and chapter 5). Even within the South-west there is great difference between the remote ethnic mountainous area and the relative flat and favoured areas (cf. chapter 6 and 7).

More than two thirds of China's maize area is temperate in environment over Region 1 and Region 2, the Northern plain, and the remaining area is subtropical and tropical in its growing environment in the Southwest (cf. section 1.3.2. in chapter 1). The Northern plain has a climate similar to the U.S. Corn Belt, whereas the South-west is a remote mountainous region with harsh and heterogeneous farming systems.

The original double-cross hybrids introduced during the 1950s and 1960s were based on elite Chinese Flint germplasm crossed with U.S. Corn Belt lines, including 38-11, L289, W19, W20, W24, and M14 (Li, 1987). By the end of 1960, new inbred lines with multiple disease resistance had been selected for the development of single-cross hybrids. Hybrids based on U.S. dent germplasm are used by 65% to 70% of farmers (Timothy, Harvey and Dowswell, 1988), and these U.S. related hybrids are used in the temperate growing environments over the Northern plain.

Determined by its mandate and research priority, CIMMYT's collaboration with China focuses on the tropical and subtropical maize areas in the Southwest (cf. section 1.4. in chapter 1). CIMMYT follows its usual indirect strategy by supporting the Maize Programmes in the Southwest with the supply of improved germplasm. The choice for hybrid or/and OPV breeding is a decision left to the Chinese NAARS and the provincial programmes.

Conflicts in research priority setting

Owing to the striking divergence between the two main maize regions and the different requirement of types of maize varieties, some conflicting ideas have arisen concerning breeding priority-setting and cooperation with CIMMYT, between the breeders at national level and breeders at regional level. The author has interviewed[1] most of the leading maize breeders in the three provinces and some at CAAS. Their main ideas are summarised and presented in the following sections in order to illustrate the differences and conflicts (some are direct quotation of what they said; however, their names are omitted for reasons of confidentiality).

Leading maize breeders at the provincial level

All the maize breeders interviewed at this level considered that varietal crosses, top-cross, and three-way cross hybrids, rather than single cross hybrids, are the appropriate

[1] 1. The interviews were conducted by the author during September 1995 to March 1996 in the three provinces and during February and March 1997 in Beijing. A total of 28 breeders were interviewed during the field work.

technologies for the South-west. The main reasons given are the difficult farming environments and farmers' lower purchasing power for external inputs, and also the higher cost of single cross seed production. However, in going together through the lists of varieties bred out in the past three decades, it was found that most of the improved OPVs, varietal cross and double-cross hybrids were released mainly in the 1980s. The majority of materials bred out in the 1990s are single cross (see chapter 5). One leading breeder's explanation of this conflict between informed judgement and actual practice was:

> *"Mainly because of the government's hybrid bias policies. Our research project has to be approved by the government and it directly connects to the research funds, promotion and other rewards for us. Increasingly government effort has been put into the extension of hybrids in the last 5 years due to the national need to increase food production. Bureaucratic intervention, such as quotas, rewards, subsidies etc., are used for hybrid extension. However, most farmers are refusing the recommended hybrids and make their own choice. So actually the hybrid area has been decreasing rather than increasing in the last decade in our province".* Another leading breeder added *"our financial problem is another reason for our increasing effort in single-cross hybrid breeding. We have to make profit from hybrids for the survival of our institution, although we know farmers in mountainous areas need improved OPVs".*

However, the majority of breeders at this level think that CIMMYT's improved populations, such as *Tuxpeño 1*, *Tuxpeño P.B. C15*, and *Amarillo Dentado-2*, etc., which are used either directly by farmers or by breeders in breeding, have contributed significantly to the maize production in the Southwest.

Leading maize breeders at national level (CAAS)

One of the leading maize breeders interviewed in CAAS thinks that the future of maize in China lies with the single cross hybrid and depends on the North of China. Therefore, in his view the cooperation between CIMMYT and China should focus on the breeding of single cross hybrids for the North rather than the improvement of OPVs and conventional hybrids for the South-west. He thinks that although CIMMYT's germplasm is mainly tropical and subtropical, it is not difficult to adapt them to a temperate environment through genetic introgression. When asked about the research focus of the South-western provinces his answer is: *"We should also mainly develop single cross hybrids and try to extend them and let farmers know their advantage.....".*

The hybrid bias policy has been strengthened by privatisation and the introduction of a market economy. Together, the two forces have increased the bias towards 'profitable' hybrid breeding and seed multiplication and away from 'non-profitable' OPVs (see chapter 5 for more detail). The following cases illustrate how women farmers in

different environments are making efforts to maintain and improve the OPVs, which are ignored by formal breeding but preferred by farmers, totally based on their self-initiative.

4.5.3. Farmers' breeding efforts: cases of Wenteng and Zhichen villages

It was found in the field that farmers are making efforts to maintain and improve preferred improved OPVs and landraces due to the failure of the formal breeding to meet their diverse needs. Owing to the feminization of agriculture and other factors, local seed production and breeding are mainly done by women. The following two case studies illustrate women farmers' initiatives and methods in maintaining and improving *Tuxpeño 1* and three landraces in two villages in Guangxi province: Wenteng and Zhichen.

Tuxpeño 1 (local name *Mexican 1*) is an improved population which was developed by CIMMYT from a landrace that originated from Tuxpe, Mexico. *Tuxpeño* varieties (*Tuxpeño 1* and *Tuxpeño PB C15*) were introduced in South-west China in 1978, originally as constituents for variety improvement and hybrid combination. However, *Tuxpeño* varieties were rapidly disseminated through the three provinces, mainly through informal seed exchange, and are currently grown on 310,000 hectares annually. Due to its broad adaptability and stability and strong tolerance to stress, especially lodging resistance, *Tuxpeño* became particularly popular with farmers in difficult farming systems in the remote mountainous areas. *Tuxpeño 1* also has been used by some farmers in the relatively flat and favoured areas since the early 1980s where the dominant varieties there have been varietal crosses, top-cross, and three-way cross hybrids. In the last decade more and more farmers in the favoured areas have shifted from hybrids to *Tuxpeño* varieties (cf. chapters 5 and 6).

However, since maize is an out-breeding crop, without improvement effort from formal breeding, *Tuxpeño* varieties have degenerated greatly by out-crossing in the last 15 years, resulting in decrease of yield, increase in plant height and loss of stress resistant characteristics to a certain degree.

The two cases here, Wenteng and Zhichen villages, represent the two contrasting environmental and economic conditions. *Tuxpeño materials* are now the dominant varieties in both Wenteng and Zhichen villages. Nevertheless, Wenteng has maintained and improved *Tuxpeño 1,* while Zhichen has chosen to maintain local landrace varieties. Farmer's contrary adaptive strategies towards *Tuxpeño 1* in the two cases show that farmers' breeding objectives reflect their environmental conditions, market and institutional relations, socio-economic positions and risk management.

Wenteng

Wenteng has a favourable environment, people are relatively well-off, educated and integrated into the market economy. Pig raising is the main source of income for most villagers and maize is mainly used as pig feed.

Tuxpeño 1 was introduced into Wenteng in the early 1980s, but has become increasingly popular after the early 1990s. Wenteng villagers replaced their hybrids with *Tuxpeño 1*, largely due to the unreliable quality of hybrid seeds and the favourable characteristics of *Tuxpeño 1*, which is maintained and improved by a group of women in the village.

Due to lack of institutional support, and due to the popularity of *Tuxpeño 1*, women in Wenteng village have organised themselves to maintain and improve Tuxpeño 1 since the later 80s. This selection activity was initiated by a innovative woman who has tried to maintain *Tuxpeño* 1 since its adoption. The selection methods used by the women include: spatial separation through field dispersal, temporal isolation and seed selection. The women explained that due to the popularity of *Tuxpeño 1* and the women's initiative in breeding, it is easy to organise women farmers to grow *Tuxpeño 1* in adjoining fields isolated from other varieties. The selection method the women farmers use is mass selection. The three steps in seed selection are to select best plants (good plants with big ears in the middle of the field), then best ears (based on cob size, length and number of seed rows) and then best grains (from the middle part of the ears seeds are selected for kernel size, shape, quality, colour). They claim that their skills have been passed-on for generations, as they have also used similar techniques for the maintenance of landraces in the past.

Photo 4-2: Designing maize breeding by a women farmer in Wenteng village

As a result the quality of *Tuxpeño 1* has been maintained and even improved in the sense that it is adapted better to the local conditions than before. It is not surprising that the improved *Tuxpeño 1* has spread rapidly to the neighbouring areas through farmers' informal exchange systems. It was stated by one of the women breeders that "most of our product is required as seed by farmers from other villages and areas". This has contributed greatly to the increasing shift from hybrids to *Tuxpeño 1* in this area (cf. chapter 6 and 7).

Zhichen

Zhichen, on the other hand, has a harsh and rugged environment. Farmers plant maize in minute pockets of soil on steep mountain slopes and between rocks in flat fields. Water is a serious problem due to calcareous rocks, while rains easily flood the land and wash away the crops. There are no roads and access to the market is very limited. Maize is produced for consumption (chapter 6).

Tuxpeño 1 was introduced in Zhichen at the end of the 1970s and became the dominant maize variety soon after. In Zhichen, 90 percent surveyed in this study said that resistance to lodging and higher yield are the most important criteria for their selection. Other preferred characteristics include white kernels, good stalk with strong root system, relatively short plant stature; wide adaptability, little external input (seed, fertiliser). From 20 local maize varieties planted in the 1960s, Zhichen villagers now only plant *Tuxpeño 1* along with three local varieties *(Local Sticky, Duan 1 and Local White*). However, *Tuxpeño 1* has degenerated greatly in Zhichen. The farmers felt this was a pity and made a request for governmental support to improve it. There has not been much government response to the request due to the lack of financial incentive.

However, why did Zhichen villagers not do much to maintain *Tuxpeño 1* themselves? Zhichen villagers feel that the *Tuxpeño 1* has degenerated beyond their skills to improve it. Instead, they hope that the government would improve the *Tuxpeño 1*, since they consider this a government variety. Yet, they also know that they have to maintain their local varieties because no outside help will ever bother. When forced to make hard decisions, instead of *Tuxpeño 1*, the farmers chose to maintain and improve the three local varieties based on their own usage. *Local white* is maintained by some farmers for its sweet stalks, on which children like to chew as sugarcane. *Local sticky* is a waxy variety used as speciality food for local festivals. Almost every household maintains a small plot in their vegetable garden, despite its low yield. *Duan 1*, an OPV improved by the county extension station in the 1960s, is maintained due to its strong drought resistance. Despite its low yield, the variety is used by the farmers to grow in the second cropping season in the Autumn, when no other variety survives the severe drought. The methods used by the women farmers to maintain the three local varieties include spatial isolation (grown in isolated gardens or separate valleys) and selection for the best ears and then best seeds. Similar to Wenteng, Zhichen villagers claim that this knowledge has been passed-on by their ancestors.

Some reflections on the cases

- The self-initiatives of both villages to maintain and improve their own maize varieties are largely a reflection of the inadequacy of the formal seed system, which distributes seeds that fail to meet farmers' requirements, but also reflect the initiative and capability of farmer-breeding and farmers' informal knowledge systems which are playing quite a significant, if not a dominant, role in meeting farmers' needs.

- The different choices made by the two villages offer insights into farmers' breeding strategies. Given the fact that maize is their staple food crop, Zhichen farmers strategically chose maize varieties that reflect their risk-aversion strategies. Despite the agronomic popularity of *Tuxpeño 1,* for Zhichen farmers in subsistence agriculture and risk-prone environments, other varieties were maintained and improved due to a combination of nutritional value, cultural practices and reliable supply in the most adverse environmental conditions. On the other hand, maize as a commercial crop for Wenteng, *Tuxpeño 1* fits the variety requirement of Wenteng. The surplus in production extends their level of risk-taking. In addition, their more advanced skills of varietal improvement may also reflect a greater access to information and education as compared with Zhichen where women farmers live in isolation and some of them are illiterate (cf. the survey finding in chapter 7).

- Due to the feminisation of agriculture and women's potential and initiative in breeding shown in the case, gender should become an important factor in technology design and development.

4.6. Conclusion

- Development of a more holistic approach for breeding is necessary to create more flexible technology options for farmers. For instance, a wider range of variety selections, including hybrids, improved OPVs and landraces, could enable farmers, especially poor and women farmers, to shift their limited resources around according to changing circumstances. Similar evidence and findings are shown in studies conducted in other parts of the developing world (Friis-Hansen, 1994; et al).

- Given the experimental ability of farmers and the constraints of the formal agricultural system in adapting technologies to diverse environments, local breeding for local adaptable and stable varieties is necessary to close the gaps. It is suggested that agriculture frameworks should attempt to strengthen the adaptive and experimental strategies of farmers as a basis for the development of the local-level breeding (Amanor, 1993).

- Informal seed systems and local knowledge show a lot of potential and need to be better understood if collaboration between farmers and formal systems are to improve. Therefore, farming system research and participatory approaches are essential for formal breeders to better understand the complex use contexts and diverse farming systems farmers are coping with.

- Farmers' potential capability and problems with the public seed production have revealed the strong possibility and necessity of a direct cooperation between scientific breeders and farmers in seed production.

The above story of maize, discussion about maize technology development and strategies in formal and informal systems, and a comparative analysis of formal breeding and farmers breeding with reference to CIMMYT, Chinese NARS and two cases of farmer breeding provided us a general picture of the difference between the two systems technically and institutionally. The following three chapters is an spelling out and further exploitation of the findings in this chapter through the impact study of CIMMYT Collaborative Maize Programme in the South-western China.

Chapter 5

Institutional Context and General Impact of the Programme

5.1. Introduction

The general objective of this chapter is to assess the macro-level impact of the CIMMYT Collaborative Programme on Maize Breeding in South-western China. This is done in a constructive manner. First, the institutional context of the Programme, within which the technology design, development and diffusion happened, is observed and analysed as a prelude to assessing the technology construction process. Then the general results of the Programme are studied to assess the extent of impact, and decide what it means in respect to the main concern of the present study.

This chapter includes two main parts; first it focuses on the description and analysis of the principal institutional and organisational contexts both at CIMMYT and the Chinese national system levels. The study then moves on to study the macro impact of the Programme using varieties released from CIMMYT germplasm, their adoption rate and incremental production as the main indicators. In addition, information about numbers and types of improved maize varieties and hybrids developed from CIMMYT material by local breeders, and information about some CIMMYT populations directly used by farmers are generated for examining trends in the extent and ways in which CIMMYT germplasm has been used in the three provinces. Finally some preliminary observations are discussed for further in-depth case study in next chapter.

5.2. CIMMYT and its Maize Programme

5.2.1. CIMMYT, its overall mission, general impact and challenges

Mission and mandate

CIMMYT is one of the earliest established and most important centres among the 16 international research centres of CGIAR. Its overall mission is to help the poor through poverty alleviation, food security and natural resource conservation. Its work focuses on maize and wheat improvement.

Since its establishment, CIMMYT has adjusted and amended its mandate and mission in response to the changing circumstances. The origin of CIMMYT can be traced back to 1943 when a joined research and training programme between the Rockefeller Foundation and the Mexican Ministry of Agriculture started (cf. chapter 4). The formal establishment of CIMMYT, however, was in 1966 and coincided with the early stage of the Green Revolution. It was considered that CIMMYT was created in the midst of the experience of the Green Revolution "in an effort to secure and extend the remarkable gains achieved, much as revolutionaries throughout history have sought a means of perpetuating change" (CIMMYT, 1991). CIMMYT's original mandate in 1960s and 1970s was to promote and carry out, nationally and internationally, programs to improve in all its aspects maize and wheat *production*..... through research, the distribution of

germplasm, training, scientific and technical meetings, and information (CIMMYT, 1980).

In the 1980s, CIMMYT's mission was amended from the increase of the maize and wheat production to raising the *productivity* of resources applied to these crops. The change was prompted by new thinking about the role of agriculture as an engine of economic growth. Food self-sufficiency in developing countries ceased to be the utmost important goal for the scientists. CIMMYT's work with national programmes was no longer focused on increasing crop production. Instead, increasing productivity of the resources available to maize and wheat became the first priority of CIMMYT's research efforts (CIMMYT, 1991).

This new thinking views agricultural technology improvement not just as a source of increased output but a source of new income obtained by various means and in different parts of the economy. It assumes that adopters of technical innovations gain additional income from the increased productivity of their resources and input either by increasing output or lowering the production costs (CIMMYT, 1992). Meanwhile, improvements in agricultural productivity begin to exert positive effects outside agriculture through lower grain prices. Consumers, for example, can spend more money for products other than food. And this stimulates the development of other sectors of the economy. It is assumed that the main beneficiaries of this improvement are the rural as well as the urban poor. The latter benefit most from lower food prices and from the new jobs that are created in a more vigorous agriculture and in other areas of the economy (CIMMYT, 1992).

Some environmental problems emerged in the 1980s, which were thought primarily to be caused by modern agricultural technologies like chemical fertilizer and pesticide etc. So in the beginning of the 1990s CIMMYT amended its mission statement to do research to test that its agricultural technologies did not have a potentially negative effects on the environment, and to highlight the importance of collaboration with national research systems.

Since 1995, CIMMYT increasingly has emphasised *sustainability* and natural resources conservation, and enlarged its partnership to integrate more with NARS and interact with NGOs, and other actors in its networks. In its research style CIMMYT also has changed greatly in the sense that it shows more concern for making research more responsive to real needs by involving more Farming System Research (FSR) and participatory approaches into its research agenda-setting, although the level of institutionalisation of these user-driven approaches is still limited.

In summary, it can be seen that during more than three decades' development there have been several shifts in, and adjustments to, CIMMYT's initial mission. However it has persisted in its core mission, i.e., to help the poor, through research, by increasing food grain productivity and thereby ensuring food security in developing countries.

General impact and challenges

CIMMYT's improved germplasm has spread widely throughout the developing countries. 50 million hectares of land in low-income countries is now planted to CIMMYT-related wheat varieties (about 70% of the total wheat area in those countries) and about 13 million hectares in low-income countries is now planted to CIMMYT-related maize varieties (about half of the improved maize varieties grown in developing countries) (CIMMYT, 1997). This has been achieved mainly through CIMMYT's cooperation and networks with NARSs, which have been strengthened, at the same time, by CIMMYT through the supply of breeding material, information and training in the last three decades.

The overall mission of CIMMYT is commendable and the general impact is impressive. Furthermore the present adjustment and increasing emphasis on stress-prone environments and difficult production systems in its research priorities and research style seem good and positive for the poor in general.

However, the world situation is rapidly changing, economically, politically and environmentally; the scientific, socio-economic and political situation in both the developed and developing countries is getting more complex. While some developing countries have improved their situation dramatically, others have become less capable and prepared to adapt to rapid change. This happened also between regions of large countries like China. Especially the poor of these countries and regions most vulnerable to change and risk. Severe challenges from the environment and society are confronting agricultural scientific research aimed at helping the poor.

The diverse socio-economic situations in different nations and regions, however may warrant additional special measures for further realising the mission and reaching more poor people in the developing countries, especially women. More attention, special consideration and careful study should be given to policies and institutional environments of specific countries, such as China, which has experienced tremendous changes in its economy and society in the last 15 years. Its national agricultural research and extension systems for modern varieties are confronting great challenges in terms of food security, poverty alleviation and natural resource conservation.

5.2.2 CIMMYT Maize Program, its geographic focus and flow of germplasm

Geographic focus

Based on its mandate and due to the fact that the overwhelming majority of poor farmers in developing countries is living in tropical and subtropical production environments, CIMMYT focuses its research on the lowland tropics, tropical mid-altitudes, highland tropics, and the subtropics (Edmeades, 1989).

Flow of germplasm

CIMMYT Maize Programme has assembled and improved a broad range of germplasm, including pools, populations, inbred lines (cf. chapter 4). The populations and other types of germplasm improved by CIMMYT are not intended for direct release to farmers, but rather as intermediate breeding material for development of hybrids and OPVs. CIMMYT maintains a firm policy that it does not release its own varieties. This is contrary to the widely held view that CIMMYT produces finished varieties to be delivered directly to farmers through national systems (Miguel and Morrise, 1994). CIMMYT's germplasm is made available to cooperators in national programmes in two ways: through the informal sharing of germplasm from either the pools or populations, and through the more formalized international maize testing programme, which includes International Progeny Testing Trials (IPTTs), Experimental Variety Trials (EVTs), and Elite Experimental Variety Trials (ELVTs).

Therefore, CIMMYT's networks with NARSs and other actors are quite critical in completing the technology design, development and distribution process. The priority and focus of CIMMYT's collaboration is to support breeding programmes in the public sector, thus, CIMMYT relies heavily on national public systems for its technology transfer. This is especially true in the case of China with its centrally controlled government, planned economy, and its dominant public research and extension systems.

CIMMYT's maize germplasm flows through an international system between CIMMYT and NARS. The whole technology development and transfer model followed by CIMMYT is a linear process as show in Figure 5-1.

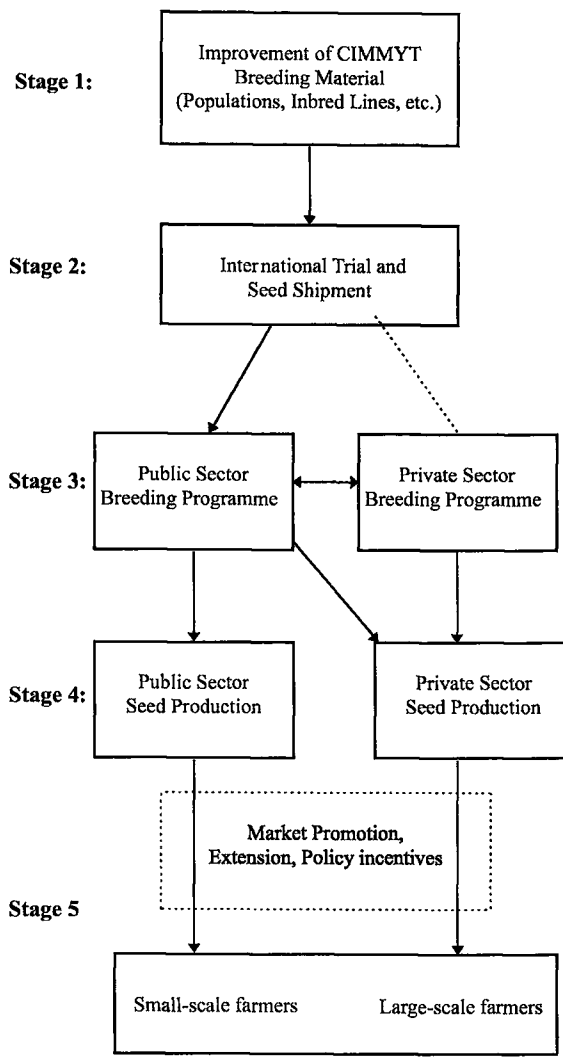

Figure 5-1. Flow of CIMMYT maize germplasm.

Source:Lopez and Morris, 1994

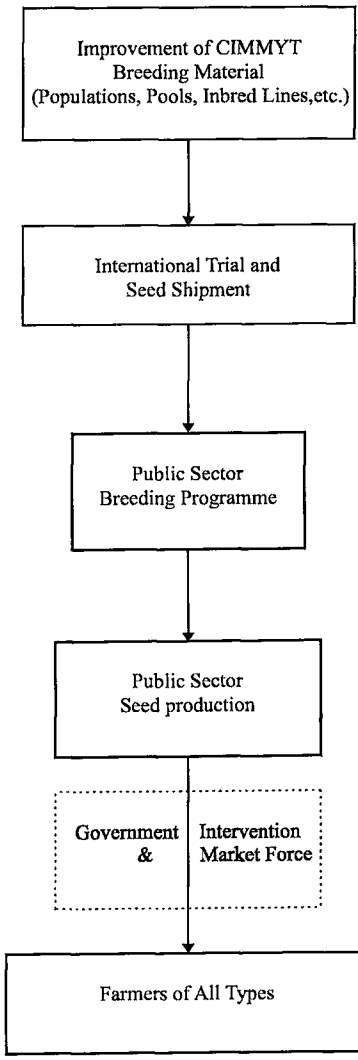

Figure 5-2. The situation in China

Source: Compiled by the author (1998)

The entire technology development and transfer process is roughly divided into five stages, with the first two stages operating at the international level and the later three stages at the national level. The flow system follows a top-down, linear technology transfer model with limited feedback and horizontal interaction. In the China case, the flow becomes even more linear, and centralised, and dominated by public sector agencies (cf. Figure 5-2), since as yet the private seed sector is needed, and in reality a direct offshoot of the public system.

5.3. China, its Agricultural Research and Extension System for Modern Varieties

5.3.1. The overall goal of the system

The public agricultural research and extension system for modern varieties was established in the end of 1950s and has actively functioned since the early 1960s, which is the most noteworthy change in government policy resulting from the 1959-1961 famine in China (Lin, 1998). The overall goal of the agricultural research and extension system is food security via national food self-sufficiency and it is assumed that the only way to achieve this is to increase productivity through technology application, i.e. modern varieties, mainly hybrids, in food crop production. Therefore, hybrid research and extension, mainly with the three main food crops; rice, wheat and maize, have been the first priority for the systems since the early 1960s. This hybrid approach has been embedded in the entire institutional structure and reward system of national agricultural research and extension.

5.3.2. Agricultural research system

One of the distinct characteristics of the Chinese agricultural research system is the dominance of public research. The network of the Chinese Academy of Agricultural Science (CAAS), and the national and provincial agricultural academies and institutes form the body of the system. The national academy has 35 research institutes and centres and each provincial academy consists of several institutes. Most prefectures and counties also founded research institutes at their levels (cf. Figure 5-3: Organizational system of CAAS). In addition, some agricultural research is also conducted by agricultural universities at national and provincial levels.

The system is directly controlled by the Chinese Ministry of Agriculture (MoA) in terms of administrative and research management, while it is also under the administration of State Science and Technology Commission (SSTC) for professional linkage. Thus, the system is under so-called double leadership (both under MoA and SSTC) at every governmental level (Figure 5-3). The agricultural research academies and institutes are funded by government budgets at their corresponding levels.

The division of labour and research priority setting among the four levels (national, provincial, prefecture, and county) of research institutes follows the hierarchy of the centrally controlled government bureaucratic system, i.e., each institute sets its own research agenda under the supervision of its corresponding level of government and institute at a higher level.

Private agricultural research is quite limited in China, although some private institutions have emerged and made impressive achievements, especially in the last ten years. The most outstanding example is Laizhou Academy of Agricultural Science (in Shangdong Province), a research institution founded and organized by farmers, which

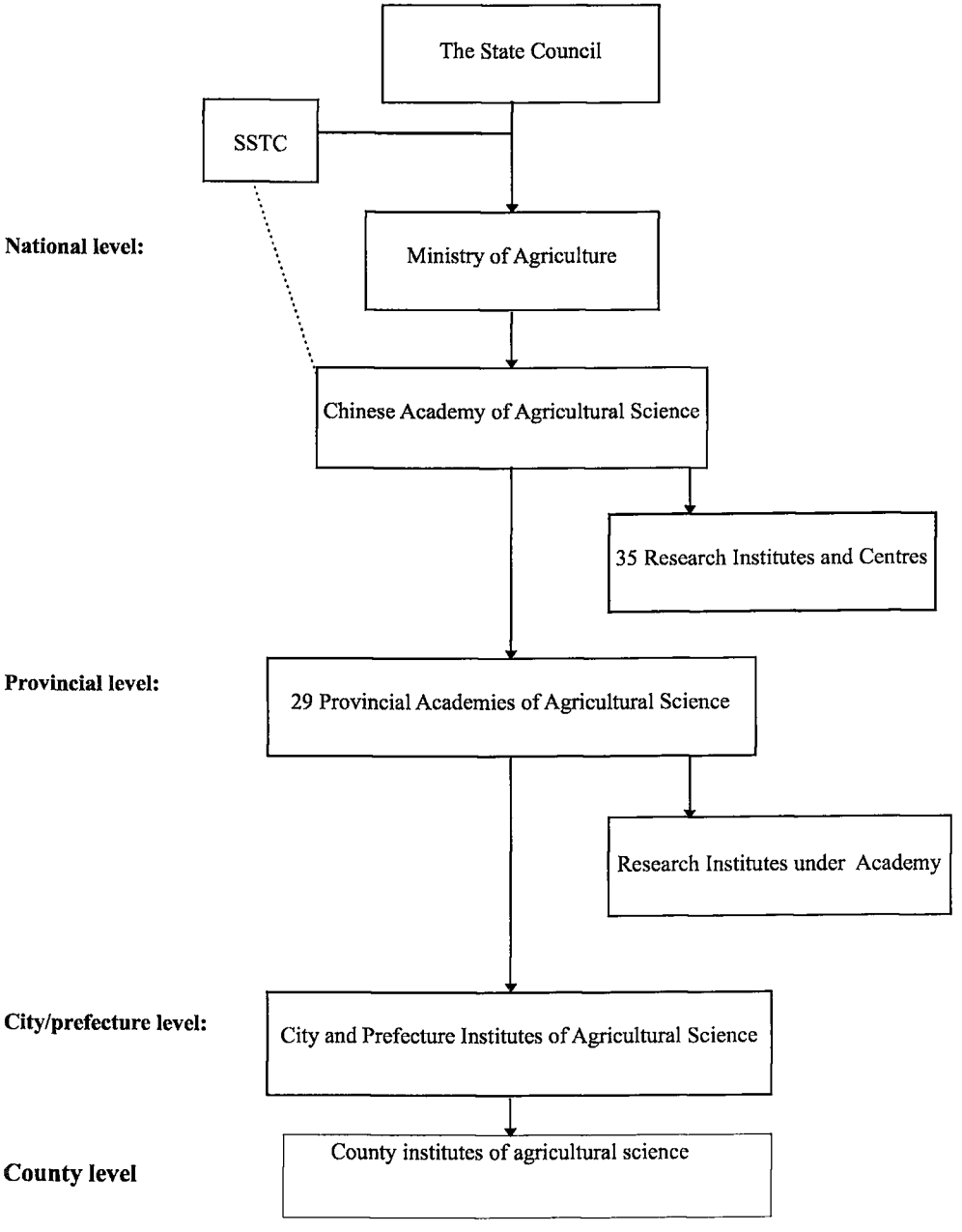

Figure 5-3: Organizational system of CAAS

Source: compiled by the author (1998)

has developed a series of improved maize varieties that have been widely adopted by farmers all over the country. It was estimated that Laizhou's maize varieties cover about 30% of the total maize growing area in China (Interview with staff members the CAAS, China, 1996. Further analysis of this case is limited by the time and scope of this study, it is hoped will be followed up in later work).

5.3.3. Agricultural extension and seed production systems

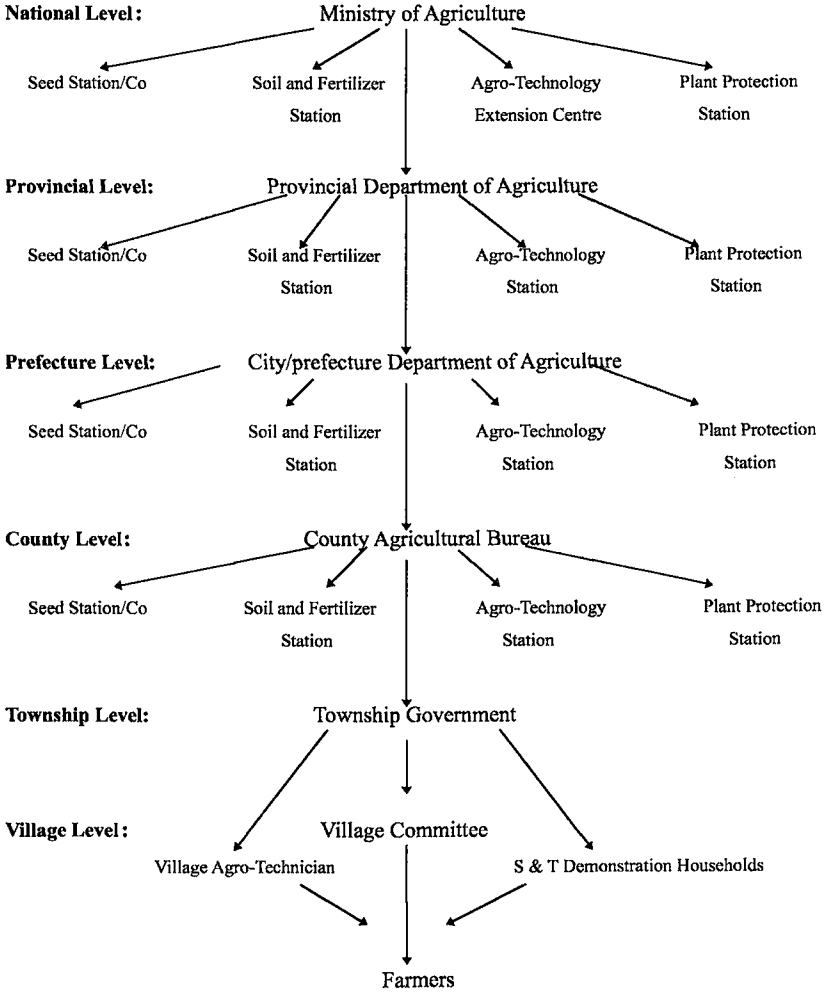

Figure 5-4: Agricultural Extension Agencies under MoA

Source: Author's field work 1995-97

Agricultural extension and public seed production in China are directly governed by MoA which serves as a governance mechanism for transfer and distribution of scientific technologies developed by the public research institutions. It operates and functions as part of the Chinese government administrative and bureaucratic system having different levels; i.e. the national, provincial, city/prefecture, county and township levels. Four professional agencies, specialised in seed, soil and fertilizer, agro-technology extension and plant protection, operate at each level. Their main tasks are transfer and extension of modern technologies, mainly MVs, focusing on the several government targets for food grain crops, cotton and oil, by means of bureaucratic intervention, such as quota for hybrid growing (each county and village has a fixed production quota set by the governments at corresponding levels) and control of agricultural input and output (cf. Figure 5-4).

