ICIMOD

Making Tibet Food Secure
Assessment of Scenarios

Major food-production systems in Tibet

Nyima Tashi
Liu Yanhua
Tej Partap

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Assessment of Scenarios

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International Centre for Integrated Mountain Development (ICIMOD)
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- *Tej Partap*

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Dedication

This book is dedicated to my late mother, who unfortunately passed away before its completion

Foreword

The Tibetan plateau is a vast area of soaring mountains, moving glaciers, high altitude plains, turquoise lakes, and steep gorges. This high mountain area covers over one-third of the Hindu Kush-Himalayas (HKH) and one-fifth of the area of China, along with smaller parts of most neighbouring countries in the region. The great rivers of Asia originate in this area, including: the Brahmhaputra (Yalongzangpo), the Ganges/ Pong Qu, the Indus (Shiquan He), the Mekong (Lancang), the Yangtze, and the Yellow rivers. Averaging around 4,000 metres above sea level, much of the central and western parts of the Tibetan plateau receive limited rainfall. Low temperatures and limited arable land also constrain the growing season.

The Tibet Autonomous Region of China occupies 1.2 million square kilometres of this region with more than 2.5 million Tibetan inhabitants. Although agricultural and pastoral systems have evolved over the millennia to provide uniquely adapted subsistence livelihoods, most of the population depends on food production from environmentally fragile and socioeconomically marginal production systems. Livelihoods are vulnerable to weather and outside forces, and subsistence depends on combining agriculture with pastoralism and trade.

Increasing food security in Tibet has been a government priority for the last 40 years. However, the unique ecological and socioeconomic circumstances of this remote mountain area have constrained the effectiveness of technologies developed in the plains, and reduced market opportunities. Expensive transport and limited purchasing power have made the supply of food from outside difficult. The adoption of a policy for food self-sufficiency by the Government of the Tibet Autonomous Region in 1994 has enabled production to increase in recent years.

However, there remains a knowledge gap about food production and food security in Tibet. There have only been limited studies on the food production systems currently used, the changing trends in food supply and demand, and the scope for improving production and food security.

This study by Dr. Nyima Tashi is thus a major contribution to the understanding of food security issues in Tibet and the formulation of appropriate policies. It focuses on assessing the scenarios for food security in spatial and temporal dimensions. It identifies current status and trends in both production and consumption in various zones.

The research for this book was carried out under ICIMOD's Tibet Fellowship

Programme with funding from the Royal Netherlands Embassy in Beijing. Dr. Nyima Tashi was the first of four candidates for Ph.Ds in this programme. His research was conducted under the direct supervision of Dr. Liu Yanhua, currently the Deputy Minister of the Ministry of Sciences and Technology, China, and Dr. Tej Partap, currently the Vice Chancellor of CSK Agricultural University of Himachal Pradesh, India (formerly Head of Mountain Farming Systems, ICIMOD). ICIMOD is grateful to these scientists for initiating and managing the Tibet Fellowship Programme and their contribution to human resource development and capacity building in Tibet.

ICIMOD is also grateful to our partners in this fellowship programme: the Institute of Geographical Sciences and Natural Resources Research of the Chinese Academy of Sciences (CHECK) and the Tibet Academy of Agricultural and Animal Husbandry Sciences (TAAAS) for their continuous collaboration with and support for this programme.

J. Gabriel Campbell
Director General

Executive Summary

The Himalayan region has been studied extensively, but Tibet is often noticeably absent from such studies and discussions. Although an increasing number of researches and studies have been conducted recently, they tend to focus more on either the survival of the household or of the community than on biophysical processes. Broad-based research on the Tibet Autonomous Region as a whole that gives an overall picture of the region is necessary.

This publication focuses on the food security issue of the Tibet Autonomous Region. This research will begin with a general introduction to Tibet (Chapter 2) and then describe the local population's current access to food (Chapter 3) and identify different food production systems currently in use (Chapter 4). Changes in food production are discussed in Chapters 5 and 6, and changes in demand in Chapters 7 and 8. The potential to increase the productivity of various food-production systems is treated in Chapter 9, and policy recommendations to make Tibet food secure in the future are made in the final chapter (Chapter 10).

Tibet's food security is analysed based on key indicators such as the gap between food production and demand. Although food production has increased, the present situation of food security in Tibet is still not optimistic. Low per capita food production and food trade, great variations among regions and fluctuation of food production over time; and relatively low energy intake by the indigenous people have shown the overall low level of food security in Tibet.

Socioeconomic and biophysical data were combined with GIS technology to identify the dominant food production systems. Four food production systems – crop-dominated, agro-pastoral, pastoral, and agro-pastoral-forestry – were delineated. Based on this analysis, the potential productivity of these different food production systems was examined in terms of their ability to raise both crops and livestock animals. The crop dominated food production system has a much higher potential food productivity than any of the other regions, and it must be the focal region if Tibet is to achieve sustainable food security. The pastoral food production system has been overstocked, and it is crucial to work on the conservation and sustainable use of the rangelands in Tibet.

There are great zonal variations of availability of per capita calories and protein; there has been a decline of total food production in the north and north-west, while production is increasing in central and south Tibet. Moreover, per capita production of cereals is low in north-western Tibet and high in central Tibet. These zonal variations of food grain production were attributed to change of cropland area, while the spatial dynamics were attributed to changes in per unit crop yields. There has been a big increase in meat production, particularly in areas where cropping is possible. Milk production has declined in the pastoral zone, while it has been increasing in crop-dominated zone. Currently, meat and milk production bases are shifting towards central Tibet. Expansion of the crop-livestock farming system is desirable for further increasing both meat and milk production, while in the pastoral system, increases in per unit yield of meat and milk production are needed. The overall agricultural production structure is changing. The percentage of crop and forestry production value in gross output of agricultural production has increased, while the proportion of livestock production value has declined. But crop and livestock production still dominate agricultural production. Fluctuations in agricultural production have been due not only to climate variations but also to inappropriate and frequent changes in agricultural policy and input over time.

Although the balance between total production and total demand in Tibet has improved, deficits of special food items, such as rice, vegetables, pork, and so on (and the lack of high quality and nutritious food, shortages of food in some regions, and poor food distribution among regions), remained persistent problems. Food preference and consumption patters are changing, driven by population growth and increase in per capita income. The gaps of income and consumption between urban and rural populations have been growing significantly, and the food preferences between the two are now quite different. In urban areas, food preferences and consumption are now getting close to the Chinese diet, while, in rural Tibet, food preferences remain more traditional, focusing mainly on tsampa, yak meat, butter tea, and chang (barley beer). Although overall more food is produced than the minimum required, there are food-deficit counties that are trying to become self-sufficient. Already a policy promoting cereal self-sufficiency is in place. New policies and external investments are opening up new opportunities for economically productive agriculture. The policy of "central government concerns and nation-wide support" propounded in 1994 has stimulated huge investment and technical and staff support to develop Tibet. As a result, food production has increased steadily, and food security has been enhanced.

However, many weaknesses remain. Economic transfusion is a trap from which the Tibetan agroeconomy has not been able to extricate itself; changes in thinking and perceptions have been slow. Food shortages are the manifestation of low farm productivity and a fragile agroecosystem in Tibet. Underdeveloped and low capacity markets are an obstacle to developing a commercial farm economy. Science and technology have not been applied to maximise agricultural resource potential. Thus, Tibet faces many challenges, including increasing food demand and limited cropland; increasing demand for livestock products and low carrying capacity rangelands; increasing natural disasters in a fragile ecosystem; weak institutional capacity of agricultural research, an extension system unable to help transform traditional farming systems into competitive and commercialised production systems, and a fragile and marginal agroecosystem that is faced with large-scale investments from outside that will accelerate faster economic growth in Tibet.

To cope with these weaknesses and challenges, harnessing the comparative advantage of Tibet's natural resources; promoting highland agricultural products for external markets; strengthening the application of agricultural technology; harnessing the potential for increasing cereal production; and developing the livestock production of the crop-dominated farming systems zone are the main options for making Tibet food secure.

Key Words: Food security, Tibet, food production, food supply, food consumption, changing scenarios, highland, scope for food security

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Nyima Tashi

Abbreviations and Acronyms

CAVAVAIL	the average calorie availability
CAVREQ	the average calorie requirement norm
CAVUNNUR	the average availability of calories for the undernourished in the population
CP	crude protein
DBMS	database management system
FA	food adequacy
FAO	Food and Agriculture Organisation
GDP	gross domestic product
GIS	geographic information system
ICIMOD	International Centre for Integrated Mountain Development
ICN	International Conference on Nutrition
LIFDCs	low-income food-deficit countries
PTOTAL	total population
PUNNUR	number of undernourished individuals
SEU	sheep equivalent unit
TAAAS	Tibet Academy of Agricultural and Animal Husbandry Sciences
TAR	Tibet Autonomous Region
TDN	total digestible nutrients
UNDP	United Nations Development Programme
USA	United States of America

Note

1. Food energy equivalents are given in terms of kcal, the quantity of energy required to raise the temperature of 1 kg of water by 1°C. This unit is often written simply as 'calorie' and is approximately equal to 4,184 joules.
2. Food grain, in Chinese is called 'Liang Shi' and includes cereals, pulses and tuber crops.

Glossary

Ali	A prefecture in Tibet Autonomous Region; Ngari in Tibetan
Anduo	County name in Chinese Pinying; Amdo in Tibetan
Angren	County name in Chinese Pinying; Ngamring in Tibetan
Bai	A minority group in Tibet
Bailang	County name in Chinese Pinying; Panam in Tibetan
Bange	County name in Chinese Pinying; Palgon in Tibetan
Baqing	County name in Chinese Pinying; Bachen in Tibetan
Baxu	County name in Chinese Pinying; Paksho in Tibetan
Bayi Town	Chinese Pinying name for a town in Nyinchi prefecture
Bianba	County name in Chinese Pinying; Palbar in Tibetan
Biru	County name in Chinese Pinying; Dirl in Tibetan
Bomi	County name in Chinese Pinying; Pome in Tibetan
Buoyi	A minority group in Tibet
Changdu Town	In Chinese Pinying for Chamdo town
Changdu	County name in Chinese Pinying; Chamdo in Tibetan
Changdu	A prefecture in Tibet Autonomous Region; Chamdo in Tibetan
Changtang	The vast northern land of Tibet (in Tibetan)
Chaya	County name in Chinese Pinying; Dayak in Tibetan
Chengdu	The capital city of Sichuan Province
Cultural Revolution	Pronounced by Chairman Mao and undertaken during 1966-1976
Cuomei	County name in Chinese Pinying; Tsome in Tibetan
Cuoqin	County name in Chinese Pinying; Tsochen in Tibetan
Dangxiong	County name in Chinese Pinying; Damshung in Tibetan
Dazi	County name in Chinese Pinying; Taktse in Tibetan
Dengba	A minority group in Tibet
Derung	A minority group in Tibet
Dingjie	County name in Chinese Pinying; Tingkye in Tibetan
Dingqing	County name in Chinese Pinying; Tengchen in Tibetan
Dingri	County name in Chinese Pinying; Tingri in Tibetan
Drogba,	A nomad group (Tibetan)
Dueba	Tibetan name for people from western Shigatse and Ali Prefecture in western Tibet
Duilongdeqing	County name in Chinese Pinying; Tolung Dechen in Tibetan
Gaize	County name in Chinese Pinying; Gertse in Tibetan
Gangba	County name in Chinese Pinying; Gampa in Tibetan

Ge'er	County name in Chinese Pinying; Gar in Tibetan
Geji	County name in Chinese Pinying; Gakyi in Tibetan
Gongbujiangda	County name in Chinese Pinying; Kongpo Gyamda in Tibetan
Gongga	County name in Chinese Pinying; Gonggar in Tibetan
Gongjue	County name in Chinese Pinying; Gongjo in Tibetan
Gyangtse town	Tibetan; Jiangzi town in Chinese Pinying
Han	The main Chinese nationality
Henan	A province of Chian
Hengduan	Name of a mountain
Hor	Tibetan name for people from Nagchu (Naqu) in northern Tibet
Hui	Chinese word for Moslem
Jiali	County name in Chinese Pinying; Chali in Tibetan
Jiangda	County name in Chinese Pinying; Gyamda in Tibetan
Jiangzi	County name in Chinese Pinying; Gyantse in Tibetan
Jiazha	County name in Chinese Pinying; Gyatsa in Tibetan
Jilong	County name in Chinese Pinying; Kyirong in Tibetan
Jinshajiang	Name of a river
Jue	Tibetan word for safety and nutrition
Kangma	County name in Chinese Pinying; Khangmar in Tibetan
Khampa	Tibetan for people from Chamdo
Kulun	Name of a mountain
Lancang Jiang	Name of a river
Langkazi	County name in Chinese Pinying; Nakartse in Tibetan
Lazi	County name in Chinese Pinying; Lhatse in Tibetan
Leiwuqi	County name in Chinese Pinying; Rioche in Tibetan
Lhasa	County name in both Chinese Pinying and in Tibetan
Lhasa	A prefecture; also the capital city in Tibet Autonomous Region.
Lhoba	A minority group in Tibet
Linzhi	County name in Chinese Pinying; Nyingtri in Tibetan
Linzhi	A prefecture in Tibet Autonomous Region; Lhoka in Tibetan
Linzhou	County name in Chinese Pinying; Lhundup in Tibetan
Lisu	A minority group in Tibet
Longzi	County name in Chinese Pinying; Lhuntse in Tibetan
Luolong	County name in Chinese Pinying; Lhorong in Tibetan
Luozha	County name in Chinese Pinying; Lhodak in Tibetan
Man	A minority group in Tibet
Mangkang	County name in Chinese Pinying; Markham in Tibetan
Mengarbu	White medicine (Tibetan)
Miao	A minority group in Tibet
Milin	County name in Chinese Pinying; Miling in Tibetan
Monba	A minority group in Tibet
Mongolian	A minority group in Tibet
Mozhugongka	County name in Chinese Pinying; Medro Gongkar in Tibetan
Muotuo	County name in Chinese Pinying; Metok in Tibetan
Naidong	County name in Chinese Pinying; Nedong in Tibetan
Nanmulin	County name in Chinese Pinying; Namling in Tibetan
Naqu	County name in Chinese Pinying; Nakchu in Tibetan
Naqu	A prefecture in Tibet Autonomous Region; Nakchu in Tibetan
Nashi	A minority group in Tibet
Nianqingtanggula	Name of a mountain

Nielamu	County name in Chinese Pinying; Nyalam in Tibetan
Nierong	County name in Chinese Pinying; Nyerong in Tibetan
Nima	County name in Chinese Pinying; Nyima in Tibetan
Nimu	County name in Chinese Pinying; Nyemo in Tibetan
Nu	A minority group in Tibet
Nujiang	Name of a river
Nyachu	Name of a river
Pulan	County name in Chinese Pinying; Purang in Tibetan
Qinghai	A province of China
Qiongjie	County name in Chinese Pinying; Chong-Gye in Tibetan
Qushui	County name in Chinese Pinying; Chushur in Tibetan
Qusong	County name in Chinese Pinying; Chosum in Tibetan
Renbu	County name in Chinese Pinying; Rinpung in Tibetan
Rikaze	County name in Chinese Pinying; Shigatse in Tibetan
Ritu	County name in Chinese Pinying; Rutok in Tibetan
Saga	County name in Chinese Pinying; Saga in Tibetan
Sajia	County name in Chinese Pinying; Sakya in Tibetan
Samadrog	Tibetan word for farmers practising both cropping and animal husbandry
Sangri	County name in Chinese Pinying; Sangri in Tibetan
Shannan	A prefecture in Tibet Autonomous Region; Lhoka in Tibetan
Shenzha	County name in Chinese Pinying; Shantsa in Tibetan
Sherba	A minority group in Tibet
Shigatse	A prefecture in Tibet Autonomous Region
Shingba	Cropping farmers (Tibetan)
Shuanghu Admin. Office	A county-level special office for managing the Shuanghu area in northern Tibet
Sichuan	A province of China
Suoxian	County name in Chinese Pinying; Sokshan in Tibetan
Tanggula	Name of a mountain
Tsampa	Tibetan word for roasted barley flour
Tsangba	Tibetan word for people from the Shigatse region
Tu	A minority group in Tibet
Uhba	Tibetan word for people from the regions of Lhasa and Shannan Prefecture
Uygur	A minority group in Tibet
Xietongmen	County name in Chinese Pinying; Tongmon in Tibetan
Xinjiang	Xinjiang Uygur Autonomous Region of China
Yadong	County name in Chinese Pinying; Chomo in Tibetan
Yalong valley	A valley in central Tibet
Yalongtsangpo River	Tibetan word for Brahmaputra River
Yi	A minority group in Tibet
Yunnan	A province of China
Zedang town	Chinese Pinying; Tsetang town in Tibetan
Zha'nang	County name in Chinese Pinying; Dranang in Tibetan
Zhada	County name in Chinese Pinying; Tsada in Tibetan
Zhongba	County name in Chinese Pinying; Dengpa in Tibetan
Zhuang	A minority group in Tibet
zo	Crossbreed of yak and cow
Zuogong	County name in Chinese Pinying; Zogong in Tibetan

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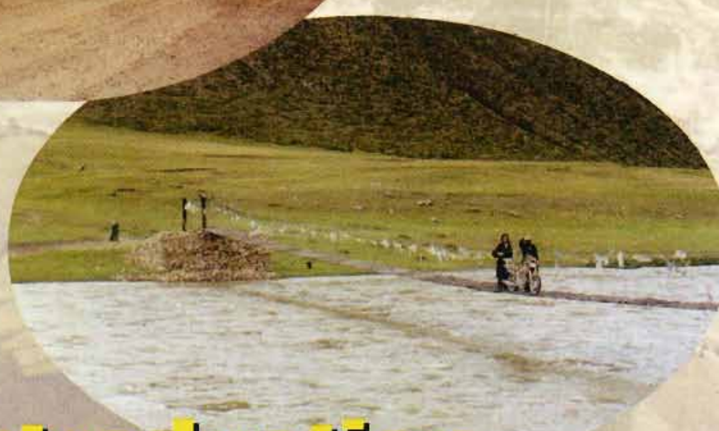


introduction

Background: Farmland in central Tibet
(Gongga County)
- *Nyima Tashi*

Top Inset: Rainbow over village
- *Nyima Tashi*

Bottom inset: Traditional suspended bridge and
modern motorcycle in
Dangxiong County at 4,200 masl
- *Nyima Tashi*

Road on the roof top of the world - Nyima Tashi

Chapter 1
Introduction

Tibet Autonomous Region (TAR; subsequently referred to as Tibet) has been known to the world because of its high altitude, spectacular landscape, and mysterious culture and history. It is one of the few areas where a yak-farming system has been practised, and it is the only region where barley production is the predominant agricultural sector. These unique food production systems and way of ensuring food security are interesting but relatively unexplored and unknown to the rest of the world.

Concept and Definitions of Food Security Used

As a result of the world food crisis of the early 1970s and the World Food Conference in 1974, the concept of food security was highlighted, and emphasis was placed on maintaining the stability of supplies to ensure the availability of food in the event of widespread crop failure, and particularly to be able to sustain levels of consumption in the most vulnerable countries (FAO 1996). Various studies undertaken during the late 1970s recognised that the attainment of food security depends on the growth of food production, particularly in the low-income food-deficit countries (LIFDCs). In 1983, the FAO adopted the following reconceptualisation of food security: "The ultimate objective of world food security should be to ensure that all people at all times have both physical and economic access to the basic food they need."

In 1992, the International Conference on Nutrition (ICN) defined food security as: "all people at all times [having] access to safe and nutritious food to maintain a healthy and active life". These definitions have broadened the concept of food security to include not only the food supply consequent to physical and economic conditions, but also the economic and physical accessibility to food, and the safety and nutritional value of the food intake as well. Moreover, they also concern the natural resources and the environment that might be affected by efforts to obtain food security. Therefore, the FAO and UNDP concluded that food security should be attained "without compromising the productive capacity of natural resources, the integrity of biological systems, or environmental quality". This idea of food security aims to ensure production of adequate food supplies, to improve the accessibility to the available food supplies where they are needed, and to maximise the stability of the flow of food supplies, all on the basis of maintaining and promoting the sustainability of the environment and natural resources.

Assessment of Scenarios of Food Security

Food security is a very dynamic subject, and has become related to economics and sociology by its use of methodologies and tools. The concept of food security presented here helps to clarify the reasons behind food insecurity, but it remains difficult to know where and when food shortage or hunger may occur, as it can be regional, transitory, seasonal, or chronic. For instance, it is difficult to predict where and when serious transitory or seasonal food insecurity may occur.

To achieve sustainable food security has been one of the main goals of overall agricultural development in Tibet for the past few decades. However, many aspects of ensuring food security for Tibet remain to be studied. These include the overall potential food production, the zonal variations of food production, the changing trends of food production and consumption, the kinds of food production systems now in place, changes in local food consumption, how and where food demand is changing, the opportunities for ensuring food security for Tibet, and so on. These issues are the fundamental basis of a better understanding of food security. Particularly, where and when food insecurity in Tibet may occur has remained poorly understood. Assessments of scenarios of food security in spatial and temporal dimensions are valuable for reorienting policy-makers and planners to ensure food security. Knowing the status and changing scenarios of food production and consumption over time would allow us to learn from the past and to make better decisions for the future. Understanding the scenarios of regional or zonal variation of food demand and supply, where there is surplus and where there is deficit, would help to better redistribute food, and so on. Therefore, this book attempts to assess different kinds of scenarios of food security for Tibet along both spatial and temporal dimensions.

Food Supply and Demand Analysis

The supply and demand of food are dominant but general factors that determine food security status.

Food production

The supply of food and its stability are mainly determined by the total amount of food available, which in turn depends on food production, food reserves, food trade, the capability of importing food, the market price, and the pricing system. Food production is determined by land availability, water resources, technology, input, per unit productivity of the land, and so on. Food reserves are affected by the policy of food grain procurement, price, and the capacity to store food. Moreover, the effective supplies of food depend upon the spatial and temporal availability of food. In the spatial dimension, distribution of food production and food production potential are important to produce adequate food for an area. In the temporal dimension, food production changes and fluctuation of food supply affect food security status. Food trade is complex and many factors affect it.

Geographically, Tibet is characterised by mountainous topography and a rainfed water supply, which form a very vulnerable and fragile ecosystem in which food security depends on opportunities for production and exchange, which are few (Jodha 1995). Tibet is also isolated from the outside world by both physical inaccessibility and socioeconomic marginality. Physical remoteness is exacerbated by the lack of roads. However, even though some roads exist, the long distance contributes to remoteness. In such circumstances, to produce enough food within the region and to minimise the dependency of acquiring food through exchange are the essence of food security. On the other hand, biophysical diversity is also a distinct characteristic of Tibet, which provides diverse possibilities for producing many food items and reduces the dependence on food exchange. Tibet also possesses a comparative advantage or niche in its potential to produce unique resources such as herbs and solar energy.

Thus, most of the research reported here focuses on food production and its spatial distribution. Changing trends, potential productivity, zonal variation of food production, and opportunities for increasing food production were studied. Food production systems/zones were delineated through using Geographic Information Systems (GIS).

Demand analysis

The effective demand for food and its stability are determined by population and its growth, purchasing power (which depends on per capita income), price of food, food supply, culture, and information about the market. Per capita income in turn is affected by numerous factors such as natural resource availability, pricing policy, population group, GDP of a nation, and so on. These also have spatial and temporal dimensions.

Rapid growth of income and changes in population distribution, such as urbanisation and industrialisation, often contribute significantly to rapid growth of per capita food intake, but have not done so in Tibet. Growth of income often results in changing food consumption habits, influencing choices for more luxurious food such as livestock products that will later be reflected in the demand for food grain. Migrations of rural population into urban areas may also result in changes in food consumption habits that increase demand for particular foods. Tibet, however, has not yet reached a level at which increases in income lead to significantly increased demand for food . Population growth, on the other hand, has been the predominant factor accounting for increased food demand in Tibet for the past few decades.

Tibet's food demand was analysed by considering the population growth and its zonal variation as major factors, followed by changing trends of food preferences in the urban and rural population, income elasticity's relationship to food consumption, and zonal variation of food demand.

The Need for the Study

For the last 40 years, local government has made great efforts to make Tibet food secure. Although progress has been made in achieving food self-sufficiency and providing adequate food to the highlanders of Tibet, new issues and challenges have emerged due to rapid population growth, a poverty-stricken population, poor agricultural education, limitations of farm land, low productivity of the land, widespread overgrazing and degradation of grassland, poor farming infrastructure, lack of appropriate technologies and related farmer usable materials, poor capabilities in agro-science and technological development and dissemination to farmers, and insufficient capital input for agricultural development. In addition, with the development of the market economy, both the government and consumers face increased food prices and pressure from a limited financial capacity. Since 1994, there has been major improvement in food supply and availability in Tibet. In addition, some studies on the population-carrying capacity of the land showed that there was potentially productive cropland in central Tibet (Liu Yanhua 1991). Other studies, however, indicated that there was lack of food resources and that with its growing population, Tibet would face food shortages and have to import considerable amounts of food grain from other parts of China. (Zhang Junliang 1994).

However, a systematic study of food security in Tibet has not been carried out previously, although there have been some analyses of the status and characteristics of food consumption and production (Hu Songjie 1995; Liu Yanhua 1991; Sun Yong 1991; Zhang Junliang 1994; Xiao Huaiyuan 1994; Yang Gaihe 1995). Many of these studies also have indicated that Tibet has to import considerable amounts of subsidised food grain from other parts of China. In addition, with the development of the market economy, both the government and consumers face increased food prices and pressure from their limited financial capacity. Therefore, since 1994 the Tibetan government has adopted a policy of food self-sufficiency. Little is known, however, about the actual situation of food production and what the food production systems are. The changing trends of food supply and demand, both spatial and temporal; the potential for food production; and the scope for making Tibet food secure have not been studied. Many areas therefore remain to be understood properly. Trends of changes in food production and consumption need to be understood properly. With this information, agricultural policy and development strategy can be geared towards making Tibet food secure.

This publication aims 1) to provide a general introduction to Tibet (Chapters 1 and 2); 2) to study the state of access to food by the local population (Chapter 3) and identify different food production systems (Chapter 4); to understand changes in food production and consumption both temporally and spatially (Chapters 5, 6, 7, 8); to examine the potential of various food-production systems (farming systems); to understand potential food production (Chapter 9); and to make recommendations for agricultural policy and technical measures to make Tibet food secure in the future (Chapter 10).

highland and people

Background: A highland Khampa agropastoralist of Tibet
- *Tej Partap*

Top Inset: Tibetan women farmers taking a break from field work
- *Tej Partap*

Bottom inset: Highland yak herders on the pasturelands - resting while yeks graze
- *Tej Partap*

A street cornor of Naqu town - Nyima Tashi

Chapter 2

Highland and People

Tibet has a beautiful, unique, and wild landscape that gives it an aura of mystery. To add to this natural grandeur, the Tibetan people over a long period of history have created a unique cultural heritage and agricultural practices that sustain their livelihoods in the harsh conditions of the plateau.

The Geographic Location and Administrative Regions of Tibet

Geographic location

Tibet is situated in the south-western part of China, from 26° 50'N to 36°53'N (2,000 km), and from 78°25'E to 99°06'E (1,000 km). It borders the Chinese provinces of Qinghai and Xinjiang to the north, Sichuan and Yunnan to the south-east; and India, Nepal, and Bhutan in the south-west. The total area of Tibet is more than 1.2 million sq.km. It occupies more than a third of the Hindu Kush-Himalayan region and an eighth of the entire territory of China. It is one of the largest Chinese provinces in area, but one of the least developed and least populated.

With an average altitude of more than 4,000 metres above sea level (masl), the vast and magnificent Tibetan plateau is known as the Roof of the World. In the south-west, on the border with Nepal, there is the highest and the most magnificent mountain range in the world, the Himalayas. In the north-east, there is open, vast pastureland, the Changtang (which means "the vast land in the north" in Tibetan). It is the native land of yak, and the nomads of Tibet live by yak husbandry. The centre of Tibet contains valleys and mountains between 3,500 and 4,500m; this is the land of barley farming. In central Tibet the majority of Tibetans live and eat barley as their staple food.

The administrative regions of Tibet

Within the Tibet Autonomous Region, there are six prefectures, Shigatse, Shannan, Naqu, Changdu, Ali, and Linzhi; and one municipal city, Lhasa (Figure 2.1). There are 71 administrative counties; one county under the jurisdiction of a city, the downtown area of Lhasa; one city at county level, Shigatse; and one special administrative office, the Shuanghu Administrative Office. The seven prefectures have nearly 900 townships and more than 7,000 villages.

The Physiogeographic Divisions and Climate Types of Tibet

In 1992 the Chinese Academy of Sciences classified Tibet into seven different physiogeographic units. This was more a natural, vegetation-oriented classification than an exclusively topography-oriented one (Leber et al. 1995). These seven physiogeographic units were described as follows.

- The southern slope of the Himalayan zone includes rainforest and mountain evergreen broadleaf forests. This area lies

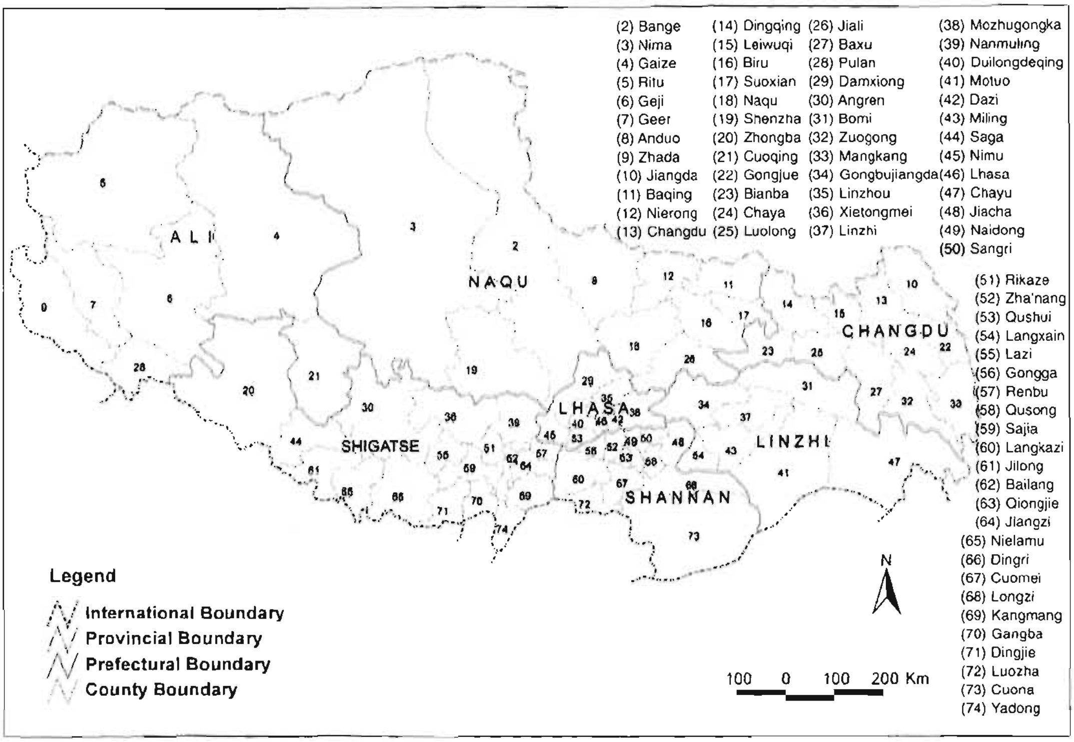


Figure 2.1: **Administrative Map of Tibet Autonomous Region**

mainly between 2,500m and 500masl, and has tropical and subtropical monsoon types of moist climate, with mean monthly temperature of 18-24°C, annual mean temperature above 10-18°C and annual precipitation of 800-2,500 mm. This region borders with north-eastern India along the lower reaches of Yalongtsangpo River. Most of Chayu county, Motuo county, and Cuona county are in this region.

- The mountain ranges and gorges of the East Tibet zone are mountain coniferous forests characterised by plateau temperate monsoon semi-moist climate, with annual mean temperature ranges from 3-9°C, although in some areas can reach 8-12°C and total precipitation can vary from 400-1,000 mm. This region is mountainous and cut from north to south by several rivers such as the Nujiang, Lancang Jiang, and Jinshajiang rivers. A vertical differentiation of above 1,000m elevation can be found in this region of many gorges. Most of Changdu Prefecture lies in this region.
- Naqu and the upper reaches of Nujiang zone are mountain shrubby steppe, covered mostly by alpine meadow in the south and alpine shrubby steppe and meadow in the west, with annual mean temperature ranges from -3 to 1.5°C. Rainfall varies from 400 mm in the west to 700 mm in the eastern part of the region. This region is a typical plateau cold monsoon type semi-moist climate. Counties in Naqu Prefecture, such as Baqing, Nierong, Biru, and Suoxian, belong to this region.
- The South Tibetan zone includes broad valleys and basins of mountain shrubby steppe, and this region is the main producer of grain and crop products in Tibet. Most of the population is concentrated in this region along the Yalongtsangpo, Lhasa, and Nyachu rivers. It is characterised by a plateau cold monsoon type semi-arid climate, with a mean temperature of 1-7.5°C Annual precipitation

ranges from 200 mm in the northwest and to 500 mm in the southeast. Precipitation is concentrated in the months of June to September, which account for about 90% of the total rainfall in a year. The major parts of Shigatse, Lhasa, and Shannan prefectures are in this region.

- The Changtang Plateau zone of alpine steppe, which is now largely a protected natural preserve for wildlife, has an annual mean temperature of only about 0 to -3°C, and total precipitation is about 150-300 mm. This region is a very typical region of plateau cold monsoon type semi-arid climate. It includes most of the eastern part of Ali Prefecture and the western part of Naqu Prefecture.
- The Ali zone consists of mountain steppe and desert. With annual mean temperature of 0°C and annual precipitation of only 50-200 mm, this region is a very dry and cold area. The climate is plateau sub-cold monsoon type arid. Ge'er, Zhada, and Ritu counties belong to this region. Despite the dry and cold climate, or perhaps because of it, this region is the largest producer of cashmere goats in Tibet.
- The Kunlun mountain and basin zone of alpine desert steppe and desert, the major part of which is uninhabited by humans, has an annual mean temperature of about -4°C, and the annual rainfall is only about 100-150 mm. This is mostly under the area of the Changtang natural preserve for Wildlife. This region has a plateau cold monsoon type arid climate. The far northern part of Nima County of Naqu Prefecture, and northern Gaize and Ritu counties of Ali Prefecture, fall into this region.

In general, the climate types of Tibet were classified into five distinct types. Depending on the altitude and climate, different types of animals can be raised and different crops can be grown. The range of altitude for each climatic zone and farming system in western and central Tibet vs. eastern Tibet is different. (Table 2.1)

Main Agro-ecological Zones in Tibet

Tibet is very diverse in agro-ecosystems, with seven different agro-ecological zones delineated (Figure 2.2).

There is a hot, humid agro-forestry pastoral zone, in South-east Tibet, where the main industry is forestry, and livestock are raised depending on the forage and pasture available. Yak, cattle, pigs, and goats are common animals. It has distinct dry and monsoon seasons. Most of the croplands are not irrigated. Winter wheat, winter barley, corn, and even rice are the major crops.

This region contains a warm, semi-humid agro-forestry pastoral zone situated where major rivers such as Jingsha Jiang, Lan Cangjiang, and Nujiang flow down to the southern part of Tibet. Moisture comes through the river valleys, and the climate is affected by the monsoon. Shrubbery pasture is the main source for livestock fodder. Yak are the predominant livestock produced. Diverse crops can be found, including rice and other warm-climate crops.

A warm, semi-dry agricultural zone is formed with increase in altitude. It is a mixed agricultural zone, with more than 70% of livelihoods of local farmers dependant on crop production. Barley, wheat, and rape seed are the dominant crops, while cattle; yak, sheep, and goats are the main animals.

A cool, semi-dry agro-pastoral zone lies in the transitional region from cropping areas towards the pure pastoral zone. Fields of barley, rape seed, and peas are found. The particular varieties of these crops raised mature early and are drought resistant. Cattle, sheep, and yak are the main animals.

The Changtang is a cold, semi-dry pastoral zone that occupies a large part of Tibet. Because of the low temperature throughout the year and very short growing season, crops do not grow in this area. Nomadism is the main practice of local people, who migrate following the availability of pasture

Table 2.1: **Climates, altitudes, and farming systems in Tibet**

Climate Type	Mean temp. in warmest month (^{0}C)	Days $\geq 0^0$C	Days $\geq$ 5^0C	Lowest temp. (^{0}C)	Main livestock	Main crops	Farming system	Altitude (m)	
								West & central Tibet	Eastern Tibet
Freezing Cold	< 6	< 120	< 50		Yak, sheep, goats	No Crop can grow	Summer grazing	> 5,000	> 4,700
Frigid Cold	6-10	120-128	50-120	< -23	Yak, sheep, goats	Scattered barley distribution	Predominated by pastoral system	4,500-5,000	4,200-4,700
Cool	10-18	180-330	120-250	> -23	Yak, sheep, cattle	Spring barley, spring wheat and rape seed, peas	Agro-pastoral system, one crop per year	4,000-4,500	3,800-4,200
Temperate					Yak, sheep, cattle, pigs	Spring barley, winter wheat, maize, apple, peach	Spring and winter crop, cropping dominated system	< 4,000	3,000-3,300
Warm and Hot	> 18	> 330	> 250	-	Cattle, pigs, goats	Winter wheat, maize, rice, apples, oranges	Agro-pastoral forestry mixed system, multiple cropping	-	< 3,000

Source: Tibet Bureau of Land Management, Land Use in Tibet Autonomous Region, Science Publication House, 1992, minor modifications by the author.

and water. The northern part of this zone is especially dry, with less than 200 mm of annual precipitation. Yak, sheep, and goats are the main livestock. Yak dominate the eastern part of the zone, while in the western part sheep and goats dominate. Pashmina goat is found in this zone, especially in the far western area adjoining Nepal and India.

The warm river valley irrigated zone and the temperate river valley irrigated zone are the major grain bowl of Tibet. Barley, winter wheat, and rape seed are the main crops. Nevertheless, diverse livestock species also can be found in this zone. Particularly, cattle raising and poultry production are growing very rapidly with the increased demand for dairy products and meat by the urban population. Livestock production in these two zones is becoming more intensified following the introduction of modern methods.

Land Resources

The total area of useable land in Tibet is about 76.03 million ha, which is about 63% of the entire territory of Tibet. This varies among the prefectures. Naqu and Ali prefectures have about 50 and 60% useable land respectively, whereas in Changdu, Shannan, Lhasa, Linzhi, and Shigatse prefectures, it is 81, 79, 78, 71, and 70% respectively. The proportions of arable land, rangelands, and forestry lands to total area are about 0.4, 12, and 5%, respectively. More than 36% of the total land of Tibet cannot be used for any

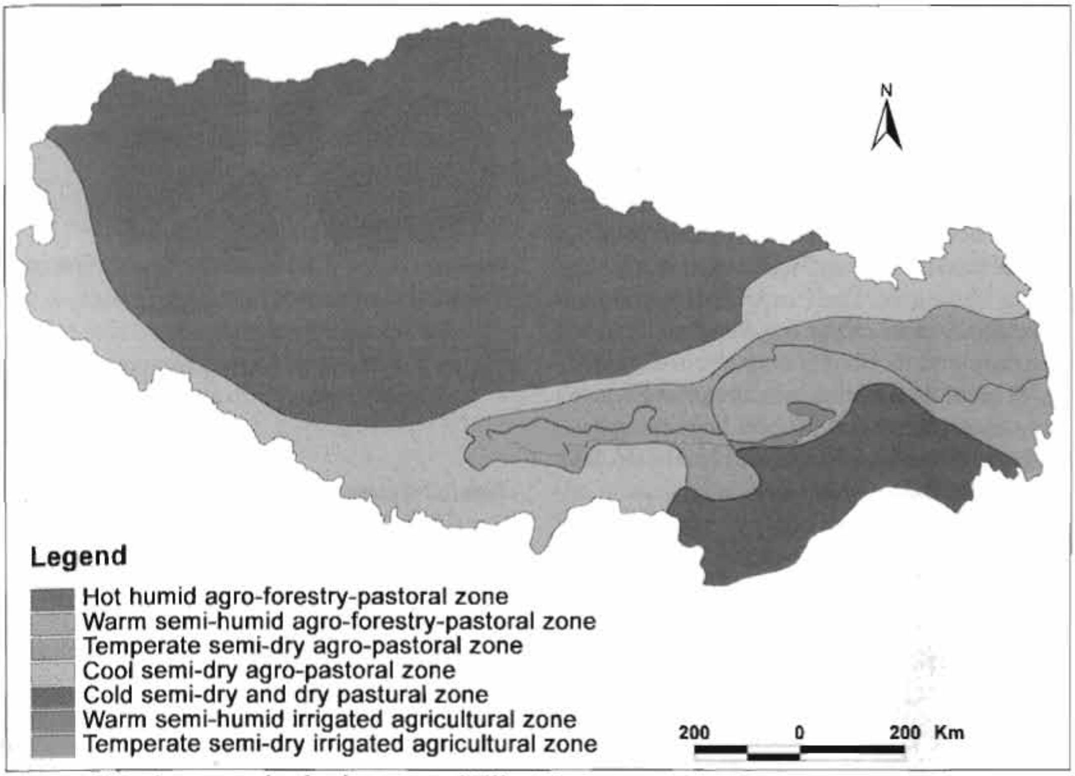


Figure 2.2: **Agro-ecological zones of Tibet** (source: author)

purpose of cropping, livestock, or forestry development. The total areas of arable lands, rangelands, forestry lands, and barren land of Tibet are shown in Table 2.2 by prefectures. Chapter 9 will elaborate more on the characteristics and potential to use different land resources in making Tibet food secure.

The total areas of arable land in Tibet is about 493,190 ha. Of this, 36.6 and 19% are distributed in Shigatse and Shannan prefectures, respectively. Very little arable land is found in Naqu and Ali prefectures, and comprises less than 2% of the total arable land in Tibet. The rangelands in Tibet total about 61.61 million ha, of which about 32 and 29%

Table 2.2: Land resources in Tibet

Prefecture	Arable land		Rangeland		Forest land		Barren land	
	Area [a]	% [b]	Area [a]	% [b]	Area [a]	% [b]	Area [a]	% [b]
Lhasa	67.9	13.6	2,073.1	3.4	168.6	1.2	642.20	1.4
Changdu	89.5	18.2	4,818.7	7.8	3,818.5	27.4	2,140.93	4.8
Shannan	94.7	19.2	3,075.3	5.0	3,099.7	22.3	1,617.94	3.6
Shigatse	180.4	36.7	12,112.1	19.6	319.9	2.4	5,522.09	12.4
Naqu	8.4	1.7	19,455.9	31.6	422.6	3.0	19,653.15	44.8
Ali	7.0	1.4	18,029.7	29.3	7.5	0.	11,592.67	26.1
Linzhi	45.3	9.2	20,39.3	3.3	6,095.3	43.7	32,14.39	7.2
Total Tibet	493.2	100	61,604.2	100	13,932.0	100	44,376.70	100

Source: Tibetan Bureau of Land Planning (1992a)

a. Area of the land ('000 ha)

b. Proportion of the land area of each prefecture to the total area of the land in Tibet

61.61 million ha, of which about 32 and 29% are found in Naqu Prefecture and Ali Prefecture, respectively. Shigatse Prefecture also has nearly 20% of the rangelands of Tibet. About 14 million ha of land are suitable for forestry. Most of it is distributed in Linzhi, Changdu, and Shannan prefectures. These prefectures include about 44, 27, and 22% of the total area of forestry land in Tibet, respectively.

Croplands and crops for food

The cropland in Tibet is only about 230,000 ha. A great deal of this is in Shigatse Prefecture, which alone has 80,580 ha; Changdu Prefecture has 51,670 ha, and Lhasa 37,800 ha (Figure 2.3).

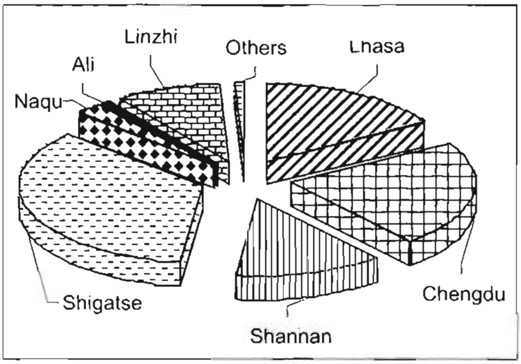


Figure 2.3: **Total area of crops by prefectures**

Barley, the staple food of Tibetans, is cultivated on more than 50% of the total cropland — about 126,310 ha in 1998. Shigatse Prefecture has 50,230 ha of barley production, Changdu Prefecture has about 34,530 ha, Lhasa 18,450 ha, and Shannan Prefecture 13,410 ha. Barley in Naqu and Ali prefectures accounts for 3,910 ha and 1,890 ha, respectively (Figure 2.4).

The agro-climatic diversity in Tibet allows Tibetan farmers to grow all kinds of crops such as rice, wheat, corn, millet, potatoes, vegetables, pulse crops, forage crops, and barley. Rice, corn, and millet, among others, are grown in south-eastern Tibet. At above 3,200m, barley (hull-less barley), wheat, potatoes, peas, and rape seed are the major crops grown (see Table 2.3).

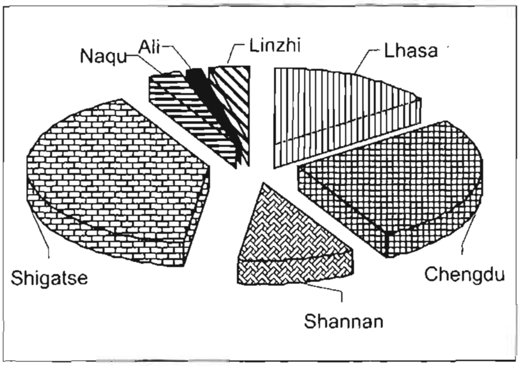


Figure 2.4: **Area of barley by prefectures**

Table 2.3: **Farming activities and their altitude limits in Tibet**

Activities	Crops and lands	Upper limit of the altitude (m)	Locality
Cropping	Spring barley	4,750	Jia Jia, Sajia County
	Spring wheat	4,460	Dalong, Langkazi County
	Winter wheat	4,320	Linzhou
	Rape seed	4,700	Wenbu, Shenzha County
	Potatoes	4,850	Jia Jia, Sajia County
Forestry	Natural forestry	4,400	Biru County
	Walnut	4,200	Lazi County
	Apple	4,040	Jiangzi County
	Tea	2,500	Dongjiu, Linzhi County
Livestock and pasture	Seasonal pasturelands	5,500	Changtang
	Yak grazing area	6,000	Himalayas
	Sheep grazing area	5,000	Himalayas

Barley is the staple food for Tibetans. Tibetan traditional medicine believes that roasted barley flour (tsampa) has the most 'jue' (safety and nutrition), and is regarded as a 'mengarbu' (white medicine). Studies on barley have confirmed that barley has medicinal properties and value. In particular it has the potential to contribute fibre (soluble and insoluble) and beta-glucan to the diet. It has an inhibitory influence on cholesterol absorption from the small intestine and so inhibits or prevents diseases such as colon cancers and heart disease. In rural Tibet, large quantities of hull-less barley are consumed, approximately about 155 kg/person/year. For the farmers and herders it is the only significant source of fibre in the diet. Local governments and researchers believe there could be markets for barley outside of Tibet, and production of barley therefore increased from 109,380 ha in 1995 to 127,100 ha in 1999.

Wheat is the second major crop, with a total sown area of 55,040 ha. As shown in Figure 2.5, most wheat cultivation is distributed in Lhasa, Shigatse, and Shannan prefectures, which account for 13,720 ha, 13,320 ha, and 11,220 ha, respectively. Spring wheat is one of the traditional crops of Tibet. Winter wheat was new to most of the farmers in central Tibet when introduced in early 1960s. By 1978 wheat was cultivated on nearly 52,000 ha of cropland, making up almost 30% of the total area of grain production. Since 1980, with introduction of the household responsibility system, the cultivation of winter wheat has decreased gradually. In recent years, the area under winter wheat cultivation expanded again, mainly because of the higher yield of winter wheat compared to barley or spring wheat, but the area of winter wheat production is now declining once again because of the poor quality of grain and low market competitiveness. High quality wheat flour is these days imported from both Nepal and central China.

Some cropland is also put under pulses — mainly peas (12,470 ha), potatoes, and other tuber crops that have been added to Tibetan agriculture (110 ha). Rape seed dominates the oil-bearing crops. The total area of rape seed cultivation was 16,950 ha in 1998.

For the last few years, the area of vegetables, particularly greenhouse vegetables, under cultivation has increased very rapidly, with the present total area being around 7,500 ha. With development and expansion of greenhouse vegetable growing in Tibet, all types of vegetables are now produced locally and available in the market. Even so, more than 40% of the vegetable supply comes from outside of Tibet. Lhasa is the largest consumer of vegetables. To meet this demand, there are only 1,700 ha of vegetable growing area and 67,800 tonnes of production. Changdu produces 4,500 tonnes on 1,400 ha. Shigatse Prefecture has 1,140 ha vegetables under cultivation and produced 46,550 tonnes (Figure 2.6).

The area devoted to forage and fodder crops has also increased considerably in recent years, and now stands at 4,500 ha, of which more than 50% (2,940 ha) is in Changdu Prefecture.

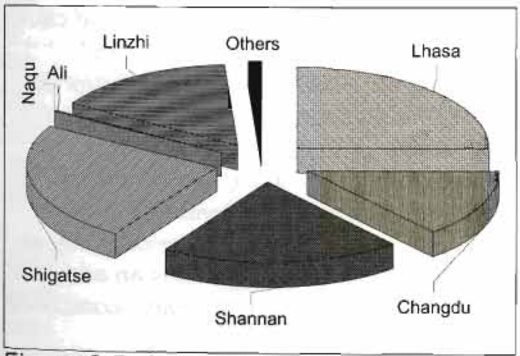


Figure 2.5: **Area of wheat by prefectures**

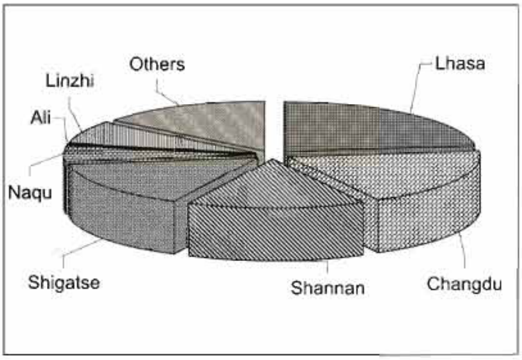


Figure 2.6: **Area of vegetables by prefectures**

Grasslands and livestock for food

The rangelands of Tibet total about 77.38 million ha (both controlled and disputed areas). Out of this, about 55.62 million ha are usable rangelands, with nearly 80% of that in Naqu and Ali Prefectures (Table 2.4). By 1995, there were 5.42 million ha of fenced rangeland for winter grazing and rangeland protection. About 4.17 million ha of this fenced rangeland is in Naqu Prefecture. A total of 4.4 million ha of irrigated rangeland is mostly distributed in Shigatse Prefecture. In recent years, there has been major progress in promoting fenced and irrigated rangelands in Tibet. However, with increasing population of livestock in the pastoral areas of Tibet, overgrazing of rangelands is common and they face serous degradation.

Table 2.4: **Area of usable, fenced, and irrigated rangelands by prefectures in Tibet**

Prefectures	Total area	Area usable	Area fenced	Area irrigated
Lhasa	1,528.7	1,112	12.7	75.3
Changdu	5,975.3	4,965.3	4.7	5.3
Shannan	2,263.3	1,731.3	14	26
Shigatse	9,849.3	4,331.3	29.3	309.3
Naqu	36,046	26,041.3	416.7	0
Ali	21,513.3	17,324.7	0	0
Linzhi	206	115.3	64.7	23.3
Tibet	77,382	55,621.3	542	439.3

Tibet has all kinds of livestock, the most common large animals being yak, cattle, donkeys, horses, mules and zo (cross-bred from yak and cow); there are also sheep, goats, pigs, chickens, and so on.