5.3.4. Flow of CIMMYT's maize germplasm in China

CIMMYT's maize germplasm flow in China is different from that in most other countries because it goes totally through public systems (cf. Figures 5-1 and 5-2). This is the normal and regular way of modern technology development and transfer in China. The development and distribution of modern maize varieties, mainly hybrids, are conducted by three independent organizations, i.e., maize breeding institutes, seed station/ companies, and agro-technology extension stations, which belong to two separate systems, NARS and MoA (cf. Figure 5-5).

In China the regular way of maize technology development and transfer is as follows: maize breeders develop hybrids and improved varieties and sell seed of the parental inbred lines to public seed company/stations at prices fixed by government (about 10 yuan/kg). The hybrid seed production is carried out by farmers in villages, selected by the seed companies. In principle, seed farmers should sell all their harvested seed to seed companies; which distribute the seed to farmers through the MoA extension system. The fact that seed companies rely on farmer seed producers is evidence that greater decentralization might be possible.

5.3.5. Emerging changes and conflicts

Some institutional conflicts have emerged since the introduction of the market economy, especially after the reform in agricultural research funding policy in 1990. The government reduced its fiscal appropriation for agricultural research, shift funding from institutional supports to competitive grants, and encourage research institutes to commercialise their technologies, using part of the proceeds to subsidise their research (Lin, 1998). The agricultural research institutes have had to become more profit driven either through their research or other activities. Hybrid breeding and hybrid seed production have drawn more attention and effort than ever before. Some maize breeders complain that they develop hybrids which bring profit to seed companies only. Some breeding programmes are reluctant to sell hybrid parent seed to the seed companies and in some cases maize institutes carry out hybrid seed multiplication themselves although this is not officially allowed. As one leading breeder said to the author:

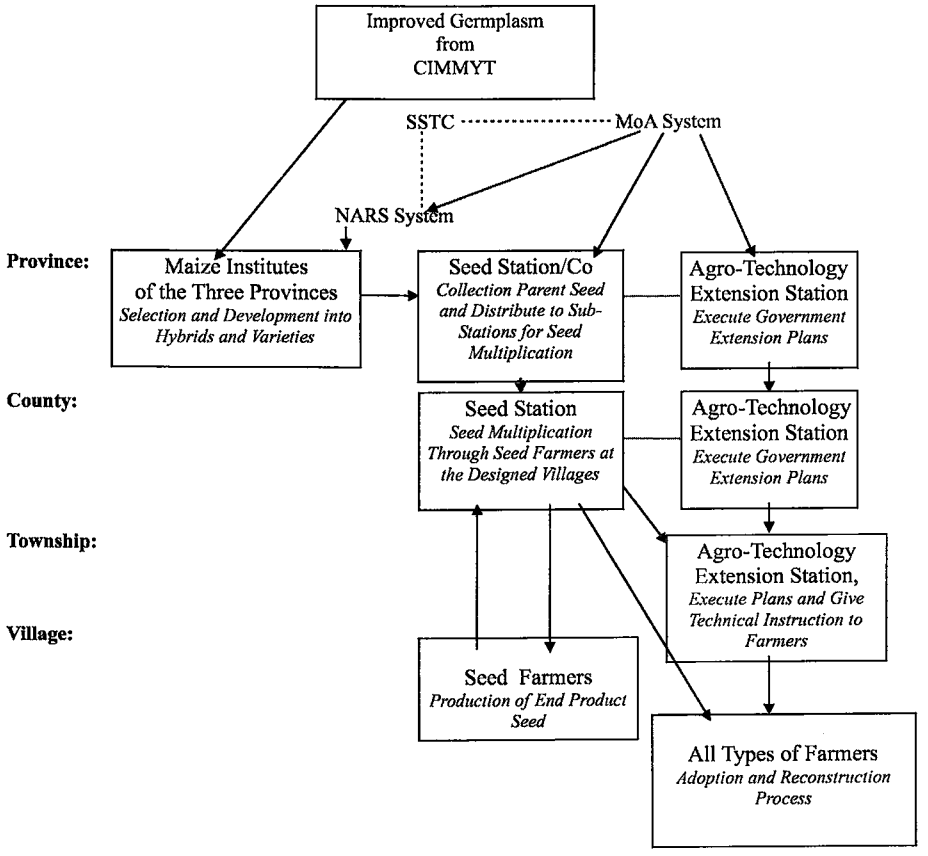

Figure 5-5: Flow of CIMMYT's germplasm in the three provinces

Source: Author's field work 1995-97

"we have to make money and try to support our research partially by ourselves now". This results in the overwhelming public sector efforts on several profitable hybrids and neglect of non-profitable OPVs needed by farmers in unfavourable marginal areas.

There are also some conflicts between seed company and extension agencies within the MoA system. As one extension agent said during this study:

> *"we used to do management and technical work in seed production, like selection of seed producing area, giving technical advice to seed farmers, etc. Now, owing to profit reasons, seed companies try to control the entire seed production and marketing process. However, poor management and lack of appropriate technical advice have resulted in poor quality hybrid seed ".*

The disorder in the formal public seed system, and the introduction of profit-driven competition, have negatively affected the powerless farmers, who are driven by two forces: governmental intervention and market competition. In the last several years some fake seed incidents have occurred and the victims are helpless farmers, who have seen an entire year's cultivation result in a substandard harvest. The reliability of good hybrid seed is often problematic and some farmers have shifted to OPVs, which are less risky in the sense that farmers can maintain seed for themselves (cf. Wuenteng Case in Chapter 4). The poor functioning of the public seed supply system and the underdevelopment of the private seed production sector result in the absence of effective seed supply.

5.4. Macro-level Impact of the Programme

5.4.1. Introduction

Owing to its overall mandate of poverty/hunger alleviation with a focus on the poor in the tropics and subtropics, CIMMYT's collaboration with China has been concentrated on maize production in the tropical and subtropical areas in South-western China. The cooperation initiated by CIMMYT in the latter half of the 1970s and the early 1980s formally started with a collaborative breeding program through the research system of CAAS. The Maize Research Institutes of the three South-western provinces, Guangxi, Yunan and Guizhou, are directly involved in this programme. CIMMYT's maize germplasm is transferred directly to the institutes for evaluation and improvement. So far, more than two thousands germplasm entries have been transferred to the three provinces. Some of them have been used in hybrid and OPV breeding by breeders, some are directly used by farmers. Others are reserved for different types of international testing or are maintained for future use.

The objective of this section is to assess the macro-level impact of the Programme through analysing the extent of and trends in maize breeding based on CIMMYT germplasm since 1980. First the section focuses on documenting the total number of MVs used, local releases and derivatives of CIMMYT materials. It then moves on to describe patterns in total releases and in releases of the derivatives of CIMMYT materials. After that a summary of the current use of CIMMYT's germplasm is presented. Finally the trends in maize breeding and the extent of the use of CIMMYT germplasm during the period under study are shown.

The data on variety releases are based on the results of a survey of breeders and information from other sources in the three provinces. As part of the study, all varieties released by the three provincial maize institutes since 1980, and the time they started to use CIMMYT germplasm in breeding, are listed. For each varieties, the following additional information was collected: pedigree, type of variety, breeding institution, morphological and agronomic characteristics (e.g., colour, yield etc.) and the period of usage and area planted. Data on area planted with each variety and types of variety in 1996 were also collected.

Data on MVs adoption and yield gain were collected from many sources at different levels. First the official statistical data of annual maize area, productivity, and production from 1970 to 1995 were collected to show trends in maize production and the relation among the three indicators. Then, relevant data on certain representative provinces, and counties were collected from seed companies and corresponding governments to show yield impact at various levels. Additional data on some trends in maize production with respect to trends in the release of the different types of variety in different periods of time were also collected. In total, the data collected provide comprehensive information on maize breeding with and without CIMMYT germplasm in the three provinces. However, owing to the limited time and scope of the present study only part of the data collected is used below.

5.4.2. Materials derived from CIMMYT germplasm, 1980 to 1995

Owing to the out-breeding nature of maize it is difficult to classify maize varieties using clear-cut genealogical criteria. Therefore the improved maize materials used and released in the three provinces are categorised into four workable and practical classes. Class 1 indicates materials from other areas within China outside of the three provinces, e.g., materials developed by CAAS and another provinces such as Zhongdan 1 and 2. This class normally does not directly contain CIMMYT germplasm. Class 2 indicates the local releases without CIMMYT materials. Class 3 are the local releases with CIMMYT germplasm; each normally containing 50% CIMMYT genetic material since CIMMYT germplasm is used as one parent line in the hybrid formation. The fourth class is improved populations from CIMMYT used directly by farmers.

General information on MVs release and patterns of release

From 1978 to 1995 more than 2000 entries of germplasm were shipped from CIMMYT to the three provinces. The seed shipments to Guangxi and Yunan started in 1977 and that to Guizhou in 1987.

Table 5-1. MVs of Maize used in the three provinces, 1980-1996

province	Total number of MV used	MVs from areas within China	Local without CIMMYT germplasm	Releases with CIMMYT germplasm	Directly used CIMMYT populations
Guangxi	22	3	4	12	3
Guizhou	25	2	3	12	8
Yunan	23	3	2	15	3
Total:	64(70-6)	8	9	39	8(14-6)*

* Among the 14 directly used CIMMYT populations, 6 are used at the same time in different provinces, so the actual numbers should be reduced by 6.

Source: Author's field work 1995-97

As shown in Table 5-1, a total of 64 improved maize varieties were used in the three provinces, which were distributed through Government systems during the period of 1980 to 1996. Among these 48 are local releases, including 39 entries with CIMMYT germplasm making up 81% of the total local releases. In addition 8 improved populations are directly used by farmers and three of them, *Tuxpeño 1, Tuxpeño P.B. C15, and Suwan 1*, are quite popular under the difficult farming conditions in the mountainous areas of the three provinces.

Types of releases derived from CIMMYT materials

In total 47 CIMMYT-related varieties are used in the three provinces, which makes up 73% of the total MVs used. The 47 CIMMYT-related materials consist of 31 hybrids, 8 OPVs and 8 directly used populations, comprising 66%, 17% and 17% of all CIMMYT-related MVs respectively(cf. table 5-2).

It is clear that CIMMYT germplasm is used more in hybrid breeding than as OPVs. Within the 39 CIMMYT-related releases, 31 are hybrids (80%) and 8 are OPVs comprising only 20% of all local releases containing CIMMYT materials.

Nevertheless, it is important to examine the types of hybrid released, which can further reveal the priority and focus of the breeders. Table 5-3 indicates that of the total CIMMYT-related hybrids, 9 were single-cross hybrid comprising 29%, and 10 three-ways cross comprising about 32%, the remaining 12 were conventional hybrids (here including varietal crosses, and top-cross), making up 39% (cf. Table 5-3).

Table 5-2. Releases derived from CIMMYT germplasm by type and region

Type of Release: / Region:	Releases with CIMMYT germplasm				Total MVs Used	CIMMYT related MVs by region (%)
	Hybrids	OPVs	Populations	Total		
Guangxi	11	1	3	15	19	79
Guizhou	10	2	8	20	25	80
Yunan	10	5	3	18	20	90
Total release	31	8	8*	47	64	73
CIMMYT MV by types (%)	66	17	17	100		

* See note 1 in table 5-1 .

Source: Author's field work 1995-1997

Data in table 5-3 indicate and imply that although the state's breeding priority and supervision has been on single cross hybrids, at the provincial level more research effort had been put in to conventional hybrids rather than single-cross F1 hybrids before 1990.

In the author's survey, all breeders interviewed in the three provinces stated that the more conventional hybrids, like varietal crosses, top-cross, three-way cross, adapted better to the natural and socio-economic environments in the three provinces than single-cross hybrids.

Table 5-3. Types and percentage of CIMMYT related hybrids 1980-1996

Release / Regions	Total Hybrids (No)	Single-cross (No)	Varietal crosses & Top-cross (No)	Three-ways cross (No)
Guangxi	11	2	7	2
Guizhou	10	5	1	4
Yunan	10	2	4	4
Total	31	9	12	10
Percentage(%)	100	29	39	32

Source: Author's field work 1995-1997

How is CIMMYT germplasm used?

From the above description and analysis it could be concluded that CIMMYT's germplasm is used in three major ways in the three provinces.

1. *Use of CIMMYT germplasm, mainly populations, for development of OPVs, varietal crosses, and top-cross*

The introduction and use of this type material in breeding has made a considerable contribution to maize production in the difficult maize farming systems. Further description and analysis are given in the subsequent sections of this chapter and chapter 6. The most frequently used CIMMYT germplasm in this category are *Tuxpeño 1 (pop21), Tuxpeño P.B. C15, Amarillo Dentado-2* and *Suwan 1* (came through Thailand). For example, from *Tuxpeño 1* and *Suwan 1,* Yunan province, has selected 6 improved populations. These locally released populations together with the directly used CIMMYT populations have been popular and dominant in the difficult maize farming systems in less favoured areas since 1980s. Meanwhile, 2 improved populations and 7 top-cross hybrids have been developed using *Amarillo Dentado-2, Tuxpeño 1*, and *Tuxpeño P.B.*

C15 crossing with local single-cross hybrids. These top-cross hybrids have been widely adopted in the relatively flat and favoured areas in Guangxi since 1983.

2. *Use of CIMMYT germplasm for development of inbred lines*

From CIMMYT germplasm 30 inbred lines have been selected and they have been widely used in hybrid breeding. About 70% of the hybrids released contain CIMMYT-related inbred lines. Some CIMMYT material shows very good combining ability with local materials. The most outstanding example is Amarillo Dentado which is frequently used for variety formation as well as for the development of inbred lines.

3. *Direct use of CIMMYT populations*

CIMMYT does not intend to make direct releases to farmers. Yet several populations like Tuxpeño 1, Tuxpeño P.B. C15, and Amarillo Dentado obtained originally as constituents for breeding, have made their way directly to farmer's fields and have disseminated rapidly through farmer-to-farmer seed exchange. This process started in the late 1970's in Guangxi and has spread to Yunan and Guizhou provinces. These populations have become dominant varieties in the less favoured areas with a low yield potential, comprising an acreage of 310,000 ha, about 15% of the total annual maize growing area in the three provinces. Some description and analysis of the local dissemination and maintenance of these varieties are given in chapters 4 and 6.

In short, CIMMYT germplasm plays a very dominant role in maize breeding and production in the three provinces. It was stated, in the author's survey, by one of the leading breeders that " almost all varieties; hybrids, OPVs and landraces, currently cultivated are to some degree genetically related to CIMMYT material (Yang Huaquan, 1995 in interview).

Trend in maize breeding by period of time

CIMMYT has continuously shipped germplasm to China since the end of the seventies until now; this coincides with the social and economic transition period in China. It is significant to study the trends in maize breeding and the use of CIMMYT's germplasm in the three provinces during this period.

CIMMYT's germplasm has been playing an increasingly dominant role in maize breeding (cf. Figs 5-6 and 5-7). From 1991-1995, all releases were based on CIMMYT germplasm. Yet, the trend shown in Figure 5-6 is worrisome: although the percentage of CIMMYT-related releases is increasing, the total number of releases has decreased considerably after 1985. The causes for this decrease in general could be attributed to the financial constraints resulting from the introduction of the market economy and the increasing commercialization of the public research and extension system. This is

especially true after 1990, when governmental investments in agricultural research started to shrink and the agricultural research institutions had to financially support themselves to certain degree (cf. sections: 1.3.1. and 5.3.2. in this book). In most cases the situation is just as described by a leading breeder via a Chinese saying that "we are now 'You Qian Yangbing, Wu Qian Dazhang' ", which means "we can just keep ourselves alive and don't have much money for research".

Number of varieties released:

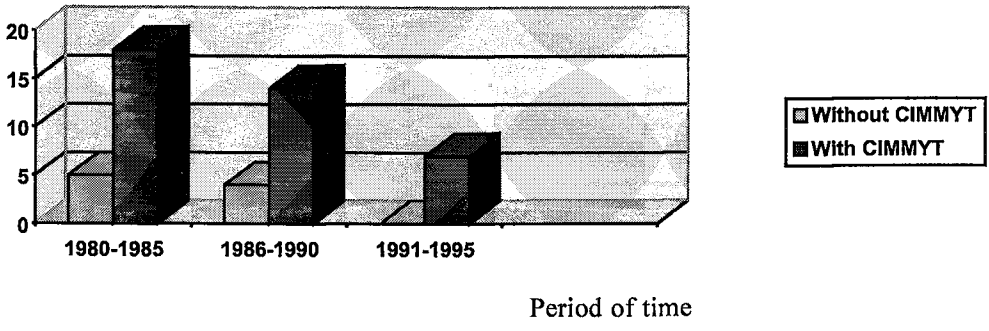

Figure 5-6:. Trend in breeding with CIMMYT germplasm in the three provinces 1980-95

Source: Author's field work 1995-97

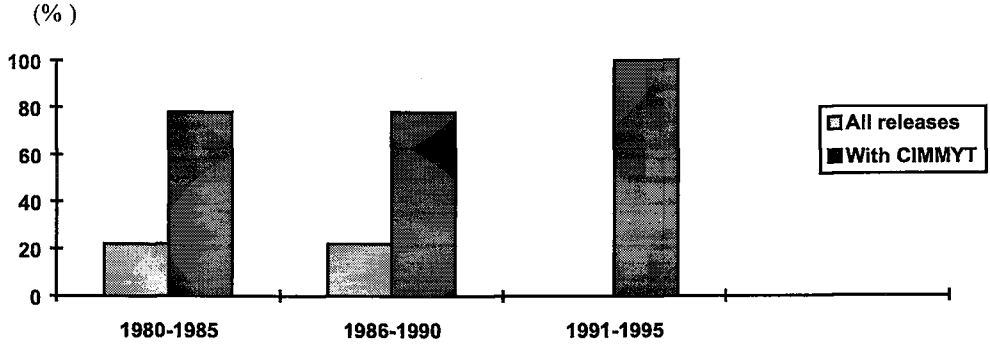

Figure 5-7: Releases with CIMMYT germplasm in the three provinces, 1980-95

Source: Author's field work 1995-97

5.4.3. General impact of the programme

This section first presents trends in maize production in the three provinces over the period from 1970 to 1995. Then, a more detailed analysis of the total adoption and adoption of CIMMYT-related MVs is presented to assess the impact of all the MVs in general and the impact of CIMMYT materials in particular. Types of MVs adopted are also studied by addressing the different needs and interests of farmers in relation to diverse natural, socio-economic environments.

Trend in maize production

In showing the trend in maize production, three values i.e., maize growing area, total production and yield per/ha, are used to indicate the macro level impact (See Figure 5-8).

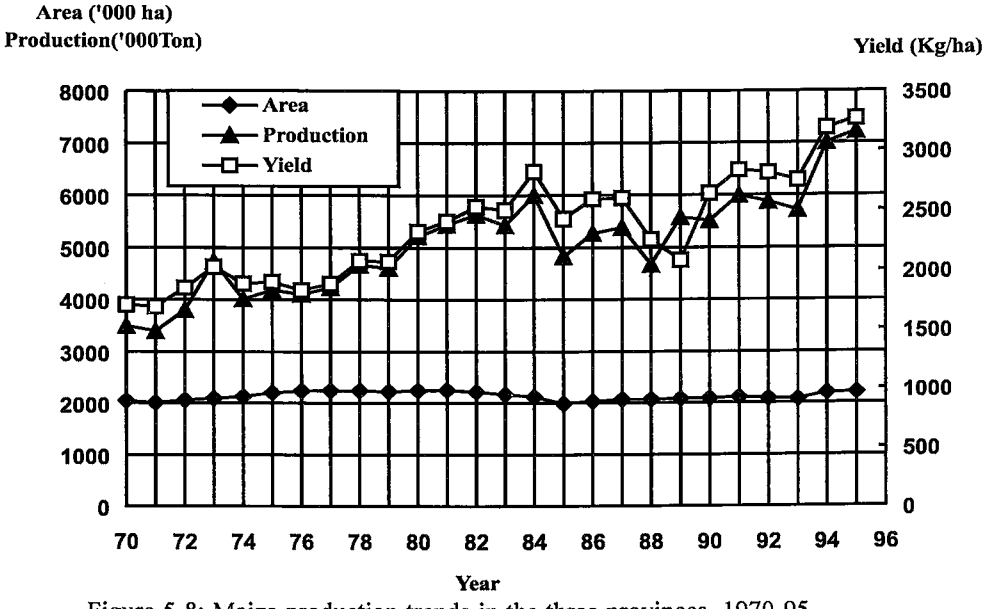

Figure 5-8: Maize production trends in the three provinces, 1970-95

Source: Compiled by the Author from Chinese Statistical Year Book 1970-95

Figure 5-8 shows a general trend of a continuous increase in average yield and production while the growing area remains, more or less, the same during the period from 1970 to 1995. The production line is almost parallel the yield/ha line which means that the yield increase resulted from the increase of productivity (rather than that of the area). The figure also shows that production and average yield increased significantly

in the period between 1978 and 1995. Although there are two years of low yields the trend is generally upwards. The introduction of CIMMYT's germplasm started from 1977 and the direct adoption of a few popular populations already began in 1978. Therefore the following annual incremental production can be attributed partially to the contribution of CIMMYT germplasm. Further analysis of the adoption rate of CIMMYT-related germplasm is necessary to assess the extent of CIMMYT's contribution.

Adoption of all MVs and CIMMYT related ones

Owing to the open pollinate character of maize and the limited official data are available it is very difficult to estimate the area under improved maize germplasm. Most of the data used result from cross-check of several sources, i.e., government statistic, data from seed companies, and data based on the author's surveys and interviews with leading plant breeders, leaders of seed companies, and senior workers for the extension services in the three provinces. The area covered by hybrids is estimated more from comparison and combination of seed sales data provided by the seed companies, government statistical data and data estimated by breeders in the Maize Research Institutes. However, estimates of the area covered by OPVs is even more difficult, since farmers can keep OPV seed from season to season. In order to get a more realistic estimate of the area sown to improved OPVs, the data are based on a cross-check of data from official statistical year books and data resulting from the survey and interviews with breeders, government officials and other professionals at different levels. The overall rate of adoption of improved germplasm is shown in table 5-4 below.

Table 5-4. Area planted to improved OPVs and hybrids in the three provinces, 1996

Province	Total maize area (000 ha)	Improved OPVs (%)	Hybrids (%)	All MVs (%)	MVs with CIMMYT germplasm (%)
Guangxi	545	12	34	46	97
Guizhou	605	14	55	69	75
Yunan	967	20	50	70	90
Total	2117	15.3	46	65	87.3

Source: Author's field work 1995-97

The overall record of adoption of improved maize is impressive. Table 5-4 shows that area covered by improved materials is about 65%, with 46% hybrids and 15.3% improved OPVs (the rest is landraces). The proportion of MVs derived from and directly using CIMMYT germplasm in 1996 was as high as 87.3% including improved OPVs and hybrids.

The adoption of improved varieties had a significant impact on maize production, especially in the first few years. CIMMYT populations directly adopted by farmers

yielded 25-35% more than their previous varieties in the first few years after introduction. Improved OPVs based on CIMMYT material also yielded about 25% more than local landraces previously used. For hybrids, most estimates suggest that they could yield 30-40% more than landraces in favoured areas under good farming conditions. Table 5-5 shows the trend in MVs adoption and use of maize in Guangxi from 1980 to 1995.

Table 5-5: Adoption area with different types of variety and utilisation of maize in Guangxi, 1980-1996

Item: / Year:	Total Maize ('000 ha)	Hybrids (%)	Improved OPVs (%)	Landraces (%)	Maize consumption	
					Food (%)	Feed (%)
1980	535200	10	5	85	90	10
1981	569133	13	17	70	90	10
1982	546466	4	16	80	90	10
1983	520733	3	19	78	90	10
1984	507400	7	21	72	90	10
1985	476066	11	21	68	90	10
1986	478000	9	26	65	85	15
1987	504666	13	25	62	85	15
1988	530866	26	25	49	85	15
1989	533333	30	31	39	85	15
1990	533333	35	32	33	80	20
1991	486133	32	25	43	80	20
1992	441933	43	30	27	80	20
1993	533333	36	23	41	75	25
1994	533333	35	15	50	75	25
1995	533333	35	14	51	75	25
1996	544666	34	12	54	75	25

Source: Guangxi Seed Company and Guangxi Maize Institute, collected during Author's field work 1995-97

5.4.4. Types of Adoption by production environments

It is important to note that the adoption patterns of varieties differs significantly by types of environments and farming systems. For example areas where hybrids have been

adopted extensively, are most irrigated environments favourable for maize, where most maize is grown for feed. The less favoured rainfed areas are mostly planted with improved OPVs and landraces, and maize is grown mainly for human consumption. Wuming and Duan are two counties in Guangxi where farmers grow much CIMMYT related materials. **Wuming** is a relatively flat and favoured area and **Duan** is a mountainous rainfed area. A comparison is done between the two production environments (See Figures 5-9, 5-10).

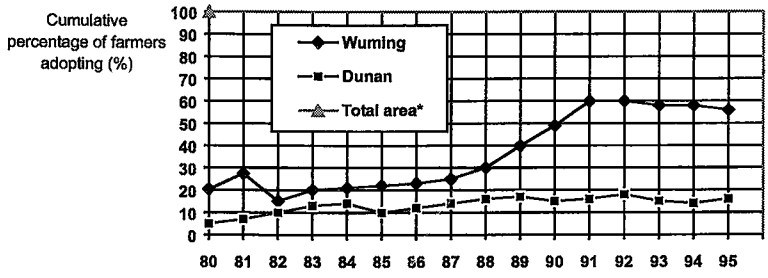

Figure 5-9: Adoption of hybrid maize in two counties, Wuming and Duan, 1980-1995

* Total area here means total maize growing area supposed as 100%

Source: Statistical data from the county governments, collected during the author's field work 1995-97

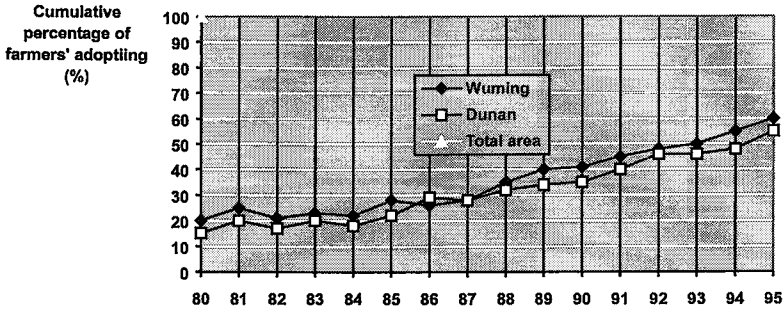

Figure 5-10: Adoption of improved OPVs and hybrids in two counties, Wuming and Duan

Source: Statistical data from the county governments, collected during the author's field work 1995-97

Figure 5-9 shows a striking difference in adoption of hybrids by farmers in Wuming and Duan, whereas Figure 5-10 indicates that the total adoption of MVs, including improved OPVs and hybrids, in the two counties have increased at an identical rate. In order to understand the trends and differences and to assess their impact at village and

farmer's household level, a comparative in-depth case study has been carried out by the author in the two counties. The results are presented in the next chapter.

5.5. Observations and Discussion

The general impact of the Programme is quite impressive in the three provinces. 80% of the MVs used are CIMMYT-related germplasm and 73% of the total local releases are based on CIMMYT germplasm. About 956,700 hectares are planted to the CIMMYT-related improved OPVs and hybrids annually (about 43% of the total maize area in the three provinces). Improved OPVs are adopted mainly by farmers in less favoured rainfed areas. The three popular CIMMYT varieties, *Tuxpeño 1, Tuxpeño P.B. C15* and *Suwan 1* have had an annual use of 310,000 hectares, comprising about 15% of the total maize area since the early 1980s. These improved populations have become dominant varieties in most of the less favoured areas with difficult maize farming systems. In the relatively favoured areas, Varietal crosses, top-cross and three-way cross hybrids are widely accepted and dominant, such as Guangxi Top-cross 1 to 5, which are conventional hybrids derived from CIMMYT germplasm. The total use of MVs has been growing in both favoured and less-favoured areas, although the types of materials adopted are different. There is little doubt that the wide adoption of the improved OPVs and hybrids have contributed significantly to the continuous increment in maize production and productivity in the last 15 years.

However, further observations revealed the different needs and interest of farmers in different environments and gaps in meeting these diverse needs and interests:

- It was noted in the field that the adoption pattern is obviously different between the relatively developed, favoured areas and the less-favoured poor areas. In the remote mountainous regions, the area planted to the improved materials containing CIMMYT germplasm is mainly under improved OPVs, which are CIMMYT's improved populations and OPVs derived from CIMMYT's germplasm. In the relatively flat and favoured regions, the area planted to CIMMYT-derived materials mainly consisted of hybrids, mainly conventional hybrids; varietal crosses, top-cross, and three-ways cross. Accordingly improved OPVs are appealing as an appropriate technology for farmers in the difficult maize farming systems, since farmers can save the seed from year to year. OPVs mean less input and less risk and more manageability for poor farmers. Conventional hybrids are more acceptable to farmers in the relatively favoured areas. However, it was noted that farmers in both favoured and less favoured areas have problems to get access to the appropriate varieties, services and supports from public systems, mainly owing to policy and institutional constraints.

- It was found that more locally-adapted materials, like varieties with stress resistance, e.g., drought tolerance, lodging resistance, are often not available for the harsh rocky

and mountainous environments. In these areas the major improved varieties are CIMMYT populations and locally improved populations, which have been continuously used for almost 20 years without replacement. They have degenerated greatly owing to inter-crossing. For example, *Tuxpeño 1* and *Tuxpeño B.P. C15* from CIMMYT have been widely adopted in mountainous areas in Guangxi since 1978. No public efforts have been made to replace or improve them. Some female farmers, however have tried to maintain and improve these varieties (cf. case of Wuenteng in Chapter 4). For the more favoured area, top-cross and three-way cross hybrids are suitable and widely accepted by farmers. However, as hybrids depend on the use of purchased input such as seed and fertilisers, farmers' adoption of hybrids has been conditioned strongly by government policies and institutional constraints with respect to seed supply, extension service, prices of input and output. It was noted that even in environmentally favoured areas farmers are increasingly shifting from hybrids to OPVs.

- Based on the author's observations and interviews with different actors of the Programme, the above mentioned problems and institutional constraints in meeting farmers' needs mainly resulted from two major causes. The first is the government's modern technology-oriented policy focusing breeding on F1 hybrids, which underlies the agricultural research and extension system and determine the reward criteria for the breeders and extensionists. The second major cause is the commercialisation of public institutions, which has caused the formal breeding increasingly to shift to profit-driven rather than user-responsive operations. These two causes have resulted in an increasing bias towards hybrids and neglect of OPVs development by the formal breeding programmes. This is especially true after 1990. It was noted that the public research and extension systems in the three provinces all focus on the development and distribution of hybrids rather than improved OPVs. For instance, all the 11 locally improved OPVs mentioned previously were released before 1990 and another example is that the seed companies in Guangxi have not produced any OPV seed after 1990.

- Feminisation of agriculture: It was observed that women are playing a predominant role in agriculture and food production in both rich and poor areas, which is the case in the three provinces and also in the whole country. In the developed and favoured areas about 85% of the farm managers are women with most of the males working in local rural industries. In the poor and remote mountainous areas women farmers constitute about 90% of the agricultural work force, since male farmers largely migrated to urban areas searching for new opportunities.

- What is the implication of the F1 hybrid policy and the resulting institutional environments for farmers in different natural and socio-economic contexts, especially for the poor and the women in inaccessible mountain areas? What is the implication of the Feminisation of agriculture for maize technology design and development in order to tackle food security at both national and farmers' household levels?

Based on the above observations and questions, an in-depth case study at village and farmer household levels was considered necessary to examine the micro-level impact of the Programme, with special respect to poor farmers and women. Based on the finding that environmental variation greatly influenced farmers' responses to MVs, and in order to assess the impact in different environments and find out farmers' differential needs and interests, two distinct areas were selected respectively from a relatively flat and favoured environment, and a remote mountainous rainfed environment, which can represent the two major maize farming systems in the Southwest. The comparative case study of the two areas is presented in the next chapter.

Chapter 6

Comparative Case Study of Two Distinct Environments and Relevant Gender Issues Emerging

6.1. Introduction

Based on the observations and findings presented in Chapter 5 this chapter deals with in-depth case studies of two different farming areas.

Heterogeneity and complexity of farmers' cultivating environments and their livelihoods are dominant features of small holder subsistence agriculture in the three provinces. A comparative and in-depth study of the indigenous farming systems and local livelihood is quite necessary to illustrate the different responses of and impact on farmers, and to reveal the reasons and causes of the differences.

China now is experiencing two transitions: from a central command economy to a market based economy and from a rural, agricultural society to an urban, industrial one. Major economic and social transformations are occurring which are changing the structure of agriculture and households, with differential effects in various environments. While industrialisation and urbanisation of the rural economy, and the diversification and specialisation of agriculture, are taking place in the favoured and developed areas, extreme poverty, food insecurity and malnutrition among women and children are occurring in the marginalized poor remote areas.

Under the two transitions, male out-migration from agriculture is occurring as a dominant phenomenon underlying the process of feminization of agriculture in the whole research area. Nevertheless, different types of migration have brought different changes in agricultural structure and local livelihood systems in different areas.

In the relatively favoured and developed areas, the majority of the rural surplus labour force has been absorbed by the development of local industries, i.e., a so-called internal community flow. In the resource poor and less developed areas, where rural industry is underdeveloped, rural migrants mainly become physical labour force in urban areas, i.e., an external community flow. In both cases, the majority of migrants are men rather than women (the causes and reasons are presented in chapter 2).

As stated by Jiggins (1986) "different types of male migration may result in different structural change in small holder agriculture, which has something to do with the specifics of the nature of technological and organizational innovations" So within the broad social framework of change, rural women's changing roles under the stress of the two Chinese transitions, in the context of different farming systems and technology choices necessarily became a main focus of the comparative case studies.

The information and analysis of this chapter is based on the qualitative field study (second period of the field work) in two counties at three different levels, county, village and farmers' household. The writer interacted with government officials at county and township levels and stayed with farmers at village and household levels for about 1 year

for participatory observation and evaluation. Most of the information has been collected by free chatting, direct observation, and semi-structured informal interview. It was inevitable that the majority of farmers encountered in the field work were women.

This chapter begins by focusing on Duan county, starting with a brief introduction to the area. Then, description and analysis move to village and household levels. The second section deals with the second case, Wuming county, following the same presentation format. After presentation of the two cases at three different levels, a cross-case comparative analysis is presented to show variations and causes for the different interests and needs of farmers in different natural environments and diverse socio-economic and cultural contexts. A brief conclusion ends the chapter.

Duan represents the poor, remote and rocky mountainous areas with difficult maize farming systems.

Wuming represents the relatively flat, irrigated and favoured areas with a diversified agriculture.

Figure 6-1: Location of the two case study areas in Guangxi province

6.2. Duan Case

6.2.1. County level: understanding the context

Duan County (23 N lst. 108 E long) is situated in the North-West part of Guangxi province, 160 km north of the capital Nanning. With a total area of 4810 km, and arable land of 35580 ha, it has a population of 616,000 and 90% of them dwell in the rural area. It is a designated Yao Minority County by the government because 23 % of the State's Yao minority people live here. The Yao population constitutes 20% of the county's total population and the remainder are mainly Zhuang, the biggest minority group in China, comprising 72%, and several smaller minority groups like Molao, Yi, etc. So in all the total minority population in this county totals 96% of its total population.

More than 90% of the rural population of 590,000 live in the poor rainfed mountainous area and most of them are minority peoples. The annual per capita income is about 250 Yuan (about $ 32), and average grain produced per person per year is about 150 kg. Both levels are far below the 1988 government-designated poverty line, i.e., 300 yuan of income and 200 kg of grain per capita per year. Half of Duan's rural population is in absolute poverty and it is one of the State-identified 28 extremely poor counties in China.

A difficult geographical environment and scarcity of arable land restrict agricultural development and are primarily responsible for the low income of the region. It has been considered by some foreign experts that this area is unsuitable for human habitation. However, in such 'unsuitable' living areas farmers have lived and cultivated for about 2000 years, since 300 BC during the Qing Dynasty. Their ways and style of living and farming have a close connection with maize cultivation. Maize has played a significant role in the sustainability and development of the local livelihood and farming system.

Physical Environment

Geography:

Duan county is typical of the limestone mountain area which covers a large part of South-Western China. 84.3% of its total area of 6,500 km is a limestone mountain region, with typical karst topographical features. The mountain slopes are steep, with the highest peak 1,000 m above sea level, with an average township elevation of 800 m. The toe slopes and sink holes between the karst rocky mountains have been cleared and are used for intensive agriculture, usually maize production. Access to many villages is by walking track only.

Soil and water:

Soils in the county are very poor and thin, the average top soil for cultivating is only about 15 cm. Some areas are extremely poor with little patches of soil in-between the

rocks. The soils used for agriculture on the low hills are typical of the soils in South-Western China, i.e., generally acid and low in phosphorous and organic matter. The soils on the mountain slopes and toe slopes are reported by the Duan Agriculture Bureau to range from mildly acid to mildly alkaline.

Water is a big problem in some extremely poor and remote mountain areas, where in the winter season, there is normally 2-3 months' scarcity period of drinking water.
Climate and vegetation:

Like most of the mountainous area in South-western China, the climate in Duan is influenced in winter by the cold northern land mass and in the summer by the monsoons from the south. This combination results in colder winter temperatures than would be expected for the latitude and proximity to the ocean. Occasional frost occurs but frost, in general, is not a hindrance to crop production. The summers are hot and humid, at times hail, accompanies the onset of the summer wet weather.

Well distributed rainfall with a summer peak is adequate combines with a warm summer and cool, but not so cold, winter to give growing conditions suitable for many tropical and sub-tropical plants. There is a diversity of wild species of plants and cultivated plants. For example, it is a place of origin for the local waxy maize and is rich in maize landraces (see Chapter 3). More than 100 local maize germplasm accessions have been collected from this county and kept in the gene bank for maize breeding at the provincial Maize Institute.

A selection of climatic indicators is shown in table 6-1.

Table 6-1: Climate data for Duan County

month / item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug.	Sep	Oct.	Nov.	Dec.	Annual
Mean monthly max. temp (C)	16	17	21	25	29	31	33	32	32	28	23	19	26
Mean monthly min. temp. (C)	10	11	15	19	22	24	25	25	24	20	16	12	19
Mean monthly rainfall (mm)	36	44	70	129	254	368	258	295	109	78	49	44	1734
Mean monthly evaporation	87	78	90	118	161	165	188	180	194	169	121	93	1644
Frost free days per month	30.3	27.8	31	30	31	30	31	31	30	31	30	30.6	363.7
Mean monthly rel. humidity (%)	69	74	78	79	78	79	79	80	72	68	67	69	74

Source: Information from the Duan Meteorological Station for the period 1954-1992

Socio-economic contexts

Government Structure:

Administratively, Duan is divided into 22 townships and 247 administrative villages. Townships are divided into administrative villages with each administrative village responsible for several natural villages. Each level of government, county, township and administrative village, has an administrative structure headed by a chief administrator and a party Secretary. At Administrative Village level a village committee and a village leader are responsible for village matters.

Land Tenure:

The 1978 rural reform brought an end to the communal collective-based production system and started the Household Responsibility System. A farming household is a contract unit for allotting land. Land allocation is according to the number of family members. The head of the household, traditionally the husband, is the household member to whom the allotted land is officially registered. It was stated in 1978 by the state government that farmers have the land use right of several years, a period that was too short for farmers to do any long-term investment in their lands. In response to this concern the government subsequently extended the period of land use right to 30 years, then 50 years. However the land right still belongs to the state.

Women, as family members, nominally have equal access to land as men. Nevertheless, some issues of gender equity with respect to land access have emerged. For example, there is no official law or state policy for land reallocation, which is a crucial issue for women who married after the land reform, and for their children. In some areas there exist local policies for land reallocation; however, implementation is difficult and problematic. It was found during the field work that in most cases women who married after 1980 have had problems with their legal right to land.

In many parts of the county, mountain land, too, has been allocated to households. This land is held by agreement with the village and township authorities and can be allocated and reallocated relatively freely. The mountains close to villages are often allocated for fuel wood collection, etc.

Migration

Male out-migration and agricultural feminization became important features of the agricultural economy in Duan after the late-1978 reform, especially since the introduction of the market economy in the 1980s.

Duan, as an absolutely poor county, has an underdeveloped local economy and rural industry. So the large rural labour force has migrated to urban areas searching for new

opportunities. Male migration is locally considered as the most efficient route to poverty alleviation by farmers as well as by the government. Male farmers constitute by far the majority migrants, about 80%. Their remittances have become the major income for their families in the rural areas. Meanwhile, women, who are left behind, are taking care of the family and playing an increasingly dominant role in agriculture.

It is not surprising that of all the farmer households interviewed by the author in this county, about 90% were women headed.[1] Women are playing key roles in maize production, seed selection and variety improvement. They also make efforts to maintain local varieties for the multiple needs of production and usage in their diverse and specific local contexts.

Photo 6-1: Woman farmer in difficult maize farming system

Agriculture and the role of maize

The main food crops in Duan are maize, rice, sweet potato and soybean. Maize is the most important staple food crop with an annual average growing area of 34000 ha. Comparatively, the areas of rice and soybean are much smaller, only about 4000 ha and 6700 ha respectively.

[1] The registered head of the household is still the husband, who, however, works in urban areas and non-agricultural sector. It is the wife who manage the farm and the household.

The cultivated area of sweet potato is about 12,000 ha per year. Maize is normally intercropped with sweet potato and soybean. Two seasons of maize planting are possible, although the second season planting is modest in terms of yield and growing area because of autumn drought.

Local agricultural production is not sufficient to support the population. There is about 20% to 30% of food insufficiency every year on average in the county. In some poor areas the insufficiency is as high as 50% of the requirement.

Maize plays a predominant role in the subsistence food production and it is a traditional crop and staple food for the rural people. 95% of the maize harvested is for human consumption. The maize planting area is more than 80% of the total cultivated land. In some poorer areas maize is the only food crop, covering about 98% of the arable land in such areas. In these areas, people eat maize porridge every meal, some times mixed with sweet potato. As one old woman put it "maize is our life, we grow maize, eat maize and live on maize for generations" (interviewed in Gushang township 1995).

Adoption of CIMMYT-derived maize technologies

CIMMYT-derived varieties adopted in this county are mainly two types: improved population and hybrids. *Tuxpeño 1*, and top cross hybrids; *Nanning top-cross* and *Nanning yellow top-cross.* The two top-cross hybrids were respectively released by the breeders in Duan county and another mountainous county, Tiandeng. Their adoption is quite limited comprising only 5-7% of the total maize growing area. The improved population, *Tuxpeño 1* is a direct release of CIMMYT. At its initial adoption in 1980, it had its highest yield of 5153 kg/ha in this county, about 2000 kg higher than the previously used local varieties in the first year. Then it spreads rapidly among farmers and became quite popular. It is now the dominant variety in the difficult farming systems with an annual coverage of 24,000-27,000 ha, comprising about 70-80% of the total maize growing area in the county.

The wide spread of *Tuxpeño* 1 in Duan was accompanied by the disappearance of indigenous maize varieties. Said one of the agricultural officers interviewed (Zhang Fuli, 1995):

> *"There used to be about 35 maize varieties cultivated by farmers in this county , some were landraces, some were locally improved OPVs but none of them yielded much. Since the introduction of CIMMYT's population variety, Tuxpeño 1 in 1980, most of these former varieties have been gradually replaced. Only a few local varieties are maintained in small areas for specific production conditions and special domestic usage".*

Situation conversation 1: Government official's role conflict

❑ It was a cold winter evening when the author and two county officials and an extensionist on their way back from a field trip to a rocky mountainous village, in an old Beijing Jeep,

with a strong wind blowing outside and the jeep bumping along the rough mountain road, when the silence in the Jeep was broken by "Why do farmers like *Tuxpeño 1* so much and hybrids not at all"? Zhang (Director of the agricultural Bureau in the county) said: "because farmers are too poor to buy inputs like fertilizer and seed. Thus under their low input conditions *Tuxpeño 1* yields better than landraces and as well as hybrids in this mountain area". "Not only yield" the extensionist continued, "*Tuxpeño 1* has a strong resistance to drought and lodging, which are quite important issues for the rocky mountain maize farming system". Then, "why is not more public effort put in *Tuxpeño 1* and other OPVs needed by farmers?" asked the writer. "This is a complex issue" said the extensionist "as government officials we have to serve government. Hybrid is government's target and our task is to extend it. Besides, OPVs are not as profitable as hybrids for us. Now we have to consider our own survival, although we know farmers need good OPVs rather than hybrids in this mountainous area." ❑

6.2.2. Village level: women in difficult maize farming systems

Village Case 1. Zhichen Village (Duan county)

Geographical environment and basic infrastructure

Zhichen village is located 23 km north-east of the county government seat. It lies in the midst of rocky mountains rising to 600 to 800m above sea level. The motor road from the county seat to the township was built in 1987 but access to the village is by walking tracks only. Drinking water is a big problem, especially in the winter dry season. The main source of drinking water is rain water collected in protected ponds owned by one or shared by several households. Access to markets is quite limited, with only a few small grocery shops around the government township. The farmers have to go to the county seat for most of their agricultural inputs and daily necessities. There is no financial institution at township and village levels and there is almost no possibility for farmers to get credit from the formal financial system.

Its social infrastructure is quite limited, too. The public commune medical network collapsed after the end of the commune system. Villagers have to go to the county seat for medical care. The main transport between the village and county seat for local villagers is a kind of small auto with only three wheels, which is not a safe means of transport for the rough steep mountain road. Several accidents have happened in recent years.

So far there is no electricity or telephone connection to the village and its neighbourhood. TV and other electricity-powered possessions are just impossible, so each village is a kind of remote and isolated place, with people dwelling in different mountain valleys.

There are five primary schools, although in very poor condition, in the villages situated in the main resident valleys. One woman farmer's statement, which generally presents the local villagers' view is as follows: "we all know study is the only way to

change our fate and reach the outside world, so we are trying to send kids to schools and kids are studying very hard too".

Most of the houses are built with wood, bamboo, grass and leaf walls and a tile roof. Some houses are grass or leaf roofed and their residents are normally Yao people, who are considered as the poorer group in the village. Houses in the village normally have two storeys, an upper storey for people and lower storey for animals and storage. The upper storey living place is divided into 2 major parts, a front and a back, with several small sub-divisions separated by bamboo and soft wood panels. The middle of the front part serves as living room while the rooms at both sides of the living room are the men's bed rooms. The back part is used for the kitchen, storing room and women's bed rooms. Normally there is no window, or just a very small one, to avoid the cold and strong wind blowing in the mountainous area in winter.

Table 6-2: Trends of land, grain production, and income in Zhichen village, 1984-1995
Socio-economic and cultural context

Year	Population	Arable land (mu)*	Total production (kg)	Per capita grain (kg)	Per capita income (yuan)*
1984	2236	2345	274067	122	120
1985	2200	2303	265637	120	132
1986	2197	2300	248500	113	145
1987	2234	2268	304000	136	140
1988	2283	2247	300015	131	158
1989	2301	2211	328680	142	150
1990	2208	2202	290194	131	152
1991	2200	2206	270210	122	158
1992	2190	2204	264000	138	154
1993	2196	2200	260000	118	189
1994	2145	2150	226000	105	302
1995	2146	2100	292000	136	413

* mu: 1 ha=15 mu

** Yuan: 1 US dollar=about 8.1 Yuan (exchange rate of 1997)

Source: Author's field work 1995-95, compiled from Statistical Year Books of Zhichen village

Zhichen village has a population of about 2000 people and arable land of about 140 ha. The annual average per-capita income is less than 166 Yuan (about $ 20) and the

per capita grain produced is less than 150 kg. It is an absolute poor village and a target of poverty alleviation in the county.

All the inhabitants are minority peoples, with 60% Zhuang 30% Yao and 10% Molao. Zhuang is the dominant group. The other two smaller minority groups are locally considered as poorer and inferior groups. For example it is no problem for a Zhuang man to marry a Yao and Molao woman, whereas it is not locally accepted if a Yao man marries a Zhuang women. So gradually Yao and Molao minority groups have become smaller and smaller. Now some Yao and Molao farmers are not willing to let others know their true peoples.

However, the Zhuang culture here has been largely affected by, or imitated from, Yao culture. For example the house style are quite like the Yao. This is probably because the Yao are the original mountainous inhabitants, therefore their style of living and culture are more sustainable in this rocky mountain area. So the dominant 'Zhuang culture' in the village is, more or less, Yao in origin.

The villagers give strong respect to their ancestors and every household has a family pedigree according to the patrilineal line and places an altar in the living room. Normally, farm households are composed according to the clan. The head of a clan is a male local authority in charge of important matters like birth, marriage and death, etc. of the whole clan. Household activities traditionally are controlled and dominated by the husband. Now, most men have migrated out, virtually the majority of households are headed by women, who are playing key roles in farming activities and domestic work. However, even under such circumstances, men still maintain a patriarchal authority in the family. It was observed that when government officials visit a household, if the husband is at home he must be the one to present the household. In most cases the husband does not know very much about farming and has to consult his wife. Women do not have an inherited right to household property and a remarried woman cannot bring any property with her. The traditional Chinese family kinship ideology, which is patriarchal, and patrilineal, dominates the local culture.

Male out-migration and feminization of agriculture

There is registered labour force of 1,100 people in the village and 620 of them migrated out. Among the out migrants, 88% are men and the rest are young women (cf. table 6-3).

The migration from Zhichen village can be considered as a typical external community flow[1], most of the farmers have migrated to urban areas, which are several hundred miles away within the province or one or two thousands miles away in the booming coastal cities, like Shenzhen or Shanghai. They come home once or twice a year for holiday only. The

[1] The migration out of agriculture normally is divided into two major types; external community flow and internal community flow. The former means migrating to urban sector or other rural areas, whereas the later means working in non-agricultural sectors within local community.

migrants can be roughly divided into two types. The first type includes those unmarried young men and young women who are searching for new opportunities for personal development in the outside world. The second includes the married, middle-aged men whose main purpose is earning money in order to support their family at home. Their remittances are the main source of income for the rural household. As one farmer told me: *"you can tell from a household standard of living whether it has a family member at work in urban area or not. The poorer households are normally those which have no family member at work in the city."*

As a result of the migration most people left in the village are old people, kids, the sick and women. It is women who are taking care of the family, old people, kids and the sick as well as the farm, which supplies subsistence food for the family.

Table 6-3: Changes of Labour force in Zhichen village, 1985-95

Year	Total Labour	Female labour	Agricultural labour	Emigrant labour
1985	1020	470	1008	12
1986	1054	478	1030	24
1987	897	437	893	4
1988	903	490	810	93
1989	1040	458	802	238
1990	1023	460	703	320
1991	1132	478	580	552
1992	1293	489	554	739
1993	1339*	601	630	709
1994	1265	448	479	786
1995	1292	648	576	716

*. The original note: including over-aged and under-aged labour force; 55 and 45 respectively.
Source: Compiled by the author from Statistical Year Books of Zhichen Village

Women's role in difficult maize farming system

More than 90% of the household are women headed and women are playing crucial roles in subsistence food production and food security at household level.

Maize production here is a kind of self-provisioning food farming managed and cultivated by women in a very difficult environment. In addition, all the post harvest

activities, like maize processing, storing and preparing of food are all done by women within the household using traditional domestic technologies.

The village has about 140 ha of mountain land all planted to maize. Maize is the traditional staple crop and the only grain food crop. Farmers eat maize porridge every meal and depend on maize for their survival.

The average yield of maize is still quite low, about 2200 kg/ha. Although the average yield did increase about 35% in the first several years after introduction of *Tuxpeño 1*, the increase could not be maintained without variety renewal and improvement. The low productivity is primarily due to the extremely tough and risky environment and the lack of appropriate technologies for such a difficult environment. Rugged limestone mountains cover more than 90 percent of the total area. Women farmers have to plant maize in minute pockets of soil among rocks on steep mountain slopes and in little patches of soil in between the rocks in the few fields at the bottom of sink holes. Most of the land is too steep to be ploughed with oxen by women. The hoe, and a type of shovel, are the normal tools used by the women in preparing land.

Water is a serious problem since it drains away quickly in the calcareous rocks on mountain slopes. However, rain quite easily causes flooding on the fields at the bottom of sink holes. Furthermore, women farmers' access to production resources and institutional services is quite limited owing to the geographical difficulties and isolation and their poor socio-economic and cultural status. So the maize farming system here is a kind of low input and low output subsistence food production, operating under difficult rainfed conditions. It is not surprising that the local produce is not sufficient for even bare subsistence and there is shortage during two to three months every year. The government usually provides some relief food during every shortage season. However, it is hardly enough to meet the basic food need. Most farmers have to buy maize in the free market.

Normally each household keeps one ox, one or two pigs, several goats and a flock of chickens. To my surprise the ox is not used for ploughing but to pull a big stone mill to crush maize. It is a common scene in the village that each household has one big stone mill kept below stairs. Sometimes one can see an ox with a blindfold walking slowly and mechanically around the big stone mill with a woman standing by to feed maize into the mill, which is the local way to process maize into flour.

The pigs are normally slaughtered during the Spring Festival (the most important traditional festival in China), and most of the pork is salted and kept for household consumption throughout the year. Goats and chickens and eggs are partially for family consumption and partially go to the free market for pocket money.

After harvesting, the indigenous ways to store maize and prepare as food are: first, the maize kernel is mixed with slaked lime to protect it from insects and then kept in

wooden box big enough to store the entire annual consumption. Every two or three weeks a certain amount of maize is taken out, and washed, then crushed into flour. Maize porridge is cooked by shaking maize flour into boiling water in a big pot bit by bit using a small bamboo basket, meanwhile the cook has to keep turning the water inside the pot all the time to make the flour mix perfectly with water (cf. Photo 6-2).

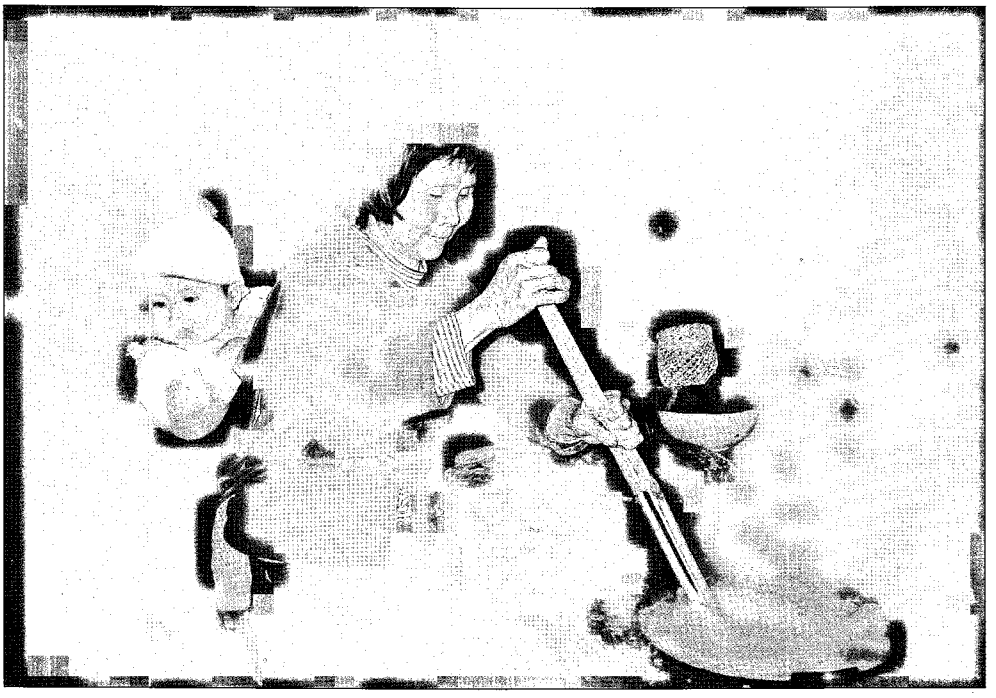

Photo 6-2: Cooking maize porridge in a rural home in Duan

Women farmers' motivation to produce maize

There is no doubt that household food security is of primary concern to all the women farmers in the village. Therefore yield and relevant characteristics to insure yield gain, like lodging resistance, drought tolerance, etc., have become critical criteria for variety selection. Food quality, processing and other characteristics are also important criteria for selection. This explains why all farmers grow at least two maize varieties each season. Some low yielding landraces are maintained in small plots for quality food and for some specific processing and production characteristics.

Women farmers' response to recommended varieties and their efforts to maintain preferred varieties

Over the past 15 years there has been continual release of government-recommended varieties and technologies, such as hybrid maize and plastic mulching package. Some of these had been tried by the farmers on a small scale but then abandoned. Only a few have been adopted on a large scale for any length of time. All of the adopted varieties are improved OPVs and most of them were locally improved at county level, such as *Duan white 1*, *Duan 2* etc. The maize varieties cultivated currently in the village are improved OPVs, *Tuxpeño 1* and three landraces. *Tuxpeño 1* covered about 90% of the maize land and the landraces in the remaining 10%.

Rejection of recommended hybrids

Owing to the central policy's hybrid bias, the township extension service has tried to extend hybrids to the village. Some government subsidies were given for hybrid adoption, such as providing free seed, free plastic sheeting for mulch, and sometimes fertiliser at lower prices. But few farmers have adopted hybrids for a long term. As one women farmer said: "I have tried one hybrid variety in my vegetable garden; in the first year its yield was almost the same as the OPVs. But in the second year its yield was much lower with the seed I maintained from the previous harvest. In this way there is no point for us to grow hybrid at all. Hybrid is for rich areas. It can not survive the hardship here."

Diffusion of Tuxpeño 1 (pop21) and emerging problems

Tuxpeño 1 was introduced to the village through informal channels. The starting seeds were brought by a women farmer from her relatives in another area in 1984. In the first two years, only a few farmers adopted it and on a small scale. With its characteristics of high yield, drought-tolerance and lodging resistance, it adapted quite well to conditions in this village. In the first several years it yielded about 4000 kg/ha, about 35% higher than the previously used local varieties. Therefore, it has diffused automatically among farmers, disseminating mainly through neighbours and relatives. More and more farmer liked it, adopted it, and meanwhile, dropped some formerly used local varieties. *Tuxpeño 1* became the most popular and dominant variety used in this area and covers now most of the growing area.

However, after being continually used for several years, inter-crossing became a serious problem leading to the degeneration of *Tuxpeño 1*, as well as that of the local varieties, in yield and other characteristics which are crucial in this area. The degeneration of *Tuxpeño 1* resulted in lower yields, the current yield is only 2400 kg/ha. The plants became rather tall and also lost their lodging resistance and drought tolerance to a certain degree.

There is a great need and requirement by the farmers for renewal and improvement of *Tuxpeño 1*. However, so far not much government attention and effort has been put on it. Farmers still use *Tuxpeño 1* in this area owing to the lack of better and more appropriate varieties.

Maintenance of local varieties

There are three main local varieties maintained by women in the village for diverse production conditions and specific domestic usage. They are *Local sticky 1*, *Duan 1* and *Local white.*

Local sticky is a sticky waxy variety. It is taken as a special quality food for festivals. Almost every household maintains a small plot of Local Sticky 1 in its vegetable garden or back yard, despite its low yield.

Duan 1 is an OPVs locally improved by the county Extension Station in the early' 60s. Its yield is not high; however it has strong resistance to drought. Some farmers grow it as a second crop. Normally the weather gets very dry during second cropping season and other maize varieties can hardly survive the autumn drought in this area.

Local White is maintained by some farmers because of its sweet stalks, preferred by kids as a kind of sugarcane.

The methods to maintain these varieties used by women farmers are mainly two, spatial separation and seed selection. They normally grow these local varieties in isolated vegetable gardens or grow them in separated valleys. Then they select the best cobs and seeds from their harvests according to the size of cob and quality of the kernel.

Maize or cash crop?

There are several government poverty alleviation projects in the village and most are successful and widely accepted by farmers, like the bio-gas project, drinking water project, etc. However, a fruit tree project elicited quite different responses from women farmers and men farmers.

Based on the idea that fruit trees are more profitable than maize and suitable for growing in the mountainous areas, the county government started a pomelo tree project in 1993 in the village and encouraged farmers to shift from maize cultivation to fruit trees. The project provided free saplings and fertilizer to the growers and promised that each household would get 2250 kg of subsidised food grain per ha for the first five years before harvesting the first fruit. Most of the households have been involved in the project and planted a certain number of pomelo trees in the midst of their maize fields, although the number of trees planted varies considerably among households. Farmers' different

responses to and perceptions of the project are presented by household level analysis and some further findings and analysis is given in the last section of this chapter.

6.2.3. Household level; sharing farmers' livelihoods

Household case 1 Household headed by a woman

Profile of the household

Family members

Wife: Ms. Lang Lijuan, 52 years old, who is the actual head of the household and considered as an able woman in the village, although she is not the formal head to whom the allotted land is registered.

Husband: Shi Yuanlou, 56 years old, is a house decorator who has worked in a city about 400 miles away since 1980. However, he has not yet got citizenship in the city. So nominally he is still the head of the household to whom the allotted land is registered. He visits home three or four times a year during the traditionally important festivals.

Son: 21 years old; works together with his father in the city and comes home one or two times a year

Grandmother: mother of the husband; 83 years old.

Three daughters; two are married and live with their husbands in other nearby villages. They visit home once every three or two months. The younger daughter works in restaurant in Shenzhen, a economically booming city 1,500 miles away. She seldom comes home because the transport is too expensive.

House; the house is newly built with wooden walls and a tiled roof, it is one of the best houses in the village. The furniture and decoration in the house also show that its owner has a better life in the neighbourhood. It is a surprise that there is a black and white TV set in the living room (powered by storage battery rather than electricity). It is the only TV in the neighbourhood and attracts some kids and villagers in evening, although the picture is not clear at all.

Land, crop and livestock

The household has 0.87 ha land, one ox, three pigs and a flock of chicken. The land is all planted to maize, half of the maize is intercropted with soybean and sweet potato, the rest is intercropped with 200 pomelo trees, as a result of the poverty alleviation project in 1993.

Household income and food

This is a better off household in the village. The main source of income is the husband's remittance, which mainly goes to big expenditures like house building, children's weddings and some fixed household expenditures, whereas the household food supply is dependent on the maize cultivated by the wife.

Lian Lijuan's promotion of maize production and her perception of the varieties:

> *"I have grown maize for about 40 years and the main purpose before and now is for food. We can not depend on maize for extra income, however; we have to rely on maize for our everyday food. I have grown Tuxpeño 1 since 1984 and it covers almost all my maize land now. I like it and consider it more like our own local varieties rather than an exotic, because it adapted quite well to our difficult conditions. It had a strong resistance to lodging and drought and needed no extra input but yielded better. Although it has degenerated greatly after the first several years, however, there is still no more appropriate varieties to replace it. Besides Tuxpeño 1, only a small amount of sticky maize is planted in the vegetable garden. It is a traditional local landrace that has very low yield. However it has very good quality. We use it to make a kind of special maize cake during festivals". "Why don't you adopt Duan 1, a drought resistant variety, as some other farmers do for the second season planting?" "Because I only grow one season maize, which is enough for the family's food. Besides, it makes me very busy and tired to cultivate 13 mu (0.87 ha) of maize as well as being responsible for all the activities of everyday life in the household all by myself." "How do you deal with the time and labour problem?" "As most of the women who live in one natural village are relatives, we try to help each other in busy seasons but in most cases I have to deal with the problems by my own efforts".*

Situation conversation 2: Conflict over food crops and cash crops between women and men

❑ One evening after dinner Lian Li Juan, the author, and Lian Li Juan's husband, who was visiting home for several day when the three of us were sitting around the fire place chatting about the local farming, the husband said: "I told her thousands time to give up maize and grow some pomelo trees, which are much more profitable, but she just doesn't listen to me". "I have to grow maize for food for the household. In response to the government's call I have grown pomelo trees in half of my maize land already but I didn't get any of the subsidies of food grain promised" said the wife. The husband then said "But I told you I would give you money to buy food before the fruit trees grow up". The wife replied: "But when I need to buy food and some other daily things for the household it's

not always easy to get money from you. You can plan for the future but I have to consider the present everyday livelihood of the household". ❑

Household case 2. Women-headed and single adult household.

The first impression of the household is the house, which is dark and damp and with a few leaks in the roof. The woman is a widow. Her husband died 5 years ago in an accident at a village coal mine (which normally have poor working conditions), 400 miles away from home. She has three kids, aged 12, 10 and 8 years respectively and they all attend school.