In 1997, the total population of large and small animals in Tibet was 23.1 million, of which 3.38 million were yak, 1.96 million cattle, 0.35 million horses, 0.13 million donkeys, 11.26 million sheep and 5.83 million goats. Goats are largely found in western Tibet and sheep in north-west and in central Tibet. There are 1.14 million milch cows. With the promotion of livestock in crop dominated areas of Tibet and increasing demand for dairy products, especially butter, cattle raising has been become a very profitable farming activity. Pig raising is also becoming popular these days. With the increase in the urban population, there has been a greater demand for pork. In 1997, there were 210,000 pigs in Tibet, of which 57.6% was off-taken to produce 6,700 tonnes of pork.

Foods and Food Production

Traditionally, yak meat, tsampa, butter tea, potato, radish, lamb, and mutton have been the common foods in Tibet, all of them locally produced. With the introduction and expansion of greenhouse vegetable and winter wheat production in the lower river valleys, consumption of wheat and vegetables has become very common in rural Tibet. Better road connections to cities in central China have increased access to rice and other food items.

Barley is still the staple food of Tibetan farmers. Of the total 1997 grain production of 800,000 tonnes, more than 60% (500,000 tonnes) was barley. Rural Tibetans get more than 80% of their total calories from barley. The way barley has been processed and consumed is not only unique but also very friendly to environmental conservation. In the process of preparing tsampa from barley, sand is used both to distribute the heat evenly to prevent the barley kernels from burning and to increase and to preserve temperature for roasting, which significantly saves fuelwood which would otherwise cause drastic loss of habitat in shrubland and deforestation. The atmospheric pressure on the Tibetan Plateau is very low due to the high altitude, and therefore food cannot be cooked quickly. Fuelwood is quite limited in most areas where barren land and pastoral land dominate. Thus the choice of barley as a staple food crop by Tibetans is an adaptive mechanism to survive in the harsh conditions of highland areas.

The People and the Population

The majority and the minorities

The total population of Tibet in 1997 was 2.42 million. The population density of about 1.96 persons km^{2-1} has doubled since 1959. There were more than 20 different nationalities, including Tibetan and Han Chinese. The total population of Tibetans was about 2.34 million, and there were nearly 70,000 Han Chinese, making up 96.4 and 2.85% of the total population of Tibet, respectively. However, this total population of Chinese does not include those who live temporally in Tibet. The Monba nationality is the third largest population, with a total of 8204. The Lhoba nationality accounted for 2699 people in 1997. Both Monba and Lhoba nationalities are mostly distributed in the south-eastern part of Tibet in Chayu County and Medog County. Other nationalities with small populations include the Sherpa, who live in the western part of Tibet bordered with Nepal with a total population of 1836; Dengba, who live in southern Tibet (1432 persons in 1997); and the Nashi nationality who live in the south-eastern part of Tibet near the border with Yunnan province (total population of 1087). In addition to these nationalities, other minorities of Mongolian, Nu, Zhuang, Derung, Lisu, Tu, Man, Bai, Uygur, Buoyi, Miao, and Yi are also settled in Tibet with total populations of less than 500 (Table 2.5)

Table 2.5: **Population of nationalities in Tibet**

Nationality	1985	1995	1997
Total Population	1,994,808	235,540	2,427,357
Tibetan	1,909,693	2,268,749	2,339,796
Chinese	70,932	67,772	69,205
Hui (Chinese Muslim)	1,529	2,357	1,933
Lhoba	2,036	2,690	2,699
Monba	6,445	8,084	8,204
Nashi	871	1,092	1,087
Mongolian	72	118	96
Nu	227	394	258
Zhuang	31	31	45
Derung	80	21	40
Lisu	62	23	75
Tu	90	150	158
Man	81	171	186
Bai	36	61	91
Bouyi	12	5	13
Uygur	6	4	8
Miao	42	82	87
Yi	21	35	37
Sherba	1,403	2,131	1,836
Dengba	1,097	1,494	1,432
Others Nationalities	42	76	71

People from different regions and prefectures

Besides the diversity of nationalities in Tibet, people who come from different regions or prefectures have been given different names such as Tsampa, from Shigatse region; Uhba, regions of Lhasa and Shannan Prefecture; Khampa, from Chamdo; Hor, from Nagchu (Naqu) in Northern Tibet; Dueba, from western Shigatse and Ali Prefecture in western Tibet; and so on. All these have distinct dialects but share the same written Tibetan language, culture, and religion. Comparing the population of different prefectures, Shigatse Prefecture has the largest population with a total of 630,000. Changdu Prefecture is the second with a total population of 557,000. Lhasa municipality has a total population of 400,000. Ali Prefecture has the smallest population with a total of 73,000 (see Figure 2.7).

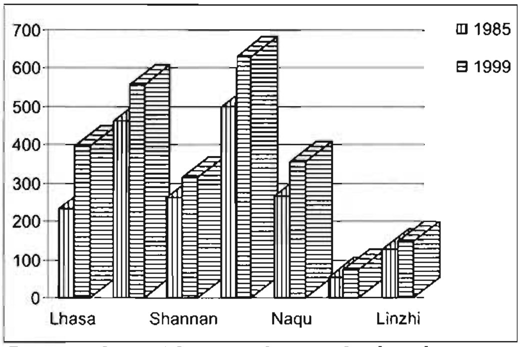


Figure 2.7: **The total population in each prefecture of Tibet**

Birth rate, death rate, and the natural growth rate of population by prefectures in 1998 are listed in Table 2.6. It shows that the birth rate of the population in Naqu Prefecture was highest with 2.17%, followed by Ali Prefecture, 1.96%. There is no big difference in death rate among the prefectures. The highest natural population growth rate was in Naqu at about 1.35%, followed by Ali Prefecture at 1.19%. The average natural growth rate of population in Tibet was 0.93%. However, on the basis of the 1990 national population census and the sample survey on population changes (the sampling fraction was 1%) in each year, the total resident population in 1998 was given as 2.45 million and the average growth rate was about 1.59%.

Table 2.6: **Birth rate, death rate, and natural growth rate of population by prefecture (1998)**

Regions and prefectures	Birth rate (%)	Death rate (%)	Natural growth rate (%)
Average in Tibet	1.62	0.69	0.93
Lhasa	1.18	0.71	0.47
Changdu	1.79	0.53	1.17
Shannan	1.35	0.68	0.54
Shigatse	1.59	0.65	0.82
Naqu	2.17	0.79	1.35
Ali	1.96	0.74	1.19
Linzhi	1.30	0.61	0.62

Urban populations

Lhasa is the capital city of Tibet and it is the centre of Tibetan culture, economy, and politics. It is also the largest city in Tibet. In 1999 its total population reached 140,000. Shigatse is the second largest city with a total population of 91,293. In south-eastern Tibet, Chamdo is the largest town, with a total population of 23,119. Tsetang town is one of the oldest towns located in the Yalong valley, the cradle of Tibet culture, but its total population is only 21,398. The capital town of Linzhi Prefecture, Bayi, is the fastest growing town in Tibet and now has a total population of 15,304. Gyangtse town used to be one of the main towns in Tibet, due to its trade connections with Bhutan and India. However the population of Gyangtse has not grown much for the last few decades, and in 1999 was only 10,356. In all these cities and towns, there are considerable numbers of people from outside of Tibet who are not included in the above figures. Therefore as far as food consumption is concerned, the actual consumers are a much greater population than that indicated by the demographic survey. In recent years, with the adoption of the policy of pairing two well-developed provinces of China with one prefecture in Tibet, and within that policy, two prefectures or cities also paired with one county or town, to provide support of cadres and staff as well as investment in development of infrastructure, all the cities and towns have developed very fast in terms of road construction, telecommunication, office building, and supply of goods. With this progress, the populations of those towns have been increasing very rapidly during the last decade. Urbanisation has begun to take place in Tibet, leading local governments to focus on the economic development of rural areas.

Farmers in different farming systems

Based on their different farming practices, people are named 'shingba', the cropping farmers; 'drogba', the nomads; and 'samadrog', farmers who are practising both cropping and animal husbandry. The farming systems on which people depend are quite different, and their livelihood systems and patterns also differ from each other.

The total population of farmers in 1997 was about 2.09 million, along with about 336,000 non-farmers, making up to 86.2% and 13.8% of the total population, respectively. The total rural population was 2.01 million in 1997, and decreased to 1.8 million in 1999. There has been a rapid increase in urban population in recent years, from 200,000 in 1984 to 687,000 in 1999. The percentage of urban population increased from 10% in 1984 to 27% in 1999.

creased slightly from 51.3% in 1959 to 50.3% in 1999, when it stood at 1.246 million. However, the percentage of females varies considerably among the counties, with the highest being 56% in Jiangda County in eastern Tibet and lowest about 40% in Angreng County in western Tibet (Figure 2.8).

The number of women employed in different industrial sectors in 1998 was 59,971, which represents about 37% of the total number of staff and workers in Tibet. This percentage has been increasing for the last 20 years from only 34.45% in 1980. Of the total female staff and workers, 23% are working in the government agencies and organisations, but this represents only 29.99% of the total staff and workers. Nearly 17% are employed in sectors like education, culture, arts, film, and TV. There were more women than men employed in health care, social welfare, and social services (see Table 2.7). In terms of management and leadership, there is at least one woman in almost all institutions and agencies. This is mainly because of the policy adopted for employing and promoting women staff. However, in most institutions, there is a preference for men, and women still face difficulties in procuring employment.

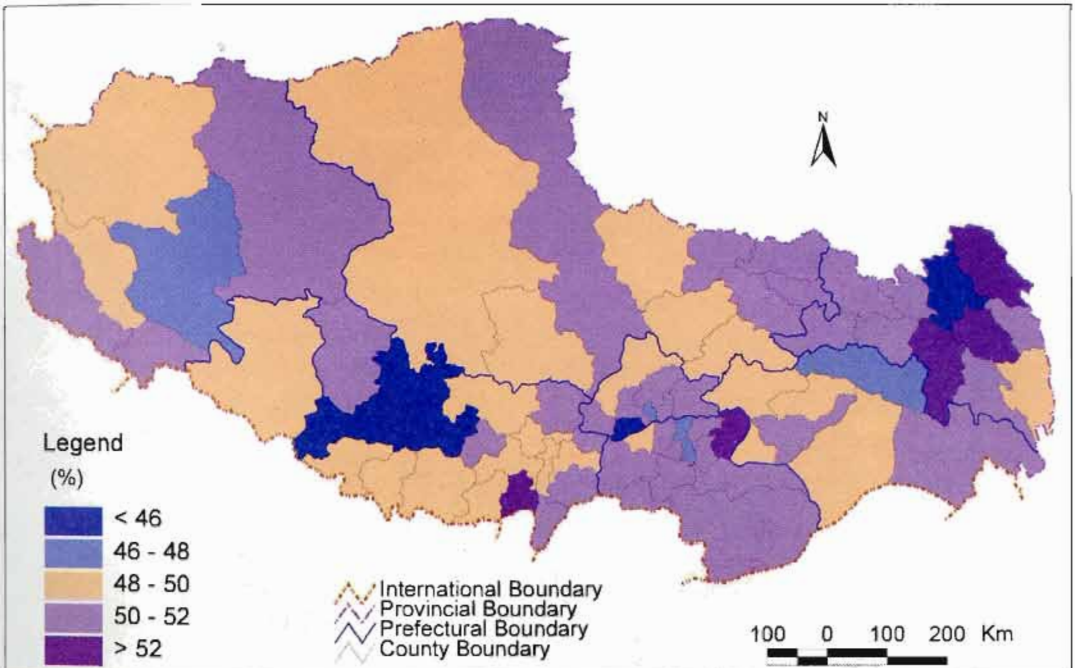


Figure 2.8: **Percentage of female population in each county of Tibet (1998)**

Table 2.7: Numbers and percentage of women staff and workers, by sectors

Sectors	Total staff and workers	Total women staff and workers	%[a]	%[b]
Agriculture	6,745	2,444	4.08	36.23
Government	46,938	14,078	23.47	29.99
Education, culture, arts, film, and TV	24,332	10,045	16.75	41.28
Transportation, post, and telecommunication	15,806	5,419	9.04	34.28
Health care, social welfare	11,665	6,140	10.24	52.64
Sciences and technology extension	2,501	1,011	1.69	40.42
Mining and quarrying	3,684	998	1.66	27.09
Production and supply of electricity and gas	5,494	1,986	3.31	36.15
Banking and finance	5,888	2,152	3.59	36.55
Retail trade and catering services	9,584	3,628	6.05	37.85
Manufacturing	11,402	4,673	7.79	40.98
Construction and building	9,642	3,246	5.41	33.67
Social services	5,694	3,088	5.15	54.23
Other sectors	3,967	1,063	1.77	26.80

a. Percentage of women staff and workers to total women staff and workers employed in all sectors

b. Percentage of women staff and workers to total staff and workers in each sector

Tibetan highland women in festive mood
- Tej Partap

Three

access to food

Background:	Increasing vegetable farming in polythene greenhouses in the Lhasa area - Sichuan farmers take land on hire from Tibetan farmers and grow vegetables - *Tej Partap*
Top Inset:	Vegetable market in Lhasa - vegetables grown in Lhasa available in the market - *Tej Partap*
Bottom inset:	Harvesting barley (crop dominated system) - *Nyima Tashi*

Seabuckthorn, girl and harvested Radish (Nima County) - Nyima Tashi

Chapter 3
Access to Food

The main goals of agricultural development in Tibet are to ensure production of adequate food supplies, to improve accessibility to available food supplies, and to maximise stability in the flow of food supplies. The issues include greater demand for food driven by increases in population and income growth, resource scarcity determined by harsh natural conditions and limited utilisation capacity; inadequate distribution of food resulting from inappropriate management of food sources, and low institutional capability for making suitable food policies. This chapter analyses the achievements and problems in ensuring that everyone has access to food.

Some simplified indicators were used to measure access to food in Tibet and to show whether everyone has access to food.

Energy equivalent (kcal) and protein equivalent (g) are commonly used for measuring food availability and consumption (FAO 1996; Lu Liangsu 1991). Both energy and protein equivalents measure the amount of food in equal units so that they are easy to compare. Per capita energy and protein availability and intake are important indicators of the levels of food availability and consumption. To calculate this, one must convert nutritional value to calorie, protein, and fat equivalents using standard nutritional values of food. In Tibet, cereals, oilseed, vegetables, meat, milk, eggs, sugar, and alcohol are the main food products, and statistics are available for supply and consumption. Calorie, protein, fat, and carbohydrate equivalents of these foods were calculated (Table 3.1).

However, the minimum energy required by the human body differs among individuals. Therefore, the ratio between the per capita energy supply and minimum required energy[1] is important for measuring the critical level of access to food. However, this does not reveal at which level the food supply is secure. Calculation of the size and percentage of the population whose average

Table 3.1: **Main foods and their calorie, protein, fat, and carbohydrate equivalents**

Food	Grain	Vegetables	Oil	Meat	Milk	Eggs	Sugar	Alcohol
Energy (kcal kg^{-1})	3,570	380	8,840	1,650	660	1,580	3,850	430
Protein (g kg^{-1})	94	16	0	187	33	128	0	5
Fat (g kg^{-1})	20	1,033	1,000	94	37	113	0	0
Carbohydrate (g kg^{-1})	754	85	0	0	47	12	995	35

Note: This conversion was based on, standard nutritional value of crops analysed by the Bureau of Agriculture of Tibet Autonomous Region (1990) and national standard nutritional values of meat, milk, eggs and alcohol.

energy intake falls below the minimum required was used to measure chronic food insecurity in a region. A more intuitive indicator to measure food adequacy (FA) was used, as defined in the following formula (FAO 1996), to calculate the level of food inadequacy.

FA= [(PUNNUR(CAVREQ-CAVUNNUR))/ PTOTAL*CAVAVAIL]* 100

(where PUNNUR is the number of undernourished individuals; PTOTAL is the total population; CAVREQ is the average calorie requirement norm; CAVUNNUR is the average availability of calories for the undernourished in the population; and CAVAVAIL is the average calorie availability).

Using these indicators, the status of access to food was analysed based on food supply and its stability, food consumption, and the balance between food supply and consumption.

Food Production and Supply

The total food supply depends on food production, food trade, and food stocks. Food trade in Tibet is not as important as other trade and does not fluctuate greatly from year to year. Food stocks depend on food production and food grain procurement policy. For the majority of the population, locally produced food is crucial for ensuring food security. Food production is affected by changes in biophysical conditions, inputs, and agricultural structure. The quantity and stability of local food production is therefore important for food accessibility and reflects the overall food supply situation.

Per capita food production and supply

Per capita food production has increased rapidly since 1978. This is attributed to the introduction of the household responsibility system of agricultural development in 1980. Production of cereals, oilseed, meat, and milk has significantly increased during the last 20 years. Per capita food grain production increased to 326 kg in 1997 from 266 kg in 1978-80. Figures for oilseed, meat, and milk also increased (Table 3.2). Strong emphasis on crop production since 1988 has also increased production of cereals and oilseed, improving food grain availability.

The stability of per capita food production can be measured by a fluctuation index. The fluctuation index[1] of production of food from 1978 to 1995 shows that stability of per capita food production, particularly cereals and meat, has improved since 1988. However, instability (negative fluctuation index) remains; milk production has fluctuated year by year. Figure 3.1 shows the overall trends of the fluctuation index of main food items.

One obvious characteristic of food production and supply is the low per capita food production and food trading in rural areas.

Table 3.2: **Per capita food production**

Food	1978-80	1981-85	1986-90	1991-95	1995	1997
Grain (kg person^{-1})	266.1	242.8	246.6	294.3	305.5	326.6
Rape seed (kg person^{-1})	4.9	6.3	6.8	11	14.3	13.8
Meat (kg person^{-1})	26.9	32.9	40.6	44.5	48	51.6
Beef (kg person^{-1})	11.6	15	20	23	26	29.3
Lamb and mutton (kg person^{-1})	14.1	16.7	18.9	19.6	19.2	22.3
Milk (kg person^{-1})	53	61.2	74.9	75.5	74.8	76.6

[1] the fluctuation index was calculated as: $FSt = (P_t - Ap_t) / AP_t$ *where*
P_t = actual value of a year
Ap_t = average value in every five years, indicates the long-term changing trends
$P_t - Ap_t$ = value of fluctuation after deducting the average value
FSt = the fluctuation index. The higher the absolute value of FSt, the less stability or more fluctuation

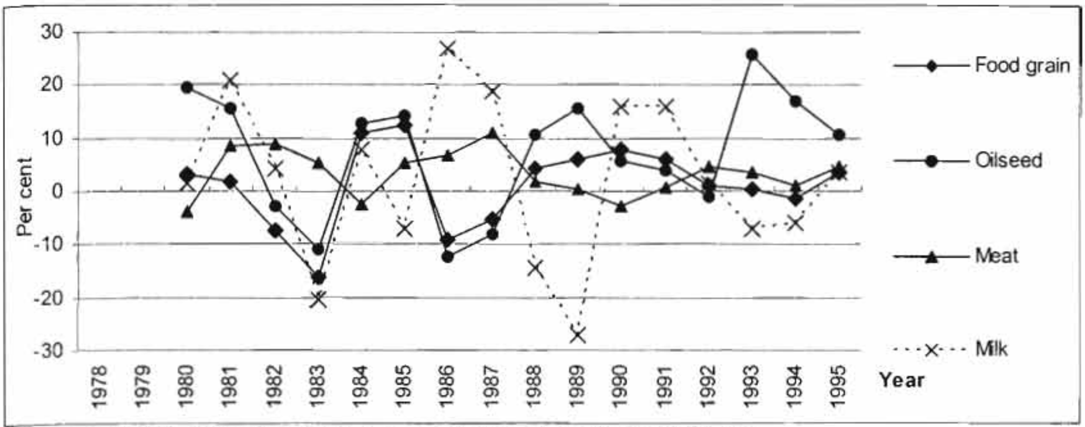


Figure 3.1: **Fluctuation index per capita of main food items**

This shows that an effective supply of food has not been achieved. The data for the last few years show that per capita food production by the rural population has decreased from 510.97 kg in 1991 to 492.82 kg in 1997. Except for pork and eggs, production of all other food items has declined (Table 3.3). The decline of per capita food production was mainly induced by rapid population growth. The proportion of food sold or traded by farmers over total production was at a low of about 1% but tending to increase. At present, assuming that per capita consumption of cereals is about 270 kg, on the basis of 10% food grain trading of 492.28 kg per capita production, then, 5-6 rural people can support one non-agricultural person.

Total food production and supply

During the 1980s, production of cereals stagnated at around 0.5 million tonnes By 1997, total food grain production had reached nearly 0.8 million tonnes. Oilseed production has grown steadily and is currently about 33,700 tonnes. Increases in both food grain and oilseed production in the past two decades have been driven by better yields rather than expansion of cultivated land. The yield of cereals has increased by 1.65 tonnes ha^{-1} from the late 1970s to 1997 and oilseed yield has doubled. This has been due to the adoption of new, high-yielding crop varieties. However, the amount of food grain imported from China (mainly rice and wheat) has increased to 70,300 tonnes/yr^{-1} in 1997, up from 25,600 tonnes yr^{-1} in the late 1970s (Table 3.4). Population growth was the driving force for this but another important factor was that more people are consuming wheat and rice rather than barley.

Meat and milk production have nearly doubled over the last two decades, to 121,500t and 186,000t, respectively, in 1997

Table 3.3: **Per capita production and trading of major food items in rural areas**

Year	1991		1993		1995		1997	
Food production and food trading	Produced	Sold	Produced	Sold	Produced	Sold	Produced	Sold
Food grain (kg $person^{-1}$)	511	80.4	529.1	42.9	528.9	56.5	492.8	51.5
Rape seed (kg $person^{-1}$)	16.9	5.2	18.5	4.2	20.9	4.3	17	3.5
Vegetables (kg $person^{-1}$)	75	8	47.5	4.8	61.7	4.3	59	9.3
Fruit (kg $person^{-1}$)	5.4	2.9	6.6	1.5	4.4	0.7	5.9	0.9
Pork (kg $household^{-1}$)	21.7	1.2	29.6	2.6	21.8	0.3	23.3	5.8
Meat (kg $person^{-1}$)	61.2	8.3	81.4	2.4	52.8	1	61.2	15.8
Milk kg $person^{-1}$)	354.9	1.9	417.9	4.9	318.3	3.1	329.1	3.4
Eggs (kg $person^{-1}$)	4.5	0.6	10.4	1.1	10.7	0.6	12.1	1.2

Table 3.4: **Total availability of major foods**

	1978–1980	1981–1985	1986–1990	1991–1995	1995	1997
Food grain production ('000 t yr^{-1})	480.6	465.1	517.7	671.5	719.6	791.9
Grain yield (t ha^{-1})	2.4	2.4	2.7	3.5	3.8	4.02
Rape seed production ('000 t yr^{-1})	8.9	12	14.3	25.1	33.7	33.7
Rape seed yield (t ha^{-1})	0.8	1.1	1.4	1.8	1.8	1.9
Meat production ('000 t yr^{-1})	48.6	63.1	85.4	101.4	112.1	121.5
Milk production ('000 t yr^{-1})	95.7	116.9	167.4	173.3	176.1	186.0
Imported grain ('000 t yr^{-1})	25.6	30.6	74.1	58.1	70.3	70.3

from 48,600t and 95,700t, respectively, in the late 1970s. This is a significant increase, but has been made at the cost of acceleration of overgrazing and rangeland degradation. With population growth, greater demand for meat and milk means that consumption is now ahead of production. For instance, total butter production is about 1,200t but average per capita butter consumption has reached 3.25 kg and total demand is 8,000t, creating a 6,800t deficit.

Food production is distributed unequally among prefectures. Almost 90% of cereals, oilseed, and vegetables are produced in central Tibet in Lhasa, Shigatse, and Shannan prefectures, whereas northern Tibet, including Naqu and Ali prefectures, produces less of these foods but relatively more meat and milk (Table 3.5). The large area of Tibet and long distances mean that unequally distributed food production creates pressures on redistribution. Thus, achieving an effective supply of food in Tibet is more challenging than merely producing more food.

Fluctuation of total production of various foods has stabilised remarkably since 1988, whereas during the 1980s there were great fluctuations from year to year (Figure 3.2). Comparing the pattern of fluctuation of food production with agricultural policies adopted between the 1980s and 1990s, the greater stability can be attributed to the emphasis on inputs, technology, and infrastructure development.