There are 8 mu (0.53 ha) of land, two pigs and several chickens in the household. When asked about farming the woman said:

> *"I have to grow two seasons maize to get more maize for the household food and also feed the pigs that will be sold in the market, to get money to support my kids' schooling. I have to work very hard all the year round to keep the family going. I didn't grow any pomelo trees as I have to grow maize to feed my kids. I use three varieties: Tuxpeño 1 plant in the first season, Duan 1 for the second dry season and local sticky maize which is just grown in the vegetable garden for quality food and the green fruits needed by my kids. I like them all because they have different characteristics and can meet my different needs".*

Household Case 3: A male-headed household

Husband: Wei Binsheng, 36 years old, who has high school education and is the deputy village head.

Wife: 32 years old middle school graduate

Two kids: a boy and a girl aged 8 and 6 respectively

Old man: grandfather of the husband, 82 years old

This is one of the few household headed by a man. One day the husband said with regret to me: *"I would rather go to work in the urban sector if I were in good health. Now I have to stay here suffering poverty"* Owing to his sickness and his work as village head actually the majority of agricultural activities are done by his wife, who has to take care also of the two kids and the grandfather. The wife is quite a strong woman cultivating 10 mu (0.67 ha) maize while keeping three pigs and a big and well-stocked vegetable garden (which is very difficult in such a water deficit mountain village). Meanwhile she takes care of 260 pomelo trees intercropped with maize Even the husband confessed: *"my wife is really taking care of everything in the household."* However, based on my observation while staying in their

house even about one week, household decision making is still dominated by the husband, especially with regard to important matters. For example the household's response to the pomelo project was decided by the husband, as illustrated by this narration by the husband:

> *"Government really tries to help us to get rid of poverty; however, the implementation and management of the poverty alleviation project is problematic. The pomelo project started as hopeful and promising; however, it, too, turned out to be problematic. The government called on all households to plant pomelo trees in the maize fields and promised to provide subsidised grain to guarantee the farmers' food security. As head of the village I had to set an example for other farmers so I have grown 260 pomelo trees and covered all my maize land, although my wife didn't agree with it. I am the only one who fully met the requirement of the project by growing pomelo in all my maize lands. Most farmers only planted half of their lands with pomelo trees. To my disappointment, after the trees have grown, there has been almost no government concern and attention to the project any more owing to some bureaucratic reasons. It turns out that there was no food subsidy and no technical support from the government at all. I had to buy maize from the market for the family's consumption. Some farmers laughed at me saying I was too naive to believe others. Those trees have an increasing influence on maize while they are growing. I am wondering whether I should totally shift to the fruit trees by stopping maize or not. Owing to a lack of fruit tree technology, I don't know what those trees could bring me. My wife keeps complaining to me and insists that the family has to eat. But I want to try to learn some technologies for the pomelo tree by myself. Once I know something about pomelo trees I can also teach other farmers here."*

6.2.4. Findings and Analysis

1. Women's significant roles in self-provisioning food farming systems

The case studies strongly suggest that the male out-migration has led to substantial changes in farming structure and patterns of obligation. Women are playing key roles in subsistence agriculture and household welfare.

As a result agriculture is reverting to less intensified farming. For example, the second planting of maize and some traditional intercropping practices have been abandoned and most households only plant maize for subsistence food. So actually agriculture has become a kind of self-provisioning food farming, a common phenomenon in most of the poor areas in the Southwest. This is mainly because of labour constraint, poor technology and lack of institutional support.

Women, usually household managers, have now become also farm managers and the major cultivators as well. They are playing a crucial role in food self provisioning to

ensure household food security and family welfare in the poor areas. It is women who are taking care of the whole family left behind by the male out-migration and playing a key role in household food security through their intensive participation in the "4 Ps"--the production, processing, preservation and preparation of food (FAO, 1977).

Much evidence documented in the case studies suggest that women and men, shaped by their traditional roles, have quite different interests in and concerns for family livelihood. Women are more concerned about the everyday welfare and food security of the family and put their primary emphasis on subsistence food production. Men, who are more easily influenced by market considerations and a willingness to accept new things, are more interested in future plans and the development of the household. The example of the pomelo project indicates that women's main idea is to ensure self provision of food. This partially draws on their experience, that household food security can neither fully rely on government's promises nor on husband's remittances; both are considered as unsure and unstable by women. The cases, and other evidence, seem to suggest that women, as a vulnerable and at risk group, especially those in the poor areas, rely more on own efforts for household food security than their husbands.

There are also differences between better off and poorer households. The latter are overrepresented by women headed-single adult households. Women in this type of household are trying their best to feed their family and keep life going. The household case 2 shows us a vivid picture of how a poor woman is struggling in poverty to support a family of three kids. Women in such households are greatly over-loaded with farming activities and domestic work and normally malnourished. The allocation of food, and other resources within the household still follows the traditional male bias favouring adult men and boys first, who are considered as breadwinners and the future and continuity of the family, then old people, then girls, finally the mother. Adult women are always the last, with least access to food.

2. Women farmers' constraints and how they deal with them

Women are playing a key role in subsistence food production in difficult maize farming systems. However, they are playing the role in the face of a lot of constraints, which they are trying to overcome by their own efforts through local networking.

Labour and Time; The big production constraints observed during the case studies were labour and time, especially at peak periods like planting and harvesting. Normally poor people have poor access to all other resources except time and labour. However, owing to their multiple roles and their natural characteristics women are overburdened by agricultural production, domestic works and reproduction, so labour and time become women's big constraining factors in production. The ways chosen by women to solve this problem are normally two; first, the most common way to deal with the problem is either to extend their own working time or to gain the help of their school daughters; both options definitely

sacrifice the interests of women in terms of health and education. The second way is through cooperation and exchange of labour among households and relatives.

Lack of appropriate equipment and farming tools; these were the second most important problem for women farmers. Owing to their physical nature women have difficulties to carry out the activities usually done by men without appropriate equipment and tools. For example, the transportation of fertilizer used to be done with the aid of a small walking tractor by men; now women have to carry the fertilizer on their back or shoulder. Another example is the plough. As women are not physically strong enough to plough with ox as the men used to do, they have to prepare the land with a hoe and shovel, which is more time consuming and labour intensive.

Lack of appropriate science-based technology and information also is a very important constraint for women farmers in maize production. For example *Tuxpeño 1* was considered as an appropriate variety by farmers; however, after it degenerated and lost its favoured characteristics, no other appropriate varieties were available for renewal. Women in remote mountainous area have limited access to science-based technology and information and their ways to deal with the problems are mainly based on their indigenous knowledge, which is gained and passed on while working together with other women or visiting relatives in other villages or through the informal knowledge and information system. For example to deal with the biggest maize production constraints, lodging and drought, they try to select cobs from a strong stalk which has a strong root systems. The ears are kept for seed. More seeds are planted in one planting hole to ensure at least one seedling survives drought. Different planting times are also used to avoid the usual drought season. In sum, farmers' indigenous ways of coping with their difficult and heterogeneous cultivating environments and conditions are complex and multifaceted.

Limited contact with agricultural extension: the lack of science-based technology and information partially results from women farmers' limited contacts with extensionists, and their limited opportunities for training. Women's access to public services is quite limited. Most of the women interviewed did not attend any training courses given by the township extension agency and a majority of them do not have any direct contact with nor receive any services from government agriculturists and extensionists. It is a common scene that when government officials and extensionists come to visit, it is the husband or elder son or even grandfather who comes to talk with them rather than the women, the key cultivators. This is mainly because of the low social and cultural status of women caused by the traditional patrilineal system.

A lower level of education and lack of access to external information also has resulted in illiteracy and a lower education level for women than men. Among the households interviewed in Zhichen village, almost all women have attained a lower education level than their husbands. The higher the age group of the women the lower the education levels they have attained. Living in the remote isolated area without TV, radio and news

papers, women farmers' main source of outside information was migrant relatives and neighbours visiting home from urban areas.

3. Gap between government intervention and women farmers' needs

Government targets focusing on maize hybrids and high yielding varieties are not appropriate to the local natural environment and not sufficient to meet the women farmers' multiple needs of different cultivating conditions and post-harvest characteristics. For example the absolute poor farmers need a type of OPV with strong drought resistance for second season planting. Women farmers need a flint maize rather than dent maize to make it more easy for milling using their domestic technologies.

Furthermore the image of the farmer still is male for the majority of government professionals. Under the influence of traditional patrilineal ideas, extensionists tend to work with men rather than women and with better off farmers rather than poorer ones. As one women from a absolute poor household complained "those government officials and extensionists seldom come to my house, because I am a poor widow".

Poverty alleviation projects normally lack a specific concern and respect for poor women's needs and their specific socio-economic contexts in the project design and implementation process. These are main factors that have led to failure of many projects. For example, the failure of Guangxi provincial governments' goat project is caused by insufficient investigation and consideration of farmers' livelihood and the local farming systems. As one woman said: *" I cannot keep many goats because they are eating the maize if they are kept in the mountain lands, but I can't keep them inside as I don't have enough feed for them"*. The example of the Pomelo tree project also suggests that relevant institutional support for basic food subsidy, technological advice and marketing are necessary for the success of poverty alleviation projects.

4. Women farmers' indigenous knowledge and expertise in maize selection and variety maintenance

Women like to try seed selection methods and experiment. It has been noticed that women have detailed, complex indigenous knowledge of seeds (Jiggins, 1986; Quisumbing, Brown et al; 1995). In my case study, when asked about who normally does seed selection, almost all the respondents, both by male and female, answered ***women.*** Seed selection and also variety testing have become a women's domain in large part.

The nature of women and their multiple roles determine their specific preferences and complex needs in production and post harvest characteristics for variety selection. To meet their complex and multiple needs, women farmers always try to select and maintain different varieties with different characteristics. It is found in the case study that with regard to selection criteria, men pay much more attention to yield, while women have much wider interest in other

characteristics. For example, all the three local varieties and landraces are maintained by women rather than men. When asked to rank the varieties used, lots of women answered "It's difficult, as each one has its own characteristics and advantage and can meet different needs. That's why I grow them all" (see chapter 7 for the relevant data in the quantitative study).

Besides women are curious enough to try unknown plants and special varieties, which are good for genetic collection and conservation. Home gardens, in my case study vegetable gardens, normally serve as conservation sites for special or preferred varieties and as testing grounds for new varieties or practices, (see Jiggins, 1986; for similar findings elsewhere). Women farmers grow the local sticky maize, their favoured variety, in the vegetable garden to avoid outcrossing. They also test most new varieties in the vegetable garden for easy observation and care.

The main source of new technology and information are neighbours and relatives. Technology diffuses mainly through their own informal network, i.e., in communication and visits among relatives and neighbours. The rapid dissemination of *Tuxpeño 1* among farmers is a typical example.

Some evidence in the case study suggested that women farmers whose husbands are away grow more varieties and become more experimental than before. Several reasons could be responsible for this. Women's access to decision making in agriculture may be the most important one to release women's potential in plant breeding and seed selection.

In sum, women farmers' significant role and potential in plant breeding and variety selection contributes significantly to food production as well as genetic conservation and biodiversity.

5. Impact and problem

Yield impact: the adoption of hybrids is quite limited and the two CIMMYT-related hybrids, *Guangxi top-cross and Nanning top-cross,* adopted in this county have very modest yield as well. The main yield impact comes from wide adoption of *Tuxpeño 1*, which brought about a great increment in maize production in the first several adoption years. This remains quite significant help to the poor in securing their basic food need. However, its degeneration and neglect by public research has greatly diminished its yield impact in the recent years.

Impact on women: Women's different roles and their specific constraints, which are not those which affect men, decide an innovation's differential impact on women and men (Jiggins, 1986).

The wide adoption of *Tuxpeño 1* and the impact on the poor has direct impact on women, who are overrepresented among the poor. Women-headed households and women

themselves directly benefited from the yield increase. Although the food quality of *Tuxpeño 1* is not as good as local varieties, quality is not first priority for the poor women-headed households.

The indirect effects mediated through women's positions within the household and society can be attributed to the patrilineal ideology and patriarchal clan system within the household and community, and the government's hybrid bias, and gender bias policies in research and extension. These forces have generated tremendous constraints for women farmers to benefit from the new technologies, who are playing new roles assigned by socio-economic changes as well as their traditional roles assigned by patriarchy. Under such circumstances the MVs tend to increase women's already high labour burden, e.g. transportation of input in the difficult mountainous areas, without necessarily increase their gains. Some women are in poor health mainly resulting from heavy labour burden and malnutrition, this is especially the case with the women in the single adult women-headed households.

6.3. Wuming Case

6.3.1. County level: understanding the contexts

Wuming county is situated in the centre of Guangxi province and is one of the two suburban counties of the province's capital, Nanning. It is about 30 km Southwest of Nanning. It has a total area of 3500 km, with a population of 632,962. About 85% live in the rural area. 80% of them are 'Zhuang' people, the biggest minority in China.

Wuming is one of the most densely populated counties in Guangxi province, with an average population density of 181/km. The average household size is 4.08. The annual population growth rate is 4.57% and the economic growth rate is 9.2% (statistic of 1994). As mentioned above, Wuming is located at the centre of the province and, as a suburb of the province's capital, it has good access to transportation, communications and markets.

Owing to its natural endowment, geographical location and socio-economic and historical factors, Wuming is a relatively favoured and developed area in the South-west. The rural average per capita income in 1995 was 1600 yuan (about $ 200) per year, which is much higher than that of poor counties like Duan (250 yuan).

Physical environment

Geography and vegetation:

Wuming county is a relatively flat and favoured area, which is representative of a considerable part of the three provinces. Within the county, rice and vegetables can be

found grown in small plains and flat areas, while maize and fruit trees can be seen in the hilly areas. The vegetation patterns closely reflects the geomorphology of the area. The most important formations are evergreen seasonal forests and derived secondary forests, which prevail in the hills and mountain foothills.

Soil and water:

Soil in this area is relatively fertile and most of the flat arable land is under irrigation.

Climate:

The county has a sub-tropical climate, with a average mean temperature of 25° C in July and 10° C. in January. The annual average precipitation is about 1500 mm, ranging between 750 and 1500 mm, 85% of the rain falls between May and October.

Socio-economic context

Government structure

Administratively, Wuming county is under the jurisdiction of Nanning City. It is one of the two suburban counties supporting the capital, Nanning. There are 16 townships, 213 administrative villages and 123,306 farm households in the county. As mentioned above the county government is an important intersection or key link in the total government system, especially in the agriculture sector. The Agricultural Bureau plays an important role in rural planning, policy making, implementation and transmission.

Land tenure

Under the central policy of land reform in 1978 the present situation of land tenure is almost the same as that of Duan. It has the same problems of land reallocation which mainly affect women's legal access to land. However, the problems and conflicts are more obvious and severe in Wuming than in Duan mainly because of the scarcity of arable land and intensification of agriculture in this county.

Agriculture and the emerging changes

Wuming has total area of arable land of 55,956 (statistic of 1995) ha including 25,449 ha. of irrigated paddy fields and 30,507 ha. of dry upland (including compound gardens), with a rural population of 548,816 consisting of 123,306 farm households. The average farmer household size is 4.45 people. The average land per person is rather small and since 1980 it has been decreasing. Now it is only about 0.087 ha. It is a typical intensive farming area in South-western China (see Table 6-4).

Table 6-4: Population and land in Wuming county, 1980-1994

	1980	1985	1990	1992	1994
Land (ha)	55878	55326	53549	55057	55317
Population	531238	578553	608688	625099	632962
Land/population (ha/person)	0.10	0.095	0.087	0.088	0.087

Source: Compiled by the author from Wuming Statistical Year Books.

There are mainly three types of land, i.e., dry upland, paddy fields and compound gardens. With easy access to water, the most important staple food crop is rice and maize is the second most important grain crop. Vegetables and sugarcane are important cash crops and fruit trees like banana, orange and water melon become more and more important.

Table 6-5:-Sown area of rice and maize in Wuming county, 1980-1994

Year	Rice	Maize	Total grain*	Total arable land
1980	30293	12822	43115	55878
1985	43344	13025	56369	55326
1890	42758	13313	56071	53549
1992	40869	14550	55419	55057
1994	39586	15207	54793	55317

* Total grain: rice and maize area and both crops are grown two seasons per year

Source: Compiled by the author from Wuming Statistical Year Books

Since the rural reform in the late 1970s and the introduction of the market economy in 1980s, the rural economy and agriculture have been experiencing rapid industrialisation, diversification and specialisation. A series of economic and social transformations are occurring, which have led to significant changes in farming system, household formation and patterns of obligations.

Township and village enterprise, male migration and feminization of agriculture

Rural industry in this area has developed quite rapidly in the last two decades. Every township has several enterprises and most of the villages have their own local industries, too. In total there are 336 township and village enterprises in the county.

The majority of male farmers have become wage labourers in local industries at different levels. It was estimated during my study by local officials that more than 75% of workers in rural industries are men. Women are less 'competitive' in labour transfer or migration from agriculture owing to their inferior socio-economic and cultural status. The migration from agriculture more or less follows social norms, based on patriarchal kinship ideology, such that men migrate before women, and closer family members before less close ones, husband before wife, son before daughter and even daughter-in-law before daughter. This is a typical patrilineal mode of resource allocation within the family either in allocation of the basic needs of life or in distribution of opportunity. In addition, women's reproductive role and domestic work have further constrained married women's opportunities to work away from home. So most of the women who work in rural industries are unmarried young women.

Agriculture has largely become married women's work. About 90% of the households interviewed in this county were headed by women.

The changing farming systems since the reform

In the commune period farmers cultivated collectively. All the decisions about farming activities were made by the leaders of production teams instead of farmer households and farmers themselves. Those leaders made decisions mainly based on the orders, plans and quotas which came from the government above and little consideration was given to the need of farmers themselves. As the government's predominant priority has been food security, food production was the number one task. As Mao emphasised " food production is the principle and base for all other development...." Tremendous attention had been given to staple food crop like rice and maize in this case and agriculture only means food production to a certain degree.

After the rural reform in 1978 farmers began to cultivate as individual households and have increasing freedom in decision making about their own farm. Food grain crops with comparatively lower profit are not the principal and only target of agricultural production anymore. Most farmers' motivation in food production is just self sufficiency; after that they begin to search for market profit from other agricultural produce. Some rice fields have shifted to cash crops like vegetables and banana. It is estimated by local officials that the rice growing area has decreased about 25% in the last ten years. Meanwhile the second important food crop, maize, gradually has become a feed crop in line with the rapid development of household hog enterprises in the county.

Especially in the last decade agriculture in this area has been diversified and specialized tremendously. Many farmers are beginning to specialise and some small scale specialised farms or specialized households have emerged (e.g. households specialized in hog raising, fruit tree growing, etc). As women are the dominant labour force in agriculture, most of these specialized households are headed by women.

It is not surprising that there is a growing demand by farmers of more varied agricultural technologies and knowledge not only in production but also in farm management and product marketing to cope with the changed situation. However, institutionally and technologically it is difficult for public research and extension, which has long been focused only on food grain crops and limited to production technology, to meet the new needs of farmers. As some farmers complained *"we urgently need some techniques and knowledge for our cash crops. However, all that can be provided by extensionists are hybrid rice and maize, in which we don't have much interest now."*

It was found in the fieldwork that some farmers are struggling to adapt to the new situation through their own efforts by organising themselves and co-operating with formal scientists. For instance, some farmers in Wuming county have organized themselves to open a free market in water melons in order to protect themselves against exploitation by private business men and some government institutions. It has become a well managed and quite successful farmers' organisation now. Another case in Taiping township is provided by a group of farmers who intended to start an orchard. Lacking scientific techniques in horticulture, they tried to contact and invite some relevant scientists from the provincial Academy of Agriculture Sciences to provide field consultation and advice. After working together for a period of time, the farmers and scientists set up a long-term co-operative and participatory programme, including training, field testing and also management of the input and output market. When asked about the initiative one farmer said "It's difficult for those scientists to know us and our problems but we can just try to contact them directly and invite them to our fields". The above cases have shown us the urgent need and potential of farmers, and also strongly suggests the necessity and possibility of collaboration between farmers and formal scientists through a participatory process.

Changing role of maize and maize technology

Maize used to be a traditional food crop and the second most important staple. However, in the last ten years maize is mainly used for feed, especially for pigs. In the last five years, the maize planting area has increased about 10-20% and even some paddy rice fields have been shifted to maize cultivation. This is mainly because of the considerable rise in the maize price in the free market due to the growing demand for pork by the urban population. Hog raising has become an important sideline income for most the farmer households. Some specialised hog raising households headed by women have emerged at the same time.

The current maize varieties used are mainly top cross hybrids, which are *Guangxi top cross 1 and 3* developed by Guangxi Maize Institute from CIMMYT materials, in production since 1986. The hybrid growing area is about 80% and the rest is planted to OPVs including *Tuxpeño 1*, with a current coverage of 13%, and several local varieties. Its interesting to find out that in the last seven to eight years more and more farmers have

shifted from the hybrids to *Tuxpeño 1*. Several reasons are responsible for this, but, the major factors are the low quality of hybrid seed and the changed role of maize as feed.

The campaign to extend F1 hybrid with plastic mulching

Single-cross hybrids with plastic mulching technique has been considered a way to increase maize production, and this package has been recommended and extended by government in the last five years by means of bureaucratic interventions such as propaganda, subsidies, quotas etc. The author attended a field demonstration of the hybrid and plastic mulching technique on January 24th, 1996 in Pinggou county, Guangxi province. This was a provincial level meeting with 126 participants, all of whom were agricultural policy-makers at different government levels. For example, the participants included the deputy director general of MoA in Guangxi province, the director general of the General Extension Station in Guangxi and the heads of 37 maize growing counties in the province. The remainder were mainly heads of agricultural bureaus and chief extensionists at county and township levels. The meeting started with a speech by the deputy director general of the province:

> *"There are still 6 million rural people who live in absolute poverty in our province and all of them are living in maize-growing areas, which are mainly remote mountainous areas. So we can say that maize means poverty and poverty is represented by maize in our province. The most efficient way to alleviate poverty and help the poor is through scientific technology and increase in productivity. Hybrid maize planted with plastic mulching has been proved to be a very efficient technology to increase maize yield. We should make every effort to extend this package----------."*

After several such encouraging speeches the participants were led to a nearby demonstration field which was quite impressive and convincing with strong stalks and big ears. "It looks rather good and why don't farmers adopt it ?" was my question arising from the meeting.

Several days later whilst staying in Taiping township extension station I got an answer to the question. I learned a lot from an evening's free-chatting with Lao Wei, a senior extensionist and head of the station. Lao Wei is about 50 years old, a graduate of an agricultural school in the 1960s. He is native to this area and his wife is a farmer in a nearby village. Having worked in the township for about 30 years he is quite popular among the farmers.

Situation conversation 3: Government extension and farmers needs through the eyes of a senior extensionist.

❑ "There are six extensionists in our station, five men and one women. Our work roughly includes four main parts. The first is to carry out tasks and orders from the

government like the extension of hybrid maize with plastic mulching, sugarcane growing quota, etc. The second is to give technical advice to farmers in the station or at farmers' field. Our focus has been food crops. However, there is a growing interest by farmers in knowledge and techniques of fruit tree and other cash crops, rather than food crops. Farmers are not interested very much in increasing the yield of food crops. There is a saying by farmers: "food from rice, income and development depend on cash crops and non-agricultural activities". There is gap between farmers' need and our supply. The third part of our work is training, which is less than before for the reason of the supply gap. The fourth one is to work in a small shop owned by our station to sell hybrid seed, fertilizer, pesticide, etc. This is new work which started about 5 years ago. However, it has become our major work and an important means to support our station financially". "Then, what do you think of hybrid with plastic mulching technique? Why have few farmers adopted this in this township?" "Well, sometimes government's extension task is not realistic and appropriate for farmers, because most policy makers don't know the real situation in farmers' fields and their livelihood. The government officials considered hybrid maize+plastic mulching technique as a wonderful technology for farmers, whereas farmers don't think so. It depends. If there is not enough rain or irrigation it could be worse because the plastic mulching would reduce the efficiency of small showers. And it needs more investment and much more labour than normal maize: First farmers have to make thousands of holes by hand in the plastic mulching for every seedling to come out, then after harvesting all the plastic mulching mixed with mud has to be cleared out by hand. If not, it would cause terrible pollution for the soil and environment." "But the demonstration field looks quite well and impressive----" " Yes, I know the field and I know the farmer himself. It's true that the maize grew quite well, however, with two conditions, which most farmers don't have. First the field has a very good irrigation system, and the second important factor is its easy access to market. The maize planted in the field is sweet maize and would sell as fresh fruit in the market and would gain a much higher profit than as a food crop. So it's worth to invest more." ❑

6.3.2. Village level; Women in diversified agriculture

Village Case 2: Geyang Village (Wuming county)

A brief geographical orientation of Geyang

Geyang lies south of Wuming. It is about 10 km from Wuming and 50 km from Nanning, the capital of the province. It is linked to these cities by a trunk road and paved road. The popular modes of transport for men are motorcycle and small vehicles. Women normally use bikes. The basic infrastructures in farming are comparatively well-developed in terms of transportation, irrigation etc. The social infrastructure is also quite developed compared with Zhichen village. All of the houses are built with cement blocks and more than half of them are newly built in a rather modern style. It is not surprising

that the most outstanding new building is the village primary school which is the result of contributions from all villagers.

A brief overview of its socio-economic and cultural context

Geyang has a total cultivated land of 410 ha, and a population of 4,620 consisting of about 810 households. 95% of the inhabitants here are Zhuang people. However, the Zhuang culture is quite assimilated and the local life style is urbanised to a certain degree. Most households have a motorcycle, TV, radio, but few have ever subscribed to a newspaper.

Table 6-6: Trends of production and population growth in Geyang village 1981-1995

Year	Population	Total grain production (kg)	GDP (Yuan)	Per capita grain production(kg)	Per capita income (Yuan)
1981	4142	2243100	727800	542	176
1982	4140	2963500	719800	676	174
1983	4172	2722700	1305000	653	313
1984	4229	2352650	1423800	556	337
1985	4271	2739400	1679300	641	393
1986	4241	2789550	1921800	658	453
1987	4343	3218600	2492900	741	574
1988	4376	2861650	2825800	654	645
1989	4410	3007500	3174600	681	719
1990	4447	1687800	4459300	379	1003
1991	4530	748300	4258200	165	940
1992	4481	1765350	5709500	394	1050
1993	4492	1947300	5899800	433	1130
1994	4510	1848200	6102300	409	1240
1995	4620	1760800	6286300	381	1450

Source: Statistical Year Books of Geyang village

Industrialisation of rural economy and feminization of agriculture

There are five small enterprises in the village and most men work there full time and some women work part time too. It was estimated by the village head that 75% of the workers are men and the rest are mainly unmarried young women. He explained "married women have to take care of farm and family. It's difficult for them to work in the enterprises".

The migration in the village is typical of an internal community flow, as the majority of migrants just work in the local industries. For most of them it is not necessary to leave home. It is so-called "Litu Bu lixian" meaning "leave agriculture but not the community". The migration also follows the patrilineal model of "man first, women later and married women the last". As a result there has emerged a new pattern of gender division of labour: "the women till and the men work in industry". This has led to a virtual feminization of agriculture in the village; about 90% of the farms are managed by women.

Women's dominant role in diversified agriculture

Geyang used to be an intensive food farming area with rice and maize as the two most important grain food crops. The traditional cropping system is based on an irrigated paddy field and maize in hilly dry land intercropped with bean, peanut, sweet potato and cassava. However, agriculture has been greatly diversified over the last 15 years. A considerable amount of the rice fields is now covered by banana, vegetables and some maize, and most of the hilly dry lands are planted with a variety of cash crops like fruit trees, tobacco, sugarcane, water melon, etc. It was estimated by the head of the village that in the last 10 years, the rice growing area has decreased by about 30-40% while that of maize has increased about 10% especially in the last five years owing to the development of the household hog industry. Cash crops cover about 40% of the arable land; this is normally considered an underestimate because a considerable amount of cash crops are planted in non-official arable lands, i.e., mainly barren hills brought into cultivation by farmers after the land allocation in 1978.

Table 6-7: Trends of arable land and grain production in Geyang village 1965-96

Year	Total arable land	Paddy field	Dry land	Rice area	Maize area
1965	5920	4699	487	8273	297
1970	5850	5293	557	9445	300
1975	6396	5444	489	10144	228
1980	6393	5360	945	10853	198
1985	6258	5238	1020	9678	550
1990	6343	4903	1440	9377	1408
1995	5772	4374	1398	8627	1700
1996	6151	4441	1710	7956	2100

Source: Compiled by the author from field interviews 1996 and Statistical Year Books of Geyang village

The shift from rice cultivation to the production of cash crops is mainly because of the low economic benefit of the food crop. Some farmers even buy rice from the free market in order to fulfil government's food grain quota. As one women farmer said "Banana is much more profitable than rice. With part of the money from banana I can buy the grain quota required by the government. Furthermore, banana needs less labour." Nevertheless the majority of farmer households still maintain at least 50% of their rice area which normally is planted for food for household consumption. This is mainly because of tradition and the idea of food self-sufficiency, about which women show a stronger concern than men. As one man said *"we can easily buy rice for food from the market; it is sometimes even cheaper than growing it, but my wife won't like to give up rice cultivation."*

Accompanying the process of diversification, some specialized households have emerged and most of them are managed by women who usually have higher level of education and master new technologies quicker than others. There are 20 different types of "specialized households" in the village and 19 of them are headed by women. The enterprises focus on fruit trees, vegetable, hog, poultry, fish, etc. It was found in the field work that most women-headed specialized households tend to deal with traditional domestic crops and animals, and activities associated with domestic techniques like weaving and knitting. Male-headed specialized households seem more interested in new cash crops, such as tobacco (e.g., household case 5).

In sum, it can be felt everywhere in the village that women are playing a predominant role in diversified agriculture and increasingly complex livelihood systems. They are key producers of food and cash crops as well as keepers of domestic animals for household consumption and the market. They have to be able to make decisions and deal with almost all the farming activities by themselves and they look and behave more independently and confidently than women in the poor village.

Women farmers' motivation in maize production

Maize, a traditional food crop, has become mainly a feed or cash crop in the village over the last ten years. It is obvious that women farmers' motivation in growing maize now is economic interest rather than food self-provisioning. The realisation of maize's market profit is mainly through raising hogs for the market. Hog raising is a traditional domestic activity in the village. Each household used to keep one or two pigs mainly for household consumption and animal manure for production. With the introduction of market and recent growing demand for pork by the urban population hog raising has become an important sideline activity and an important source of income for most of the farmer households. Some specialised hog-raising households have emerged and all of them are managed by women.

Women farmers' perception of the "hybrid+plastic mulching" technology and their own interests and needs

No one in the village has adopted the technology for a long period. The main reasons are, more or less, as stated by a women farmer:

> *"It needs more labour, time and money, whereas it is not as profitable as a cash crop like vegetable and water melon".* The village head interjected: *"Normally, since its adoption in 1987, about 85% of the maize growing area in the village is covered by Guangxi Top-cross 1; the rest is planted to Tuxpeño 1 and a small amount of the local sticky yellow varieties which are planted in vegetable gardens or backyards. However, in the last several years more and more farmers have shifted from the hybrid to Tuxpeño 1 and this year more than 30% of the maize is Tuxpeno 1"*

The main reasons for the shift given by the women farmers in a informal group discussion were stated to be: the poor quality of hybrid seed, the degeneration of Guangxi top crosses, which have been continuously used for about 10 years, and the advantage of Tuxpeno 1 as an OPV that farmers can keep for seed themselves, and other characteristics like hardship tolerance. As one women said: *"The best thing about Tuxpeño 1 is that I can select and keep seed all by myself, and I don't have to rely on the market which is unreliable."* Another women said: *"Hardship tolerance is also very important and I don't need to invest so much in terms of labour, time and money. For example during the dry season I don't have time for watering which is OK for Tuxpeño."* When asked how about the yield, one women said: *"Yields is not that important for us now; besides the improved Tuxpeño 1 from Wenteng yields almost the same as Guangxi top crosses."*(see Wenteng case in chapter 4).

6.3.3. Household level; going into a farmer's life world

Household case 4: Women headed-household

Wife: 56 years old with primary school education, the only agricultural labourer in the family. She is the one who brought the seeds of Tuxpeno 1 from Wenteng and has a great interest in maize selection herself.

Husband: 58 years old with high school education, owner of small scale coal mine in the village.

Three kids: elder daughter is 28 years and works in the village shop. Younger daughter is 25 years and teaches in township primary school. The son is 22 years old and works in a village enterprise.