Per capita calorie and protein supply

Converting the food produced in Tibet into calorie and protein equivalents, the maximum production of per capita calories and protein in 1997 was 3,936 kcal day^{-1} and 113g day^{-1}, respectively (Table 3.6). These

Table 3.5: **Total supply of major food items (1997)**

Prefecture	Crop-based food			Livestock-based food			Total population ('000 persons)
	Food grain ('000 t)	Rape seed (t)	Vegetables (t)	Meat ('000 t)	Milk ('000 t)	Eggs (t)	
Lhasa	153	9,668	43,148	12.1	14.7	343	39.3
Changdu	121.5	747	6,836	35.2	43.3	16	54.5
Shannan	140	5,067	20,552	13.2	33.1	834	31.1
Shigatse	295	16,090	39,836	21.1	4.3	428	61.8
Naqu	4	8	1,897	29.1	28.8		34.5
Ali	4.7	31	75	5.1	6.1		7.2
Linzhi	70.6	2,045	7,174	4.2	16.6	427	14.4
Other	3	26	21,959	1.4			
Tibet	791.9	33.7	141;478	121.5	186	1,418	2,408

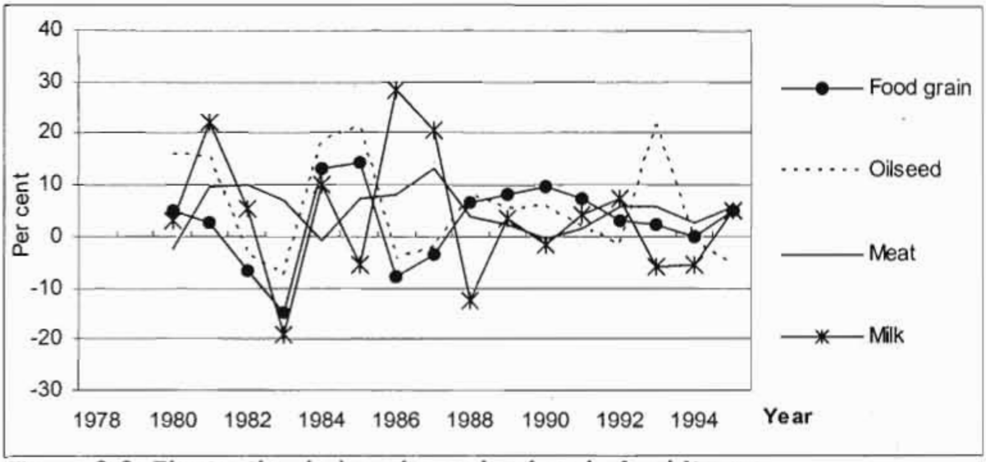


Figure 3.2: **Fluctuation index of supply of main food items**

Table 3.6: **Per capita calorie and protein available**

	1978–80	1981–85	1986–90	1991–95	1995	1997
Total energy (kcal person^{-1} day^{-1})	2,938.9	2,786.3	2,895.7	3,482.7	3,686.3	3,936.3
Total protein (g person^{-1} day^{-1})	87.1	84.9	91.1	105.42	110.	113.7

are considerable increases from 2938 kcal day^{-1} and 87g day^{-1} in 1978-1980. However, 20% of food grain is estimated to be used as seed, animal feed, or lost during storage and distribution, and 10% of meat, milk, vegetables, and other food items are lost during redistribution, storage, and processing. After deducting these losses from total production, the actual availability of calories and protein were estimated as 2796 kcal day^{-1} and 97g day^{-1}. These amounts of calories and protein are slightly higher than basic requirements for people in the plains of China (2,400 kcal day^{-1} calories and 70g day^{-1} protein; Lu Liangsu 1993). Considering that more energy and protein are required for people living at higher altitudes (FAO 1990), the amounts of calories and protein produced in Tibet at present are only just meeting basic requirements.

Calorie and protein production are not only low, but also exhibited great geographic variation. In 1995, 4615 kcal day^{-1} of calories were available in Shigatse Prefecture, while only 630 kcal day^{-1} were produced in Ali Prefecture. The availability of protein in Linzhi Prefecture was about 137g day^{-1}, twice as much as in Naqu and Ali Prefectures (Table 3.7). These two prefectures are in pastoral zones that can produce more animal products such as meat and milk per capita. Per capita protein produced from meat and milk is much higher than other prefectures but still limited in quantity. Lhasa, Shigatse, Shannan, and Linzhi prefectures produce large quantities of food grain and other food products per capita. Prefectures such as Ali and Naqu need to import large amounts of cereals to meet basic requirements for energy. When there is difficulty in importing cereals, then food grain inadequacy and even food insecurity occur. Undernourishment of some of the population may be unavoidable, and some areas are particularly vulnerable to disturbances in food grain distribution. Large quantities of cereals from Qinghai and central Tibet are imported each year to Naqu Prefecture; similarly, the Xingjiang Autonomous Region and Shigatse Prefecture supply

Table 3.7: **Per capita supply of the major food items and expressed as energy and protein in each prefecture**

		Lhasa	Changdu	Shannan	Shigatse	Naqu	Ali	Linzhi	Tibet
Food grain	kg $person^{-1}$	314.5	150.5	374.4	423.3	3.7	62.1	410.9	268.2
	Calories $person^{-1}$ day^{-1}	3075.9	1471.8	3,661.7	4140.5	36.6	607.5	4018.6	2,623
	Protein (g $person^{-1}$ day^{-1})	81	38.7	96.4	109	1	16	105.8	70
Rape seed	kg $person^{-1}$	8.2	0.3	5.3	9.1	0	0.1	5.03	4.7
	Calories $person^{-1}$ day^{-1}	199.8	7.6	128.6	220.4	0.3	1.9	121.9	114.3
Vegetables	kg $person^{-1}$	60.6	13.	73.3	1	0	1.3	72.3	26.9
	Calories $person^{-1}$ day^{-1}	63.1	13.6	76.3	1	0	1.3	75.2	28.
	Protein (g $person^{-1}$ day^{-1})	2.6	0.6	3.1	0	0	0	3.1	1.2
Meat	kg $person^{-1}$	26.9	56.3	43.6	28.8	93.85	81.7	34.2	47.6
	Calories $person^{-1}$ day^{-1}	121.5	254.7	197.1	130.4	424.27	369.6	154.5	215.1
	Protein (g $person^{-1}$ day^{-1})	13.8	28.9	22.3	14.8	48.08	41.9	17.5	24.4
Milk	kg $person^{-1}$	34.4	73.9	99.7	66.5	93.85	89	117.5	74.7
	Calories $person^{-1}$ day^{-1}	62.3	133.6	180.3	120.3	169.71	161.02	212.5	135.2
	Protein (g $person^{-1}$ day^{-1})	3.1	6.7	9.	6	8.5	8	10.6	6.8
Eggs	kg $person^{-1}$	0.4	0.	1.9	0.7	0	0	1.9	0.6
	Calories $person^{-1}$ day^{-1}	1.7	0.1	8.3	2.9	0	0	8.1	2.6
	Protein (g $person^{-1}$ day^{-1})	0.1	0.	0.7	0.2	0	0	0.7	0.2
Total	Calories $person^{-1}$ day^{-1}	3,524.4	1,881.4	4252.3	4,615.6	630.9	1,141.3	4,591	3,118.3
	Protein (g $person^{-1}$ day^{-1})	100.6	74.9	131.6	130.1	57.5	66	137.7	101.6

food to Ali Prefecture under government subsidies so that nomads can meet their basic energy requirements[2].

In general, there has been a remarkable increase of calories and protein production over the last 30 years. It is now important to put efforts into adequate redistribution of food, particularly from areas of surplus to areas with deficiencies. Trends of the increase of calories and protein are similar to the food grain curve compared to other food items. Coefficiencies of correlation between per capita food production and energy and protein show significant correlation between food grain and both calories and protein, with correlation coefficients of 0.97 and 0.91, respectively (Table 3.8). Nearly 86% of energy and 56% of protein were provided by cereals in 1995.

The fluctuation index of availability of calories and protein was calculated using the same method as their stability from year to year. The general pattern of the fluctuation index was the same as total food production (Figure 3.3). In general, about half of the increase in agricultural output during 1978-84 can be attributed to the improvement of incentives arising from changes of farming institutions from the collective system to the household responsibility system (FAO 1996). Since 1987, the overall situation of food production has stabilised. Food production in Tibet is generally affected by biophysical conditions, especially climatic conditions. It is still not possible to alleviate the loss of food production to natural disasters such as snowstorms and drought.

Constant and stable increases in food production may not be attained unless there is continuing prioritisation of production from both livestock-based food and cereals. With rapid population growth and a decrease of per capita land-resource availability as well as increasing demand for food, food production needs to be stable and increasing.

Table 3.8: **Correlation between per capita food production, calories and protein**

	Grain	Rape seed	Meat	Milk	Calories	Protein
Grain	1					
Rape seed	0.64	1				
Meat	0.33	0.77	1			
Milk	0.16	0.30	0.58	1		
Calories	0.97	0.79	0.53	0.30	1	
Protein	0.91	0.63	0.67	0.44	0.98	1

Note: Calculation of the co-efficiency of correlation was based on data of per capita food grain, oilseed, meat, milk and vegetable production over 20 years.

Food Consumption

Food consumption and demand have increased with the growth of population and the increase in food consumption attributed to increased per capita income. Per capita food consumption is determined by age, sex, occupation, income, and health condition. It is also affected by the structure of food consumption, which depends on nationality, social status, age, food habits, and environmental conditions. Unavailability and imprecision of data on food consumption do not allow elaboration of these aspects. However, dividing the population into three groups — urban, rural, and poor — allows the examination of status of food consumption and implications for food security.

Calculation of calories and protein were based on eight main food items (cereals,

[2] Personal communication with people from these prefectures. No exact data were available, but 3-4 million tonnes of food grain are deficient in Ali Prefecture. Out of that, 2 million tonnes are provided by Xingjiang Autonomous Region and 1-2 million tonnes by Shigatse Prefecture. Naqu has a much greater deficit of cereals and much more is provided from Qinghai Province.

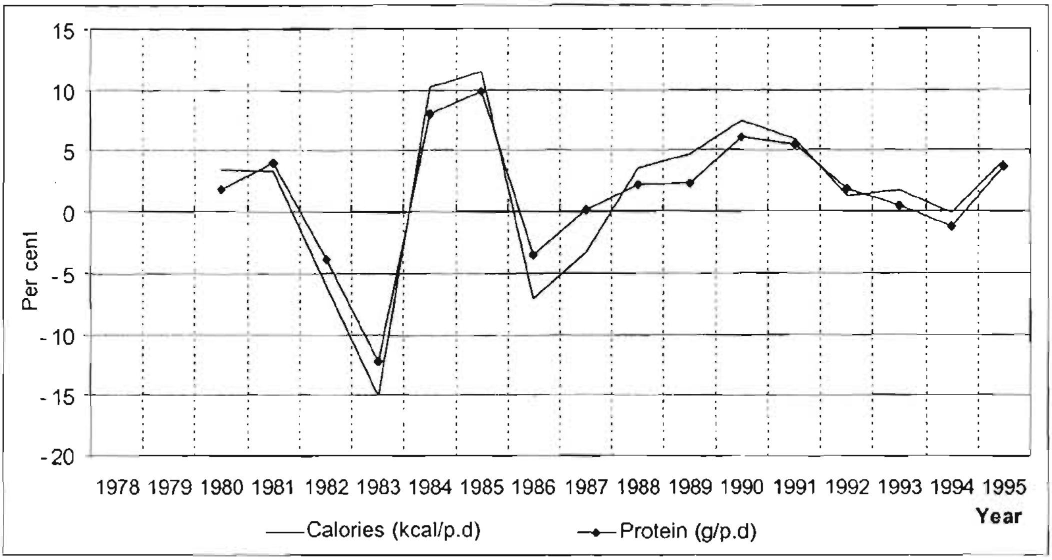


Figure 3.3: **Fluctuation index of major food items expressed in calories and protein**

oilseed, meat, milk, vegetables, eggs, sugar, and wine).

Food access and consumption in urban areas of Tibet

The total population of urban areas in 1995 was about 420,000, of which around 47% derived a certain portion of their livelihood from agriculture. The total expenditure of this population in 1995 was 3,912 yuan person^{-1} yr^{-1}, and 2,254 yuan person^{-1} yr^{-1} was spent on food. This is 57%, a considerable amount. This is probably because many foods such as fine wheat flour, poultry, and vegetables, which are the main food items for urban dwellers, are imported from other parts of China and some from Nepal. The market price of this food is high because of transportation costs. The urban population spends more than half of its livelihood expenditure on food, although actual food consumption is not high. Total consumption of food grain is about 143.7 kg person^{-1}, and meat and milk consumption are 25.1 kg person^{-1} and 102.3 kg person^{-1}, respectively (Table 3.9). The total amount of per capita calorie and protein intake is 2104 kcal day^{-1} and 66g day^{-1}, respectively. Comparing this with the basic requirement of calories and protein for people in central China (2,400 kcal day^{-1} and 70g day^{-1}; Lu Liangsu 1993), it is inadequate.

Almost all the urban population lives between 2,600 and 4,700m. In 1990, the FAO examined the energy requirement of the body at different elevations, for different exercises, and for different age groups. It

Table 3.9: **Food consumption in urban areas (1995)**

	Food grain	Vegetables	Oil	Meat	Milk	Eggs	Sugar	Wine	Total
Urban (1995)	143.7	94.1	8.6	25.1	102.3	8.5	3.8	14.6	
Calorie (kcal day^{-1})	1,405.5	98	208.3	113.5	185	36.8	40	17.2	2,104.3
Protein (g day^{-1})	37	4	0	12.7	9.2	3	0	0.2	66.3
Fat (g day^{-1})	7.8	0.3	23.6	6.5	10.4	2.6	0	0	51.2
Carbohydrate (g day^{-1})	296.8	21.9	0	0	13.1	0.3	10.4	1.4	343.9

found that the higher the elevation, the more calories the human body requires (FAO 1990). Assuming that the estimate of the basic requirement of energy and protein (2,400 kcal day^{-1} and 70g day^{-1}) for people in central China is acceptable, then the basic requirement of calories and protein for people in Tibet should be at least 2,500 kcal day^{-1} and 80g day^{-1}. Based on this assumption, the urban population's ratio of calorie intake to basic requirement is about 84%, which is close to critical.

Food access and consumption in rural Tibet

The majority of the population is rural, 86% of 2.4 million people. In 1995, the total expenditure of farmers was about 896.6 yuan $person^{-1}$ yr^{-1}, of which 667 yuan $person^{-1}$ yr^{-1} was spent on food, about 74%. In 1997, the total expenditure decreased to 830.68 yuan $person^{-1}$ yr^{-1} and expenditure on food to 533.25 yuan $person^{-1}$ yr^{-1}. The proportion of expenditure devoted to food was reduced to 64%. Rural farmers consumed about 2941 kcal $person^{-1}$ day^{-1} of calories and 78.26g $person^{-1}$ day^{-1} of protein in 1995, which was derived from 264 kg $person^{-1}$ of food grain, 12.17 kg $person^{-1}$ of meat, and 14.04 kg $person^{-1}$ of milk (Table 3.10). Comparing the structure of food consumption of rural farmers and urban dwellers, rural farmers consume more food grain but less vegetables, eggs, meat, and milk. The proportion of rural farmers' energy intake to the basic energy requirement was about 117%; much higher than that of the urban population. This is attributed to the large consumption of cereals. Protein intake for the rural population was lower than for the urban population as a result of taking much less milk, meat, and eggs in their diet.

Table 3.10: **Food consumption in rural areas (1995)**

	Food grain	Vegetables	Oil	Meat	Milk	Eggs	Sugar	Wine	Total
Rural (1995)	264.6	23.3	4.6	12.2	14	1	2.4	91.4	
Calories (kcal day^{-1})	2,587.6	24.3	111.2	55	25.4	4.6	25.6	107.6	2,941.3
Protein (g day^{-1})	68.1	1	0	6.2	1.3	0.4	0	1.3	78.3
Fat (g day^{-1})	14.5	0.	12.6	3.1	1.4	0.3	0	0	32
Carbohydrate (g day^{-1})	546.5	5.4	0	0	1.8	0	6.6	8.8	569.2

Food access and consumption in poor areas of Tibet

The total number of officially registered poor was about 480,000 in 1995. They were distributed in 18 counties, of which five were national-level poverty counties. Most of the poor live in areas with a frigid climate, rugged topography, poor natural resources, poor technical options, frequent natural disasters, and backward infrastructure. By 1997, 270,000 people were lifted above the poverty threshold in nine counties. The livelihood and food security of this population are limited by the relatively poor endowment of natural resources, level of agricultural productivity, and the condition of socioeconomic infrastructure as well as the availability of technical and physical capital. For example, in Dingri County in 1998, expenditure on livelihood was around 330 yuan $person^{-1}$ and in Sajia County, in 1997, it was 266 yuan $person^{-1}$. In both counties, over 89% of income was spent on food consumption. On average in Tibet, the total per capita consumption of cereals, meat, and milk in one year was 176 kg, 8 kg and 12 kg, respectively. In 1995, total per capita calorie and protein intake were 1956 kcal day^{-1} and 52g day^{-1}, respectively (Table 3.11). The calorie intake of this population was much lower than the basic per capita requirement of 2,500 kcal day^{-1}. This population certainly falls in the category of undernourished.

Using the food inadequacy (FA) index, the FA value for Tibet in 1995 was 4.2%. In

Table 3.11: **Food consumption in poor areas (1995)**

	Food grain	Vegetables	Oil	Meat	Milk	Eggs	Sugar	Wine	Total
Poor areas (1995)	176.3	10.2	3	8.5	12.3	0.7	1.6	56.6	
Calorie (kcal day^{-1})	1724.6	10.6	74.1	38.4	22.2	2.9	16.5	66.7	1956.1
Protein (g day^{-1})	45.4	0.4	0	4.4	1.1	0.2	0	0.8	52.3
Fat (g day^{-1})	9.7	0	8.4	2.2	1.3	0.2	0	0	21.7
Carbohydrate(g day^{-1})	364.3	2.4	0	0	1.6	0	4.3	5.4	377.9

1997, the FA index decreased to 2.2%. mainly due to strong and effective emphasis on poverty alleviation since 1995. However, the calorie intake for those who are still poor remained at the same level, while per capita calorie availability in Tibet increased to 2794 kcal day^{-1} in 1997.

Discussion and Conclusions

Overall, Tibet has a low level of food security. Per capita food production and food trading in rural areas is low; food production not only has great regional variation, but also has strong instability from year to year; and per capita calorie intake, particularly in poor rural areas, is still low.

Three stages of a region's development of food security were considered: food self-sufficiency, well-off livelihood, and affluence (Lu Liangsu 1993). Per capita availability of cereals, the percentage of food cost in total livelihood cost (Engel's law), the ratio of calorie availability to basic calorie requirement, and per capita GDP were selected as the main indicators of food security status (Table 3.12). In the food self-sufficiency stage, per capita food production is about 500 kg year^{-1} and Engel's law is less than 60%. People focus on food quantity for survival. If per capita food availability falls below this, food inadequacy and even hunger may occur. In the well-off livelihood stage, per capita income is high; people look for quality of food with food adequacy. In the affluent-livelihood stage, per capita food availability is sufficient and there is surplus, per capita income is high, and people look for nutritious and healthy food.

The stage of food security in Tibet is that of food self-sufficiency. In 1995, the per capita food grain availability was 305 kg, Engel's law was 62%, average per capita calorie availability was 2522 kcal day^{-1}, and the ratio of per capita calorie availability to basic calorie requirement was 83%. The per capita protein availability was 72.3g day^{-1} and the per capita net income was 1,691 yuan. Broadly speaking the urban population of Tibet is in the transition stage from the food self-sufficiency stage to the well-off livelihood stage. Similarly, the rural population is in transition from poverty to the food self-sufficiency stage. A few farmers reached the well-off livelihood stage. Most of the poor are in transition from food inadequacy to food self-sufficiency. There remains a small number of poor who are hungry and undernourished (4.6%).

Table 3.12: **Indicators of food security**

Indicator	Self-sufficient	Well-off	Affluent	Tibet
Grain possessed (kg person^{-1})	$\leq$500	500–5,000	$\geq$5,000	305.2
Engel's law (%)	$\geq$60	60–30	$\leq$30	62.4
Ratio of energy supply to requirement (%)	$\leq$80	80–100	$\geq$100	83.3
Average per capita income (Yuan person^{-1} yr^{-1})	$\leq$400	400–4,000	$\geq$4,000	1,691.6

The problem of low per capita food production and food trading is mainly attributed to low-quality food products and lack of competitiveness in the market. The incentives for producing more and better-quality food and the desire by rural farmers to sell food products will only be developed when there is a market for them and farmers benefit from such activity. The market for local food products is only Tibet itself. For local farmers, exporting food products is currently not possible. The food market in rural areas is still small because almost every household produces its own food. There is a subsistence food-production system with hardly any surplus food items exchanged among farmers.

There is little possibility for formation of rural food markets except barter trade with herders in small quantities. In addition, in most rural areas, difficult topography and low population density mean that local farmers depend upon a subsistence food-production system to sustain their livelihoods. Also, the economic level of local farmers is still too low to enable them to purchase food and other necessities from outside.

Nonetheless, there is a demand and a market in urban areas for food produced in rural areas. Almost half a million permanent urban dwellers and a large temporary population depend on food supplied from rural areas. They are not producers of food. Unfortunately, the food required by this urban population is, by and large, imported. Over 70% of the food required by the urban population comes from neighbouring provinces of China. A small portion of the population purchases tsampa and locally produced wheat flour. However, because of the small demand, there is no large-scale marketing of these products. There is great demand for meat and butter, but with inadequate processing, storing, and sanitation, most of the urban population, particularly the Chinese, prefer imported meat, pork, and butter from central China. Thus, there is obvious disjunction between food demand in urban areas and food production in rural areas. The urban Tibetan market for local food products is not accessible to the Tibetan farmers. The main reasons for this are as follow.

- The varieties of food produced by Tibetan farmers are not suited to the demands of the urban population of Tibet. Many Tibetans still do not realise that Han Chinese will not eat tsampa as a staple food. Even many Tibetans, who now have a higher standard of living, no longer eat tsampa as a staple food. However, barley cultivation still accounts for over 50% of the cropland area and production of food grain. The structure of food consumption in urban areas is changing towards rice and wheat flour as staple foods, along with vegetables, fruit, pork, and poultry. However, local farmers are not yet ready to produce these food products. More surprising is that many farmers, who have become rich, themselves purchase rice, imported wheat flour, vegetables, and pork. This flow of food from urban areas even to those rural areas that otherwise produce enough is surprising.
- Poor options and technology for processing high-quality, local food products, particularly food grains such as barley and wheat, mean that local food does not suit the demands of the urban population. Barley has its own unique nutritional quality for people who consume relatively more butter and meat and less vegetables and fruit — such as those living in the highlands. Barley has a high content of beta-glucan that reduces cholesterol and the risk of heart disease from high fat in the diet. Despite this, tsampa is not liked by city people and the well-off. This limits the market for tsampa. Wheat is produced by most farmers in the lower valleys, and there is great demand in the urban market. Unfortunately, the average protein content of locally produced wheat is about 11%, which is too low for processing into bread and noodles. Therefore, despite adequate production, wheat is imported from either Nepal or other parts of China. Meat and milk, theoretically, have a great

potential market but, owing to lack of well-processed products, external and exotic meat and dairy products have taken over the market. Vegetables have a promising market. Products produced in rural areas can be sold in urban areas. However, this is being done by farmers from other parts of China such as Sichuan and Henan provinces. Local farmers are yet to benefit from greenhouse vegetable production.
- Subsidies used to make locally produced food grain attractive to the urban population. However, such subsidies on food grain have now been banned.

It is clear that these problems are restricting the commercialisation of Tibetan food products in the urban market. Without sufficient market incentives, farmers may not even attempt to commercialise their food products. When products cannot be sold at a profit, farmers will not have the incentive to produce more food. Thus, farmers are trapped in a vicious cycle of low food production and low food trading. To improve this situation, the quality and palatability of local food products must be made suitable to the demands of the urban population. Second, farmers should be mobilised and trained to restructure food production according to demands from urban areas. Third, the food-production system should be specialised and intensified so that farmers benefit from it. Fourth, market facilities and food-distribution centres should be developed in rural and urban areas. Finally, subsidies on imported food products should be ended so that local products have an equal chance in the market. The rights of farmers to have access to the urban market should be respected. Farmers should be supported to establish a food-production base that has market competitiveness.

Compared with other parts of China, per capita calorie intake in Tibet is low. The main reasons are lower income and higher prices of food. The average price of commodities in Lhasa is 60% higher than in Chengdu and 40% higher than in Beijing. The price of food is 70% and 45% higher than in Chengdu and Beijing, respectively. The proportion of total livelihood expenditure on food is about 62%, whereas in central China it is 58%. For poor people, who have lower incomes and greater costs, the ultimate result is that people take fewer calories. Low per capita calorie intake also results from low digestibility of food such as tsampa and dry meat, especially in poor areas. People may psychologically feel full after eating these foods, but physiologically they lack energy. This results in people resting or undertaking only light activity, rather than doing intensive, laborious work. Without intensive labour, the output of agricultural activity remains low. A vicious cycle of 'hidden hunger' is created (Figure 3.4).

Therefore it is critical to produce adequate food in Tibet so that it can sustain itself. The long-distance distribution of food has been not only a great financial pressure on the local economy, but has also put the local population at greater risk from natural disasters. Self-sufficiency in cereals and other food items is needed because of the huge cost of distributing food from other parts of China. It is imperative to increase the income of local people and improve food quality and palatability. Most importantly, promotion of market competitiveness for local food products would financially benefit farmers and improve the well-being of rural Tibet. It is also very important to adopt a good policy for agricultural development. Agricultural development in Tibet has been uneven. At some stages it was rapid, while at others it stagnated. Whenever a policy was rational and fitted the reality of agricultural development, it ensured local food security and the well-being of the local people. Under the backdrop of the hidden hunger scenario, the long-distance transportation of food to meet this demand increased costs and the poverty prevalent among the people. A new agricultural development policy announced for the Tibet Autonomous Region in 1993 was aimed at food grain, meat, and oil (milk and oilseed) self-sufficiency (the three self-sufficiencies). It was an integrated approach to developing agriculture and was intended emphasises both agricultural and livestock development. There has been constant growth of agricultural production during the last seven years.