'In total we have 10 mu (0.67 ha) of land: 2 mu rice, 2 mu maize and the rest, 6 mu, is covered by sugarcane. Besides we have 5 mu of fruit on hilly land (which is not government contracted land). I used to intercrop maize with soybean and cassava but gave up several years ago. I am too busy to deal with too many crops, besides my health is not very good now I have to hire labour to help me during peak seasons". "I have three pigs now. Each year I can raise 5 to 6 pigs and the maize grown is mainly for the pigs and a flock of chickens and ducks. Sometimes I also eat maize just for a change. I like maize but my kids and husband don't like it at all". "Yes, I like seed selection very much, it's a kind of fun and entertainment for me. I got the seed of *Tuxpeño 1* from my sister in Wenteng three years before and it has spread to other villagers in the last two years. Now all my maize land is covered by Tuxpeno 1 and more and more farmers have adopted it. Now I am trying to persuade other farmers in the same area to grow it to prevent it from mixing with other varieties. Meanwhile, me and several other women, who have a shared interest, have done seed selection together to maintain *Tuxpeño 1* in the last two years". (the seeds selected by the group of women are widely used by other farmers in the village).

Household case 5: Household headed by a man

Husband: 34 years old and graduate of high school. He is one of the few young men still cultivating in agriculture and is the manager of the only male-headed specialized household in the village.

Wife: 30 years old with middle school education

Two kids: one daughter and one son, 7 and 4 years old respectively.

Two grandparents: over 70, parents of the husband.

There are only 4.5 mu (0.3 ha) of land in the household because the wife and two kids do not have allotted land. The household leases in 2 mu of irrigated land from its neighbour under the only condition that they will fulfil the rice quota for the land "owner". So together the household cultivates 3.5 mu of paddy rice and 3 mu of maize and some fruit trees. Tobacco grows in the winter fallow land. All the maize land is covered by Guangxi top cross.

When asked why he still is in agriculture when the majority of young men work in local industries and non-farming activities, the husband answered: *"I like agriculture. When I graduated from high school I had been admitted by Guangxi Agricultural University. However, because my parents were too poor, as the eldest son, I had to give up and work to support the family. Besides, I like to work and stay together with my family and live a peaceful life"*. He is one of the few young farmers I met in the field who still attached a sentimental value to the vanishing agriculture. But he has great interest in new technology. When asked why he grows

tobacco and, more or less, specializes in it when most farmers reject this new cash crop although recommended by the government, because of its higher risk and investment, he said:

> *"Yes, it has more risk than maize because it needs new technology and relies on the market. However, it also has much higher profit than maize. Besides the growing time of tobacco is in the winter slack season; it doesn't need extra land or take labour from food crops. Technology is not a big problem for me. I have learnt some relevant knowledge through self reading and by visiting tobacco farmers in other villages and discussing with them. Then I experiment in my own field, which I enjoy very much. What worries me about is the market for our production, which is underdeveloped, and with a lot of government intervention. For example, last year all the tobacco produce was collected by a public enterprise in the village. However, no one knows whether the truck of the enterprise will come or not, or the new price etc.".*

When asked about the role of his wife he said with pride *"yes, my wife is a great helper to me. She is responsible for tobacco backing, and women are usually better than men in doing this because they are more careful".* The wife sat beside him, with a light smile, did not say much; she seems a traditional Chinese woman, quiet and meek.

Household case 6: Hog raising specialized household headed by a woman

Husband: 58 years old, with middle school education. Head of the village

Wife: 56 years old, with primary school education.

> *"I have three kids and all of them work in the township and village enterprises and my husband is always busy with the village work and his own business. I am the only agricultural labourer at home. We have 10 mu (0.67 ha) of land. Now I only cultivate 4 mu of maize and the rest is leased out. Since 1992 I have started a small pig farm, which has an annual production of 60 pigs. All the maize grown is for the pig farm. I used to grow Guangxi top cross but since last year I have converted to Tuxpeno 1. Now half of my maize is Tuxpeno 1, because I found Tuxpeno 1 is more appropriate as feed for pigs with its white colour and floury characteristics. Besides it needs less labour".*

6.3.4. Findings and analysis

Women's key role in diversified agriculture and the changing farming structure

The case strongly suggests that the social and economic transformation have substantially changed the structure of agriculture in that the agriculture of single food production has converted into a complex and multiple component rural economy.

Agriculture has largely diversified, specialized and commercialised. Women have been assigned new roles in the changing process and become a dominant force in the agriculture.

As a consequence, some structural changes in the farming system are taking place. Food production has become, more or less, only a sideline activity for food self-sufficiency. Meanwhile, cash crops and other non-farm activities, e.g., fruit tree, household fish ponds, pig and poultry farms have become important sources of cash income for farmer households. With their husbands as wage workers, women have become the main tillers at home and they are almost the only food producers, but also the main cash crop growers and important managers within family enterprises.

Some evidence from the field study suggests that in the face of these changes, women seem more "conservative" or careful with regard to risk-taking; for instance, most women try to maintain a certain amount of rice to ensure food self-sufficiency. They are trying to reduce and spread out risk by largely relying on themselves for the family's basic need. This is mainly shaped by their traditional domestic roles and the complex and risky livelihood they have.

Women farmers' main constraints and their ways to deal with it

Labour shortage is the biggest constraint for the women in playing multiple roles in farming and non-farming activities, domestic production and reproduction. The labour shortage has resulted in some reversion to less intensified farming, less complex crop mixes, and more labour saving technologies, especially for food crops which is less profitable than cash crops (cf. chapter 1). For instance, the shift from rice to maize, from rice to fruit and the giving up of some traditional sustainable intensive farming practices like maize-soybean intercropping, winter green manure, etc., are partially because of the labour constraint. In addition, labour shortage is also one of the deterrent factors in selection of technology, for example the rejection of "hybrid+plastic mulching" technology, the shift from hybrid to OPVs, etc.

One of the major ways chosen by women farmers to overcome labour constraint are hiring labour, mainly from remote poor areas, and leasing out of land (see the examples of household case 4 and 6). Exchange of labour and co-operation among neighbour and relatives are not popular in this case due to the increasing opportunities and income from non-farming activities. However, the most common way for women to overcome the labour problem is by extending their own working time and intensifying their own labour. It was found that most women farmers work about 14 to 16 hours per day. Adult women are normally the first ones to get up in a family and the last to go for rest. As one little rural boy said "Mama is the one who opens the day and closes the day."

Lack of appropriate science-based information and technologies is another major constraint for women in production. Faced with new crops and new practices in the

changing farming system, women farmers urgently need new tools to support their new roles. However, the supply from public research and extension is quite limited. The most popular and important way for women farmers to deal with the constraint is to learn from each other through their own informal networking, i.e., visiting relatives, field demonstrations and discussions with relatives, neighbours and other growers. As one woman said: "Most of my knowledge and techniques about orange trees are from my neighbour. She grew it two years' earlier than me." Neighbours become an important source of knowledge and 'farmer to farmer' exchange network is a significant way of technology development and diffusion among farmers.

Gaps between supply and demand and farmers' own efforts

The public research and extension service still continue serving the single minded goal of food production and their interest and supply are still mainly limited to development and distribution of hybrids of food crops, rice and maize. But the great changes in agriculture and the rural economy have brought an increasing demand for more varied knowledge and information by farmers to cope with the changes and emerging technique and marketing issues.

Some cases show that farmers are trying to fill the gap on their own initiative. For example, the successful co-operation between farmers in Wenxu village and scientists in Guangxi Academy of Agricultural Science was initiated by the farmers (cf. 6.3.1. this chapter). The case strongly suggests the necessity and potential of interaction and collaboration between farmers and scientists, and an integration and combination of indigenous and scientific knowledge through participatory processes. It also implies that more attention and consideration should be given by the government to facilitate the emergence of such cooperation in technology design, development and diffusion.

Furthermore it was found that farmers increasingly are able to realise the strength and necessity of their own organisation and are trying to organise themselves to solve problems through joint and collective forces. Some farmers' organisations are emerging. Farmers' organisation significantly empower farmers to protect their own interests in the face of government intervention and market forces.

Gap between government's interest and women farmers' needs in maize production

There is great gap between the government's interest and farmers' motivation in maize production. The criteria for technology selection are quite different. For the government the focus is on yield-increasing technology, whereas farmers search for labour saving, hardship tolerant varieties. This has resulted in quite opposite actions on the demand side and supply side. On the one hand, government is trying every effort to extend the "excellent" high yielding technology, hybrid + plastic mulching, through government channels. Whereas on the other hand, farmers increasingly are shifting from hybrids to

OPVs and making efforts to maintain, improve and disseminate appropriate OPVs, like *Tuxpeño 1*, and landraces, through their own informal networking.

Women are key actors in the indigenous networks for varietal selection and dissemination. It was found that most of the local varieties and OPVs are maintained and disseminated by women. Based on their familiarity with the farming system and their domestic obligation, women normally have multiple criteria and wide interests when selecting varieties.

Impact and problem

The yield impact of the wide adoption of Guangxi top cross 1, 2, 3 and 5 since 1986 in Wuming is quite obvious (showing in Figure 5-9, chapter 5). These top-cross hybrids appealed to farmers and yielded about 20% higher than the previously used materials. Their adoption has brought a great increase in maize production, especially over the first five years. However, these top-cross hybrids have gradually lost favour among farmers due to the problem of seed quality, higher input requirement than for OPVs, and other agronomic and economic reasons brought about by the changed farming system.

The impact on women; The positive impact on women lies in the direct benefit from the yield increase, that in general has ensured food security at household level. The negative impact on women as maize growers is mainly related to the nature and characteristics of hybrids and the government's hybrid bias and gender bias in research and extension. The typical example is the government-recommended package "hybrid+plastic mulching" which is a time and labour consuming technology and which has increased the labour burden on the already over-loaded women farmers. The indirect impacts on women, which are mediated through women's positions within the family and the society, is illustrated in the following section through the study of women's changing roles and status.

Women's changing roles and status

Broadly speaking women's economic status has improved as result of the economic growth and women's intensive participation in production. Women farmers act more on their own initiative and independently than before. The new division of obligation has assigned new roles to women and for first time in Chinese history they have become the main agricultural producers and independent decision makers in most farming practice and household sideline activities.

Nevertheless, the women farmers' working burden has enormously increased owing to the lack of institutional support and the poor social service and welfare. It was found that most women farmers are over-loaded, which has affected women's health to a certain degree.

6.4. Cross case Analysis and Conclusion

- Generally speaking, the yield increase in both areas has benefited from CIMMYT related materials. However, the impacts are quite various between areas, types of households and groups of population due to the different adoption patterns and heterogeneous situations in farming systems and farmers' livelihood. Broadly speaking, farmers in favoured areas benefited more than those in harsh environments, and women gained as well as lost from the MVs. So the conclusion is that increase in production does not necessarily bring equal benefit to all farmers.

- One of the main research questions of the comparative case study is why different types of technologies are required in the two counties. The facts, evidence and farmers' own perceptions presented in the chapter have strongly illustrated the great differentiation and characteristics of the two farming systems. Duan is an extremely economically poor and harsh area with a subsistence agriculture and a difficult maize farming system. Whereas Wuming has relatively favourable environment and developed economy, it also has a small scale subsistence agriculture, however, its agriculture is experiencing diversification, specialisation and industrialisation. Moreover, differences and variation exist not only between areas, but also among types of farmer household and between different periods of time. Heterogeneity, complexity and diversity are the characteristics of small-scale subsistence farming in the whole research area. So when uniform high yielding hybrid maize was widely adopted in Wuming but was not appealing to the mountain farmers in Duan. Even within Wuming, 10 years before *Guangxi top-cross 1 and 3* were widely accepted as appropriate technology but are losing favour now. One technology could be good in one area but would be a disaster for another. The conclusion is that good technology is not always good and appropriate to all farmers in all areas all the time. Therefore, to know farmers' interests and needs by understanding their livelihoods and local farming systems is a 'must' and not optional for the design, development, and diffusion of technology.

- Farmers' different motivation, interests and needs in maize technology result from their different life strategies, generated from their different natural environments and socio-economic and cultural context. In less favoured, rainfed risky environments, where maize is used as staple food such as Duan, farmers have not much interest in high yielding varieties that require more external input and are less durable. Instead they are keen on stress resistant varieties and quality-enhancing innovations. In contrast, in favoured and intensive farming areas such as Wuming, where maize is mainly used for feed and the market, farmers are more interested in yield increasing technology that require inputs. However, because of the comparatively lower economic interest of agricultural products, especially food crops and labour shortage resulting from male migration, labour-saving varieties and stress resistance varieties become

number one selection criteria in both areas. Besides, the quality of varieties and post harvest characteristics are of particular interest to the women growers.

- In the great social and economic transformation, the two cases have followed two different models, which are two typical ways of transition from agriculture to industry, from rural to urban in the Chinese rural economy now. The first one is mass out-migration to the urban sector in the resource poor and remote area and the second is development of rural industries in the favoured area. Whatever the case, men are always prior to women in opportunity allocation. Detailed analysis of the reasons and causes is given in Chapter 2. Mass male out-migration, both to urban areas and local rural industries, has become a dominant feature, which has virtually led to the feminization of agriculture in both areas. In the first case, women are playing crucial roles in subsistence, self-provisioning, food farming, and women farmers in the second case have become the only food producers, main cash crop grower and important farm enterprise managers in the diversified agriculture. It is the women who are playing key roles in sustaining the small-scale subsistence farming and food security at both farmers' household level and national level.

- Broadly speaking, women's economic status has improved in both cases in different degrees. They behave more on their own initiative and more independently than before. Comparatively women in the second case are better off than the first in terms of economic status and household decision making, in spite of the fact that in the second case husbands stay at home and those in the first case are normally far away in cities (see the relevant data in chapter 7). This is mainly due to the amount of women's own income and their economic contribution to the households. In the first case the main source of household spending is the husband's remittances, whereas in the second case, household expenditure is mainly financed by women's own income from cash crops and other non-farming side line activities. Upon the basis of this finding it could be concluded that women's power of decision making is largely decided by their own income. However, it is the unequal gender relation that constrained women's access to income and other resources and opportunities.

Compared to men, women are still in inferior positions both within family, and in society in social and economic transformation. In division of labour, women are always ranked in the inferior positions in terms of grade of work and amount of income. That is why agriculture, which is considered an inferior and less profitable profession, has become women's domain in the social transition. Yet, women's key roles and significance in agriculture, especially food production are largely ignored and underestimated by policy makers. Farmers are still generally perceived as "male" by policy makers, breeders and extensionists. Little attention and concern has been given to women's needs and their characteristics. As result of the hybrid bias and male bias policies women farmers are indirectly affected by the introduction of MVs that are not targeted at them and are rarely designed specifically for their needs. Lack of

institutional support, women farmers are cultivating in agriculture in the face of enormous constraints. Furthermore, lack of social welfare and social services in the rural areas means that women farmers are, at same time, playing their traditional roles in domestic work and reproduction under difficult condition. For example, most women interviewed have to take care of children by themselves or get help from their mother-in-law. As a consequence, women farmers are enormously overloaded by their multiple roles. This again has proved the finding that Chinese rural women's labour, which is less paid or unpaid, has subsidised and benefited the Chinese economic development much more than the other way around (Song, 1993). Therefore gender inequities tend to be increased and reinforced in ways which hold food production and family welfare below the potential. A more equal distribution of existing resources between women and men and sufficient attention to address the specific constraints women faced are urgently needed for a equitable development and could substantially contribute to reduce poverty and ensure food security at the farmer household level (Jiggins, 1986; Quisumbing and Brown, et al. 1995).

- Given the conflict situation between breeders' research priority and women farmers' needs and gaps, and between government's interests and women farmers' motivation in maize production, a fundamental institutional change in the public research and extension system, away from top-down technology transfer should be enhanced and facilitated. A participatory approach is needed and gender analysis should be integrated to inform about the poor and women's livelihoods. For instance, given the multiple roles of women, policy-making for technology design, development and diffusion should focus on how innovations will affect time allocation and labour arrangement.

Chapter 7

Support From Quantitative Data

7.1. Introduction

Chapter 5 presented the impact of the Programmes at macro level and chapter 6 has covered impacts at micro level by in-depth comparative case studies, which have given a vivid picture of different farming systems and farmers' livelihoods.

Based on the evidence and findings at the macro and micro levels, it was felt by the author that a quantitative study to further investigate and validate the qualitative findings was necessary to complete the research. So the general purpose of this chapter is to further investigate and validate the findings using quantitative methods.

This chapter deals with a quantitative survey of 200 farm households. The objectives of the survey were to:

- identify the principal characteristics of and differentiation between the farming systems in the two major maize farming areas studied, and the maize adoption patterns
- determine farmers' preferences for different types of maize germplasm and find out the reasons
- find out the methods used and process of technology dissemination among farmers and to identify factors restricting and promoting the adoption of the technologies
- further focus on women's roles in agriculture and their specific interests and needs in relation to maize varieties.

7.2. Sample selection and data collection

As described in chapter 5, the maize farming systems in the three provinces roughly can be categorised into two major types, i.e., relatively flat and irrigated low land and rainfed mountainous upland. Two counties, Wuming and Duan, were selected as case studies, respectively representing the two major types of maize farming system and, within the counties, two villages were selected (as representative) for in-depth investigation of the two major types of farming environment (see chapter 6).

Farming households in the two villages, Zhichen and Geyang, formed the sampling frame from which the samples were selected. In order to ensure representative coverage of farming households, the sampling was fully random, using the farm households files maintained by the village committees. Hundred farming households were randomly selected by lot (drawing file numbers out of a small basket) respectively for each village. The composition of the samples in the two villages is shown in Table 7-1 below.

Table 7-1: Composition of the sample in the two villages

Village	Total number of Households	Households Interviewed No	%	Total Population	Population Interviewed* No	%	Women-managed households No	%	Women-managed house-holds interviewed No	%**	%***
Zhichen	320	100	31.2	2000	100	5	294	92	92	92	29
Geyang	810	100	12.3	4620	100	2.2	729	90	87	87	11
Total	1130	200	17.6	6620	200	3.02	1023	91	179	89	16

* The survey is designed to interviewed the main women labourer in each household, she is normally the household and farm manager

** Percentage of total households interviewed

*** Percentage of total households in the village

Source: Calculated from survey data (1997)

7.2.1. Survey logistics

All the interviews were carried out during the period from November 1996 to January 1997. Consideration was given to the following factors in the time chosen; it was the end of a farming year and just after the harvesting of the second maize cropping season, and it was the winter slack season when it is more easy to reach the respondents and organise the interviews.

It was decided to choose women as main respondents, due to the fact that feminization of agriculture has become a predominant feature in the research areas. Based on the observation and findings drawn from the qualitative study it was clear that women are playing an key role in agriculture. As shown in table 7-1, in both villages, about 90% of the households are, in fact, managed by women in the sense that women are the tillers and farm managers (in their households). However, some of the husbands participated in the interviews as well. In 29 interviews in Geyang, in households where the husband worked mainly in the local enterprises, the questions were answered by women in their husbands' presence. The same situation occurred in 40 cases in Zhichen, where some husbands had come back for (the holiday of) the Spring Festival. In most of these cases, the husbands were trying to answer questions first although being told that the respondent should be the women. However, it is ironic that most of these aggressive respondents failed to answer most of the questions concerning agricultural production, cropping patterns, variety use and preference, etc. Then, the wives stepped in and answered all the questions in a much clearer way.

7.2.2. Questionnaire design and scope

The questionnaire was formulated on the basis of the exploratory and qualitative phases of field study in the same area by the author (see chapter 3, the three phases of study). The questionnaire included the following sections:

- demographic characteristics of the household
- production resources and cropping systems of the households
- information on maize cultivation, sources of technology and times of adoption
- varieties used and their characteristics and farmers' preference of the five commonly used materials
- Gender division of labour in three historic periods, i.e., during the commune period, The period from 1978 to 1990 and after 1990.

The questionnaire was pre-tested in November 1996 through farmer interviews conducted in a village near Nanning. Some small corrections and adjustments were made after the test.

7.2.3. Data collection and analysis

In order to ensure the quality of the research, to obtain more contact with farmers and to carry out more participatory observation for further qualitative information, all the interviews of the 200 respondents were done by the author herself. Help was only needed for showing the places and pointing out the households. It was physically hard work, especially in the mountainous village, as all the sample households were scattered in different mountain valleys. However, spiritually it was enjoyable and the author benefited a lot from the after-interview free chatting with farmers in understanding their life worlds and their real needs.

All the data entry and analysis were done by the author using the SPSS computer programme. Two main research steps were adopted in the survey data analysis; the first was descriptive, using the frequencies and means to show counts, percentages and averages of some relevant variables of the two sample villages. Then, comparison between the two samples was done to show differentiation and significance. The second step was more analytical and explanatory, in order to explore and reveal the relationship and causality between factors. The results of the two steps are presented in the following sections.

7.3. Basic Information and Comparison

7.3.1. Basic characteristics of respondents

All the 200 respondents were married women except one who was a 17 years old girl and one of the full time agriculture labourers in her household. There were 16 and 4 single-adult, women-headed households in Zhichen and Geyang respectively. All the respondents were minority people with 96% Zhang and 4% Yao. The respondents in Geyang were younger and had a higher education level (see Table 7-2).

Table 7-2: Basic information on sample women farmers

Village	Mean age (Year)	Mean family size (No)	Mean education level (Year)	Peoples Zhang (%)	Yao (%)
Zhichen	48.5	4.7	4.5	92	8
Geyang	42.8	5.1	6.5	100	0
Total average	45.6	4.9	5.5	96	4

Source: Calculated from survey data (1997)

About 95% of the sample women were full time working in agriculture; only in Geyang there were 5 respondents who had two occupations, an agricultural and non-agricultural one. In Zhichen, 64% of the respondents' husbands were non-agricultural workers and most of them worked far away in the economic booming areas outside or within the province. In Geyang, 58% and 31% of the husbands were nonagricultural labourers and dual occupations holders respectively, and the majority of them worked locally in the county (see Table 7-3).

Table 7-3: Main occupations* of the women farmers interviewed and their husbands, as well as the

Village	Women (%)			Husbands** (%)			Husband's work place (%)		
	Agri	Nonagri	Both	Agri	Nonagri	Both	County	Province	Outside
Zhichen	99	1	0	10	64	10	30	19	35
Geyang	94	0	5	7	58	31	93	3	0

* Main occupations are categorised into three major ones i.e. agricultural, nonagricultural and dual occupations which include both agricultural and non agricultural work

** There were 16 single-adult women headed households in Zhichen and 4 in Geyang

Source: Calculated from survey data (1997)

Based on participatory observation, however, the author noted that most of the male "dual occupation holders" in Geyang were nonagricultural workers. They were just not full time workers in enterprises but, did business and other non-agricultural work outside the farms. So the real number of male non-agricultural labourers should be higher than that presented in Table 7-3.

7.3.2. Land holding

The average land size holding in both villages was rather small; however, comparatively that in Geyang was much larger than Zhichen (almost double). The type

of land holding was also quite different; all the cultivated lands in Zhichen were rainfed dry upland, whereas, the main part of the lands in Geyang were irrigated paddy land (see Table 7-4). Furthermore, the dry upland in Geyang was much better quality than the rainfed upland areas in Zhichen, that in the majority of the dry land was irrigated by using the small water pumps possessed by almost all the households in Geyang.

Table 7-4: Land holding, sample households in the two villages

Village	Mean irrigated paddy land (mu)*	Mean dry upland (mu)	Mean Farm size (Total land in average) (mu)	Mean maize area** (mu)	(%)
Zhichen	0	4.4 (0.29 ha)	4.4 (0.29 ha)	4.4 (0.29 ha)	100
Geyang	5.0 (0.3 ha)	2.1 (0.14 ha)	7.2 (0.48 ha)	1.7 (0.01ha)	24.1

* mu: 1 ha=15 mu

** Land for maize in the first cropping season

Source: Calculated from survey data (1997)

The distribution of land holding in the two villages is shown in Figure 7-1. The majority of the sample households' total land holding was between 2.1-5 mu (57%) and 24% of the households had between 5-8 mu. Only 8% of households' land holding were 10-14 mu and none had more than 14 mu in Zhichen. The situation in Geyang was a bit different with more farmers who possessed between 5.1 to 10 mu, and 9% over 10 mu. The unexpected finding is that there was 5% of the households with access of land between 14 to 20 mu, which is comparatively large considering the official even-land distribution system in China, especially in such an intensive and land scarce area. This could suggest that a land upscaling process has started and differentiation is increasing in the relatively developed rural area to a certain degree. Comparatively, such differentiation is larger in Geyang than in Zhichen (see Figure 7-1).

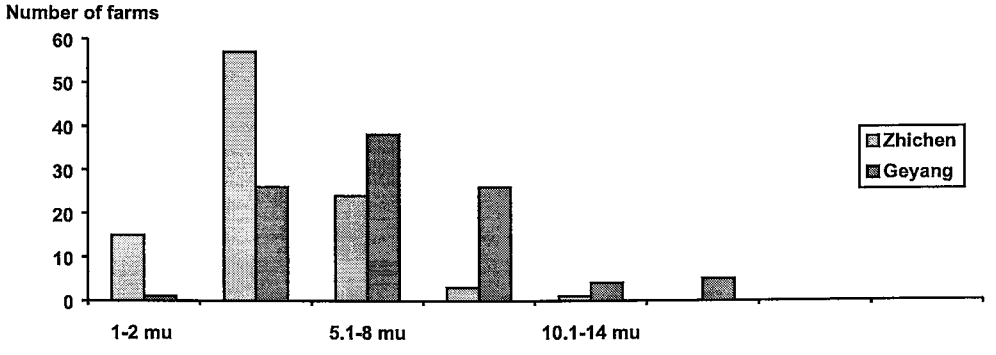

Figure 7-1: Farm size distribution in the two villages, 1996-97

Source: Calculated from survey data (1997)

7.3.3 Cropping patterns

As the cropping system is largely decided by the cultivation environment (land, soil, etc.), the cropping patterns obviously differ between the two villages. In Zhichen, 100% of the land was planted with maize intercropped with beans and sweet potatoes. All of them are dry upland crops, which can survive the dry and difficult environment. Maize is the only traditional staple food crop for the Zhichen villagers. Pomelo is the result of a government's poverty alleviation project during the last several years (see chapter 6 village case 1).

The cropping systems in Geyang are much more variable and diversified. Rice is the most important food crop. Maize used to be the second staple food but increasingly has become a feed crop in the past decade. Maize comprised only 24.1% of the total cultivated land and 20% of the total crop growing area (see Tables 7-4 and 7-5).

Table 7-5: Main crop pattern, sample farmers in the two village

Village	Proportion of Farms growing (%)	Mean area planted (mu)	Proportion of total crop growing area*** (%)
		Maize	
Zhichen	100	5.1 (0.34 ha)	53
Geyang	100	2.4 (0.16 ha)	20
		Rice**	
Zhichen	0	0	0
Geyang	96	5.6 (0.37 ha)	47
		Bean	
Zhichen	96	1.6 (0.11 ha)	17
Geyang	43	0.9 (0.06 ha)	8
		Sweet potato	
Zhichen	92	1.6 (0.11 ha)	17
Geyang	0	0	0
		Cassava	
Zhichen	0	0	0
Geyang	70	1.3 (0.09 ha)	11
		Fruit trees****	
Zhichen	70	1.3 (0.09 ha)	13
Geyang	86	1.6 (0.11 ha)	14

* Two cropping seasons of maize

** Two cropping seasons of rice

*** proportion of total cropping growing area which included multiple cropping area

**** fruit trees here means pomelo for Zhichen and banana for Geyang

Source: Calculated from survey data (1997)

There were more cash crops in Geyang such as cassava, sugarcane, tobacco, banana, orange and other types of fruit trees (some crops which only a few farmers grow were not included in the survey). The mean area under fruit trees for Geyang includes only banana planted in the paddy land which used to be planted with rice (Table 7-5). So the area of banana equals exactly the decrease of rice area which is consistent with the finding in chapter 6 (village case 2). Other types of fruit tree are normally planted in hilly land or orchards (which are not officially calculated as cultivated land). So in Geyang the actual mean area under fruit trees is much larger than 1.6 mu.

7.3.4. Utilization of maize

Table 7-6: Main usage of maize by the sample farmers from the two village 1996

	First cropping season				Second cropping season			
	Zhichen		Geyang		Zhichen		Geyang	
Main usage	(No)	(%)	(No)	(%)	(No)	(%)	(No)	(%)
Food	100	100	1	1	100	100	3	5
Feed	--	--	83	83	--	--	50	79
Quota	--	--	2	2	--	--	1	1.6
Feed & market	--	--	2	2	--	--	1	1.6
Feed & quota	--	--	5	5	--	--	3	5
Food & feed	--	--	7	7	--	--	5	8

Source: Calculated from survey data (1997)

Table 7-6 shows clearly that maize is playing very different roles in the two different environments. In Geyang the main usage of maize is as feed for pigs, while in Zhichen all maize is used for food. Sweet potato serves here as the main feed for pigs.

7.3.5. Livestock and fishpond ownership

Ownership of the five most common types of livestock and fish pond in the two villages is tremendously different in terms of numbers and types of animals (see Table 7-7). The mean number of pigs owned is as high as 14.8 in Geyang, which suggests that pig raising is rather commercialised there. Table 7-8 presents the categories of pig ownership, showing that most of the farmers in Geyang kept more than 10 pigs, while 22 households kept between 20 to 40 and 3 kept between 40 to 80. The three categories are considered respectively as small scale, medium scale and big scale household pig enterprises according to Chinese standards.

There are 10% of sample farmers who owned a fish pond and they are specialized households specializing in fish ponds in Geyang. However, fish and ducks are just impossible in Zhichen with its extremely dry and upland environment where even drinking water for people is a big problem.

Table 7-7: Ownership of livestock and fish pond, sample households in the two villages

	Number of animals and fish ponds per household (In brackets are the proportion).											
Village	Cattle		Pigs		Goats		Chickens		Ducks		Fish pond	
Zhichen	0.81	(80)	1.86	(96)	2.06	(68)	6.97	(92)	0	(0)	0	(0)
Geyang	1.41	(85)	14.8	(97)	0.28	(3)	12	(85)	8.19	(79)	0.32	(10)

Source: Calculated from survey data (1997)

Table 7-8: Distribution of number of pigs per household in the two villages, 1996

Categories by number of pigs	Number of households		Percent of households	
(No)	Zhichen (No)	Geyang (No)	Zhichen (%)	Geyang (%)
1-4	94	14	98	14.4
5-10	1	18	1	18.6
11-20	0	40	0	41.2
21-40	1	22	1	22.7
41-80	0	3	0	3.1

Source: Calculated from survey data (1997)

7.4. Maize production, varieties adoption and comparison

7.4.1. Maize area

As the mean farm size is rather small for both villages, the mean area planted with maize per farm is only 0.34 ha in Zhichen and 0.16 ha in Geyang (Table 7-9). Maize is planted to all the cultivated land in the first cropping season in Zhichen, but occupies only 24.1% of Geyang's farming land. Maize areas in the second cropping season are much smaller than in the first season in both villages. This is consistent with the finding presented in chapter 6 that some farmers have given up all or part of the second season maize production, which used to be done by the majority of farmers on most of their maize lands.

Table 7-9: Area planted to maize, sample households in the two villages

Village	Mean maize area cultivated per households (mu)	Maize area * as a proportion of cultivated area (%)	Mean maize area of first cropping season (mu)	Proportion of farmers growing first season (%)	Mean maize area of second season (mu)	Proportion of farmers growing second season (%)
Zhichen	5.1 (0.34 ha)	100	4.4 (0.29 ha)	100	0.73 (0.05ha)	72
Geyang	2.4 (0.16 ha)	24.1	1.7 (0.11 ha)	100	0.71 (0.05ha)	61

* Maize area of first season

Source: Calculated from survey data (1997)

7.4.2. Intercropping practices with maize

The dominant and traditional cropping pattern in Zhichen is maize+bean and maize+sweet potato; 96% of the interviewed households intercropped their maize with these two crops (see Table 7-10). Bean is locally considered as the best intercropping crop for maize as it can improve the soil and is good for maize. Besides, bean is a kind of luxurious dish for farmer households. Sweet potato is a type of "inferior" food crop for the poor. Some farmers cook maize porridge together with sweet potato during periods of food shortage. Besides, sweet potato is the main feed for pigs in Zhichen .

In Geyang intercropping is also an intensively used traditional practice. However, the intercropping pattern is more variable and diversified owing to the characteristics of its environments. Cassava and bean are normally the important crops intercropped

Table 7-10: Intercropping practice of maize farming 1996, sample farmers in the two village

	Combination of crops								
Village	Monocrop (%)	Bean (%)	Sweet potato (%)	cassava (%)	peanut (%)	Several crops (%)	Bean+sweet potato (%)	Bean + Cassava (%)	Cassava peanut (%)
Zhichen	2	2	0	0	0	0	96	0	0
Geyang	39	12	1	25	1	15	0	4	3

Source: Calculated from survey data (1997)

with maize. The survey revealed that some farmers in Geyang had abandoned the intercropping and maize cultivation during the second season. Both used to be normal farming practice in the intensive and land shortage farming area. This finding is consistent with that in qualitative case study; the main reasons and causes were presented in chapter 6 already. Comparatively, there were more farmers in the rich village who had abandoned both the second season maize cultivation and intercropping practice than in the poor village, as shown by cultivated area and number of farmers. This could suggests that maize is more crucial for the livelihood of the farmers in the difficult food self-provisioning farming system.