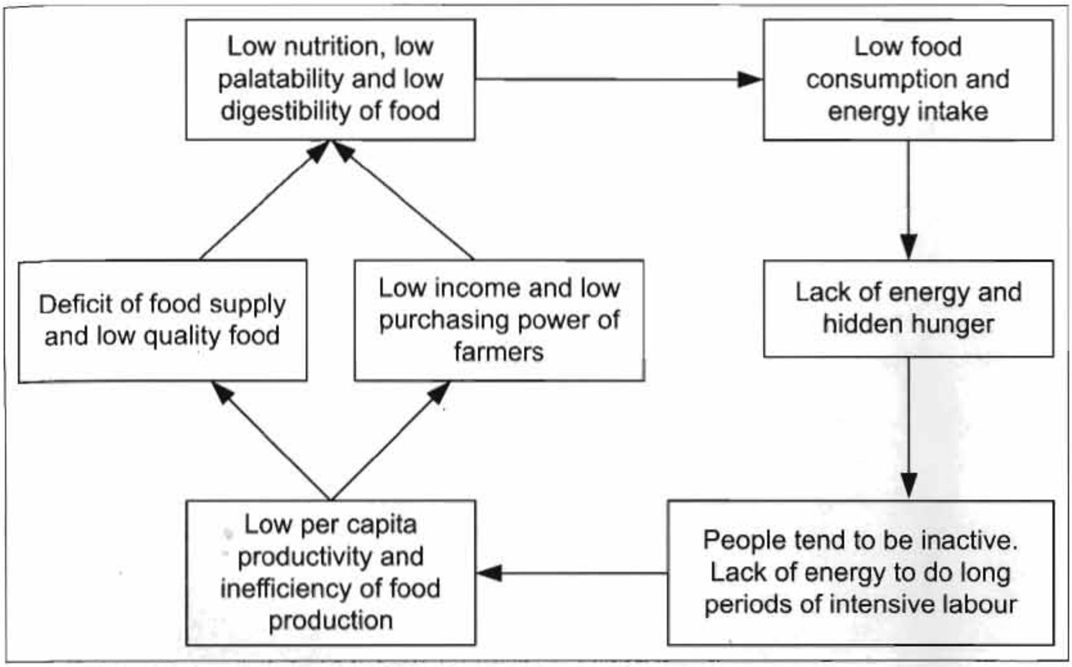
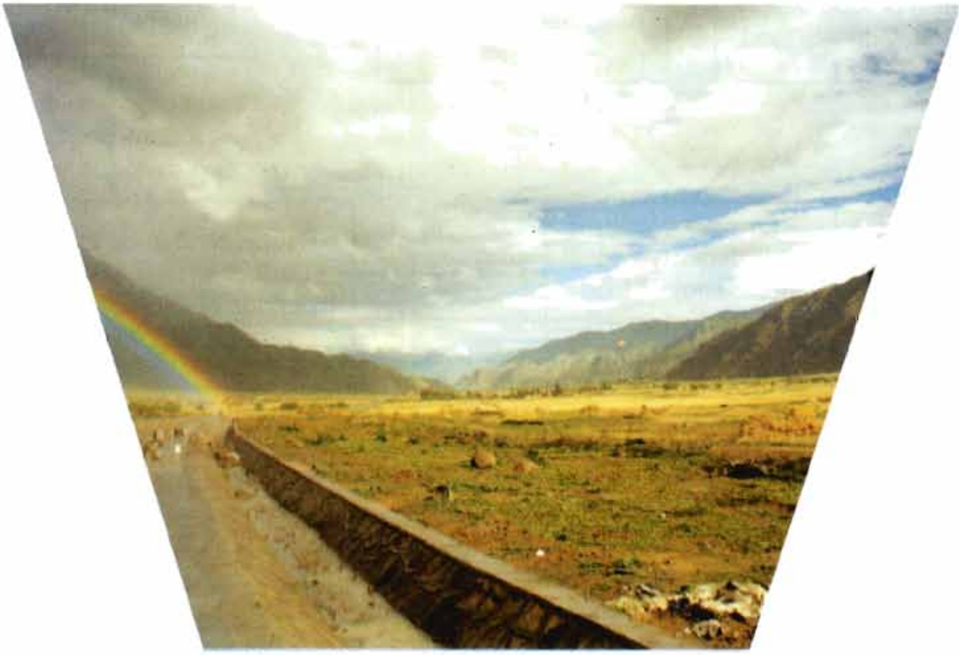
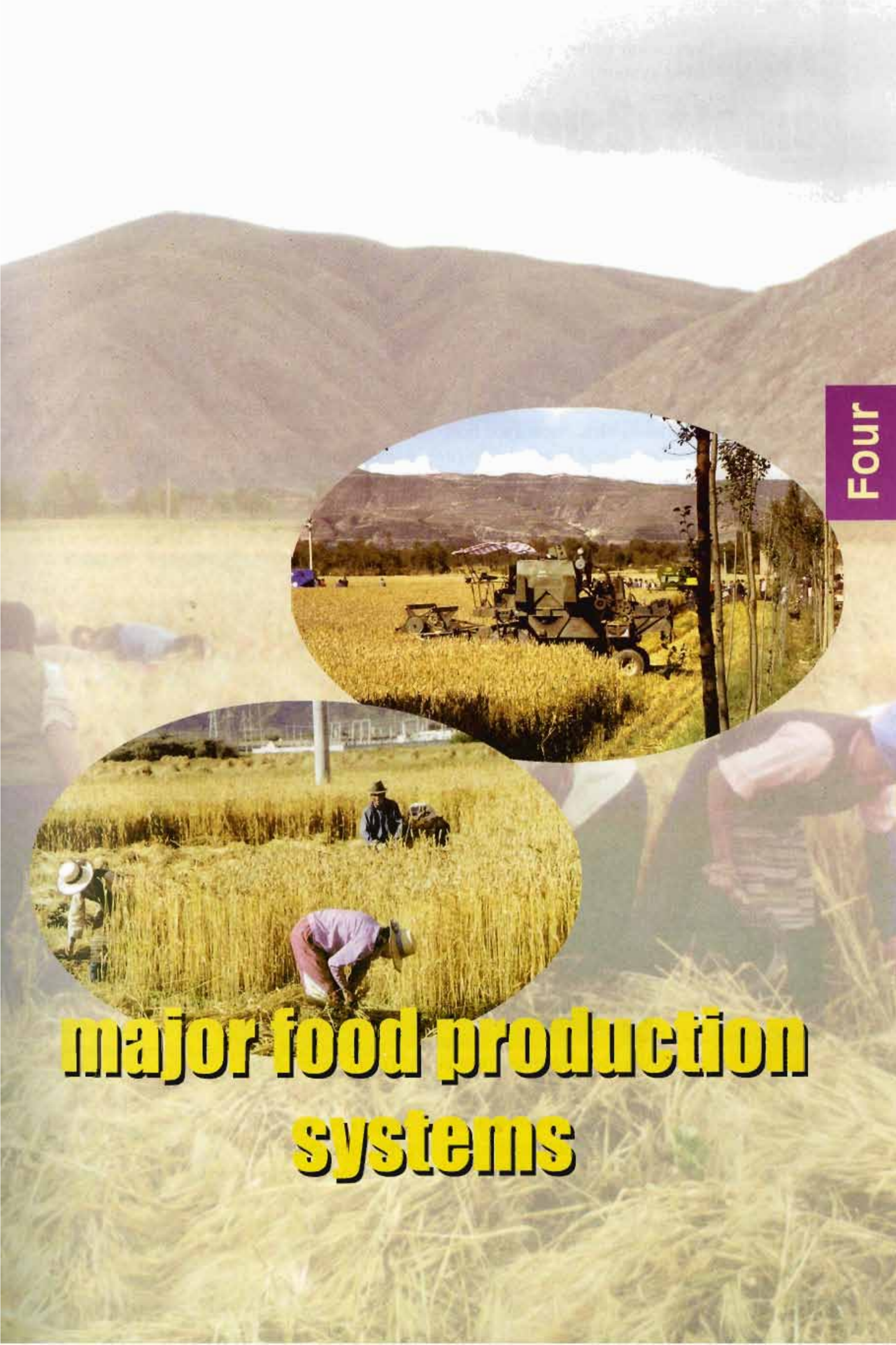


Figure 3.4: **Vicious cycle of hidden hunger in poor areas**



Duilong valley near Lhasa - Nyima Tashi



Four

major food production systems

Background: Harvesting barley (crop dominated system)
- *Nyima Tashi*

Top Inset: Combined harvester harvesting wheat crop in Tibet
- *Tej Partap*

Bottom inset: Harvesting winter wheat (Duilong County)
- *Nyima Tashi*

Harvesting season in Central Tibet - Nyima Tashi

Chapter 4

Major Food Production Systems

The law of regional differentiation is the theoretical base for delineating zones for food-production systems. Food-production systems are determined by land characteristics and human requirements for food. Land characteristics decide what types of food and how much of them can be produced. Human requirements determine what kinds of food and how much of them need to be produced.

Socioeconomic development in Tibet depends upon farming. Cropping, livestock raising, and forestry, which depend on biophysical conditions, are the predominant economic sectors and land uses. In some areas, raising livestock is the only means of producing food, and in others all three are integrated. Intensive and extensive adjustment of land-use patterns has not been carried out. This means that food-production systems are determined by natural, biophysical conditions according to human requirements. Therefore, socioeconomic data related to food production were used to delineate different zones of food-production systems. Contributions of crops, livestock, and forestry to the gross agricultural-production value were considered key indicators.

Delineating Food-production Systems

Maintaining the integrity of the administrative region or county was necessary to incorporate the delineated zone into the decision-making process for planning and development of agriculture. However, there also had to be basic similarities in natural conditions and socioeconomic situations, and similarity in the status of food production or farming. Finally, there needed to be relative consistency of development perspective in food production or farming.

To understand the production system, a county administrative map was created using a geographic information system (GIS). Separate databases for production value of cropping, livestock, and forestry were built. By using the following formulae, the proportion of cropping, livestock, and forestry production value in total agricultural-production value — and an index of comparative advantage of cropping, livestock, and forestry for each county — were calculated and a database established. The results were linked with the county administrative map.

Proportion of X = (X production value / total agricultural production value) iÁ 100%

K= (X production value of a county / total agricultural production value of a county) / (X production value of Tibet / total agricultural production value of Tibet)

Where X means crop, livestock, forestry, fishing and K means the index of comparative advantage of a farming activity component of a county.

As fishing is limited and the percentage of fishing production value in total agricultural-production value is nearly zero, it was not compared with others or used in the delineation of food-production systems.

According to the percentage of cropping, livestock, and forestry production value in total agricultural-production value, and the index of comparative advantage of each sector (Table 4.1), it was possible to delineate four major food-production systems/farming systems of Tibet (Figure 4.1). These four zones are a pastoral production system zone, a crop-dominated production system zone, an agro-pastoral production system zone, and an agro-pastoral-forestry mixed production system zone. The crop-dominated production system zone is situated in the centre of Tibet among 18 counties. The pastoral production system zone is in northern Tibet among 17 counties. Between these is the agro-pastoral production system zone with 27 counties. The agro-pastoral-forestry mixed production system zone consisted of nine counties in south-eastern Tibet.

Although Tibet has been divided into four major food-production systems, there is still great diversification within each production system, particularly in the crop-dominated production system. Almost all households raise livestock and diversify activities to generate income and ensure food security. Further delineation of subsystems was not possible owing to lack of sufficient data.

Counties belonging to each food-production system are listed in Table 4.3, along with their prefectures. Most counties in Naqu and Ali prefectures belong to the pastoral food production system/farming system; counties in Linzhi Prefecture are in the agro-pastoral-forestry mixed production system. Counties in Lhasa Municipality mostly fall under the crop-dominated production system. Shigatse and Shannan prefectures are divided into the crop-dominated zone and the agro-pastoral zone.

Food resources, food supply, and the main features of food consumption in each food-production system are described in Table 4.4.

Table 4.1: **Data derived from delineated map for each food-production system**

Index	Crop-dominated production	Agro-pastoral production	Pastoral production	Agro-pastoral forestry mixed production
Proportion of crop production value in TAPV (%)	72.9	46.3	4.2	42.2
Proportion of livestock production value in TAPV (%)	25.9	47.9	95.8	36
Proportion of forestry production value in TAPV (%)	1	1.2	0	19.6
CAI of crop production	1.4	0.9	0.1	0.9
CAI of livestock production	0.6	1.1	2	0.6
CAI of forestry production	0.3	0.4	0	6.7

Notes: TAPV = total agricultural-production value; CAI = comparative advantage index.

In the process of delineation, adjustment of a particular county was done on the basis of land-use patterns and the requirement for regional continuity. Materials from the Tibetan Bureau of Land Planning (1992a; 1992b) were used as references.

Climatic data were collected for the main ecological zones in each food-production system. There are distinct differences in terms of temperature, precipitation, evaporation, and humidity (Table 4.2).

Crop-dominated production system zone

The crop-dominated zone includes the majority of Lhasa Municipality and some counties of Shigatse and Shannan prefectures. It is located in the river valleys of the middle reaches of Yalongzangpo (Brahmaputra) River and its two tributaries, Lhasa Stream and Nyachu Stream (known locally as 'One River, Two Streams').

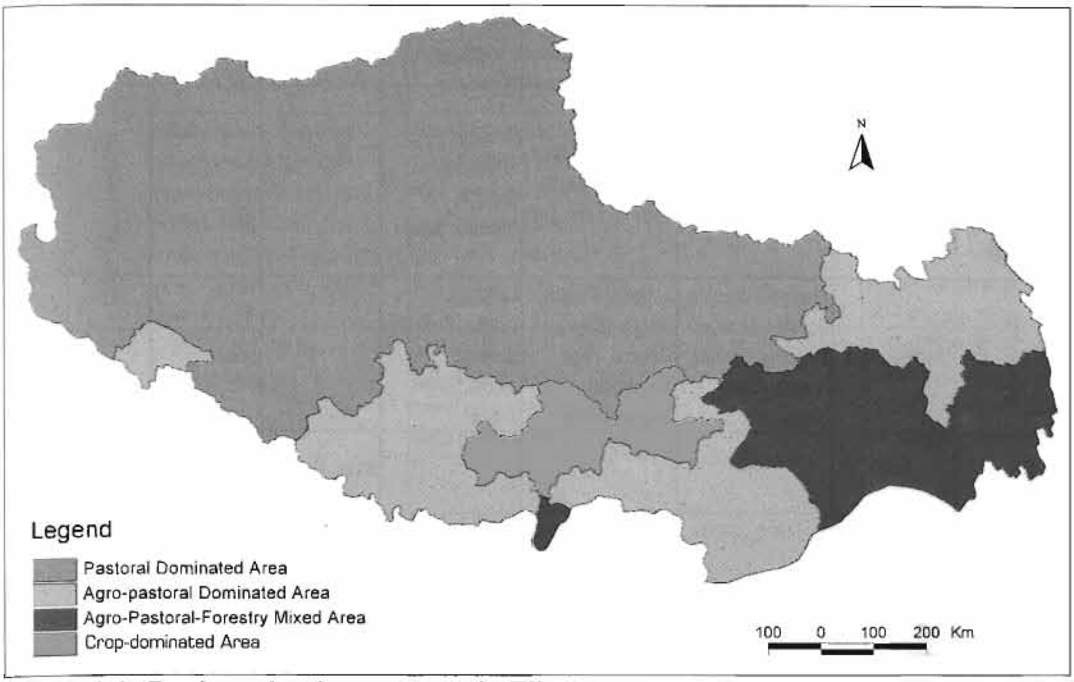


Figure 4.1: **Food-production systems in Tibet**

Table 4.2: Climatic data for each food-production system

Systems	Annual mean temp. (°C)	Annual mean evaporation (mm)	Annual mean rate of sunshine (%)	Annual mean precipitation (mm)	Annual mean relative humidity (%)	Average temp. range day to night (°C)	Annual mean minimum temp. (°C)	Annual mean maximum temperature (°C)
Crop-dominated production system	7.0	2,425.5	70	390.7	43	15.3	(-0.3)	15.1
Agro-pastoral production system	3.0	1,878.5	63	422.5	54	14.0	(-2.9)	10.9
Pastoral production system	-0.5	1,924.3	65	382.0	46	14.8	(-7.5)	7.3
Agro-forestry-pastoral mixed production system	8.3	1,641.1	44	679.5	62	13.3	2.8	16.1
Tibet on average	4.5	1,967.3	60.5	468.7	51.6	14.3	(-2.0)	12.3

Table 4.3: **Counties in each food-production system**

Production system	Lhasa	Changdu	Shigatse	Shannan	Naqu	Ali	Linzhi
Crop-dominated production system	Linzhou, Dazi, Lhasa City, Qushui, Duilongdeqing, Nimu		Nanmulin, Renbu, Jiangzi, Shigatse, Bailang, Sajia, Lazi	Gongga, Zhannang, Qiongjie, Naidong, Sangri			
Agro-pastoral production system	Mozhugongka	Changdu, Jiangda, Gongjue, Leiwuqi, Dingqing, Luolong, Bianba, Chaya, Basuo	Kangma, Gangba, Dingjie, Dingri, Nielamu, Saga, Xietongmen, Angren, Jilong	Langkazi, Luozha, Cuomei, Qusong, Jiacha,Longzi, Cuona		Pulan	
Pastoral production system	Dangxiong		Zhongba		Naqu, Biru, Jiali, Suoxian, Anduo, Shengzha, Bange, Baqing, Nima	Zhada, Ritu, Geji, Gaer, Gaize, Cuoqing	
Agro-pastoral forestry mixed production system		Mangkang, Zuogong	Yangdong				Linzhi, Milin, Gongbujiangda, Langxian, Bomi, Chayu, Muotuo

The total area of this production system is 55,900 sq.km, and the area of arable land is about 180,100 ha, accounting for about 50.5% of the total arable land in Tibet. It contains only 6.5% of the total area of rangelands in Tibet. Cropping, livestock, and forestry account for 73%, 26%, and 1% of the total agricultural production value, respectively (Figure 4.2), and the indices of comparative advantages of cropping, livestock, and forestry are 1.44, 0.62, and 0.33, respectively (Table 4.1). Cropping is generally combined with livestock raising. The main production is food grain and rape seed. This area is the source of commodity food grain.

The average altitude is 3,800m. The area has high solar radiation and long hours of sunshine. The average annual radiation is 191 kcal cm^{-2}. The percentage of sunny days is over 70% and the amount of annual sunshine is 3,000 hr. The weather is cool, with seasons that are not clearly demarcated. There is great difference between day and night temperature but little fluctuation from year to year. The average annual temperature is about 7°C, and the daily temperature variation is 15.3°C. The average temperature is 15.1°C in the warmest month and -0.3°C in the coldest month. Precipitation is mainly concentrated in late summer and early autumn. Dry and rainy seasons are clearly demarcated, and most rain falls during the night. The average annual precipitation is 250-450 mm except for the north-eastern part with higher elevation where average annual rainfall reaches 550 mm. Precipitation in this zone is not distributed evenly either spatially or seasonally, with 90% occurring during June to September and 80% falling during the night. Spring and winter are dry, with annual average relative humidity of

Table 4.4: **Food resources and supply in each food-production system**

		Crop-dominated production system	Agro-pastoral production system	Pastoral production system	Agro-pastoral forestry mixed production system
Crop-based food production	Main food sources	Barley (spring & winter), wheat (spring & winter), rape seed, potatoes, buck wheat, faber bean, maize, peas, vegetables (glasshouse & non-glasshouse), apples, peaches, pears	Naked barley (spring), wheat (spring & winter), rape seed, potatoes, buckwheat, peas, vegetable (glasshouse & non-glasshouse), peaches	Early matured naked barley, rape seed, peas, buckwheat, vegetables (short season)	Naked barley (spring & winter), wheat (spring & winter), rape seed, potatoes, buckwheat, faber bean, maize, peas, vegetables and all kinds of fruit, tea, etc.
	Situation of food supply	Supplier of crop-based food, surplus exported	Self-sufficient in crop-based food, but importing some crop based food from other areas of Tibet	Importer of crop-based food	Self-sufficient in crop-based food, but need to import some crop based food from other areas of Tibet.
Livestock-based food production	Main food sources	Yak, cattle, sheep, goats, pigs, chickens, ducks, fish, etc.	Yak, cattle, sheep, goats, pigs, chickens, fish, etc.	Yak, sheep, goats, fish, etc.	Yak, cattle, sheep, goats, pigs, chickens, ducks, fish, etc.
	Situation of food supply	Importer of livestock-based food	Self-sufficient in livestock-based food, and export some to other areas of Tibet	Supplier of livestock-based food to other areas of Tibet	Self-sufficient in livestock-based food, but importing some livestock products from other areas of Tibet
Food consumption structure		Consume mostly grain; lack of meat, milk, eggs, vegetables and fruit in diet	Mostly grain and meat, lack of vegetables and fruit in diet	Mainly meat, milk and grain, lack of vegetables, fruit, and grain in some cases	Balanced food consumption structure (grain, meat/milk, and vegetables)

43%. Strong sunshine and wind, especially during the spring, lead to high annual evaporation of 2,425.5 mm, almost 10 times more than precipitation. Crops in this zone are prone to drought during the spring and flooding during the autumn. In higher areas, crops are damaged by both spring and autumn frost, and by hail in late summer and early autumn.

A little over 50% of the arable land and 51% of the urban area of Tibet are in the crop-dominated zone. Rangeland, forest, orchards, and water cover relatively small areas, accounting for 6.5, 0.9, 0.9, and 2.8% of the total area of each land type in Tibet, respectively. Arable land accounts for only 3.06% of the total area of the zone, whereas rangeland covers about 73.8%. Forests and orchards occupy 2.03 and 0.06%, respectively, and barren land covers 18.2%. The remainder of the land area is covered by water bodies and roads. Tibet has only a small area of arable land compared to rangeland and barren land, and it is mostly distributed in this zone. Most of the urban area is also concentrated here. It is predominantly a crop-based food production system, but there is also considerable livestock raising — mainly cattle, sheep, and goats. Crops and livestock co-exist in this crop-dominated zone of Tibet.

This zone accounts for over 56% of Tibet's grain production and 70% of rape seed production. The main crops are barley, wheat, rape seed, peas, and potatoes, which occupy 46, 16, 5, 7, and 5%, respectively, of the total cropping area. In the upper, drier

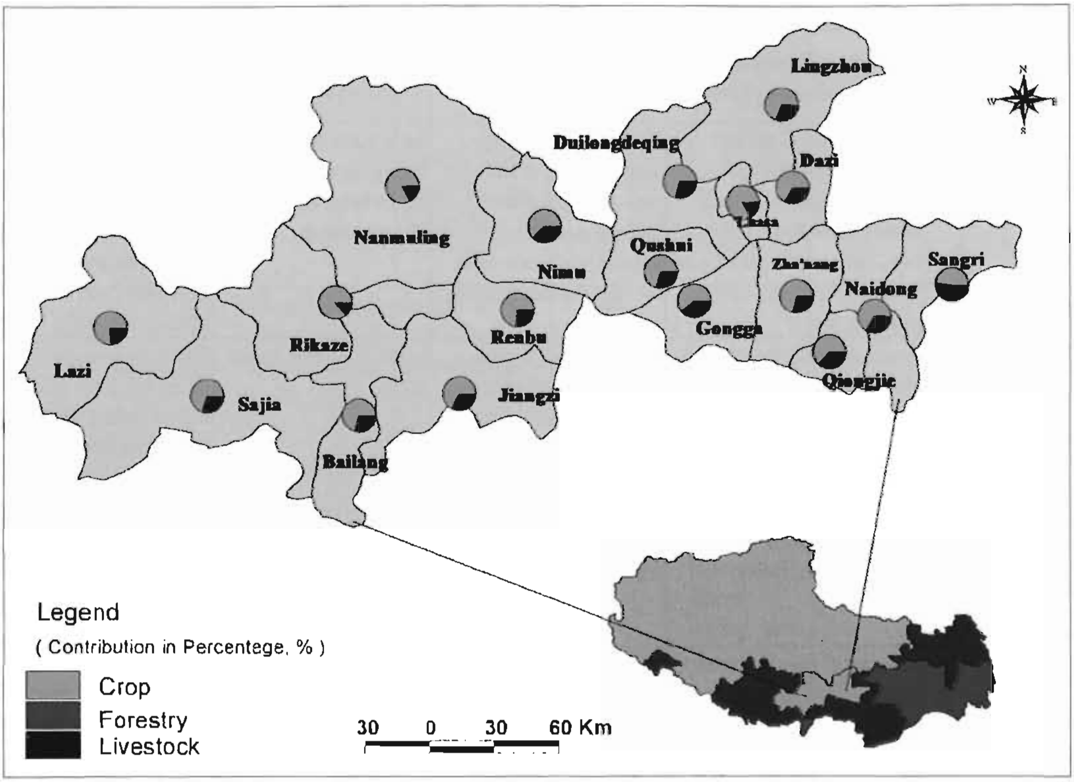


Figure 4.2: **The proportions of cropping, livestock, and forestry in total agricultural-production value in the crop-dominated production system of Tibet**

shrinking. Vegetable farming is increasing rapidly with the development and promotion of greenhouse-vegetable cultivation. Many local farmers rent their cropland to Chinese farmers from central China to grow greenhouse vegetables. After a few seasons of working with the Chinese farmers, local farmers have now started growing greenhouse vegetables by themselves. At present, more than 45% of Tibet's total vegetable supply is produced from this zone. Many kinds of fruit trees, such as peach, apple, and plum, and so on, can be grown. Some orchards were established during the 1960s and 1970s, but now most have been abandoned or turned into cropland because of low productivity and competitiveness with imported fruit in the free market. Selection of new, high-quality fruit tree species and varieties for this area is becoming increasingly important and could be an alternative for local farmers for generating income.

Although cropping dominates the economy of this zone, raising livestock is also an important activity. The number of animals, meat, and milk produced here comprise 16, 16, and 22%, respectively, of the totals for Tibet. Yak, cattle, sheep, goats, pigs, and chickens are the main animals. Pastureland has relatively poor productivity as it lacks irrigation and precipitation. Raising livestock depends mainly on the use of crop residues and by-products as feed, especially during the spring and winter. Yak and zo are the main draught animals. In the lower river valleys, milk is mostly from cows but on higher lands yak milk is the main dairy product. Driven by demand for pork and poultry products in urban areas, the raising of pigs and chickens has increased rapidly in recent years. However, large amounts of poultry and pork products are imported from other parts of China.

Compared to other areas of Tibet, the crop-dominated zone is important for production of cereals. Over 70% of the total food grain production is from this area, and there is considerable surplus of cereals, oilseed, and vegetables that supplies other areas. Although a large number of animals produce large quantities of meat and milk, as the zone has over 56% of Tibet's population, there is a severe deficit of livestock products, particularly meat and milk. More than 76% of all meat and milk consumed has to be imported.

In this zone, people consume mostly grains, little meat, and milk as butter tea. In the rural zone, there is a severe shortage of eggs, vegetables, and fruit in the diet. In terms of energy intake, barley makes up over 77% for farmers. In urban areas, wheat and rice consumption is increasingly common, and those grains account for 35% of the total energy intake.