7.4.3. Maize varieties grown in 1996

The farmers grow different types of maize, including landraces, improves OPVs, and hybrids in both villages. Table 7-10 presents six varieties commonly used in 1996. *Guangxi top-cross 1 and 3* and *Nanning top-cross* are conventional hybrids combined with CIMMYT germplasm, which are developed by Guangxi Maize Research Institute. Zhongdan 1 is a *single cross* hybrid developed by CAAS, *Tuxpeño 1* is an improved OPV that came directly from CIMMYT. *Local White* and *Local Waxy* are landraces used for generations.

Most of farmers in the mountainous village (Zhichen) grew *Tuxpeño 1* in the first cropping season and some planted *Local white* on their worst lands. In the second cropping season *Local White* is the most popular variety followed by *Tuxpeño 1*. *Local White* is prefered becaues it can survive the autumn drought quite well. *Local waxy* is preferred by women farmers as quality food for festivals and it is usually planted in vegetable gardens (it is normally not included by farmers when they count the number of varieties used in production). There was an unexpected finding in the mountainous village that there were six and three sample farmers who had adopted hybrids in the first and second seasons respectively. The main reason can be concluded from a farmer's answer: *"because of the degeneration of Tuxpeño 1 there is no appropriate variety, I just want to try other varieties and get an appropriate one."* It is not a surprising comment, since in fact as all the hybrid adopters just grew the hybrids like OPVs.

The varieties used in Geyang, the relatively flat and rich village, are quite different from the ones used in Zhichen. The most popular material in the first cropping season is *Guangxi top-cross 1* and the next one is *Tuxpeño 1*. However, in the second cropping season *Tuxpeño 1* is the most popular. The main reasons given by *Tuxpeño 1* growers are: the poor quality and unreliability of hybrid seed, no need to change seed with *Tuxpeño 1*, less labour requirement and stronger drought resistance. Furthermore, hybrid seed production is usually carried out in the second cropping season so hybrid seed is available only for the first season. That is the season for more adopters of *Tuxpeño 1* in the second cropping season. And this also means that the second season hybrid growers have to use unchanged seed from their previous harvest. Use of landraces is quite limited

in Geyang, although some farmers still maintain a small plot of *Local Waxy* and other preferred landraces in their vegetable gardens (they are normally not counted by farmers).

Table 7-11: Use of varieties by sample farmers from the two villages in the first and second seasons of 1996. (In brackets are the relevant proportion).

	Proportion of farms growing in the first season				Proportion of farms growing in the second season*			
	Zhichen		Geyang		Zhichen		Geyang	
Variety								
Guangxi/Nanning top-cross	3	(3)	55	(55)	3	(4.2)	16	(25.6)
Zhongdan 1 (single cross)	3	(3)	3	(3)	0	(0)	1	(1.6)
Tuxpeño 1 (improved OPV)	77	(77)	42	(42)	30	(42)	40	(64)
Local white (landrace)	17	(17)	0	(0)	33	(46)	4	(6.4)
Local waxy (landrace)	0	0	0	0	6	8.4	0	0

* In the second cropping season there were 28 nongrowers in Zhichen and 39 in Geyang

Source: Calculated from the survey data (1997)

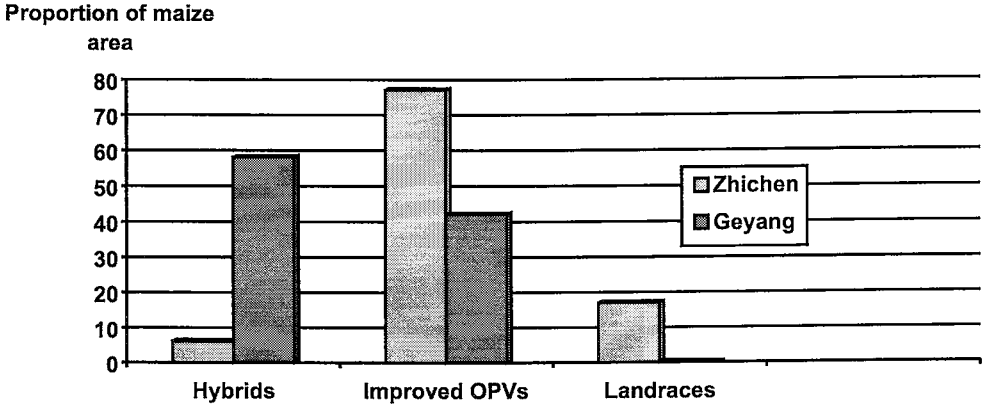

Figure 7-2: adoption of different types of materials, 1996

Source: Calculated from the survey data (1997)

Furthermore, it is found that different types of variety have been adopted in the different types of land and the different cropping seasons by farmers in the villages. This explains why some farmers have adopted more than one variety in a cropping season (see Table 7-12). This is especially true in the poorer village with a harsh and risky environment, what could suggest that the farmers just tried to spread the risk by using more than one variety.

Table 7-12: Number of farmers growing more than one variety per season, 1996. (In brackets are the relevant proportion).

	First season				Second season			
	Zhichen		Geyang		Zhichen		Geyang	
Varieties package								
Guangxi top-cross 1 and Tuxpeño 1	1	(1)	4	(4)	1	(1.6)	1	(1.4)
Guangxi/Nanning top-crosses, Tuxpeño 1 and local white	37	(37)	0	(0)	0	(0)	0	(0)
Tuxpeño 1 and Local white	14	(0)	0	(0)	3	(4.2)	0	(0)

Source: Calculated from the survey data (1997)

7.4.4. Adoption of CIMMYT-related materials

Three materials adopted by the farmers which are direct CIMMYT-related germplasm, i.e., *Guangxi top-cross 1, Tuxpeño 1, Nanning top-cross*. The first two are widely used by farmers in both villages. *Nanning top-cross* has been tried by farmers in Zhichen in the last several years.

Guangxi top-cross 1 as a conventional hybrid, performed well at Geyang and was accepted as an appropriate variety by farmers there. Meanwhile *Tuxpeño 1* became quite popular at the mountainous village. They became dominant varieties respectively in relatively flat and irrigated areas and mountainous harsh environments. However, both varieties increasingly are losing favour among their former adopters owing to the technological and institutional reasons given in chapter 6. It is interesting to find that increasing numbers of farmers in the irrigated area have shifted to *Tuxpeño 1*, where it is maintained much better than in the mountainous areas (see Wenteng case chapter 4). Meanwhile, some farmers in harsh environment are trying *Guangxi/Nanning top crosses* in search of appropriate varieties. The relevant findings revealed by the survey are approximately consistent with the qualitative study. Only the degree is bigger than expected (see Table 7-13 and Figure 7-3).

Table 7-13: Proportion of sample farming household that use CIMMYT related varieties, 1996

	First Season						Second Season					
	Guangxi top-cross 1		Nanning top-cross		Tuxpeño 1		Guangxi top-cross 1		Nanning top-cross		Tuxpeño 1	
Village	No	%	No	%	No	%	No	%	No	%	No	%
Zhichen	1	1	2	2	77	77	0	0	3	4.2	30	42
Geyang	55	55	0	0	42	42	16	26	0	0	40	64
Total No	56		2		77		0		3		70	

Source: Calculated from the survey data (1997)

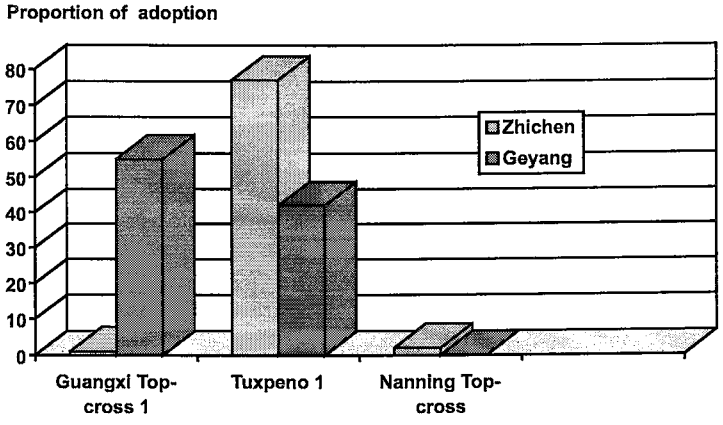

Figure 7-3: Adoption of CIMMYT-related varieties, 1996

Source: Calculated from the survey data (1997)

7.4.5. Sources of seed

Information about seed sources was collected for three types, i.e., source of the first adoption of the seed currently used; and seed used during the first cropping and the second cropping in the year of survey. As presented in Table 7-14, neighbours and relatives were the main sources of seed for the first use in both villages, although more farmers in Geyang obtained seed for their initial adoption from the extension station. This finding is consistent with that in the case studies, that farmers' informal networks,

mainly neighbours and relatives, are the main path of a technology dissemination and development, and, were functioning well to meet farmers' needs.

Table 7-14: Origin of maize seed (%), at first adoption and in the survey year

Origin of maize seed	First adoption		First season survey year		Second season survey year	
	Zhichen	Geyang	Zhichen	Geyang	Zhichen	Geyang
Extension station	8	38	--	22	--	3.3
Seed company	2	--	--	1	--	1.6
Free market	--	1	--	1	--	--
Seed Farmers	--	9	--	15	--	1.6
Neighbours & /relatives	81	52	2	22	--	9.8
Self selected	--	--	98	39	100	83.6
other	9	--	--	--	--	--

Source: Calculated from the survey data (1997)

Since almost all the maize varieties used at Zhichen village are OPVs, the seeds for the first and second cropping seasons in the current year are almost all selected by farmers themselves (except to two farmers who are new adopters of hybrids for experimentation). In the better off village, the sources of seed in the year of survey were more varied and multiple. As about half of the farmers grow hybrids, they have to purchase seed. The extension station is the main official seed seller; however, there were still quite some farmers who purchased (or exchanged) seed from nearby seed farmers, who are seed producers for government seed companies (see chapter 5 for seed system in China). Usually part of the seeds produced go directly and "illegally" to maize farmers through informal exchange channels. It is commonly accepted by farmers that seeds from seed farmers are more reliable than those from the extension station and public seed company. Most of the *Tuxpeño 1* adopters in Geyang saved seed from the previous harvest and most of the new *Tuxpeño 1* adopters obtained seeds from neighbours and relatives, who are the only available suppliers of OPV seeds.

7.4.6. Fertilizer used

The survey captured data only on chemical fertilizers, although use of organic fertilizer is still common in the survey areas. However, chemical fertilizer is more commonly used for maize. Furthermore, the calculation of organic fertilizer used varies greatly from farmer to farmer. Based on the author's participatory observation, the use of organic and inorganic fertilizers is higher in Geyang than Zhichen, as the latter is limited by its harsh geographic condition and its poor economic status.

In the poor village, the majority of the farmers used a certain amount of chemical fertilizer (compound fertilizer) in the first maize cropping season; however, about 66%

Table 7-15: Frequency distribution of farms for fertilizer use in maize during the first and second cropping seasons of 1996

Amount of fertilizer kg/mu*	First Season Zhichen No**	%	Geyang No	%	Second season Zhichen No	%***	Geyang No	%
0	4	4	3	3	47	66	5	8
1-20	14	14	1	1	19	27	2	3
20-50	77	77	12	12	2	3	18	29
50-100	5	5	63	63	1	1	37	59
100-150	--	--	18	18	2	3	1	1
150-200	--	--	3	3	--	--	--	--

* 1 ha=15 mu

** Number of farmers using/not using certain amount of fertilizer

*** Percent of maize growers

Source: Calculated from the survey data (1997)

of the second season maize growers did not use any chemical fertilizer at all. The average amount of fertilizer used in Zhichen is 40 kg/mu (600 kg/ha,) in the first season, but only 11.9 kg/mu (178.5 kg/ha) in the second season. The main reason given is that the weather condition is so poor, e.g., autumn drought or flood, and farmers can not afford to run the risk to invest and harvest nothing. In Geyang, the amount of fertilizer used is obviously higher. The mean amount of fertilizer used is 99.6 kg/mu (1,494 kg/ha) in the first season and 65.4 kg/mu (981 kg/ha) in the second. The amount in the first season is much higher than the second one. In both cases the second cropping season is considered as less important and more risky so less input was invested.

7.4.7. Maize Yield

It is not surprising that the average maize yield in the two environments are obviously different as result of the different natural environment and socio-economic contexts.

Table 7-16: Average yield in 1996, sample farmers in the two villages

Village	First cropping (kg/ha)	Second cropping (kg/ha)
Zhichen	1860	870
Geyang	3953	2993

Source: Calculated from the survey data (1997)

7.5. Decision-making on variety adoption, reasons and preference

7.5.1. The main decision makers and seed selectors

As women are the key managers and tillers in agricultural production they have increasingly become dominant decision makers in relation to farming activities as well, especially in variety selection. In total 86% of the sample household's variety adoption was decided by the wives in the first cropping season; in the second season the percent is as high as 90%. Comparatively, there are more cases of women deciders in Geyang than in Zhichen, despite the fact that the majority of the husbands in the former village work locally while those in the latter work mainly far away from home.

Women are the traditional seed selectors in the survey areas. Almost all the seed selection currently is done by women in both villages, as has been the case also in earlier historic periods. There is no significant change between the areas and the periods of time.

Table 7-17: Decision makers in relation to variety adoption, 1996

	First cropping season						Second cropping season					
	Wife		Husband		Together		Wife		Husband		Together	
Village	(No)	(%)	(No)	(%)	(No)	(%)	(No)	(%)	(No)	(%)	(No)	(%)
Zhichen	79	79	10	10	11	11	60	86	3	4	7	10
Geyang	93	93	4	4	3	3	60	95.2	0	0	3	5
Total	172	86	14	7	14	7	120	90.2	3	2.3	10	8

Source: Calculated from the survey data (1997)

Table 7-18: Proportion of maize seed selectors (%) at three different historic periods

	After 1990		Before 1990		Communes*	
Selector	Zhichen	Geyang	Zhichen	Geyang	Zhichen	Geyang
Wife	100	96	99	96	99	94
Husband	--	2	1	1	1	3
Together	--	2	--	3	--	3

* During the period of People's Commune

Source: Calculated from the survey data (1997)

7.5.2. Reasons for adoption

The question of the primary reasons for adoption were elicited through an open-ended question so that all the reasons were given by the respondents themselves and then categorised by the author. The reasons given by the women farmers for their adoption of five commonly used varieties are quite diverse. The main reasons are categorised and listed in Table 7-19.

Table 7-19: Primary reasons for adoption

TYPE.	Primary reasons given	First cropping season				Second cropping season			
		Zhichen		Geyang		Zhichen		Geyang	
		(No)	(%)	(No)	(%)	(No)	(%)	(No)	(%)
A	Good as feed							1	1.7
	Just try and test	3	3						
	Government recommended			3	3				
B	High yield			10	10			1	1.7
	Drought resistant			5	5			1	1.7
	Good as feed			3	3			4	6.8
	Good for inter-cropping			3	3				
	Just try and test	3	3	2	2	2	2.9		
	High yield and drought resistant			10	10			2	3.3
	Multiple reasons			4	4			4	6.8
	Following other farmers			9	9			1	1.7
	Government recommended			10	10			3	5.0
	Early maturity			2	2				
C	High yield	2	2	2	2				
	Drought resistant	2	2	1	1	5	7	3	5
	Lodging resistant	38	38			16	23		
	Good as feed			4	4			2	3.4
	High yield and drought resistant	15	15	11	11	5	7	5	8.3
	No need to change of seed			13	13			21	35
	Poor quality of hybrid seed			2	2			1	1.7
	Multiple reasons			6	6			5	8.3
	Following other farmers	22	22			5	7		
D	High yield and drought resistant	3	3			25	36	2	3.4
	Lodging resistant					2	2.9		
	As quality food					4	6	2	3.4
	follow other farmers					1	1.4		
	Stable yield & Stress resistant	2	2						
	Traditional variety	9	9			5	7		

* Type: Types of varieties, A: Zhongdan single cross; B: Guangxi/Nanning top-crosses; C: Tuxpeño 1; D: Local white and local yellow;

Source: Calculated from the survey data (1997)

Although respondents were asked to give the primary reasons only, many respondents said their concern in variety selection is multiple and complex. So in some cases more than one reason was given as "primary". It was realized increasingly by the author that the heterogeneity and complexity of the farming system is quite difficult to quantify and model. However, the survey revealed the multiple requirements of farmers based on their complex and heterogeneous farming systems.

The primary concerns of the farmers in the mountainous village, Zhichen, emphasised stress tolerance, e.g., lodging and drought resistance. It is noted that the former is more important for the first cropping season, while the latter is more important for the second season. For the farmers in the environmentally favoured village, Geyang, high yield seems more important, but not most important; drought resistance and other characteristics are required together with yield. It is clear that the farmers in Geyang have more complex and multiple reasons for their adoption. This is largely because of the rapidly changing and diversifying agriculture and more complex farming systems there. It was surprising to find out that quite a few farmers' primary reason for adoption is just to "follow other farmers". This is especially true in the poor village.

7.5.3. Farmers' preference

Based on the observations and findings in the qualitative study, the survey respondents were asked to compare and rank the 5 commonly used varieties. It was designed as a multiple-response question; however, some farmers' answered: *"different varieties have different characteristics and meet my different requirement and that's why I grow several different varieties every year"*. These responses are significantly showing farmers' multiple needs. So option 6 was added, as shown in Tables 7-20, and 7-21.

The first preference of the farmers in both villages is *Tuxpeño 1*, the improved OPV directly from CIMMYT. However, the degree of the preference of *Tuxpeño 1* is unexpectedly stronger and more obviously shown by the respondents from the favoured village than the poor one. In Zhichen, 42% of the respondents gave the answer *"different varieties have different characteristics....."*. Such responses represent a type of complex and regretful feeling towards the degenerated *Tuxpeño 1* which had been a most favoured and dominant variety in the village for more than 10 years. This could suggest that *Tuxpeño 1* is increasingly gaining popularity among farmers in the better-favoured area, meanwhile losing its favour in the mountainous village. One explanation is that the poor have fewer "space" resources to invest in seed maintenance. Such investment becomes more common in the other area as maize planting reduces and as the entire agricultural system becomes more differentiated and specialized.

For the two hybrids, *Guangxi to-cross 1* and Zhongdan 1, a few farmers in both villages like *Zhongdan 1*, a single-cross F 1 hybrid, more than half of the farmers like *Guangxi top-cross 1*. The farmers in Zhichen ranked *Tuxpeño 1* as first over *local white,*

Table 7-20: Preference of five commonly used varieties in Zhichen village

Variety	Best		Very good		Good		So so		Not good		6**		Nonuser
	No	%*	No	%	No	%	No	%	No	%	No	%	No***
Tuxpeño 1 (OPVs)	44	44	10	10	4	4	--	--	--	--	42	42	--
Guangxi top-cross (hybrid)	4	6	--	--	4	6	20	30	37	55	2	3	33
China single cross (hybrid)	--	--	--	--	2	4	3	6	45	86	2	4	48
Local white (Landrace)	9	9.3	39	40.2	6	6.2	--	--	11	11	32	33	3
Local Waxy (landrace)	--	--	7	7.1	49	50	17	17	6	6	19	19	2

*: Percentage of valid percent of users

**: 6 here means "different varieties have different characteristics and can meet my different requirement" which mainly answered by multiple varieties adopters. This is out of the scale of designed ranking and added later.

***: Nonuser is one who had not ever use the variety.

Source: Calculated from the survey data (1997)

Table 7-21: Preference of five commonly used varieties in Geyang village

Variety	Best		Very good		Good		So so		Not good		6**		NonUser
	No	%*	No	%	No	%	No	%	No	%	No	%	No***
Tuxpño 1 (OPVs)	45	46.4	33	34	3	3	1	1	5	5.2	10	10.3	3
Guangxi top-cross 1 (hybrid)	36	36.7	35	35.7	11	11.2	2	2	5	5.1	9	9.2	2
China single cross (F1 hybrid)	--	--	2	2.3	17	19.3	34	38.6	26	29.5	9	10.2	12
Local white (Landrace)	--	--	12	14	17	19.8	27	31.4	21	24.4	9	10.5	14
Local Waxy) (landrace)	--	--	17	18.7	32	35.2	14	15.4	18	19.8	10	11	9

*: See notes to Table-7-20

**: See notes to Table-7-20

***: See notes to Table-7-20

Source: Calculated from the survey data (1997)

whereas respondents in Geyang also ranked *Tuxpeño 1* as the first and the *Guangxi top-cross 1* as second.

There is an unexpected finding that most of the farmers have used the ranked varieties. For example, more than half of the respondents in the poor village have tried the two hybrids (see non-user in Tables 7-20, 7-21). This strongly suggests that experimentation with different varieties is common with farmers. Their preferences are decided by their different farming systems and based on their own experimentation. It would be wrong to talk of non-adoption of hybrids. In many cases they are rejected after careful scenting.

7. 6. Further analysis and conclusion

The above sections have presented the principle characteristics and differentiation by describing, comparing and analysing the relevant factors between the two sample villages. This section presents some further analysis to reveal the relationships between some crucial factors and to draw the conclusions of the survey.

- **The differentiation between the two types of farming systems** is great in terms of farming environment and social economic context. Although agriculture in both areas is small-holder agriculture, the maize farming systems are quite different in terms of land holding, dependency on maize, cropping and livestock systems, input investment, utilisation of maize, etc. These differences became much greater over the past two decades. Tremendous changes have occurred in both areas which are enlarging and speeding up the regional differentiation in the farming systems in the sense that agriculture in the relatively favoured area is increasingly diversified, commercialised and specialized. Meanwhile in the less favoured area agriculture is being abandoned by most of the men; only the women left behind are trying to maintain a sort of food self-provisioning farming system in which maize is playing a crucial role as the only staple food crop for the poor. In the favoured area, maize has become a feed crop for the commercialised pig raising which has emerged in the past ten years.

- **The main trend of adoption of maize varieties** in the two sample villages is different. Conclusively, the conventional hybrids, like *Guangxi Top-cross 1 and 3,* are considered as an appropriate variety by farmers in the relatively favoured area, whereas for the poor and environment harsh village improved OPVs like *Tuxpeño 1*, have been adopted widely. F1 hybrids, like *Zhongdan 1*, which is very popular in the Northern Plain, is considered as not suitable in either environments. These are the dominant adoption patterns in the three provinces, although there are some changes according to cropping season and certain individual farmers' preferences. Based on the correlation analysis, the relationship between adoption and farm size is not significant

in either village, since land is approximately evenly distributed over farmers. Although the scaling of land resulting from specialisation of agriculture is beginning in the relatively developed area, there are still no large scale commercialised maize producers in the research area. So it could be concluded from the survey that the different adoption patterns in the two areas mainly decided by the totally different farming systems resulting from their different social/cultural, economic and natural environments.

- **The change of adoption patterns** is revealed by the survey. Quite a number of farmers in the favoured area have shifted to the improved OPV, *Tuxpeño 1*. Meanwhile some farmers in the environmentally harsh area are trying hybrids. The main reason is the lack of appropriate and good varieties for either area. For the dominant varieties, *Guangxi Top-cross 1* and *Tuxpeño 1,* respectively, have been continually used in both villages for more than 10 years without renewal. In both cases farmers are searching for appropriate varieties. The farmers in the poor village are experimenting with hybrids and other new varieties, meanwhile the farmers in the favoured area are shifting to *Tuxpeño 1* and are maintaining it in better quality than that used in the mountainous areas. The Majority of *Tuxpeño 1* growers in the favoured area got their seeds from Wenteng, where a group of women farmers has made efforts to maintain and improved *Tuxpeño 1* and its seeds have diffused over the area (see Wenteng case in chapter 4). Furthermore, poor quality and unreliability of hybrid seed and other policy issues also contributed to the shift from hybrid to OPVs in the favoured areas. It could be concluded that lack of appropriate varieties and effective seed supply and insufficient institutional and policy support from the government for the changing farming systems are the main constraints to the maize production and main causes for the shift in adoption patterns. The shift strongly suggests the limitation of the formal seed system in meeting farmers' needs, either in supplying quality hybrid seed, or in improving appropriate OPVs. The case also implies that local breeding and farmers' own efforts in breeding are a necessary, if not the only, way, to fulfil farmers needs and interests. This is already wonderfully supported and illustrated by the case of Wenteng (see Wenteng case in Chapter 4).

- **The adoption time and diffusion process**; the adoption time of the two dominant varieties, *Guangxi top-cross 1, Tuxpeño 1*, follows the famous "diffusion curve", in that there were at first few adopters and then gradually more and more adopters. However, the time of adoption has little to do with the farm size but depends more on other factors in relation to social capital, like access to information and knowledge, personal relation with community leaders and extensionists, etc. Most of the earlier adopters are comparatively more active and informed farmers.

- **Farmer's efforts and their indigenous knowledge system** is functioning actively. Except for a few earliest adopters, the main source of information and seeds for most farmers are other farmers, i.e., neighbours and relatives. It was revealed by the survey

that neighbours and relatives are the most important source of OPV seeds, but that of hybrid seeds obtained from seed farmers is considered as the most reliable source of hybrids. Quite a number of farmers' primary reason for adoption is to "follow other farmers". The influence of other farmers is much stronger than that of the government extensionists.

It was also found that farmers, especially women farmers are quite experimental and they normally try new varieties in small plots before adopting or rejecting them. Indigenous knowledge and informal networks of technology development and dissemination have been playing much more import roles in meeting farmers' true needs than the formal institutions, which act more as government policy executing than an organisation serving farmers.

- **Farmers' preference and reasons for adoption of a variety** is determined by lots of factors which are shaped by the heterogeneous farming systems and the complex livelihoods. The criteria for variety selection are multiple, mixed and changing, depending on cropping season, intercropping, usage of maize, condition of land, availability of fertilizer and also the post-harvesting characteristics of the variety, such as storage, processing quality, etc. This is especially true when women become the main farming managers. Yield is not the utmost important factor for farmers in both cases. Quality is not that important for the relatively developed area, where maize is grown for feed, and it is preferred, but a bit of a luxury criterion for the poor who can not grow enough for their basic food supply.

- It is obvious from the survey that **women are the main agricultural producers, farm managers and decision makers on farming activities**, especially in their traditional domain, variety adoption and seed selection. However, it was further revealed by the survey that the women in the relatively developed village have more power in decision making than those in the poor village. According to the relevant data of the survey and the participatory observation this is mainly because of their economic status as indicated by women's own visible income. Based on the participatory observation and study during the survey, it was found that women in Geyang, whose earnings are the main source of their households' everyday spending, have stronger household decision-making power than those women in Zhichen where the husbands' remittances are the main source (in most case, the only source) of household income. Furthermore the higher education level and easier access to information among the women farmers in Geyang also contributed to their stronger decision making power than those who live in the isolated remote mountainous village.

Chapter 8

Conclusion: New Seed for the New China

8.1. Introduction

Before drawing the main conclusions, it is worth reflecting on the research problem, general purposes, basic objectives and some of the main research questions of the study in order to make the conclusion more responsive to and consistent with the research objectives.

This book presents an evaluation and impact study of CIMMYT Collaborative Programme on maize breeding in South-Western China. The general purpose of the study is to provide feedback to CIMMYT and Chinese NARS on the level of adoption and impact of the improved maize varieties bred through collective efforts, and then to examine the impact on the farmers, especially poor farmers, so as to generate information to evaluate how far the Programme has realized its general goal of poverty alleviation. Then, gaps and constraints are analysed to be able to suggest further improvement. Based on this general purpose, three basic research objectives were set for the research (cf. the three objectives in chapter one).

The impact study was carried out from a constructivist perspective, which means that the assessment not only focused on the general impact of the technologies, but also the process of technology development in order to generate information on the influence and effects of the technology on poor farmers, especially women in marginal areas, and other second generation issues concerning sustainability. Then, the analysis reflects on how the technologies were constructed so as to find out the reasons and causes for shaping the technologies with their different impacts on different areas and various groups of people. In order fully to realize these main objectives, the field research was designed in three phases, an exploratory and macro-level research phase, a qualitative phase of the in-depth case study at micro-level, and a quantitative research phase based on a farmer survey.

In order to conclude the study, first of all, the impact assessment at both macro and micro levels will be reviewed in the following section. Then, the main findings and a general conclusion are given in section 8.3. In response to the main findings and problems, a discussion about the limitations of the TOT model and alternatives for improvement will be presented in section 8.4. After discussion some implications and recommendations are presented for both CIMMYT and Chinese government for further improvement and policy making. Finally, some concluding remarks are presented to bring the whole book to a close.

8.2. Impact Assessment and Empirical Findings

8.2.1. Macro-level impact

The general impact of this programme is quite impressive. It can be concluded that the collaboration between CIMMYT Maize Programme and Maize Breeding Programmes in the three provinces of South-Western China has been fruitful in general. Now 65%

of the total maize area is covered by MVs (improved OPVs and hybrids), with 46% hybrids and 19% improved OPVs, while the rest are landraces. About 957,000 hectares are planted to the CIMMYT-related materials every year, which comprises about 43% of the total maize area in the three provinces. 73% of the total local releases have been based on CIMMYT germplasm during the period from 1980 to 1996. 87.3.% of the MVs currently used are CIMMYT-related materials. The total adoption of improved germplasm has been growing for both favoured and less-favoured areas during the implementation of the Programme in the last 15 years. There is little doubt that the wide adoption of the MVs has contributed significantly to the continuous increment in maize production and productivity in the last 15 years (cf. Figure 5-8: maize production trends in the three provinces).

Nevertheless, further study revealed that the types of materials adopted are obviously different in different environments. Improved OPVs are adopted mainly by farmers in environmentally harsh and rainfed areas. For instance, the three improved populations from CIMMYT , *Tuxpeño 1, Tuxpeño P.B. C15* and *Suwan 1* have had an annual adoption of 310,000 hectares, comprising about 15% of the total maize area since the early 1980s. They are mainly cultivated by poor farmers in the marginal and environmentally less-favoured areas with difficult and complex maize farming systems. The three improved populations, which were held and directly used by farmers, have become dominant varieties and contributed significantly to household food security and poverty alleviation in the rocky mountainous areas in the Southwest. Although this is not reflected in the state's statistic of modern technology (mainly hybrid) adoption, however, great impact through farmer's informal ways has contributed considerably to the realisation of the general objective of the Programme for poverty alleviation. In the environmentally favoured areas, top-cross and three-way cross hybrids are widely accepted and dominant, such as *Guangxi Top-cross 1 to 5,* which have dominated in the relatively favoured areas in Guangxi for about ten years. These are CIMMYT-related hybrids. The adoption of single cross hybrids is still limited despite the larger number of releases available (cf. chapter 5).

8.2.2. Micro-level variation and empirical findings

Despite the impressive achievement at the macro level, further in-depth case studies and participatory observation have revealed variation among regions, and differentiation among farmers, in coping with the MVs. It is noted that there exists a large gap between farmers heterogeneous needs and interests and the formal breeders' single minded pursuit of and interest in yield. This is especially true for poor farmers, mainly women, cultivating harsh farming systems in remote marginal areas.

For the more favoured area, top-cross and three-ways cross hybrids, rather than single-cross hybrids, are suitable and widely accepted by farmers. However, new materials for replacement of these hybrids are limited. For instance, *Guangxi top-cross 1 and 3* have

been continually used in Guangxi on large scale since 1985. The varieties were degenerated and this is one of the major reasons causing increasing shift from hybrids to OPVs by farmers in environmentally favoured areas (see chapter 5 and 6). As hybrids depend on the use of purchased input, such as seed and fertilisers, farmers' adoption of these technologies has been conditioned strongly by government policies and institutional constraints with respect to input supply, extension service, product prices. For instance, the lack of appropriate hybrid materials, the unreliability of seed quality and the great increase in the price of inputs such as fertiliser, all contributed to the shift. Of course changing socio-economic contexts and farming systems are also partially responsible for the shift.

Improved OPVs are appealing to farmers in the difficult maize farming systems. It was claimed by the poor farmers that OPVs do not require annual change of seed and are more adaptable to their harsh farming systems. However, the supply of improved OPVs is quite limited due to the public seed system's lower interest, and at times total lack of interest, in less profitable OPVs. In the remote mountainous areas, the major improved varieties are CIMMYT populations, *Tuxpeño 1 and Tuxpeño B.P. C15,* which have been continuously used for almost 20 years without replacement. They have degenerated greatly owing to inter-crossing with landraces. Not much public effort has been made to replace or improve them, but some female farmers have tried to maintain and improve these varieties (see the case of Wenteng in Chapter 4).

Therefore, it can be concluded that that farmers in both favoured and less favoured areas have problems to get access to the appropriate technologies they need. Moreover, it was found that in areas (favoured and less favoured), landraces are degenerating and disappearing, resulting from the large scale introduction of MVs, for instance the situation in Zhichen village (see chapter 6). So it can be concluded that it is difficult for high yielding MVs to reach the poor. Where they do reach the poor in some cases there is then a social cost, in terms of biodiversity loss. An example is *Tuxpeño 1 in* Duan county. As landraces and local eco-biodiversity are degraded, this implies loss of local development potential.