Agro-pastoral production system zone

This production system or zone includes northern Changdu, north-western Shigatse, and southern Shannan prefectures, including 27 counties. It is located in the upstream valleys of the Yalongzangpo, Cuona, Longzi, Nujiang, Lancangjiang, and Jinshajiang rivers. The production value of crops and livestock is 46 and 48%, respectively, of the total production value of agriculture, and forestry output value is 1.22%. The indices of comparative advantage of cropping and animal husbandry are 0.95 and 1.09, respectively, and forestry is 0.40. In this zone, there are lakes with high reserves of fish, such as Yangzhuo Cuo and Cuona Cuo. However, local cultural belief prohibits fisheries. Therefore fishing has not been developed to bring any economic benefit to local people. It is a typical mixed crop and livestock, agro-pastoral production system zone.

The agro-pastoral system is spread over most of the cold semi-arid highlands. The average elevation ranges between 4,000-4,500m. The climate is similar to that of the crop-dominated zone, but spring temperatures rise more slowly, autumn temperatures decrease earlier, and the frost-free period is shorter. The annual average temperature is 3°C, average temperature in the hottest month is about 10.9°C, and in the coldest month -2.9°C. The temperature difference from day to night is 14°C, much higher than that of season to season. Precipitation is concentrated in summer and the beginning of autumn, and the percentage of night rainfall is high. The average annual precipitation of 422.5 mm is slightly higher than that of the crop-dominated zone. Most of this area is dry in spring and winter. Dry and rainy seasons are clearly demarcated. There is abundant sunshine. The percentage of annual sunshine is 63%. The average relative humidity of air is 54%, and annual evaporation is 1878 mm. This zone suffers from natural disasters such as gales, frost, hail, snow, and so on. This severely restrains the development of agriculture and food security for local people.

This zone covers 291,300 sq.km, 24.3% of Tibet. The percentages of each land use are 0.06% arable land, 54.4% rangeland, 1.3% forestry land, 0.01% orchard, and 17.5% barren land. The percentages of arable land, rangeland, forest, and barren land for Tibet as a whole are 36.9, 24.4, 42.0, and 18.1%, respectively. Affected by the cold and high altitude, most land resources are rangeland and barren land. Widespread crop production is limited by the high altitude and cold climate, and livestock production is undertaken instead. Large amounts of farm land have been cultivated in lower valleys of the zone. In river valleys, small-scale forestation has been carried out using willow and seabuckthorn. In a few counties in the lower area, apple and peach trees are grown on a small scale. However, the general picture of this area is of a food-production system in which livestock (cattle, sheep) have equal importance with crop farming.

Barley is the predominant grain crop, accounting for over 65% of the total area of cropland. In lower parts, spring wheat is grown where possible. Peas are the only pulse grown, and are important as the main pulse grown, and are important as the main source of plant protein for both humans and animals. The total sown area of peas and the total production of the pea crop make up over 55 and 47%, respectively, of that in Tibet. Both sown area and production of grain comprise 30% of the total in Tibet. Many varieties of peas are well adapted to the local environment. Pea grain is mostly used for human food, usually mixed with barley. It is also used as feed for animals, particularly horses. Pea straw is considered locally as the best feed for animals. Mixing barley straw with pea straw is commonly practised. Most farmers grow peas with barley or rape seed. Potatoes and small areas of vegetables, both in greenhouses and outside, are also grown.

Cattle, yak, sheep, goats, and chickens are the main livestock animals. The number of animals, production of meat, and production of milk are 47, 45, and 40%, respectively, of the totals for Tibet. Vegetable, fruit, and poultry production are limited by local environmental conditions. With the exception of these, this zone is generally self-sufficient in food. Small quantities of barley grain are imported from other parts of Tibet and exchanged for meat and other animal products. Barley and mutton meat are the main sources of energy for local farmers. There is a severe lack of vegetables and fruit in the local diet.

Pastoral production system zone

The Changtang, the vast open land of the northern Tibetan Plateau includes the entire territory of Naqu Prefecture, most of Ali Prefecture, and Dangxiong County of Lhasa Municipality, and makes up the pastoral area. Altogether it includes 18 counties. It is surrounded by the Kunlun Mountains in the north-west, the Gandisi Mountains in the south-west, the Nianqingtanggula Mountains in the south-east and the Tanggula Mountains in the east. It occupies almost 60% of Tibet, with a total area of 711,000 sq.km.

Livestock production is the predominant industry in this zone, accounting for over 95% of the total value of agricultural output . Cropland, basically given to barley and rape seed, has been cultivated since the 1960s in the lower river valleys of the southern region, but even today its percentage of total agricultural production value does not reach 5%. There is hardly any forestry in the north, although small areas of forest are scattered in the far south and lower river valleys. Pasture and livestock production are the basis for food and livelihood security for herders in this zone.

Biophysically, this area is characterised as a semi-humid temperate or a semi-humid cold zone. With an average elevation of 4,600m, it is cold and dry all year round. The annual average temperature is lower than 0°C, with an average of 7.3°C in the hottest month and -7.5°C in the coldest month. The daily temperature difference from night to day is greater than that of season to season, and reaches 14.8°C. Precipitation is greater in the east than the west, with an annual average of 382 mm. The majority of the north-western part is cold, dry, semi-desert land and unpopulated. Owing to high, strong solar radiation, long sunshine period (65% of the year), and strong winds or gales, the evaporation is high with an annual total of 1924 mm and relative air humidity of 46%. These harsh natural conditions, unfavourable climate, and a lack of oxygen seriously restrict production of food. Cropping is impossible in most of areas of this zone, and even animal husbandry is restrained by the harsh natural conditions. Moreover, disasters such as windstorms, hail, and frost are frequent, and nomads in particular often suffer from snow calamities. Heavy snow in late 1997 and early 1998 almost resulted in the collapse of the food production system. Nearly 50% of the livestock died. Food security for these nomads was threatened and many plunged into poverty despite having been rich before.

As a result of the harsh biophysical conditions, there is hardly any place suitable for cropping or forestry. Over 67% is rangeland

and 20% is barren land. This accounts for 63.8% of the rangeland and 71.7% of the barren land in Tibet. Most of the lakes in Tibet are distributed in this zone. Almost 60% of Tibet's total water surface area is here. Salt lakes provide an opportunity for herders to exchange salt for food and other necessities. It used to be a major trade for nomads but now is dying out. Fishing could generate income. It used to be practised in some places but now there is hardly any, possibly due to religion and marketing. However it can become a viable source of livelihood in this zone. Collection of herbs is increasing where possible, and is becoming a main source of additional income for households. Overexploitation, driven by market demand, is beginning to appear. Some nomads hunted traditionally as part of the livelihood system. Unique and rare wild animals fetched good value in the market. Since the Changtang Conservation Area has been established, hunting has been declared an illegal activity although it has not been fully controlled yet.

Alternative food resources are limited in this zone. There are hardly any crops, except early-maturing barley, rape seed, and peas. These are low yielding and restrained by climatic conditions. Livestock depends totally on grazing, as there is little production of forage and hay. In the eastern part, rangeland is dominated by highland meadows and swampy meadows. These are relatively productive and can support large grazing animals. The yak is predominant. Over 40% of the total number of livestock (or 80% of livestock in sheep-equivalent units) is yak. Yak provide almost 80% of meat and milk, and 70% of the income for nomads. In the west, rangeland is mainly alpine steppe and alpine desert steppe. Constrained by water scarcity, low precipitation, and low temperatures, the productivity is low. It cannot support large ruminants, but local sheep and goats are well adapted to the conditions. Figure 4.3 further illustrates the difference between the eastern and western parts of this zone. It is clear that there is a larger proportion of yak meat production in the eastern than in the western part of the zone.

For the last few decades, particularly during the 1960s and 1970s, reclamation and cultivation of cropland have been undertaken where possible. The idea was to grow food grain locally to solve the problem of shortages and to avoid the heavy cost of transportation. Unfortunately, many attempts failed as there are no suitable varieties of barley, rape seed, or turnip, and herders do not have the knowledge to manage farm land. A few farmers succeeded in growing cereals and oilseed where there were favourable microclimatic and environmental conditions such as in lower river valleys and on the banks of lakes. Those who gained knowledge and experience in growing crops later went to other counties to reclaim land for cropping. Cropland in both eastern and western parts increased rapidly during the 1970s but decreased considerably after the 1980s. One important lesson learned was that this frigid and fragile land often cannot maintain its productivity when cultivated because decomposition of organic matter is difficult. Large amounts of farm land were abandoned and became useless for both cropping and grazing. Recently, with the introduction of new varieties of barley that can adapt to local conditions and improvements in crop management, new attempts to achieve food grain self-sufficiency have been made in areas such as Ge'er, Suoxian, Biru, and Geji counties. However, food grain and oilseed production in this zone have never reached even 1% of that in the whole of Tibet. Raising livestock is still the essential means for sustaining livelihood. This zone currently supplies over 36% of the meat, 47% of the milk, 56% of the sheep wool, and 40% of the sheep leather for the whole of Tibet.

Exchanging animal products for cereals and oilseed or edible oil is a common practice. Before 1992, it was done by the herders themselves with subsidies from the government. Recently, private businessmen have begun exchanging animal products for

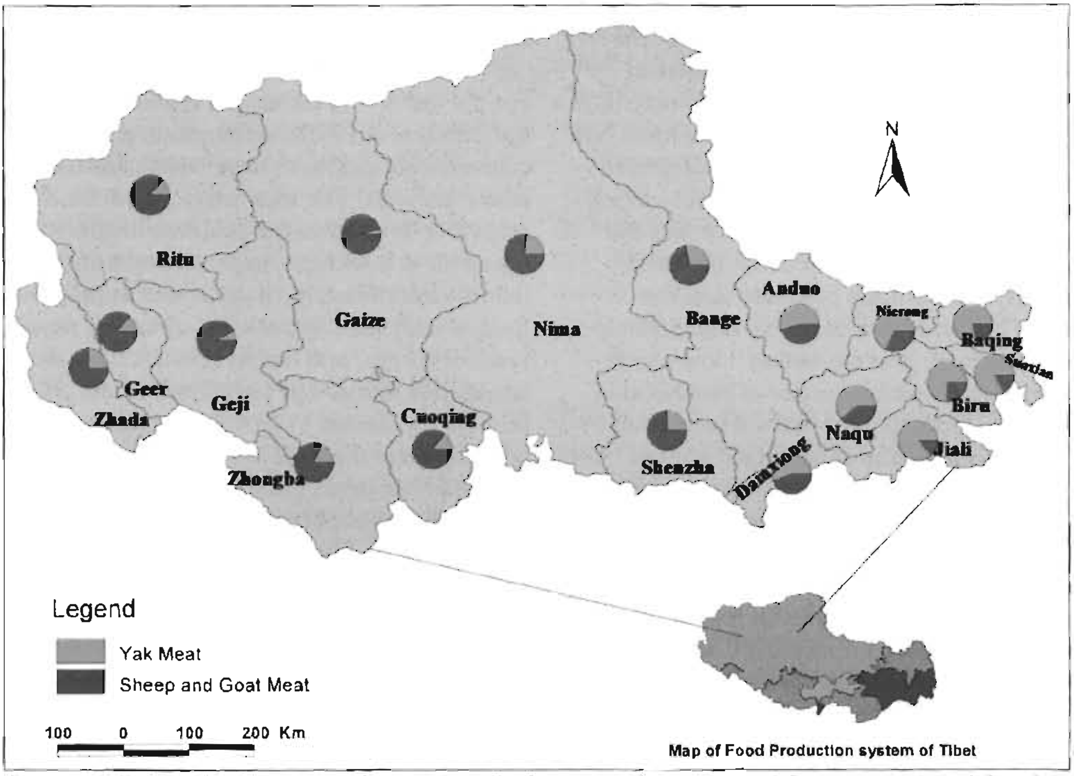


Figure 4.3: **Production of yak meat and sheep and goat meat in the pastoral food production system**

considerable amounts of barley and wheat, which make up 83% of their total energy intake. Most nomads generally feel comfortable only when they have at least 12 yak or 50 sheep, or 60 sheep-equivalent units, per person in the family, and enough tsampa. Meat and milk are sufficient in most nomads' diets. They can live without barley in their diet. Severe lack of vegetables, fruit, and poultry products is common in the nomadic area.

Agro-pastoral-forestry mixed production system zone

This production system is prevalent in the middle valleys of the Nyiyang, Nujiang, and Lancangjiang rivers. It includes the entire Linzhi Prefecture, and Mangkang County and Zuogong County of Changdu Prefecture. It has 10 counties altogether. The total land area is 142,100 sq.km, and it occupies 11.9% of Tibet. The percentages of cropping, livestock, and forestry production value to total agricultural output value are 42, 36, and 19%, respectively (Figure 4.4). The comparative advantage indices of cropping, livestock raising, and forestry are 0.94, 0.68, and 6.72, respectively. Compared to other production system zones of Tibet, forestry has a greater advantage in this zone, which is the major forestry area of Tibet. There is also scope for crop and livestock production in the more favourable environmental areas. Cropping, livestock raising, and forestry co-exist and are fundamental to ensuring food and livelihood security.

Affected by topography and atmospheric circulation (the monsoon from the Indian Ocean), the climate varies both horizontally and vertically. Vertical differentiation of climate and vegetation are much more overwhelming than horizontal differentiation, and greater than in the other three food-production systems. Climatic variation ranges from hot and humid in the south, to warm and humid in the middle range, to temperate semi-humid in the north, and even to frigid arid at higher altitudes. In general, the annual average temperature is about 8.3°C. Average temperatures of the warmest and coldest months are about 16.1°C and 2.8°C, respectively. Precipitation reaches 679.5 mm on average, with a high of up to 800-1,000 mm. The daily temperature difference is wide, on average reaching 13.3°C. Relative humidity reaches 60%. The number of sunshine hours is much lower than in the rest of Tibet, with 44% sunshine. Evaporation in this zone is much lower than elsewhere at about 1,641.1 mm.

Over 38% of the land is suitable for forestry, 27% can be developed into rangeland, and 0.03% is arable. Almost 20% of the land is barren or land that is frigid and snow-capped. This zone accounts for 62.7% of the total land that can be used for fruit farming in Tibet and 55.3% of forest land. Arable land and rangeland account for 10.7 and 5.4%, respectively, of their total areas in the whole of Tibet. Orchards and forestry have the potential to promote food security and improve the economic situation. Forestry has become one of the pillars of economic development in Linzhi Prefecture since the late 1980s (Dan Zhixu 1990).

With its many rivers and great vertical changes in vegetation, this zone is abundant in ecosystems and biodiversity. Richly endowed by the natural environment, there is wide scope for diversifying agricultural activities for generating income. There are many kinds of crops and animals. The food-production system has developed over a long time, typically incorporating different resources through cropping, livestock-raising, and forestry. Farmers here are much better off than in the rest of Tibet. Most are self-sufficient in both livestock and crop-based food production. There is a more balanced intake of food in this zone than in others.

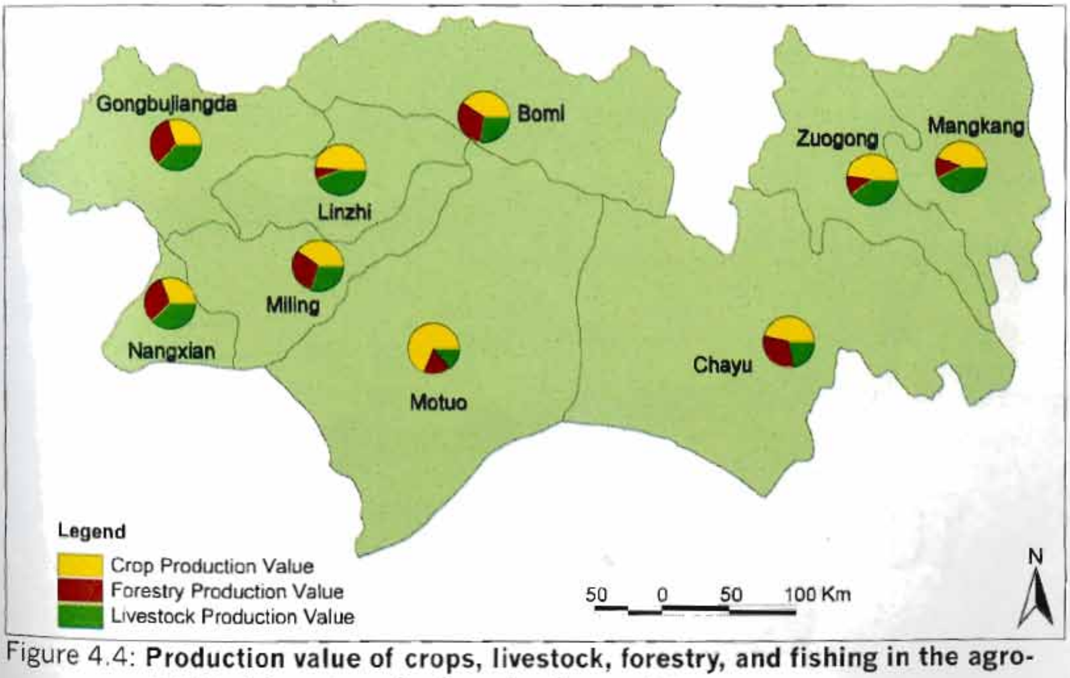


Figure 4.4: **Production value of crops, livestock, forestry, and fishing in the agro-pastoral-forestry mixed production system**

Cattles grazing near farmland (Agro-pastural system) - Nyima Tashi

A block of yak in Naqu - Nyima Tashi

Five

zonal variations in production of major foods

Background: New crops for Tibet: the Andean legume Lupin being tested in Tibet- crop flowering at an experimental station TAAAS team its propspects assess
- *Tej Partap*

Top Inset: New crops for Tibet: the Andean grain chenopod
- *Tej Partap*

Bottom inset: Farmland near village
- *Nyima Tashi*

Crop production in Central Tibet - Nyima Tashi

Chapter 5

Zonal Variations in Production of Major Foods

The area differentiation law of natural conditions controls the spatial variation of environmental conditions and land resources on which food production depends. As a result of this, types, quality, and quantity of food, which together determine food availability, have distinct patterns of zonal variation and spatial dynamics. In order to distribute food properly, balance regional food-supply gaps, and ensure that all people have adequate access to food, it is important that zonal variation and spatial dynamics of food production should be understood in light of changes in population and food consumption, so as to promote better food flow and food trade between areas and regions.

This chapter analysed the zonal variation and spatial dynamics in production of food to understand its pattern, the cause of its formation, and its changing scenarios, by using GIS.

Methodology

Over time, the regional or zonal distribution and spatial dynamics of food production and supply have changed. The area that used to be called the 'Yalong Food Grain Bowl of Tibet' (Qiongjie County and Nedong County) is no longer so. Now the three counties along the Nyachu River (Shigtse, Bailang, and Gyangtse) are the most important food grain producers and are known as the 'Nyachu Food Grain Bowl of Tibet'. Pastoral livestock production used to be the most important source of livestock products, but now crop-livestock mixed farming is showing greater prosperity. Vegetable production started just 12 years ago but with application of greenhouses and plastic-film technology, many kinds of vegetables are available in Lhasa and other urban areas, and even in some rural areas. With development of 12 food-grain production bases, promotion of crop-livestock mixed farming, and expansion of greenhouse vegetable production, the regional distribution patterns of food production will further change and form new patterns. There are a few studies on this issue that focus on food grain production (Crop Science Society of Tibet 1987 1990; Wang Xianming 1996), livestock production (Hu Songjie 1995; Yu Yungui 1994), and agricultural development (Hu Songjie 1995). The changing regional patterns of food production in Tibet have been analysed in the past (Dang Anrong 1997; Yu Xiubo 1999). However, no research has been done regarding zonal/regional patterns of food production and supply in Tibet itself.

All data related to food production were collected for the period from 1985-97, and databases were developed at the county administrative level in both attribute format and spatial format. Two of these databases were linked together by Arc/Infor GIS software, and thematic maps (ArcView GIS) were composed to present the information in spatial format. Data were further aggregated and presented on the basis of food production systems/zones and administrative prefectures. Figure 5.1 shows the procedure for mapping. Zonal variations of a particular aspect, such as spatial variation of per capita production of cereals or total production of cereals, were presented with the latest data to see which area produced the most food items. The spatial dynamics were presented by growth rate of a particular food item, and also in terms of changes in percentages and deducted value; principally this effort was aimed at understanding where food availability has increased or declined most.

Zonal Variations and Spatial Dynamics of Per Capita Calorie and Protein Availability

Per capita calorie and protein availability in each county were calculated and maps of distribution composed. The growth rates of per capita calorie and per capita protein availability for 1985-97 were calculated and mapped. All data of both availability and

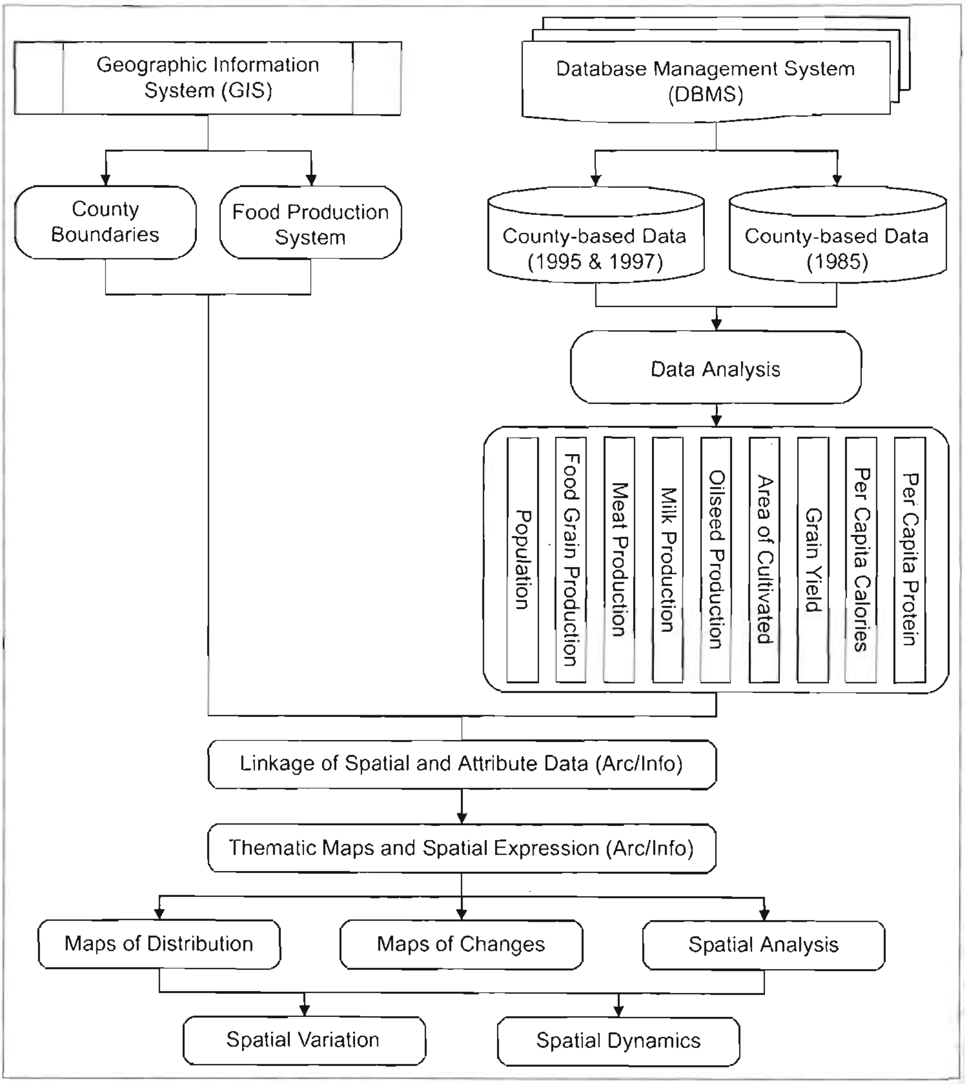


Figure 5.1: **Flow chart of the analysis of zonal variations and spatial dynamics of food production**

growth were aggregated on the bases of food-production systems and prefectures. Based on these calculations and mapping, the following characteristics of zonal variations and spatial dynamics of per capita calorie and protein availability were suggested.

There are great zonal variations in per capita calorie and protein availability

There is a huge gap of per capita calorie and protein availability among the counties (Figures 5.2 and 5.3). Gyantse County of Shigatse Prefecture boasts the highest availability of per capita calories with 10,618 kcal day^{-1} In Geji County of Ali Prefecture, only 545 kcal day^{-1} of calories per capita are available. The gap of per capita protein availability between the highest and lowest is 217.9g day^{-1}. Some counties produced over than 247g day^{-1} of protein per capita while others produce less than 30g day^{-1}.

Comparing prefectures, the average calorie production per capita in Lhasa is about 5495 kcal day^{-1}, whereas in Naqu Prefecture it about 680 kcal day^{-1}. The gap of per capita protein production is also large. Comparing food-production systems, there are also distinct gaps between per capita calorie and protein availability (Table 5.1).