Feminisation of agriculture has become a common phenomenon in the research area. Women are playing a predominant role in agriculture, especially in food production. Women constitute more than 85% of the agricultural work force as the result of male out-migration. In both favoured and difficult maize farming systems, women are playing a dominant role in production and are fully responsible for post-harvest operations, seed selection and storage, and food processing activities. In most cases, women are seed selectors and plant breeders. They have different criteria, and valuable expertise for selection and breeding, from men, determined by their specific roles as farm managers as well as household managers. However, women's significant role is not recognised and their specific needs, interests, and expertise are largely neglected in the technology design, development and diffusion process by the breeders, extensionists and policy

makers due to the fact that the perceived image of the target farmer is still male (Because technologists work mainly or exclusively with male farmers). This is a consequence of long-established patrilineal tradition in the society, and patriarchal power in the public systems of China. As a result of productivity driven and gender-biased policies, the women farmers, who are overloaded by their multiple roles, are struggling to sustain the food security of their households and state in the face of enormous constraints and difficulties (cf. chapter 6). Under such circumstances new technologies have generated costs as well as benefits for rural women, especially these in poor marginal areas.

With a single-minded purpose of productivity increment and driven by market incentives, most public efforts went into the development and diffusion of uniform high yielding MVs, especially single-cross hybrids, which are considered by formal breeders and government professionals to be high value products according to incentive structures and the institutional values of government institutions as well as market. (cf. chapters 4, 5 and 6).

As a result, regional variation and user differentiation, in terms of gender, are largely neglected by the formal knowledge system. However, farmers, mainly women farmers, were making efforts to meet their own needs with their indigenous knowledge and through their own informal system, as for instanced by the dissemination and improvement of *Tuxpeño 1* and maintenance of the landraces in the two case villages (cf. chapters 4 6).

8.3. Main Theoretical Findings and General Conclusion

8.3.1. Institutional rather than technical constraints

It is argued by some researchers that institutional factors, i.e., organisational contexts, structure of values and reward systems, mainly account for the misfit of technologies or ignorance of marginal areas and poor farmers (Richards, 1997). Some technical factors, such as variety characteristics and environmental conditions, are responsible for failure at first sight. However, technical constraints can be overcome by breeding varieties with desired traits for target area (cf. chapter 4). Plenty of evidence and cases found in the research suggest that the real causes for the failure of the formal breeding programme to address the variation of farming systems and to respond to the heterogeneous needs of farmers in marginal areas are institutional rather than technical constraints.

The institutional constraints can be classified into two categories: a) those related to the focus and efficiency of the maize research and extension systems, b) those related to the effectiveness of the seed sector.

The public research systems have failed to develop varieties appropriate to the needs and circumstances of significant numbers of target farmers. This mainly results from

the public research focus determined by the government's F1 hybrid policy together with the market incentives which pushed F1 hybrid development and distribution in all types of environments. This generalised approach ignores environmental variation and largely neglects the specific needs, interests, and expertise of farmers, especially the poor and women in marginal rainfed areas. In the poor harsh environment the best opportunity for the resource-poor farmers to improve maize production continues to be improved OPVs in which farmers play major roles in seed multiplication and maintenance.

Driven by incentives both from the market and the government's hybrid policy the public seed system was not able to produce and deliver quality seed of appropriate types to farmers. Whereas the private seed production sector is quite limited and underdeveloped resulting from the centrally controlled seed policy. The poor functioning of the seed sector became one of the major constraints for maize production.

The debates over hybrids versus OPVs are also due more to socio-economic and institutional reasons than to the physical characteristics of these two types of materials (see chapter 4). Farmers' preference and shift to OPVs from hybrids in the two study cases resulted from institutional constraints, evidence in the lack of appropriate types of hybrids, poor seed quality and unreliability of supply, farmers' irritation at, and strong aversion to the Government's forced extension approach (the package including plastic mulching, quota, propaganda, etc.). In contrast, much evidence illustrated that it is technically possible to adapt hybrids in difficult areas, and that hybrids are acceptable by small and poor farmers, even if it is not the trust option. One convincing example is the case of F1 hybrid seed multiplication. Since it is commonly assumed that F1 hybrid seed is difficult for farmers to produce, commercialised seed production is stressed. But in the research areas, F1 hybrid seed is totally produced by small-scale farmers appointed by public seed companies (Chapter 5). Even some individual women farmers were trying to produce F1 hybrids 'illegally' for experimental and market reasons. The case of Wenteng (chapter 4), where women farmers chose to improve the OPV, *Tuxpeño 1*, rather than a hybrid is more due to the controlled seed system and seed laws than to women farmers' lack of capability to manage hybrids and produce the seed. As F1 hybrid seed production is a highly protected government section in China, private companies and individual are not allowed to do it without government permission (Seed Law, 1995).

The present phenomenon of the formal systems' increasing bias towards hybrids and farmers' increasing shift to OPVs noted in the field obviously illustrate the great and growing gap between the breeders and other professionals' interests and farmers' needs, which originate in and are shaped by their different social and institutional contexts.

8.3.2. Three constructions of knowledge networks

Turning now to consider technology design, development and transfer process, at international and national levels, the Programme traces out a top-down linear 'TOT'

framework, through which CIMMYT's improved germplasm make its way to farmers. This top-down linear framework tends to use one-way communication only, hence there is little feedback and participation from farmers, and it is difficult to make corrections (see Figure 5-2).

The research revealed that three major constructions of the knowledge networks can be distinguished with respect to the technology development and distribution efforts of the Programme. Each is shaped by different social force and contexts in different historical periods and operates at different levels. The three constructs are presented as follows:

1) The social and political contexts of 1960s and 1970s in the developed and developing worlds generated the TOT model, the Green Revolution and the technology, which set the institutional base and general mandate for CIMMYT and other CGIAR centres to contribute through research to sustainable agriculture for food security in developing countries. The Green Revolution (GR) technology works well in homogenous areas with uniform conditions and has contributed significantly to food security and poverty alleviation in the developing countries in general. However, it is found by many studies that some second generation problems regarding to equity and sustainability are emerging under new circumstances.

In China, the famine in late 50s to early 60s' and the socio-economic situation stimulated the construction of a modern technology oriented and hybrid policy which, together with a top down hierarchical public agricultural knowledge system, generated the Green Revolution in China. It is widely accepted that it has been a successful formula for increasing food production and productivity to ensure national food security. The equal distribution policy and the collective production system through people's communes, in Mao's period helped to prevent inequity and extreme poverty, despite the fact that poverty was not abolished by only equally distributed by this policy.

2) Since the introduction of the market economy in China, especially after the commercialization of the national research and extension systems, market forces together with the existing hierarchical bureaucratic systems have driven agricultural research towards an even narrower focus on hybrid breeding, and provided fewer and more limited options for farmers.

When we turn to observe the actor-network that has shaped up around this narrow focus and hybrid-biased technology development process, we had all actors, public institutions and government professionals were fighting for their own interests. This observation fits Richards' statement (based on Mary Douglas) that " ----our institutions do much of our thinking for us" (1998). The maize breeders give priority to hybrid breeding which brings high institutional value and market profit for them. The public seed companies work only on profitable hybrid seed production. They are the biggest beneficiaries of hybrid development. The extension agencies are making efforts to extend

these hybrid releases since they get part of the profit from selling seed. Above all, they all serve the single minded purpose of government to enlarge the hybrid growing area with general intention of increasing food productivity, meanwhile realizing their own goals and interests, professionally and financially, through the incentive structure within the system. As a result, farmers' different interests and needs, especially the specific needs of the poor farmers and women operating in difficult farming systems, are largely neglected and by-passed by the public knowledge systems.

3) The gaps between the demand and supply resulting from the different interests and needs of farmers and scientists stimulate the third construction of technology, i.e., the indigenous and informal knowledge networks of farmers and their own organisations. Interaction with their complex farming systems has made farmers understand their farming systems and their own needs better than anyone else.

The self-initiatives of the two village cases to maintain and improve their own maize varieties is largely a reflection of the inadequacy of the formal seed system and the initiative and capability of farmer-breeding and farmers' informal knowledge networks which play quite a significant, if not a dominant, role in meeting farmers' needs. Farmers know very well what they need for their farming system, as they try to maintain and improve local varieties while significant new varieties diffuse very quickly through their own informal networks, the example of rapid distribution of *Tuxpeño 1 and Tuxpeño BP-15* (cf. chapter 5 and 6).

The three knowledge networks around the Programme are social constructions that reflect their own social realities and contexts. Actors around each network have their own interests, goals, values and conflicts, which are different from these of actors in other networks. However, institutionally the three networks can be considered as belonging to the two major systems, formal and informal. The two systems operate separately at different levels and social spheres (see 4.4. in chapter 4). The formal research institutions with the TOT approach found it hard to understand the potential of the local knowledge and farmers' informal networks and failed to incorporate farmers' ideas and their participation into the technology design and development process of the Programme. This is one of the main reasons for the existing gaps between scientists' supply and farmers' need.

8.3.3. Some facts concerning the two knowledge systems

The field research of the present study has obviously revealed some existing facts about the two systems as follows:

1) The limitation and inadequacy of the public knowledge systems:
There emerges an increasing gap between the goals of government and farmers. Before the reform and the introduction of market economy, public research, extension and

farmers in collective production all served the homogenous goal of government to increasing yield by modern technologies. However, after the reform, the agricultural production unit changed from collective to household, and farmers no longer only serve the government goals. Instead they have more freedom to make their own decisions. This results in conflicting goals and interests of government and farmers, with the government's persisting emphasis on increasing food grain productivity, whereas farmers in different regions with different natural, socio-economic contexts have different goals and strategies in the new age (see the two comparative cases in chapter 6 and 7). The public research and extension systems still predominantly serve the goal of the government despite increasing role conflicts in their work. Moreover, they are driven by market forces in order to ensure their own survival in a new social context. As a result, farmers' different needs and interests, especially these of the rural poor and women with little resources in remote and less-favoured areas, have been largely marginalized or bypassed by the public knowledge systems.

2) The great potential and initiative of farmers' indigenous knowledge systems:
Much evidence noted in the field during this study illustrates that farmers' indigenous knowledge systems function and play a dynamic role in meeting farmers' needs and interests. It is shown by the in-depth case studies that small farmers, mainly women, are capable of doing hybrid seed production and that women farmers have great initiative and expertise in variety improvement and breeding

8.3.4. General conclusion

On the whole, the macro-level impact of the Programme is great and the collaboration between CIMMYT and China NARS is successful in realising the primary goal of increasing maize productivity. However, great variation between regions and differentiation among farmers, in terms of gender, have been missed and especially the interests and needs of the rural poor and women in remote and unfavourable areas are largely neglected in the technology design and development process guided by the state's single minded focus on productivity increment. This has generated differential impacts among rural populations, by environment and by gender, at micro-level. Moreover, the development and wide introduction of MVs, mainly hybrids, designed as uniform materials for a wide range of areas, have tended to deplete local biodiversity to a certain degree.

The Programme could have made a much greater contribution to the productivity and sustainability of poor rural areas than it has done to date, if the national public research and extension systems had better communication, interaction and integration with the farmers' knowledge systems. In order to realise the potential of agricultural research and better reach the poor, and women, in marginal areas, reform of the public knowledge systems to encourage the development of more responsive links and collaboration among the actors in global, national as well as farmers' own networks is

vital for food security and poverty alleviation, on the base of natural resources conservation in China.

8.4. TOT Model and Alternative Approaches

8.4.1. Limitation of TOT model and alternative

The identification of the three social constructions, and the limitations of the formal systems, adversely affecting the impact of the Programme, helps establish the argument that the Green Revolution approach reflects its social context. That it is appropriate and efficient for certain purposes in certain historical periods and in certain areas. Political, social, economic and environmental context does not guarantee that TOT is sufficient to address the diversity and complexity of emerging issues in the new China. New supplementary approaches are necessary under changed circumstances. The constructivist approach suggests that the key to new and appropriate technology is change in the social and institutional context of technology generation.

With respect to natural resources and agro-ecology the conventional agricultural management with its single minded aim of targeting only yields has tended to degrade natural resource and agro-ecology. From an ecological point of view, "Human effort to narrowly focus on maximising the value of one target variable such as crop yield by controlling the ecosystem has led to break-down and collapse of the ecosystem" (Holling, 1996). According to Holling, this ignores the importance of long-term successional dynamics, in favour of short-term output. The environment is inherently unknowable and continuously changing. It cannot be suppressed to serve a limited goal. Therefore, human-managed systems should not only synchronise with the expected values of natural system dynamics, but managers should recognise the variability in their flows and functions, and act accordingly. Hence, Holling raises the idea of *adaptive management* which relies on flexible, diverse and redundant regulation, monitoring for responsiveness, and experimental probing rather than control and exploitation (Holling, 1996).

Moreover, as revealed by lots studies that women are the mainstay of small scale subsistence agriculture resulting from male migration and the trend of feminisation of agriculture in the developing world is obviously increasing (FAO, 1997; Jiggins, 1998). According to FAO's analysis based on data from 1950 to 1990 for the 1996 World Food Summit, women now exceed men as a proportion of the economically active population in agriculture in Africa and Asia. In China women increasingly become the dominant force in agriculture especially food production in the current social transition period. The present study revealed that women comprise more than 85% of the agricultural labour force at the two counties level, whereas the proportion of women farmers at the two villages level is as high as 90% (cf. chapter 7). The women farmers are playing key roles in food production and food supply management within their households. It is

their work that sustains food security at both national and farmers' household levels. However, many evidence in the present research suggests and confirms that poverty, and food insecurity have a disproportionately negative impact on rural women, due to their inferior social-economic status as well as their key roles as food producers and household managers (FAO, 1997). Continuing to ignore women will definitely threaten food security, poverty alleviation and natural resource conservation.

With reference of Conway's (1994) enumeration of the four indicators of agricultural performance (productivity, stability, equity and sustainability), policy making should consider, combine and balance the four indicators as policy goals in order to have a sustainable agriculture development. Getting productivity on the one hand and sustainability, equity and stability on the other, trade off among policy goals will be crucial for a healthy agricultural development.

In China, the whole agricultural institutional framework and the assumption of the so called Green Revolution approach is based on the linear "TOT" model, which has long centred on productivity by following a modern technology oriented approach through the formal research and extension system to ensure national food security. Trade-off among the policy goals of productivity, sustainability, stability and equity is quite limited and very difficult to operationalize.

As revealed by the present research, there is a gap between the government's supply of homogenous technology for yield increment and the heterogeneous needs of farmers in various environments. Poor farmers in environmentally unfavourable areas, especially women, urgently need appropriate technologies and efficient institutional support to reduce their poverty (See Duan case in chapter 6). Even in the Green Revolution areas, increasing heterogeneity resulting from environmental and socio-economic changes is difficult to satisfy with monoculture MVs, the end product of the linear process (see Wuming case in chapter 6). Meanwhile, degradation of natural resources and biodiversity (genetic diversity of maize), is happening (Duan case in chapter 6) mainly resulting from the use of several uniform MVs dominant over large parts of the area for a long period.

Confronting the rapid changes in the economy, social and natural contexts in China today, the TOT approach and the corresponding agricultural research and extension institutional frameworks are apparently not sufficient to deal with the emerging challenges in food security, poverty alleviation and natural resource conservation. It is increasingly realised that a combination of all four policy goals, rather than only productivity, is essential for a sustainable agricultural development. However, as Röling states "It is impossible to introduce more sustainable forms of agriculture through conventional technology transfer mechanisms" (1998). A more flexible institutional framework and comprehensive approach is needed to integrate more complex, varied perspectives in order to manoeuvre among the different policy goals, based on a more adaptive, rather than controlling, strategy. This change from control to adaptation in

technology generation will be critical in dealing with the emerging challenges of the new social contexts.

8.4.2. Combination of different approaches and tapping the potential of farmer

Given the specific situation in China and reflecting on the two scenarios described in chapter 1, a combination of the present modern technology-oriented approach and participatory approaches to involve farmers, mainly women, and their indigenous knowledge, and traditional farming practices, seems realistic and necessary to deal with the emerging issues. The combination of the approaches leads towards a more flexible, diverse, and more sustainable approach, allowing agriculture to take account of the heterogeneous needs of farmers, especially the specific needs and interests of women farmers and the basic dynamics of the agro-ecosystem. Only so could it be possible to change from agricultural management targeted only on productivity to more responsive and adaptive management for sustainable agricultural development

8.4.2.1. Reconsideration of the historic heritage and farmers' indigenous knowledge for the newly emerging challenges

China is one of the civilized ancient countries in the world with an agricultural history of more than two thousands years. It is well known for its traditional agricultural ideologies and farming technologies which contributed considerably to the country's development and prosperity in history (Bray, 1986). Reconsideration of this traditional heritage might highlight the search of new approaches dealing with the challenges confronting China today. In context of the present research some basic traditional ideologies and significant farming practices are remembered as follows:

1. The first is the popular ideology that: 'People are the base of a state, while food is the life of people, therefore agriculture, especially food production, is the base for the base', which is the basic philosophy fostering the idea of food self-sufficiency and underpinning the development of Chinese culture.

2. The traditional ecological ideology is expressed by a popular Chinese saying: "Heaven has its seasons, earth has its balance and people have their agreeableness" which describes the perfect harmony that should ideally exist between man and nature and in human society. The relationship between human and natural systems and the nature of their interaction became one of the most important debates starting in 300 BC which led to different thoughts in Chinese history (Gou, Zhao and Song, 1985). These illustrate the ancient Chinese people' consciousness of the conjunction of the agro-ecosystem and human society and rational utilisation of natural resources. These ecological ideas are reflected in traditional farming practices which intensively use natural recourses while maintaining ecological resilience through recycling.

3. The traditional intensive and meticulous farming system has played a crucial role in fostering and maintaining the Chinese culture and feeding its people. It is a rational cultivation system including intercropping, multicropping, rotation and fallow systems (cf. Bray, 1986).

4. Given that most farmland in China has been cultivated continuously for thousands of years, it is remarkable that soil fertility has not declined much. The traditional farming practices to maintain the fertility of land and soil are significant for Chinese agriculture to feed the increasing population with the limited arable land. "Conserving land while using land" became one of the most important farming principles for Chinese peasants. The important methods of land conservation are biological ones, such as rotation cropping of grain and beans, use of green manure, and efficient utilization of organic manure, reflecting farmers' consciousness of the inherent balance of land.

5. The traditional and indigenous knowledge of variety selection and agro-biodiversity management and conservation is very rich in China at the farming level. Several spices and varieties of plants and animals used world wide were domesticated and selected in China. Moreover, for farmers, yield is not necessarily the most important criterion for selection, instead more consideration is given to the sustainability of the entire livelihood and life style. For instance, there is a popular farming idiom " when growing grain, one must cultivate at least five varieties to prevent calamity". By-products and post harvesting characteristics are also important criteria for selection. These indigenous ideas and methods contributed significantly to biodiversity conservation in China.

Many traditional ideologies and farming practices are still maintained and practised by farmers to a certain degree in certain areas. Rethinking this historical heritage does not mean we should return to pre-industrial agriculture. However, a combination of traditional technologies from farmers' indigenous level and modern technologies from the scientific level might provide a great opportunity for additional food production and productivity gains while conserving natural resources. As farmers know their farming system best and scientists have the knowledge of scientific principles, collaboration between farmers' indigenous system and the public formal system could be a starting point to change the linear bureaucratic system. A co-operative relationship between the two systems, rather than a separated and conflicting one, is logical combination to meet both the state's need for national food security at the macro level, and the farmers' need of household food security and sustainable livelihood at the micro level.

8.4.2.2. Women's critical role in food production and household welfare

Major economic and social transformations are occurring in China which are changing the structure of agriculture and rural households. As part of the transition, male out-

migration from agriculture is generating what is known as the feminisation of agriculture (Jiggins, 1998).

The traditional pattern of obligations in the rural household, i.e., "the men till and the women weave", changed into "the women till and the men work in industry" (cf. 2.2.2.5 in chapter 2 for the discussion of reasons and causes).Women became the dominant force in agriculture, especially food production. In the research area covered by the present study, women comprise more than 85 percent of the actual agricultural labour force, the proportion of women-headed household in the two research villages is as high as 90% (cf. chapter 6 and 7 for the relevant qualitative and quantitative findings).

Much evidence in the present research illustrate that in both favoured and difficult maize farming systems, women are playing key roles in production and are fully responsible for post-harvest operations, seed selection and storage, and food processing activities. In most cases, women are seed selectors and plant breeders. They have different criteria and valuable expertise for selection and breeding from men, determined by their specific roles as farm managers as well as household managers.

In the poor marginal areas, women are playing crucial roles in subsistence, self-provisioning food farming, while women farmers in the relatively favourable and developed areas are playing multiple roles in production as main food producers, important cash crop growers and farm enterprise managers in diversified agriculture. Meanwhile, the women are still playing their traditional roles in the family. As a result, their labour burden has increased significantly. This is especially the case with the women in the poor remote areas. With their husbands working far away from home, these women alone are taking care of their families as well as their farms at subsistence level. *"It is women's work which sustains smallholder production and family well being"* (Jiggins, 1998). This generalisation has been further supported by the present research.

Neglect of gender issues and its consequence for women and the whole society

However, women's significant role is not recognised and their specific needs, interests, and expertise have been neglected by public research and extension systems in technology design, development and diffusion. This is due to the fact that the perceived image of a farmer is still male and breeders, extensionists and policy makers work mainly or exclusively with male farmers who are seldom doing the farming activities now. The durability of this outdated stereotype reflects the deeply entrenched patriarchal traditions of Chinese rural society, replicated by patriarchal power in the public systems in China.

The high yielding MVs are rarely targeted at women or designed specifically for their needs and interests. Extension services tend to be gender-biased service, and patrilineal and patriarchal traditions in family and society tend to impose greater costs than benefits on rural women under current transformations. As the result of productivity driven and

male-biased policies, women farmers, overloaded by their multiple roles, are struggling to sustain the food security of their households and the state. This confirms earlier work by the author that Chinese rural women's labour, lower paid or unpaid, has subsidised and benefited the Chinese economic development much more than the other way around (Song, 1993). Gender inequities tend to be increased and reinforced under current rapid development.

Moreover, many findings of the present study suggest and support the notion that poverty and food insecurity have a disproportionate negative impact on rural women, due to their inferior social-economic status, as well as their key roles as food producers and household managers (FAO, 1997). This is especially true with the single adult women-headed households in the poor unfavourable areas. These women became the poorest of the poor.

So continued neglect of women's specific needs and interests, and neglect of their expertise in agricultural technology design and development, will definitely hold output and welfare below potential (Jiggins, 1986), which in turn will threaten food security, poverty alleviation and natural resource conservation.

A more equal distribution of existing resources between women and men and sufficient attention to address the specific constraints women faced are urgently needed for an equitable development and could substantially contribute to reduce poverty and ensure food security at the farmer household level (Jiggins, 1986, Quisumbing, Brown et al. 1995). Overall the book has argued the case for greater flexibility in technology generation approaches. This is to ask for a flexibility capable of responding to the distinct needs of impoverished rural women experiencing rapid change. This is the focus of next section.

Integrating gender concerns and analysis in agricultural research and extension

It is women who are playing key roles in sustaining small scale subsistence farming and food security at both the farmers' household level and the national level. Therefore, integrating gender concerns and analysis, and enhancing the participation of women in the process of technology design, development, and diffusion is central, not optional, in addressing the issues of food security, poverty alleviation and biodiversity conservation.

8.4.3. Collaboration of the two systems

Efforts are undertaken to combine the formal and informal systems in plant breeding by IARCs, NARCs, NGOs and farmers' organisations. However, the ways of combining the two systems are complex and controversial. In my point of view, collaboration is more realistic than combination, as they are totally different systems, theoretically, institutionally and technically and have different bases. Actually the two systems are

playing different roles (Hardon, 1995) at different levels and they can supplement and complete each other through collaboration.

Decentralisation of the formal systems and involvement of farmers in the technology design and development process is necessary and essential to stimulate collaboration between the two systems through mutual communication and understanding. The informal sector needs to know more about the complex ways of biotechnology, while the formal system need to know more about the complexity of poor farmers' farming system and their livelihood. For instance, the importance of farmers' knowledge of landraces and their understanding of the micro-variations in the environment could become the basis for local level breeding or location-specific breeding. Through farmers' participation and cooperation, breeders can gain new insight in criteria, objectives, or evaluation techniques of farmers and the differentiation between regions and types of farmers (in terms of gender). As a result, appropriate varieties within a wide range of options can be produced to meet the heterogeneous needs resulting from regional variation and user differentiation.

A lot of evidence in the present research indicates that farmers have been trying all the time to get support and help from scientists. The case of fruit trees in chapter 6 illustrates farmers' initiatives and efforts to collaborate with scientists. Farmers' own systems in seed selection and dissemination have existed and functioned at the grass-root level, though they have been largely neglected by the formal system. The indigenous knowledge system and the local process, whether known or not, is working all the time and playing a dynamic role in meeting farmers' needs and interests. This has been obviously illustrated by the experience with CIMMYT's *Tuxpeño* varieties in the South-Western China. First the *Tuxpeños* have been distributed and spread rapidly, covering a large range, mainly as result of farmers' own initiative and through the farmers' own informal system (cf. chapters 5 and 6). Then, the same varieties are upgraded and improved by women farmers themselves using mass selection methods. This improvement is totally based on women farmers' own initiative and organized by them at the village level (cf. Wenteng case in chapter 4). These CIMMYT populations are popular with the poor and women in the marginal harsh area and have contributed significantly to local food security and poverty alleviation.

Cooperation between formal and informal knowledge systems through participatory methods and gender analysis has increasingly drawn attention from IARCs and NARSs. The CGIAR has increasingly seen the participation of farmers, particularly women, as vital to technology design and development (CGIAR, 1996 and 1997). Participatory plant breeding (PPB) and gender analysis (GA) approaches are increasingly considered an alternative to complement the limited and insufficient GR approach and TOT model in formal plant breeding.

Additional effort, however, is needed to institutionalise these approaches in order to stimulate the collaboration between scientists and farmers. This raises such questions

as: how can the collaboration between the two systems be shaped theoretically, institutionally and technically? What are the appropriate forms and degrees of farmers' participation? Some ideas are presented in the following section with reference to participatory plant breeding (PPB) and Gender Analysis (GA) in the context of China.

8.5. Implications for Practice

Based on the above empirical and theoretical findings, and discussions, some implications and recommendations are drawn for practice for both CIMMYT and the Chinese government, particularly the public agriculture knowledge systems (including NARS and MoA).

8.5.1. The role of CIMMYT

Conforming to its mandate, the role CIMMYT played in the Programme is to help the poor and ensure their food security through technology, i.e. improved maize germplasm. So the key component of CIMMYT's work in the Programme is to develop improved germplasm with built-in high yield capacity and tolerance to pests, diseases, etc., and to supply it to the public maize breeding programmes in South-Western China. By and large CIMMYT has supplied a wide range of materials, including different types of materials for hybrid development and OPV improvement for selection and requirement by the Chinese NARS. Although CIMMYT has traditionally followed an OPV approach in its research, it adopted an open policy in its collaboration with the Chines NARS. So the choice of research focus and priority has rested largely with the NARS. In our case, the focus on hybrids or/and OPVs for the favoured or less-favoured areas has been decided by the Chinese Government.

In the context of China, which exclusively centres on hybrids for high yield, almost all of CIMMYT's improved germplasm went through the public systems and was used for hybrid development. Therefore CIMMYT's formal impact is mainly reflected in the adoption of CIMMYT-related hybrids and yield increment at macro-level with limited benefit for resource poor farmers in marginal rainfed areas. Nevertheless, CIMMYT's great impact on these poor farmers continues in an informal way through the wide distribution of CIMMYT's improved populations through farmers' own systems. Although this was not intended by Chinese NARS and CIMMYT, yet it contributed significantly to the household food security and poverty alleviation for the poor and women farmers in the harsh mountainous areas.

CIMMYT actually plays a double role, i.e. a formal role through the public systems and an unintended potential role through the farmers' informal system. When CIMMYT's

technologies reached the limit of success in terms of reaching the poor in a formal way, their impact has continued in an informal way.

The absence of an appropriate institutional and policy framework to support this "double edged" technology design, development and diffusion process, as happened in China, has affected impact adversely, especially on the poor and on women in marginal areas. Appropriate institutional mechanisms and policy frameworks are crucial and urgently needed for improving the situation in China in order effectively to address the issues of food security, poverty alleviation and natural resource conservation in more sustainable and equitable ways.

As CIMMYT has long been searching for ways to improve the performance of NARS and capability building of NARS is one of CIMMYT's main approaches for effectively realising its general mission, CIMMYT has a role to play in bringing farming system research perspectives and participatory and gender analysis approaches to China in order to have a more effective collaboration and partnership with Chinese NARS.

CIMMYT has already given Chinese NARS great support in technology but it should not limit its role to germplasm supplier in China. CIMMYT can further support and help the Chinese NARS by assisting its institutional readjustment and by introducing user-oriented and farmer participatory approaches. It would offer China great opportunities to increase agricultural production and meet the needs of farmers in both favourable and marginal areas. If this happens, it can provide opportunities, perhaps no less important than those offered by technological support, to improve the food security and poverty alleviation both at national and farmers' household levels. In return, better impact, both at macro and micro levels, of CIMMYT's technology could be achieved.

Moreover, given the specific situation in China, CIMMYT should adopt a twin-track approach to cooperate with both formal and informal systems in order to bring collaboration of the two systems and achieve better impact of CIMMYT's technology. The following section is an attempt to spell out some issues involved in introducing PPB and GA approaches to China. Relevant theoretical and technical issues are mentioned linked to some concrete cases in the context of CIMMYT's Collaborative Programme.

8.5.2. Theoretical, institutional and technical issues relating to PPB and GA for the improvement of the Programme

The main concern in introducing PPB and Gender Analysis in the Programme is an attempt to develop a two-way communication approach, i.e., a twin track approach to combine formal breeding systems with farmer-breeding by stimulating communication and interaction between the two systems among the different actors at different levels for the improvement of the Programme in particular, and that of the situation in China in general.

Theoretical and institutional dimension: constructive perspectives

Institutional interactions are an inherent part of the collaboration between the two systems through Participatory Plant Breeding, and will involve IARC, NARS, in our case CIMMYT and Chinese NARS, extension agencies and seed companies (MoA system), farmers and their organizations. However, arriving at a common shared agenda among actors, institutions and individuals, who are likely to have very different objectives, is a great challenge. How to articulate these actors in the two systems and how to combine the farmers' approach with the so-called Green Revolution approach and to lead a sustainable collaboration of the two systems, scientific and indigenous, becomes our central challenge.

Two important constructive perspectives, the Actor-Network approach and Agricultural Knowledge System (AKS) are used in a complementary way for the exploration of the theoretical and institutional basis for the collaboration.

a) *The Actor-Network approach is used to identify the networks* around the programme with their different interests, goals and conflicts at different levels, global, national, regional and farmer's household. The Actor Network approach can be used to explore the existence and potential of farmers' networks and to stimulate the articulation and collaboration between the formal networks and farmers' networks. The Actor Network approach emphases the coalition of interest that emerge around certain resources, technologies, or access to power, and their struggles (cf. chapter 2 for detail of Actor-Network approach). In this respect, the Actor-Network approach is useful, for example, in understanding the tendency for the traditionalists in the formal system to try to maintain the TOT approach and the centralisation of the knowledge system. A new role for farmers' networks implies conflict and struggle, and policy intervention to strengthen farmers' interest and influence in the system. Farmers are seen by Long (1997) as active strategizers who problematize situations, process information, and bring together the elements necessary for operating their farms, i.e., farmers are actively constructing their own farming world, even if they internalize external modes of rationality.

b). *The Knowledge System (AKS) perspective and its methodology RAAKS are used to facilitate the interaction and articulation of identified networks* through communication, collective learning and negotiation (cf. chapter 2 for more detail of AKS). Whereas the Actor-Network approach emphases interest coalitions and their strategic manoeuvring, the AKS approach emphases the potential of facilitating shared learning and collective action among diverse but interdependent actors (Röling, 1990, 1996, 1998). Through these facilitating activities, a mutual understanding among different actor networks at different levels in the programme i.e., the international, national, regional and farmers' levels, is sought as a basis for the collaboration between formal and farmers' knowledge systems, and reaching common goals, i.e., to develop healthy and appropriate technologies for farmers in different environments, particularly the rural poor and women,

in order to tackle food security and poverty alleviation at a sustainable and equitable agricultural development base.

Technological aspect: mutual learning and benefit between scientists and farmers

Encountering the complexity and diversity of the different needs and circumstance at farming level, we should have a flexible plant breeding strategy with multiple goals. However, it's not easy to compose such strategies.

Hardon (1997) believes that farmer breeding and formal breeding generally occupy different niches, sometimes on the same farm. Farmer-breeding flourishes for crops ignored by formal breeding, but also in areas too marginal or remote to be effectively reached by formal breeding. For instance formal breeding focuses on population in order to enlarge the gene base. Thus CIMMYT follows a strategy that centres on populations with a broad genetic base and on germplasm testing at multiple sites to generate performance data from a wide range of environments. Farmers maintain landraces for local use, specific preference and conservation of diversity. Moreover, as revealed by the present research, the public systems plays an important role in research and distribution of hybrids for farmers in favourable areas, while, the farmers in less favourable areas play major roles in OPV improvement through seed multiplication and maintenance.