In general, there is a severe deficit of calories in north and north-western Tibet, whereas the river valleys of the Nyachu River in central Tibet have sufficient production of calories and protein. In Naqu Prefecture, Ali Prefecture, and some counties of Changdu Prefecture, the availability of per capita calories and protein falls below basic calorie and protein requirements (2,500 kcal day^{-1} calorie and 100g day^{-1} protein). The Nyachu river valleys and Lhasa river valley have achieved per capita calorie and protein production above 6,000 kcal day^{-1} and 200g day^{-1}, respectively. In general, there are surplus calories in prefectures that are dominated by crop production, whereas areas that are predominantly pastoral often have deficits of calories but enough protein. This is

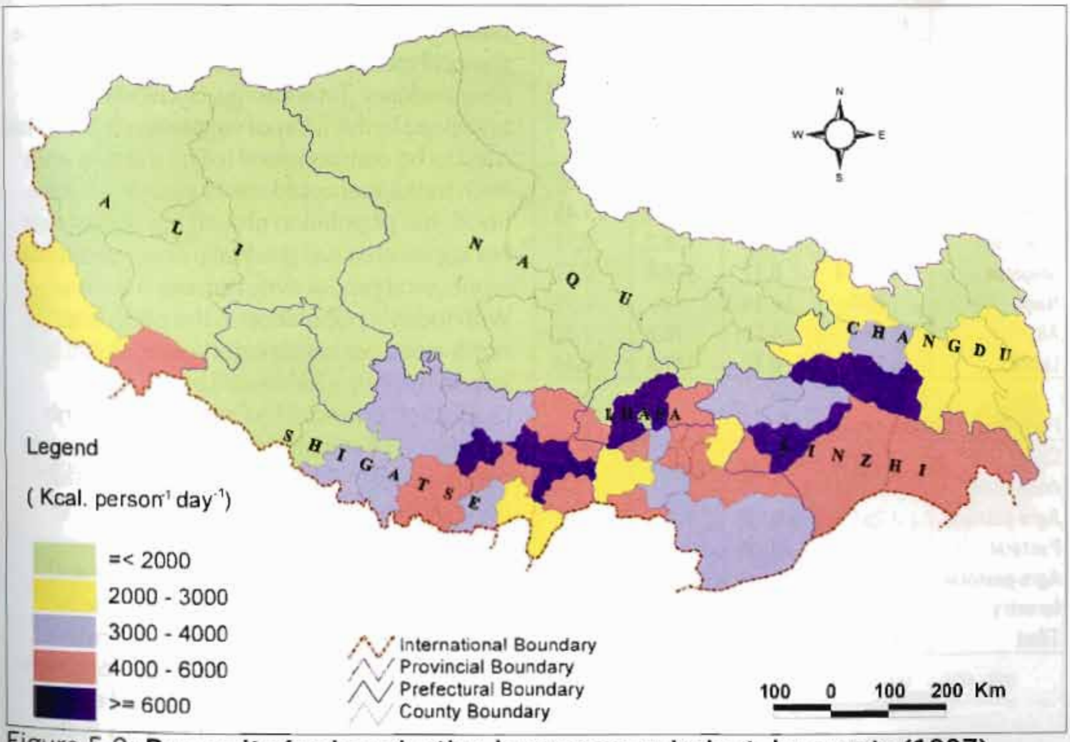


Figure 5.2: **Per capita food production in energy equivalent, by county (1997)**

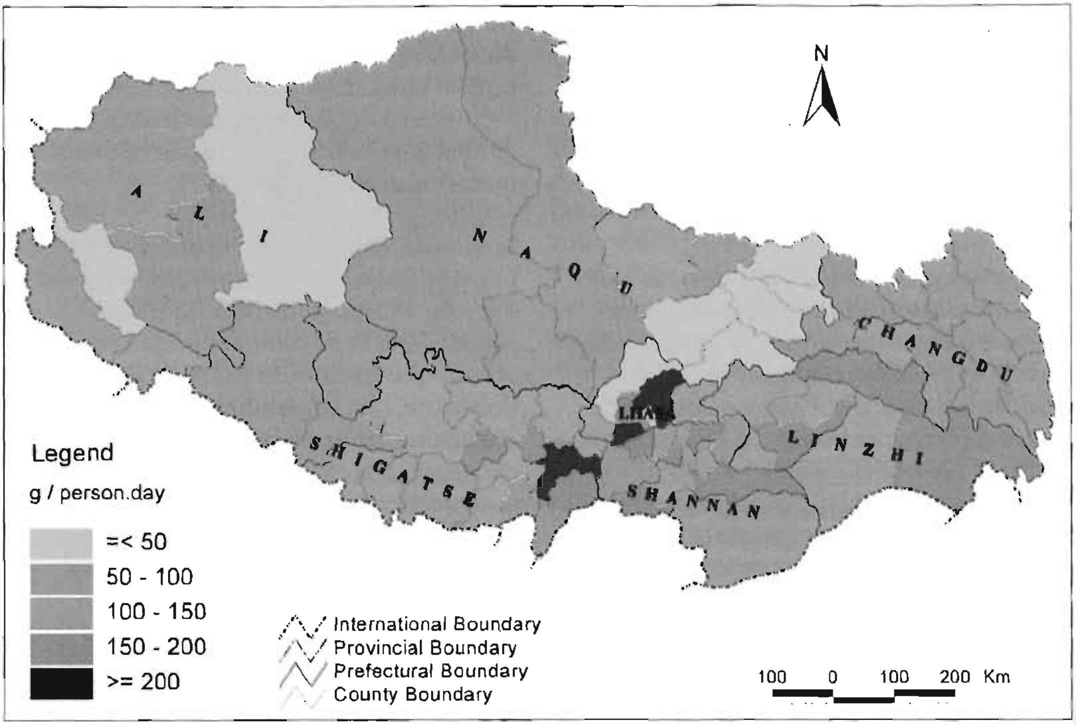


Figure 5.3: **Per capita food production in protein equivalent, by county (1997)**

Table 5.1: **Total per capita calorie and protein supply and its growth rate (%)**

	Per capita energy		Per capita protein	
	Calories	Growth rate (%)	Protein	Growth rate (%)
Prefectures				
Lhasa	5,495.2	2.82	139	2.55
Changdu	2,314.3	(-0.15)	84.8	1.45
Shannan	4,744.4	1.26	138.2	2.12
Shigatse	4,614.4	0.12	126.8	0.62
Nagu	680	(-5.15)	59	(-2.18)
Ali	1,590	(-4.29)	78.8	(-2.31)
Linzhi	5,256.4	0.12	147.4	0.40
Food-Production Systems				
Crop-dominated	6,204.3	2.64	155.9	2.48
Agro-pastoral	3,255.9	(-0.18)	105	0.95
Pastoral	1,114.2	(-4.79)	67.2	(-2.19)
Agro-pastoral-forestry	4,449.4	0.09	130.9	0.69
Tibet	3,527.8	(-0.75)	110.6	0.38

attributed to variation in biophysical conditions between the crop-dominated and pastoral areas. Biophysical productivity in the pastoral areas is often confined by low temperatures. Total energy, or calories, produced in the form of vegetation is low. This used to be compensated for by the vast area each individual could use to sustain a livelihood, but population growth has meant that per capita area has gradually decreased while biophysical productivity remains the same. With today's population in the north and north-west, per capita calorie availability is low. In the crop-dominated areas, the production potential has increased through expansion of cultivated land and increases in per unit crop yield; thus biophysical production has increased.

Although there is a shortage of calorie and protein availability in the north and north-west, there is no food inadequacy. Herders and nomads sell and barter animals and non-food livestock products such as wool and leather for cereals, receiving calories in the form of cereals in return. It is hard to estimate how many calories are obtained in this way, but during the household survey in Damshong County and Naqu, over 76% of calories and 56% of protein in the diet were estimated to come from cereals. Most herders and nomads said that they could not bear a shortage of tsampa, although they had plenty of meat and milk. Large amounts of cereals from other areas are traded for livestock products. However, food security for nomads is fragile and depends on barter and exchange. Overgrazing of the rangeland puts livestock production at risk and threatens the supply of products for barter. Also natural disasters are a problem. Crop farmers can recover in one season if there is total loss of a crop, but nomads suffer for much longer if there is a devastating loss of livestock.

There has been a decline of calorie production in the north and north-west, while in the centre and south it is increasing.

For the last 13 years, per capita calorie production in most of the north and north-west has declined or stagnated, while in the majority of counties in central and southern Tibet it has increased substantially (Figure 5.4).

Per capita protein production has followed the same pattern (Figure 5.5). Table 5.1 indicates that the growth rates of per capita calorie availability in Naqu and Ali prefectures are -5.2 and -4.3%, respectively. They have decreased significantly within the last 13 years. Per capita protein availability has also followed the same pattern. In central and southern Tibet, both per capita calories and protein have increased. In pastoral areas and in the two prefectures where pastoral farming predominates, both per capita calorie and protein availability have declined, while in crop-dominated areas or counties where cropping is the major agricultural sector, they have increased. In addition, per capita calorie production is decreasing, but per capita protein production is increasing. Over 60% of counties have decreased per capita calorie production, whereas per capita protein production has increased in over two-thirds of them.

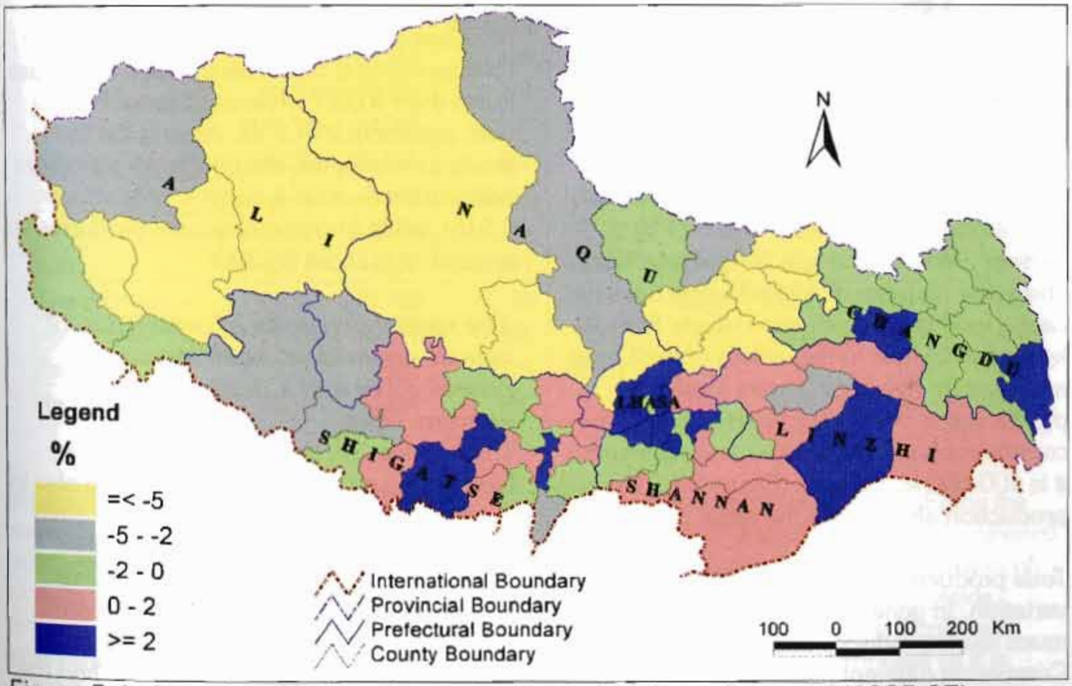


Figure 5.4: **Growth rate of total supply of calories in each county (1985-97)**

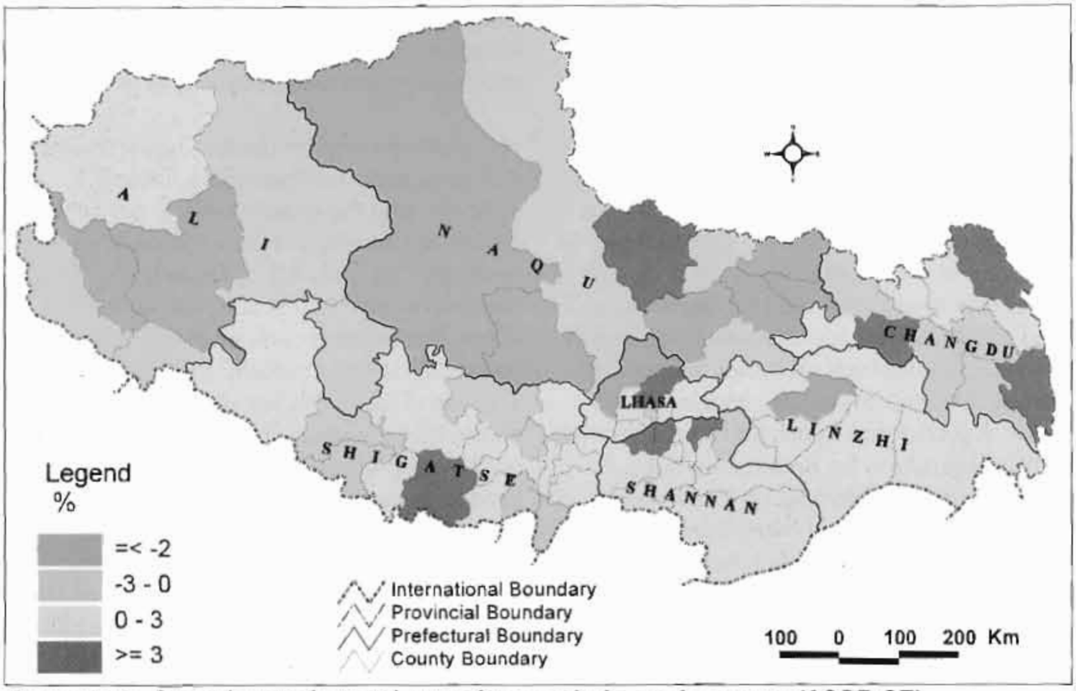


Figure 5.5: **Growth rate in total protein supply in each county (1985-97)**

Zonal Variations and Spatial Dynamics of Per Capita Production of Cereals

There is a great zonal variation in production of cereals. Per capita production is low in north-western Tibet and high in central Tibet.

Biophysical conditions and the level of socioeconomic development affect production of food grain crops. Per capita production of cereals ranges from 0 to 863 kg person^{-1}. Most counties in Naqu Prefecture and some counties in Ali Prefecture have per capita food grain production of less than 50 kg person^{-1}, while in the valleys of the Lhasa and Nyachu rivers, per capita food grain production is over 600 kg person^{-1}. In some counties of Linzhi and Shannan prefectures, it is 400-600 kg person^{-1} (Figure 5.6). Oilseed production also follows the same pattern.

Total production of cereals also has great variation. In general, north-western Tibet has much lower production than central Tibet. Comparing different prefectures, Shigatse is the major producer of food grain and oilseed, and Naqu Prefecture produces the least (Table 5.2).

The gap between the highest food grain producer and the lowest is tremendous. The total production of cereals in Naqu Prefecture is less than 3,000t while in Shigatse Prefecture, it is about 284,200t. Among the food-production systems, the total food grain from pastoral production systems is only about 4,515t, while in crop-dominated production systems, it is about 85,390t.

The spatial dynamics of production of cereals are evident as an increase in central Tibet and a decline in north-western Tibet.

There is not only great spatial variation of food grain and oilseed production, but also in the speed of the development of food grain and oilseed production between counties, prefectures, and food-production systems. Figure 5.7 shows the growth rate of food production in each county. Table 5.3 indicates that, for the last decade, Lhasa had the highest growth of both food grain and oilseed

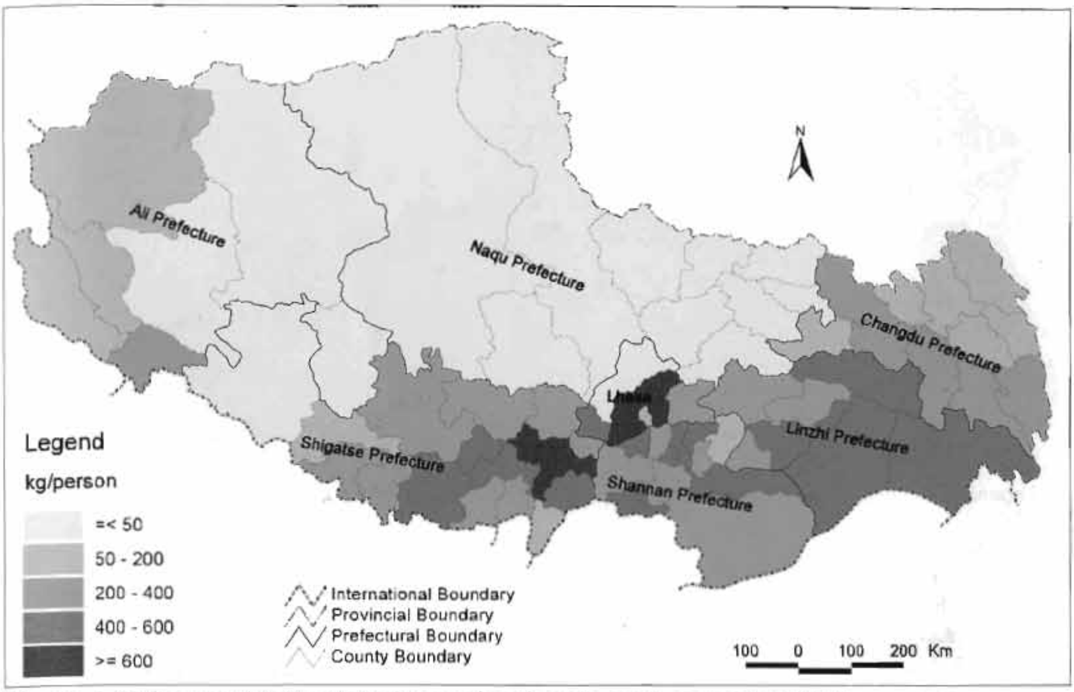


Figure 5.6: **Per capita food grain production in each county (1997)**

Table 5.2: **Regional differences in total production of cereals and rape seed**

Food production system or prefecture	Cereals (t)				Rape seed (t)			
	1995	1985	Increase (decrease)	Growth rate (%)	1995	1985	Increase (decrease)	Growth rate (%)
Lhasa	135,165	84,706	50,459	4.79	9,581	2,360	7,221	25.17
Changdu	100,200	79,460	20,740	2.44	502	424	78	3.18
Shannan	125,318	84,785	40,533	3.83	4,873	3,197	1,676	7.47
Shigatse	284,207	204,555	79,652	2.77	16,527	7,675	8,852	15.28
Nagu	2,747	4,998	-(2,250)	-(1.97)	12	/	/	/
Ali	5,171	4,798	373	-(0.77)	16	/	/	/
Linzhi	6,4771	44,306	20,464	4.06	2,063	810	1,253	96.17
Crop-dominated	85,389	87,120	-(1,730)	-(0.31)	23,946	9,252	14,694	17.89
Agro-pastoral	71,516	69,127	2,389	0.21	7,505	4,364	3,141	8.38
Pastoral	4,514	4,900	-(385)	-(0.61)	12	/	/	/
Agro-pastoral-forestry	26,196	25,586	609	0.19	2113	850	1,262	72.60

production at rates of 4.8 and 25.2%, respectively. In Naqu and Ali prefectures, production of cereals has decreased slightly at rates of -2 and -0.8%, respectively. In general, there has been growth in both food grain and oilseed production. Both pastoral areas and crop-dominated areas have decreased food grain production during the last 13 years. The decline in crop-dominated areas was mainly attributed to limitation of cropland expansion and per unit yields, while, in pastoral areas, it was attributed more to shrinking of the cropland as it is converted into pastoral land.

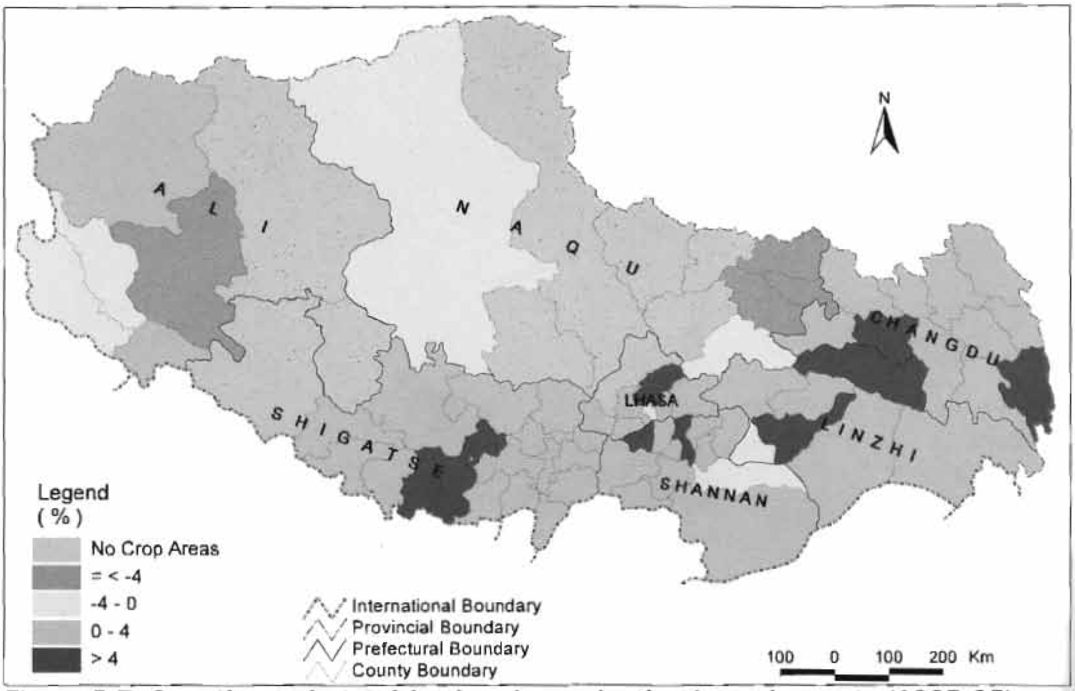


Figure 5.7: **Growth rate in total food grain production in each county (1985-95)**

Table 5.3: **Regional differences of total area and per unit yield of cereals**

Food production system of prefecture	Area of cereals cultivated (ha)				Per unit yield of cerals (t/ha^{-1})			
	1995	1985	Increase (decrease)	Growth rate (%)	1995	1985	Increase (decrease)	Growth rate (%)
Lhasa	31,745	29,640	2,105	0.17	4	2	1	4.45
Changdu	43,809	41,040	2,769	0.56	2	1	0	1.65
Shannan	25,732	27,353	(-1,620)	(-0.56)	4	3	1	5.19
Shigatse	64,709	67,353	(-2,644)	(-0.14)	4	3	1	4.06
Nagu	3,255	3,486	(-230)	(-0.49)	0	1	-0	(-3.74)
Ali	1,972	2,133	(-160)	(-0.88)	2	2	0	1.51
Linzhi	16,392	15,726	665	0.57	3	2	1	3.66
Crop-dominated	85,389	87,120	(-1,730)	(-0.31)	4	3	1	4.97
Agro-pastoral	71,516	69,127	2,389	0.21	2	2	0	2.00
Pastoral	4,514	4,900	(-385)	(-0.61)	1	1	-0	(-2.32)
Agro-pastoral-forestry	26,196	25,586	609	0.19	3	2	1	3.79

Zonal variations in food grain production were attributed to changes in cropland area, while the spatial dynamics were attributed to changes in per unit crop yields.

Spatial dynamics of per unit yield (Figure 5.8) and spatial dynamics of total production of food grain (Figure 5.9), by and large follow the same pattern. There is a similarity in the distribution of growth rate of total food grain production and growth rate of per unit yield. This means that changes in total production of cereals are mainly attributed to changes in per unit yield. The contribution from the area of cultivated land is small because there has not been much scope for increasing this. However, zonal variations of food grain production are mainly attributed to the area of cultivated land.

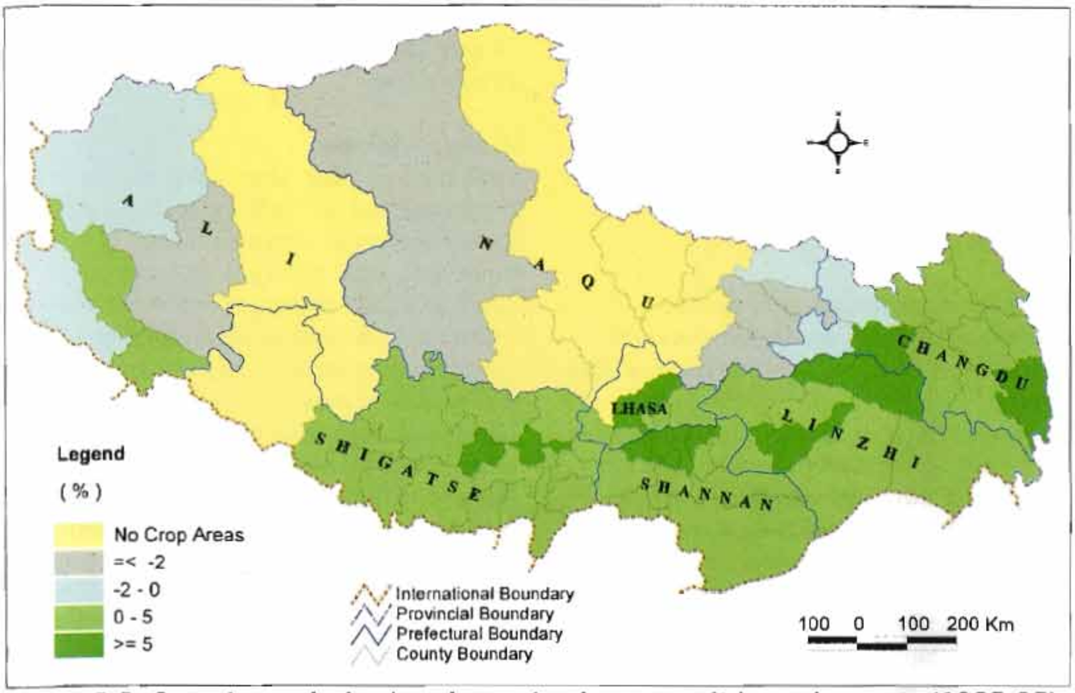


Figure 5.8: **Growth rate in food grain production per unit in each county (1985-95)**

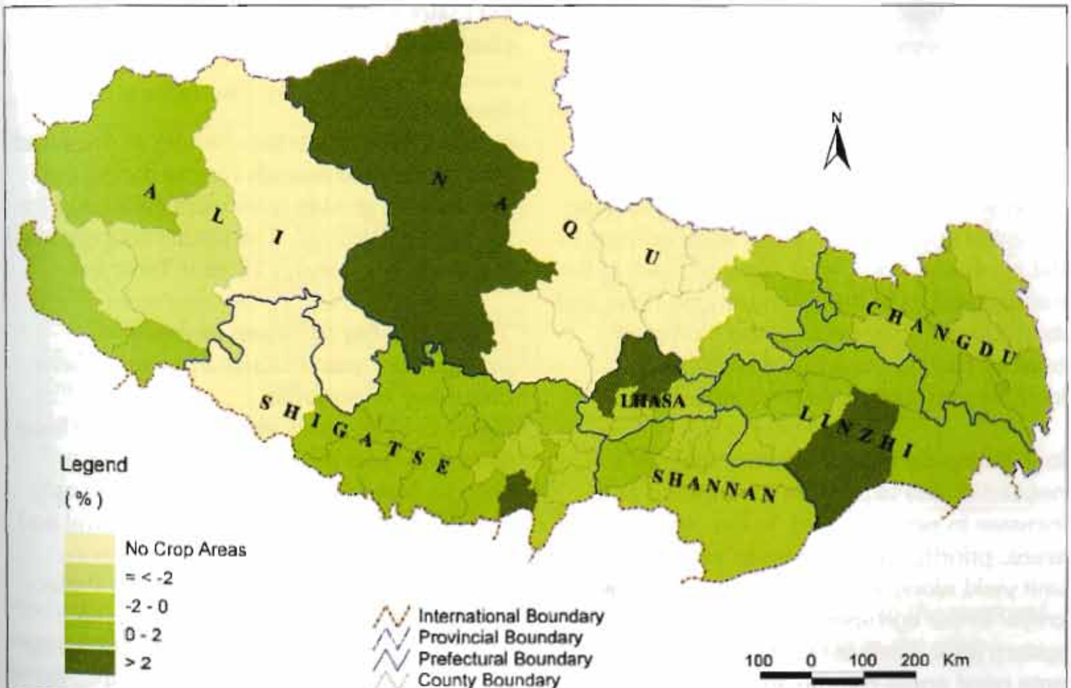


Figure 5.9: **Growth rate in food grain crop area in each county (1985-95)**

Moreover, both the increase in per unit yield and growth of sown area of food grain crops have contributed to the increase in total food grain production . Prefectures such as Lhasa and farming systems such as the agro-pastoral system have increased production of cereals by increasing both per unit yield and the sown area of crops (Table 5.3).