A more local level focus on breeding with participation of farmers at the early stage of technology design and development is very significant to address the diversity of small farm circumstances under which maize is grown in China. Farmers' indigenous knowledge of landraces and farm management, their understanding of their farming systems, and their adaptive strategy could become the basis for such local level focus on breeding. Then the collective efforts of farmers with indigenous knowledge and scientists with modern technology will contribute to the development of appropriate technologies tailored to the diverse needs and circumstances.

Technically the two systems can really play different roles in collaborative and supplementary ways. Therefore, the main factors which hinder farmers from fully playing their role in the technology development process are institutional obstacles rather than technical ones as described earlier. Millar (1993) argues for the development of a more holistic approach to research, which allows farmers to process technology in accordance with their worldviews and enables them to play a greater part in the processes of research with the aim of creating more flexible technological options.

The central question thus becomes: how can the institutional obstacles be overcome? Integration by continuous interaction and conflicting, collective learning and negotiation through communication, etc., are raised by some relevant perspectives discussed earlier. Hereby, a collective project between women farmers and scientists is proposed based on the two women breeding case in Wenteng and Zhichen villages (cf. Wenteng and

Zhichen cases in chapter 4). Some ideas concerning hybrid breeding, hybrid seed production, and OPV improvement with collective forces are discussed with reference of the two concrete cases to illustrate how it might be possible to overcome institutional obstacles and place appropriate varieties in the hand of the poor, and small farmers.

8.5.3. Some ideas about a proposed project for women-farmer breeders

Main objective

Such project might serve as a pioneering study to explore the institutional mechanisms and technical possibilities of implementing participatory plant breeding and gender analysis approaches in the context of China. Meanwhile it serves to show-case the initiatives and experimental capabilities of farmers, particularly women, and the possibility and potential of a direct collaboration between farmers and scientists in plant breeding and hybrid seed production. It will be possible to gain valuable insights by close monitoring and research in the field to highlight the significance of participatory research and gender analysis for technology development for the improvement of the public research and extension systems in China. Such concrete cases would be helpful for Chinese policy-makers, providing them with more useful, visible and convincing information to help them consider the change from a fully government-oriented approach towards a more user-oriented, farmer participatory and gender responsive approach. Moreover, participation is an efficient way to empower farmers, especially women and their organisations, which is urgently needed by the women farmers confronting the increasing market-oriented economy and changing contexts in China. The following are the two cases in the proposed project.

1) Collaboration between women farmers and scientists in hybrid breeding and seed production in Wenteng village

It is assumed that hybrids are inappropriate for small and poor farmers in environmentally unfavourable areas owing to seed production requirements and other technical constraints. A common assumption is that hybrids are for large scale farms and that commercialised seed production is necessary. However, it was found by the present research that the actual obstacles that hinder hybrids reaching the small and poor farmer are more institutional and economic than technical (cf. chapter 4 and chapter 8). Some potential technical constraints, such as characteristics of hybrids and environmental conditions of small-scale subsistence farming, can be overcome by breeding hybrids with desired traits for a target area, -by breeding for stress tolerance for instance, in terms of drought and low-N availability, typical in small-scale subsistence farming. Actual factors constraining the availability of appropriate hybrids for the poor and small-scale farmers are more related to research focus and breeding priority, and to incentives of national research and seed production sector. In reference to the present research, direct collaboration between women farmers and scientists in two aspects, i.e.,

hybrid breeding priority setting and hybrid seed production, are crucial to overcome some of these institutional constraints in the present context of China.

a) Hybrid breeding priority setting: It is noted in the present study that priority setting is crucial for targeting on poor and small farmers in marginal areas. Two research focuses can be followed for the targeting. First, research on hybrids' adaptability to difficult and heterogeneous farming systems which is quite important to bring hybrid to small farmers. Women farmers can participate with scientists in the early stage of farming system research and indicate desired traits for breeding based on women farmers' own understanding of their farming system and their needs and preferences. Based on this information scientists can play major roles in finding out and combining ideal genotypes for the target farming system. Second, research on area targeted and local-level breeding with local women farmers' participation in the whole process of technology design, development, and diffusion. Women farmers' indigenous knowledge, expertise and their understanding and adaptive strategies in relation to their own farming systems and contexts together with scientists' scientific knowledge, principles and techniques, can be used in supplementary ways in local level breeding targeted on women farmers' needs and interests.

b) Hybrid seed production by farmers: It was found in the study that small farmers are capable enough to do hybrid seed multiplication. So direct collaboration between women farmers and formal breeders in hybrid seed production could be a highly desirable way to develop hybrids for small scale and poor farmers in subsistence maize farming systems. Formal breeding could provide inbred lines and scientific knowledge, e.g., the principles and ways for separation, etc. Women farmers' incentives and carefulness, their indigenous methods, and their adaptive strategies to variable physical conditions and social/cultural and economic requirements could play a crucial role in seed selection and hybrid seed production for their own farming systems.

2). Women-led OPV improvement in Zhichen village

CIMMYT improved populations are appealing to the farmers in difficult maize farming systems in the harsh mountainous areas in the Southwest and they are playing dominant roles in food security and poverty alleviation at farmers' household level. This is mainly due to the fact that OPVs need less external inputs and are more stress tolerant compared to the recommended hybrids. Moreover, many findings in the present study indicate that OPVs are more manageable and less risky for resource-poor women farmers as they have play major roles in OPVs seed selection and plant improvement. However, just because of these farmer preferred characteristics, OPVs are less attractive to profit-oriented breeding and seed production. In the case of China, OPVs were ignored because the government's F1 hybrid policy.

Given the fact that there is great and urgent need for appropriate OPVs and insufficient supply and support from the public system, a women-led, CIMMYT supported OPV improvement project is highly necessary to meet farmers' urgent needs.

That women farmers can play dominant roles in OPV improvement has been demonstrated by themselves already in the Wenteng and Zhichen cases. However, some institutional support and technology supply from both CIMMYT and local professionals are crucial to institutionalise such farmer-oriented and gender-responsive plant improvement. For instance, supply of appropriate populations is necessary from CIMMYT directly to the women farmers in the village (this was a direct request to CIMMYT by the women farmers in Zhichen village during the author's field research there in 1997). Some policy support and technical instructions are needed from local authorities and scientists.

So direct collaboration between farmers and breeders and the two systems is possible and highly necessary to have more direct two-way communication and to prevent the existing institutional overlap and conflicts. Above all, it is central to reorient the public research and extension efforts to the marginalized areas and populations in order to have a more sustainable and equitable agricultural development.

8.6. Concluding Remarks

There is little doubt that agricultural innovation and technologies are important factors to increase food productivity and ensure food security. However, an innovation will work only if farmers adopt it. Farmers' adoption of a technology is determined by many factors. In respect to agricultural research and technology development it is crucial to produce appropriate technology to meet farmers' needs and interests.

The world is fast changing and some of the fastest change took place in China in the last two decades in social, economic and environmental contexts. Farmers in China are not a homogenous group now; instead they cultivate in heterogeneous and varied environments with contrasting socio-economic contexts. This is especially true with the case of maize which is cultivated in distinct environments in the Northern plain and the Southwest and has different roles in the two areas respectively. Even within the Southwest region the diversity of small-farm circumstances and the variation in farming systems results in heterogeneity of farmers' needs and interests for maize technologies.

The so-called Green Revolution approach, that is to tackle food security through dissemination of scale-neutral fertilizer-responsive improved food grain varieties (mainly hybrids in China), adaptable to a wide range of physical and organizational production contexts, and the corresponding research and extension systems for MVs, are increasingly insufficient and incapable to meet the heterogeneous needs of farmers.

In the author's point of view, research on more location-specific technologies is needed to produce a wider range of technology options tailored to diverse environments, both relatively uniform and favoured environment and complex and fragile ecosystems

in order to address the different policy goals rather than only the goal of productivity. Therefore, a greater institutional flexibility, responsiveness and decentralisation of the formal system and increasing involvement and participation of farmers in technology design and development are highly necessary to combine different strategies and approaches. Participatory and gender responsive approaches and farming system research methods could be very helpful for starting a mutual communication and collective learning process among actors from the two systems.

In the context of increasing market-orientation of the economy, the public systems have a continuing role to play to ensure the availability of appropriate technologies for farmers' different needs and circumstances, especially poor farmers and women in marginal and unfavourable areas. Therefore, the public systems should target on research and distribution of hybrids for farmers in favourable areas, with additional efforts given to the improvement of OPVs for less favourable areas in which millions of poor farmers cultivated.

There is little doubt that Chinese farmers are capable to continue to feed China in the future. However, this will depend on their access to the best technological options. Policy makers may be expect in the "big picture", but to the extent this big picture is made up of many little local pictures in a diverse and rapidly changing country. Scientists and policy makers need not only to acknowledge but actively work with the realization that farmers are experts in the little pictures. This book has demonstrated that in regard to difficult but diverse maize environments in SW China multiple perspectives on technological choice are likely to pay the best dividends.

Questionnaire of Quantitative Survey of Farmers

Respondent Number: 1 to 200
Date of interview:(for reference of interviewer only)

I. *Background information about the respondent and her household*

1. Name of the respondent's village:
   1. 0 Wuenxu
   2. 0. Zhichen

2. Age: ----------years old

3. Nationality:
   1.0. Han
   2.0. Zhuang)
   3.0. Yao
   4.0. other

4. Education:
   1.0. Illiterate
   2.0. Primary school
   3.0. Secondary school
   4.0. High school

5. Family size:-------

6. Husband's main work:
   1.0. Agriculture
   2.0. Non-agriculture

7. Husband's working place:
   1.0. Within the county
   2.0. Within the province
   3.0. Out of the province

8. Wife's main work:
   1.0. Agriculture
   2.0. Non-agriculture

II. *General information about the respondents' land, crops and cropping patterns and livestock*

2.1. Information about your land:

	Size: code	Pieces: code
Paddy land(irrigated)	9 -------	10 ------
Dry land(Non-irrigated)	11 -------	12 ------
Total	-------	------
Fruit orchard:	13 -------	------
Forest land	14 -------	------

2.2. Information about your main food crop and cash crop this year

	First season: area code	yield code	Second season: area code	yield code
Maize:	15 ---------	16 -----	17 ------	18 ----
Rice:	19 --------	20 -----	21 ------	22 ----
Sugarcane	23 ---------			
Peanut:	24 --------			
Bean:	25 --------			
Fruit tree	26 --------			
Cassava	27 --------			
Tobacco	28 --------			
Other	29 --------			

2.3. Information about your livestock

	Number: code
cattle	30 ----------
pig	31 ----------
goat	32 ----------
chicken	33 ----------
duck	34 ----------
fish pond:	35 ----------

III. Information about maize cultivation and varieties used in your farm

3.1. Information of maize cultivation in your farm the first and second seasons of this year

	First season: code	Second season: code
3.1.1. Varieties	36 ----------	37 ----------
3.1.2. Area	38 ----------	39 ----------
3.1.3. Yield	40 ----------	41 ----------
3.1.5. Amount of fertiliser used	42 ----------	43 ----------
3.1.6. Cultivating time	44 ----------	45 ----------
3.1.7. Harvesting time	46 ----------	47 ----------
3.1.8. Intercropping	48 ----------	49 ----------
3.1.9. Main usage	50 ----------	51 ----------
3.1.0. The varieties decider	52 ----------	53 ----------
3.1.2. The most important reason	54 ----------	55 ----------
3.1.3. First time used the varieties	56 ----------	----------
3.1.4. Source of seed then.	57 ----------	
3.1.5. Source of seed this year	58 ----------	59 ----------
3.1.6. Quality of seed	60 ----------	61 ----------

Note:

1) Varieties: 1=Singel cross hybrids, 2=Guangxi topcross 1-5. 3=Tuxpeno 1, 4=local white 5=local yellow 6. local waxy maize
2) Intercropping: 1=bean 2=sweet potato 3= cassava 4=other
3) Main usage: 1). as food 2). as feed 3). for quota 4). for market 5=1+2 6=2+4 7=2+3+4
4) The varieties decider i.e. who decided to use the varieties; 1=husband 2=wife 3=together
5) The main reasons: 1=high yielding 2=drought resistant 3= decease and pest resistant 4=resistant to lodging 5=ideal plant height 6=good colour for food and good taste 7=easy cooking 8=good for animal feeding 9= easy for storage 10=good for intercropping. 11=heavy in weight.
6) Source of information and seed : 1=extension station 2=seed company 3=free market 4=seed farmers 5=neighbour and relatives 6. self selected
7) Quality of seed: 1=good 2=ok 3=so so 4=not so good 5=not good

3.2. The varieties you have used and their characteristics:

variety / characteristic	code	Guangxi top-cross	Single-cross	Tuxipeno 1	local yellow	local white	local waxy	
yield		62	63	64	65	66	67	
fertilizer amount		68	69	70	71	72	73	
density		74	75	76	77	78	79	
drought resistant		80	81	82	83	84	85	
disease resistant		86	87	88	89	90	91	
pest resistant		92	93	94	95	96	97	
plant height		98	99	100	101	102	103	
plant shape		104	105	106	107	108	109	
lodging resistant		110	111	112	113	114	115	
colour		116	117	118	119	120	121	
taste		122	123	124	125	126	127	
cooking		128	129	130	131	132	133	
storage		134	135	136	137	138	139	
as pig feed		140	141	142	143	144	145	
as cattle feed		146	147	148	149	150	151	
inter-cropping		152	153	154	155	156	157	

note: 1.very good 2.good 3=not good 4=same 5=don't know

3.3. Grade the following varieties according to your comments

158.Tuxpeno 1----------
159.Gunagxi top-crosses----------
160.Zhongdan 1 and Shengdong single cross--------
161. Local white----------
162. Local yellow----------

1=best 2=good 3=so so 4=not good 5=different varieties have different advantages and weakness 6=don't know

VI. Gender division of labour:

Activities: \ time:	Present now	Before 1990	Commune period
ploughing land	163	164	165
prepare land	166	167	168
irrigating	169	170	171
buy seed	172	173	174
seed selection and storage	175	176	177
sowing	178	179	180
crop managing and fertilising	181	182	183
buy and transport fertiliser	184	185	186
fruit tree planting and managing	187	188	189
other cash crop	190	191	192
attending meeting	193	194	195
attending technological training	196	197	198
vegetable cultivation	199	200	201
big feeding	202	203	204
feed chickens	205	206	207
household sideline activities	208	209.	210
cooking	211	212	213
wash and cleaning	214	215	216
take care of kids	217	218	219

note: 1=husband 2=wife 3=old female 4=old male 5=husband and wife 6=wife and old female 7=old female and ole male

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Summary

China is the most populated country with the most limited amount of arable land per head of the population in the world. Development and distribution of modern varieties of the three staples, rice, wheat and maize, to insure national food security, have been the core tasks and first priority of its public research and extension systems since the early 1960s. This approach has been very successful resulting from the public effort and the initiatives and incentives of farmers. However, since the beginning of 1980s, China has begun to reform its economic and institutional systems and is experiencing a socio-economic transition period, from a planned economy towards a more market-oriented economy. New policies have been introduced and great changes have occurred in the social and economic context over the past 15 years. The changes that directly relate to agricultural innovation and food production are two important ones; rural reform started at the end of 1970s and commercialization of the public research and extension systems in the 1990s. As a result, more subsequent changes are emerging in the agricultural structure, the division of labour in the rural areas, and in the research orientation and incentives of public research and extension institutions. How to ensure food security, at both the national and farmers' household levels, through technology development and diffusion under the current circumstances in China becomes the main concern of this study.

This book focuses on the impact of agricultural technology and relevant key factors in food security. It uses a social constructivist perspective, not only in assessing the impact of technology, but also in tracing the whole process of technology development and diffusion as a social construction. The Collaborative Programme between CIMMYT and Chinese NARS on Maize Breeding in South-western China which started at the end of 1970s and which paralleled the reforms and experienced the changes, serves as an unique case for conducting a comprehensive assessment and analysis. It is expected that the impact study of the Programme will generate valuable insights into the future options and prospects for China's agricultural research and extension systems and highlight the emerging issues of food security, poverty alleviation and sustainable agricultural development in China.

The main objectives of the study are:

1. to evaluate the impact of CIMMYT derived technologies in terms of their adoption by farmers (yield, surface, type of technology adopted). This includes farmers' assessment of the technologies, the way they apply them, their sources of information, their access to inputs, and the market of the produce at the local level.

2. to study how the technologies were developed, the institutional contexts within which this happened, the objectives and perspectives of the scientists and officials

involved. The focus of this part of the study is on the analysis of the principal institutional and organisational factors influencing the design, development and diffusion of the technologies.

3. to identify the actors in the networks involved in the process of agricultural technology development and diffusion and examine ways for better linkage, integration and interaction between IARCs, NARS and the farmers' informal system, between formal science and indigenous science, and to find ways to tie into farmers' indigenous livelihood processes.

Multiple perspectives and indicators have been adopted and used in a comprehensive and complementary way to study the impact of CIMMYT-related technology at both the macro and micro-levels, in terms of the general increase in yields and coverage at the provincial levels and the farmers' responses and strategies with respect to the technology at the household level. Subsequently, the institutional context for technology development and distribution, as well as the farmers' indigenous knowledge development practices are analysed and reflected upon from a perspective influenced by the literature on the social construction of technology in order to reveal the processes through which technology and innovation are shaped by social action.

Empirically the study is designed into three major phases, i.e., exploratory, qualitative and quantitative. After the exploratory study at macro level, two distinct production environments, a relatively favourable area and a resource-poor and unfavourable area, are selected for an in-depth comparative case study using both qualitative and quantitative methods to address the emerging issues at the micro-level. The qualitative study is conducted through an in-depth investigation and participatory observation of farmers' responses and strategies towards the technology in the two contrasting farming systems. The quantitative study is carried out through a formal questionnaire survey of 200 farmers selected randomly from the two distinct case study areas. The research results of the three phases of field research were cross-checked with data and evidence obtained through different research methods.

The main empirical and theoretical findings of the research are:

- The macro-level impact of the Programme in the three South-western provinces, made visible by mainly by government's statistics, is large with respect to the total release of MVs, their wide adoption, and the increment in maize production and productivity in the last 15 years.

- Further in-depth study revealed the large variation between regions and differentiation among farmers, in terms of gender, in adapting to the MVs, which mainly resulted from the changes which emerged after the recent reforms. With a single-minded purpose to increase productivity so as to ensure national food security, and driven by

market incentives, most public efforts went into the development and diffusion of uniform high yielding MVs, especially single-cross F1 hybrids. As a result, regional variation and user differentiation, in terms of gender, are largely neglected in the technology design, development and distribution process by the formal knowledge system. This has generated differential impacts among rural people, by environment and by gender, at micro-level.

- Feminisation of agriculture has become a common phenomenon in the research area as a result of male-migration. In both favoured and difficult maize farming systems, women are playing a dominant role in food production and are fully responsible for post-harvest operations, seed selection and storage, and food processing activities. In most cases, women are seed selectors and plant breeders. However, women's significant role is not recognised and their specific needs, interests, and expertise are largely neglected in the technology design, development and diffusion process. As a result of productivity driven and gender-biased policies, the women farmers, who are overloaded by their multiple roles, are struggling to sustain the food security of their households and the state in the face of enormous constraints and difficulties. Under such circumstances new technologies have generated costs as well as benefits for rural women, especially these in poor marginal areas.

- There exists a large gap between farmers' heterogeneous needs and interests determined by their variable farming systems and livelihoods and the breeders' single minded pursuit of, and interest in, yield. This is especially true for poor farmers, mainly women, cultivating in harsh farming systems in remote marginal areas. However women farmers were making efforts to meet their own needs with their indigenous knowledge and through their own informal system.

- The real causes for the failure of the formal breeding programme to address the variation of farming systems and to respond to the heterogeneous needs of farmers in marginal areas are institutional rather than technical. Theoretically, from a constructivist point of view, the research revealed that three major constructions of the knowledge networks can be distinguished with respect to the technology development and distribution efforts of the Programme: Each is shaped by different social forces and contexts in different historical periods and each operates at different levels.

Confronting the emerging challenges of the new social context, a more flexible institutional framework and comprehensive approach is needed to integrate more complex, varied perspectives in order to manoeuvre among the different policy goals, i.e., productivity, sustainability, equity and stability, based on a more adaptive, rather than a controlling, strategy. Recommendations have been made for the improvement of the Programme in particular and for the public agricultural knowledge system in general.

1. A combination of the present modern technology-oriented approach and participatory approaches to involve farmers, mainly women, and their indigenous knowledge, and

traditional farming practices, seems realistic and necessary to deal with the emerging issues. The combination of the approaches leads towards a more flexible, diverse, and sustainable approach, allowing agriculture to take account of the heterogeneous needs of farmers, especially the specific needs and interests of women farmers and the basic dynamics of the agro-ecosystem. Only so could it be possible to change from agricultural management targeted only at productivity to more responsive and adaptive management for sustainable agricultural development

2. Decentralisation of the formal systems and involvement of farmers in the technology design and development process is necessary and essential to stimulate collaboration between the two systems. The informal sector needs to know more about the complex ways of biotechnology, while the formal system need to know more about the complexity of poor farmers' farming system and their livelihoods. For instance, the importance of farmers' knowledge of landraces and their understanding of the micro-variations in the environment could become the basis for local level breeding or location-specific breeding. Through farmers' participation and cooperation, breeders can gain new insight in criteria, objectives, or evaluation techniques of farmers and the differentiation between regions and types of farmers (in terms of gender). As a result, appropriate varieties within a wide range of options can be produced to meet the heterogeneous needs resulting from regional variation and user differentiation.

Samenvatting

China is het dichtst bevolkte land ter wereld, met de kleinste hoeveelheid landbouwgrond per hoofd van de bevolking. Sinds de zestiger jaren is de kerntaak en hoofdprioriteit van China's publieke onderzoeks- en voorlichtingsstelsel de ontwikkeling en verspreiding van moderne variëteiten van de drie hoofdgewassen, rijst, tarwe en mais, teneinde de nationale voedselzekerheid te garanderen. Deze benadering is succesvol geweest. Maar China is sinds het begin van de tachtiger jaren begonnen haar economische en institutionele systemen te veranderen. Het land ondergaat thans een sociaal- economische transformatie van een planeconomie naar een meer marktgeoriënteerde economie. Nieuw beleid is ingevoerd en belangrijke veranderingen in de sociale en economische context hebben in de laatste 15 jaar plaats gevonden. Twee van deze veranderingen houden direct verband met landbouwkundige vernieuwing en voedselproductie: de hervorming van het platteland aan het eind van de zeventiger jaren en de commercialisatie van het overheidsonderzoek- en voorlichtingssysteem in de negentiger jaren. De centrale vraag waar dit onderzoek zich op richt is hoe voedselzekerheid, zowel op het nationale als op het huishoudniveau, in de huidige omstandigheden in China door technologieontwikkeling en -verspreiding kan worden bevorderd.

Dit boek legt de nadruk op de invloed op voedselzekerheid van landbouwtechnologie en relevante kernfactoren. Het gebruikt een sociaal constructivistisch perspectief, niet alleen bij het beoordelen van de invloed van technologie, maar ook bij het traceren van de geschiedenis van technologieontwikkeling en -verspreiding als een proces van sociale constructie. Het Programma van Samenwerking tussen CIMMYT en de Chinese nationale onderzoeksinstellingen op het gebied van maisveredeling in Zuidwest China, dat aan het eind van de zeventiger jaren begon, en dat dus samenviel met de hervormingen en veranderingen, dient als een unieke casus voor het maken van een brede analyse en beoordeling. Men kan verwachten dat een studie van de invloed van dit Programma belangrijke inzichten oplevert voor keuzemogelijkheden en vooruitzichten voor China's landbouwkundig onderzoek en landbouwvoorlichting. Bovendien kan een dergelijke studie belangrijke vraagstukken betreffende voedselzekerheid, armoedebestrijding en duurzame landbouwontwikkeling in China belichten.

De belangrijkste doelstellingen van het onderzoek zijn:

1. het evalueren van de invloed van de CIMMYT technologieën in termen van de aanvaarding door boeren (opbrengst, oppervlakte, type van technologie). Dit omvat ook de beoordeling van de technologieën door boeren, de manier waarop ze technologieën gebruiken, hun bronnen van informatie, hun toegang tot inputs, en de markt voor hun producten op het lokale niveau.

2. het bestuderen hoe de technologieën ontwikkeld werden, de institutionele context waarin dit gebeurde, en de doelstellingen en perspektieven van de onderzoekers en

ambtenaren die betrokken waren. De nadruk in dit deel van de studie ligt op de analyse van de voornaamste institutionele en organisatorische factoren die ontwerp, ontwikkeling en verspreiding van de technologieën bed'nvloedden.

3. het identificeren van de actoren in de netwerken die betrokken waren in het proces van landbouwtechnologieontwikkeling en -verspreiding en het onderzoeken van de manieren waarop een betere verbinding, integratie en interactie tussen IARCs, NARS en het informele systeem van de boeren, tussen formele wetenschap en lokale wetenschap, tot stand kan worden gebracht, en in verband kan worden gebracht met lokale overlevingsmechanismen.

Meervoudige perspectieven en indicatoren zijn op een omvattende en elkaar aanvullende wijze gebruikt om de invloed van aan CIMMYT-gerelateerde technologie te bestuderen, zowel op het macro- als op het microniveau. Dit met betrekking tot de algemene stijging in opbrengsten en de verspreiding van de moderne variëteiten op het provinciale niveau en de boerenreacties en -strategieën ten aanzien van de technologieën op het huishoudniveau.

Vervolgens zijn zowel de institutionele context voor technologieontwikkeling en verspreiding, als de lokale boerenkennisontwikkelingspraktijken geanalyseerd, teneinde de processen, waardoor technologie en innovatie door sociale actie worden gevormd, in kaart te brengen. Dit is bekeken vanuit een perspektief dat bed'nvloed is door de literatuur op het gebied van de sociale constructie van technologie.

Het empirisch onderzoek waarop de studie is gebaseerd bestaat uit drie fasen: exploratief, kwalitatief en kwantitatief onderzoek. Na de exploratieve studie op het macro niveau, werden twee verschillende produktieomstandigheden, een relatief goed bedeeld en een relatief slecht bedeeld gebied, gekozen voor een vergelijkende case studie waarin zowel kwalitatieve als kwantitatieve methoden gebruikt werden om de teweeg gebrachte verschijnselen op het micro niveau te bestuderen. De kwalitatieve studie werd uitgevoerd door middel van een diepteonderzoek en participatieve observatie van boeren reacties en -strategieën met betrekking tot de technologie in de twee vergeleken landbouwsystemen. De kwantitatieve studie werd uitgevoerd in een survey van 200 boeren. Deze werden toevalsgewijze gekozen in de twee studiegebieden. In de survey is een formele vragenlijst gebruikt.

De belangrijkste empirische en theoretische uitkomsten van het onderzoek zijn:

- De invloed van het Programma op het macroniveau van de drie zuidwestelijke provincies, voornamelijk zichtbaar gemaakt door middel van regeringsstatistieken, is groot, waar het gaat om het totale aantal moderne variëteiten dat is uitgegeven, hun brede aanvaarding, en de toename in maisproduktie en -productiviteit in de laatste 15 jaar.

- Verdere dieptestudie laat zien dat er een grote variatie is in de aanpassing aan de verschillende variëteiten. Deze verschillen zijn tussen regio's maar ook tussen boeren,

en dan met name ten aanzien van de factor gender. Dit is onder invloed van de recente hervormingen: de meeste overheidsinspanning was gericht op het ontwikkelen en verspreiden van eenvormige, hoog opbrengende, moderne variëteiten, vooral enkel gekruiste F1 hybriden. Dit gebeurde vanuit een eenzijdig streven om de produktiviteit op te voeren teneinde de nationale voedselzekerheid te vergroten. Bovendien werd de overheid hierin gedreven door marktprikkels. Door dit eenzijdig streven werden verschillen tussen regio's en gebruikers (vooral waar het gender betreft) grotendeels genegeerd in het ontwerpen, ontwikkelen en verspreiden van de technologie door het formele kennissysteem. Dit heeft geleid tot differentiële invloed van de technologie op de rurale bevolking, afhankelijk van de lokale context en gender op het micro niveau.

- Feminisatie van de landbouw is een normaal verschijnsel geworden in het onderzoeksgebied als gevolg van de emigratie van mannen. In zowel het moeilijke als het beter bedeelde maisproduktiegebied spelen vrouwen een dominante rol in voedselproductie en zijn volledig verantwoordelijk voor de activiteiten na de oogst, voor zaadselectie en -bewaring, en voedselverwerking. In de meeste gevallen zijn vrouwen degenen die het zaaizaad selecteren en veredelen. Deze belangrijke rol van vrouwen wordt echter niet erkend, en hun specifieke belangen, behoeften en inbreng worden veronachtzaamd in ontwerp, ontwikkeling, en verspreiding van de technologie. Als gevolg van een beleid dat vooral gericht is op productiviteit en mannen, ploeteren de vrouwelijke boeren, die toch al overwerkt zijn door hun meervoudige rollen, om de voedselvoorziening van hun huishoudens en het land als geheel op peil te houden, onder grote beperkingen en moeilijkheden. In die omstandigheden hebben de nieuwe technologieën zowel kosten als baten voor rurale vrouwen opgeleverd, vooral in deze arme marginale gebieden.

- Er is een grote kloof tussen de heterogene behoeften en belangen van de boeren die bepaald worden door hun variabele bedrijfssystemen en overlevingsstrategieën, en aan de andere kant de veredelaars, met hun eenzijdige nadruk op, en belangstelling voor opbrengst. De kloof geldt vooral voor arme boeren, vooral vrouwen, in bedrijfssystemen in verafgelegen marginale gebieden. Toch deden vrouwelijke boeren moeite om hun eigen belangen te behartigen door hun lokale kennis in te brengen en gebruik te maken van hun eigen informele systeem.

- De werkelijke oorzaken voor het falen van het formele veredelingsprogramma om rekening te houden met de variatie van bedrijfssystemen en de heterogene behoeften van boeren in marginale gebieden zijn eerder institutioneel dan technisch. Theoretisch, en vanuit een constructivistisch gezichtspunt, liet het onderzoek zien dat drie belangrijke manieren bestaan om kennisnetwerken te construeren, waar het gaat om de ontwikkeling en de verspreiding van technologie binnen het Programma. Ieder van de drie wordt bepaald door verschillende sociale krachten en omstandigheden, in verschillende historische perioden. Ieder opereert op verschillende niveaus.

Er zijn aanbevelingen geformuleerd voor de verbetering van het Programma in het bijzonder en voor het publieke kennissysteem in het bijzonder.

Om adequaat te kunnen reageren op de uitdagingen die de nieuwe context stelt, is een flexibeler institutioneel kader nodig, alsook een meer omvattende benadering om de diverse en complexe inzichten te kunnen integreren en een afweging te kunnen maken tussen de verschillende beleidsdoelen (productiviteit, duurzaamheid, sociale rechtvaardigheid en stabiliteit). Het gaat dus meer om een adaptieve dan om een op beheersing gerichte strategie.

1. Een combinatie van de moderne technologie-georienteerde benadering en een participatieve benadering die meer gericht is op het betrekken van boeren met hun lokale kennis en traditionele landbouwpraktijken, lijkt realistisch en noodzakelijk teneinde om te kunnen gaan met de uitdagingen die zich nu beginnen te manifesteren. De kombinatie van benaderingen leidt tot een flexibele, diverse en duurzame benadering, die de landbouw in staat stelt rekening te houden met de heterogene behoeften van boeren, vooral de specifieke belangen en behoeften van vrouwen en de dynamiek van hun landbouwsysteem. Alleen dan is het mogelijk om de omslag te maken van een landbouwontwikkeling die alleen gericht is op productiviteit, naar het soort van management nodig voor duurzame landbouwontwikkeling.

2. Decentralisatie van het formele systeem en betrokkenheid van boeren in het technologisch ontwerp en het ontwikkelingsproces is nodig en essentieel om de samenwerking te stimuleren tussen de twee systemen. De informele sector moet meer weten over de complexiteit van biotechnologie en het formele systeem moet meer weten over hun overlevengsstrategieen. Bijvoorbeeld, de kennis die boeren hebben over type land en hun begrip van de microvariëteiten in de omgeving zouden de basis kunnen worden voor teelt op lokaal niveau of een lokatie-specifieke teelt. Door participatie van boeren en samenwerking , kunnen veredelaars nieuwe inzichten krijgen in de criteria, de doelen, de ervaringen die boeren hebben met technieken en de verschillen tussen regio's en boeren (in termen van gender). Als gevolg hiervan, kunnen geschikte verschillende variëteiten geproduceerd worden om tegemoet te komen aan de heterogene behoeften.