Both zonal variations and spatial dynamics of total oilseed production result from changes in sown area of rape seed.

Total production of oilseed is mainly affected by the area of rape seed cropping and per unit yield. Both zonal variations and spatial dynamics of oilseed production were mainly influenced by changes in sown area of rape seed, although per unit yield of rape seed also effected the total production of oilseed. Therefore, improvement in the per unit yield of rape seed, while increasing the sown area, will yield the greatest further increase in total production of oilseed.

To sum up, there is zonal variation of per capita and total production of cereals and oilseed. This variation also has spatial dynamics. It changes over time with changes in cropland area and per unit yield. In general, food grain and oilseed production in central and southern Tibet is much greater than in north and north-western Tibet. It is increasing in central and southern Tibet, and declining in the north and north-west. Central Tibet, in the middle reaches of the Yalongzangpo River and its tributaries, may become the food grain bowl of Tibet in the future if crop yields increase and sown area is maintained.

In the crop-dominated system, focus is needed on the expansion of cropland and increase in per unit yield. In the agro-pastoral areas, priority can be given to increasing per unit yield along with increasing sown areas of crops. In the agro-pastoral-forestry mixed system zone, both per unit yield and sown area need equal priority. In the pastoral system, cropland area will have to be increased wherever possible.

Zonal variations and spatial dynamics of per capita meat and milk production

Zonal variations

In all parts of Tibet, almost every household produces meat and milk for its members. The great variation in carrying capacity of rangeland, area of rangeland, biophysical conditions, and socioeconomic development of counties and regions means that there is corresponding variation of meat and milk production. In most counties in the north and north-west, per capita meat production is more than 60 kg; in central parts, it is less than 30 kg (Figure 5.10). Per capita milk production also follows the same pattern.

Comparing prefectures, in 1995, Linzhi Prefecture produced the least meat at 4690t, while Changdu Prefecture produced the most at about 30,000t. Ali Prefecture produced the least milk at around 6,140t yr^{-1}, while Shigatse Prefecture produced the most at about 40,000t yr^{-1}. Among the food-production systems, the agro-pastoral system zone is the major producer of both meat and milk (Table 5.4).

Spatial dynamics

In order to examine the changes in meat and milk production in each county during the last decade, growth rates were calculated for the period 1985-97. The results are presented in Figures 5.11 and 5.12, and Table 5.4.

There is a big increase in meat production, particularly in areas where cropping is possible.

Figure 5.11 suggests that most counties have increased meat production in the past decade. Meat production decreased in only 11 out of 74 counties. In most of central and southern Tibet, total meat production increased by more than 3%. Shannan Prefecture has seen the largest increase in meat production at a growth rate of 15.2%, while in Ali Prefecture the change was -0.4%. By and large, areas where cropping is possible recorded larger increases in meat production.

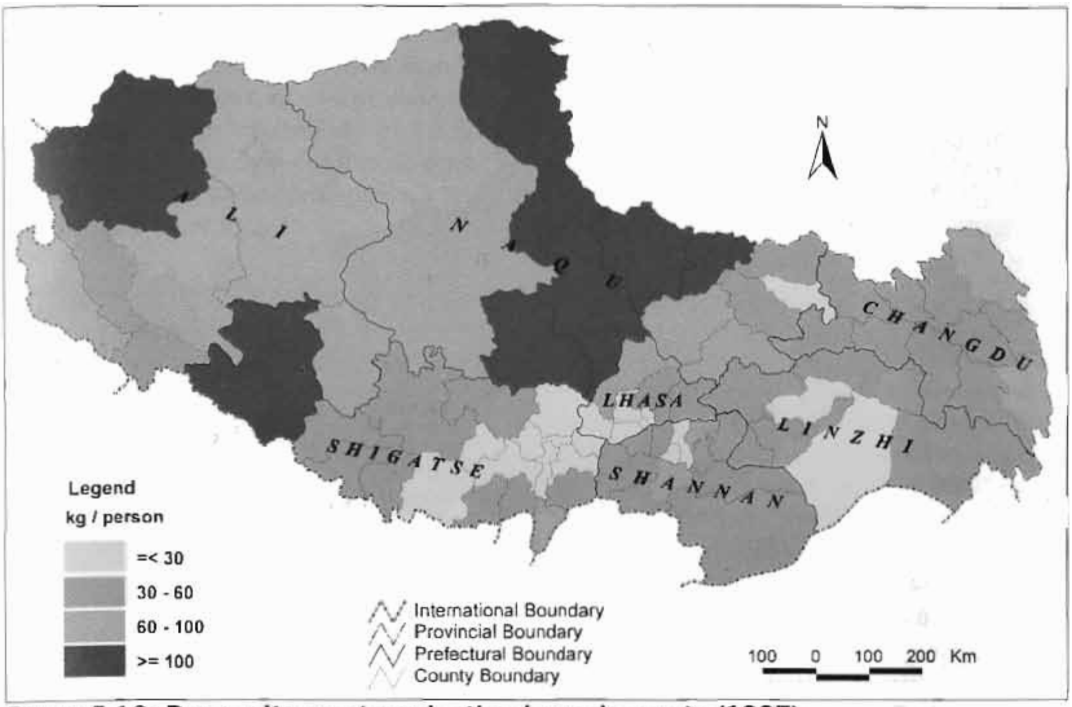


Figure 5.10: **Per capita meat production in each county (1997)**

Table 5.4: **Regional differences in total meat and milk production**

Food production system or prefecture	Meat production				Milk production			
	1995	1985	Increase (decrease)	Growth rate (%)	1995	1985	Increase (decrease)	Growth rate (%)
Lhasa	10,173	6,908	3,264	6.35	13,181	12,819	361	2.75
Changdu	29,910	15,044	14,866	10.91	39,204	43,050	(-3,846)	(-0.98)
Shannan	13,209	5,301	7,907	15.22	30,881	28,365	2,516	0.99
Shigatse	17,269	9,454	7,815	8.79	39,854	28,858	10,996	4.05
Nagu	29,553	22,660	6,892	2.48	30,128	48,445	(-18,316)	(-3.01)
Ali	5,547	6,130	(-582)	(-0.35)	6,142	6,166	-23	(-0.05)
Linzhi	4,694	2,679	2,014	6.15	16,515	9,886	6,628	6.34
Crop-dominated	17,987	8,288	9,699	11.82	8,477	3,757	4,719	16.49
Agro-pastoral	42,311	22,051	20,259	9.70	27,246	12,512	14,734	16.01
Pastoral	38,820	32,172	6,647	1.90	18,393	18,965	(-572)	(-1.86)
Agro-pastoral-forestry	11,239	5,667	5,572	7.30	5,986	2,741	3,245	10.43

Production in the crop-dominated zone increased by 11.8%, and in the agro-pastoral area by 9.7%. In the pastoral system zone, meat production increased by 1.9% in the last decade.

Milk production is declining in the pastoral zone, while it is increasing in the crop-dominated zone.

Figure 5.12 shows that milk production has decreased at a rate of more than 2% in most

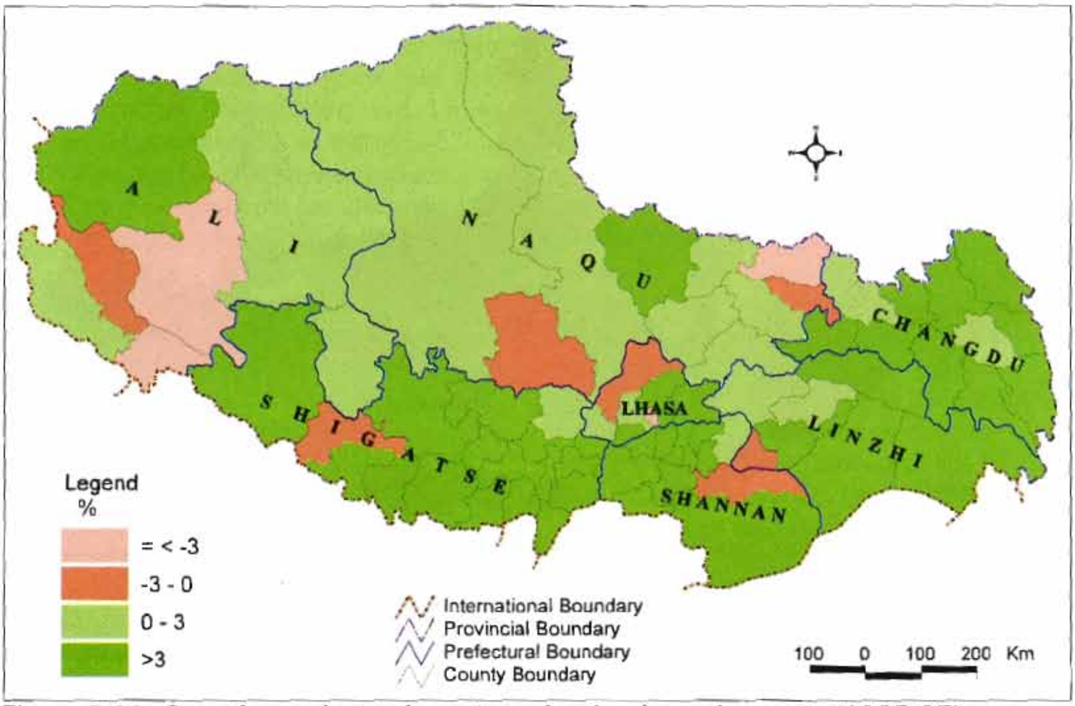


Figure 5.11: **Growth rate in total meat production in each county (1985-97)**

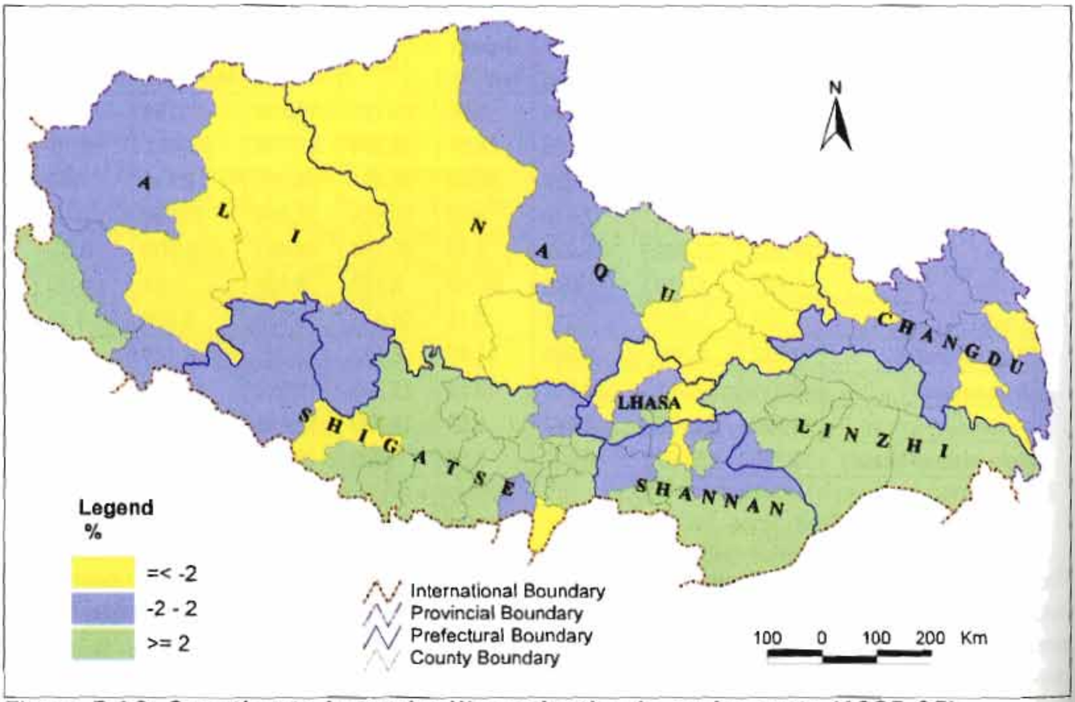


Figure 5.12: **Growth rate in total milk production in each county (1985-95)**

of the north and north-west. In areas where cropping is possible, milk production has increased at a growth rate of more than 2%. Figure 5.12 indicates that milk production in the pastoral system has declined by 1.8%, whereas in both the crop-dominated zone system and the agro-pastoral system it has increased by more than 16%.

Meat and milk production bases are shifting towards central Tibet. Expansion of the crop-livestock farming system is desirable for further increasing both meat and milk production. In the pastoral system, increases in per unit yield of meat and milk production are needed.

The above analysis indicates that in the crop-dominated zone and regions where cropping is possible, both meat and milk production have been increasing, while in the pastoral system, they are declining. This reflects the limitations of further development of livestock not only due to the low carrying capacity of rangeland but also to difficulties in improving the per unit yield. Rangeland-based livestock production may not have much growth in the near future unless there is radical improvement in rangeland production conditions. In the cropping areas, there is great potential for livestock production through using crop straw and agricultural by-products as animal feed, devoting marginal land to forage production, producing forage through promotion of multiple cropping, and developing silage production. In general, there is greater potential for biomass production in the lower river valleys of the cropping areas than in the pastoral system. Livestock production has been increased in cropping areas simply through taking advantage of feed-production potential.

Recent increases in meat and milk production are not attributed to the area of rangeland and improvement of rangeland productivity, but to increases in the number of animals. Most counties have tried to increase livestock numbers and there has been considerable growth (Figure 5.13). Table 5.5 suggests that all prefectures have increased their total numbers of animals in the last decade. However, increasing livestock production by increasing animal numbers may cause serious overgrazing and further deterioration of pastoral land. This may make pastoralism unsustainable. Thus, attention should be paid not only to increasing the per unit yield of rangeland, but also to promoting crop-based livestock production in cropping areas and introducing intensified livestock-raising, such as large-scale pig and poultry-raising, in urban areas.

Table 5.5: **Regional differences in total numbers of animals**

Food production system or prefecture	1995	1985	Increase (decrease)	Growth rate (%)
Lhasa	168,180	152,770	15,410	0.90
Changdu	354,810	346,440	8,370	0.32
Shannan	216,210	198,310	17,900	0.71
Shigatse	563,840	475,390	88,450	1.88
Nagu	689,990	626,100	63,890	0.49
Ali	271,080	253,510	17,570	0.38
Linzhi	62,310	53,090	9,220	1.23
Crop-dominated	379,760	331,320	48,440	1.12
Agro-pastoral	719,990	655,920	64,070	1.10
Pastoral	1,078,670	986,750	91,920	0.48
Agro-pastoral-forestry	148,000	131,620	16,380	1.09

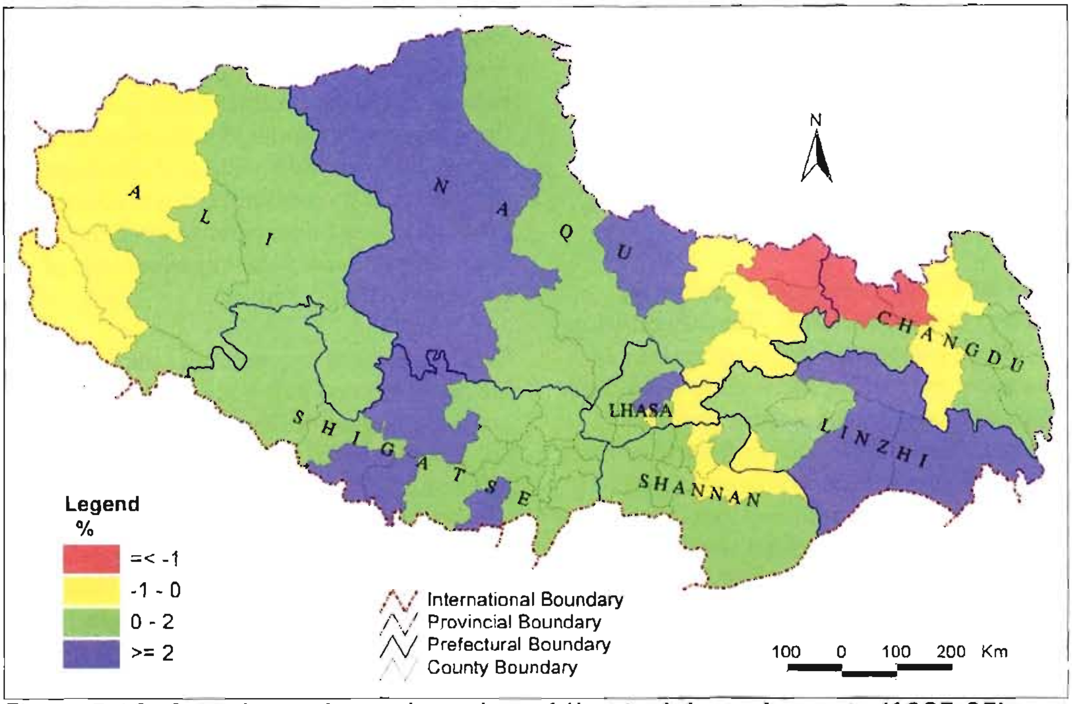


Figure 5.13: **Growth rate in total number of livestock in each county (1985-95)**

Six

food production changes over time

Background: Yak and sheep – backbones of the highland economy-grazing in the highland valleys
- *Tej Partap*

Top Inset: Planting corn at 3,680 masl
- *Nyima Tashi*

Bottom inset: Weeding a wheat field
- *Nyima Tashi*

Farmland in Central Tibet - Nyima Tashi

Chapter 6
Food Production Changes Over Time

In previous chapters, the state of access to food, food availability, and variations in different farming/food production systems were discussed. This chapter will further analyse the history and mechanism of changes in agricultural development and food production in Tibet.

Evolution and Trends in Agricultural Structure

Over the last 40 years, agricultural development has gone through both progressive and stagnating periods. The following changes and trends in agricultural structure have occurred.

Overall agricultural production has increased steadily but with imbalance among sectors and with fluctuations from year to year.

There were slow increases of agricultural production during the 1960s and 1970s. The growth rates in crop and livestock production were 4.5 and 2.7%, respectively. This was mainly due to the Cultural Revolution that devastated socioeconomic development. In the 1980s, the commune system was ended and the household responsibility system instituted to provide incentives to farmers to practice agriculture for their own interests and benefit. There was a rapid increase in all sectors of agricultural development during the 1980s. The total output value of agricultural production increased by 14.1%; in particular, crop production value and livestock production value increased by 19.1 and 12.5%, respectively (Table 6.1). Since the 1990s, agricultural production has grown an average of 18.3%. The production value of cropping and forestry grew at 25.4 and 33.6%, respectively. This can be attributed to government emphasis on food grain production and forest-industry development during this period. Constant investment was put into expansion of irrigated cropland and improvement of per unit crop yield. The forest industry was developed locally; however, policy on controlling the forest industry may affect its growth in future. The growth rate of the value of forestry production has slowed about 10% from 30% in the 1980s. In general, there has been substantial growth in agricultural production, but, at the same time, it has fluctuated highly. The fluctuation indices of production value of crop and livestock were 14.1 and 17.7%, respectively (Figure 6.1).

Table 6.1: Pattern of agricultural growth (%)

Time period	Gross agricultural production value	Gross crop production value	Gross forestry production value	Gross livestock production value	Gross fishing production value
1960s	7	6.6	0	7.4	22.9
1970s	3.9	4.5	52.9	2.7	31.6
1980s	14.1	19.2	21.8	12.6	31
1990s	18.3	25.4	33.6	16.6	10.5

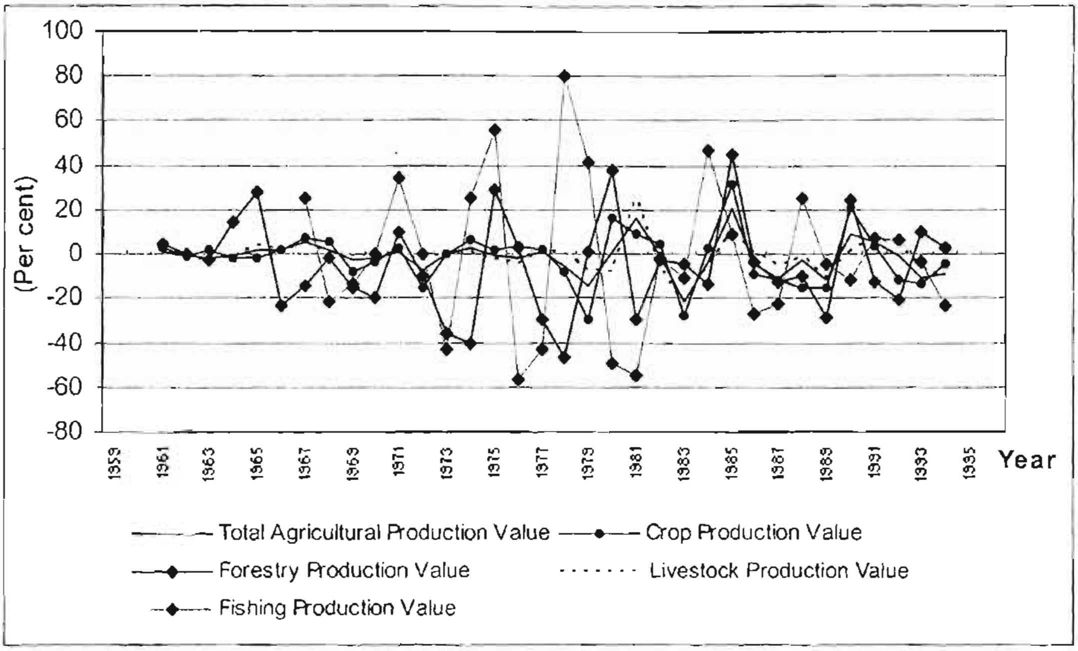


Figure 6.1: **Fluctuation in agricultural development**

There have been significant changes in agricultural structure; the proportion of crop and forestry production value in gross output of agricultural production has increased, while the proportion of livestock production value has declined.

The value of forest production increased from 0.05% of the gross value of agricultural production during 1959-69 to 2.02% during 1991-97. The percentage of crop production value increased from 32.8 to 45% during the same period. There has not been much fishing production, but the proportion of production value in total agricultural-production has increased steadily. Despite considerable increases in the absolute value of livestock production, the proportion of livestock production value in total agricultural production declined from 64.7% in the 1960s to 50.7% in the 1990s (Table 6.2).

Table 6.2: **Proportion of production value of crop, livestock, forestry, and fishing in total agricultural-production value (%)**

	Crop production	Livestock production	Forestry production	Fishing production
1959-1969	32.8	64.8	0.06	0.01
1970-1979	34.4	61.9	0.3	0.02
1980-1985	40.3	48.3	1.5	0.03
1985-1990	36.5	52.1	1.5	0.04
1991-1996	44.9	50.8	2	0.04

Crop and livestock production still dominate agricultural production as a proportion of total agricultural-production value at 50 and 48%, respectively. Forestry and fishing are limited by scale and markets.

Crop and livestock production still dominate and are fundamental to agricultural development and food security. Both have increased rapidly since the 1980s at growth rates of more than 10%. However, crop production has increased faster than livestock production since the 1980s (Table 6.3). There has been a much sharper increase in crop production value than livestock production value in recent years, and its total value has exceeded livestock production value (Figure 6.2). This difference in growth rates has lead to an increase in the proportion of crop production value in total agricultural production and a decrease in the proportion of livestock production (Figure 6.3).

Table 6.3: **Growth rate of crop and livestock production**

Years		Gross production value of agriculture		Cropping		Livestock	
		Average (10,000 yuan)	Growth rate (%)	Average (10,000 yuan)	Growth rate (%)	Average (10,000 yuan)	Growth rate (%)
1960s	1959–64	19,133.7	10.52	6,502	11.40	12,170.5	10.20
	1965–69	22,951.2	7.34	7,511.3	7.01	14,896.2	7.61
	1959–69	23,298.3	7.02	7,603.1	6.57	15,144	7.35
1970s	1970–74	29,787.4	3.58	9,886.2	9.22	19,183.6	0.87
	1975–79	37,431.4	4.25	13,369.6	-0.21	22,223.2	4.52
	1970–79	33,609.4	3.91	11,627.9	4.51	20,703.4	2.70
1980s	1980–84	64,206.4	15.48	25,666	27.91	31,349.2	11.01
	1985–89	115,690.4	12.78	41,930.4	10.43	59,716.8	14.15
	1980–89	89,948.4	14.13	33,798.2	19.17	45,533	12.58
1990s	1990–95	247,781	18.29	110,285.3	25.39	125,321	16.64
	1994–95	358,961	33.82	177,927	35.48	173,782	33.33

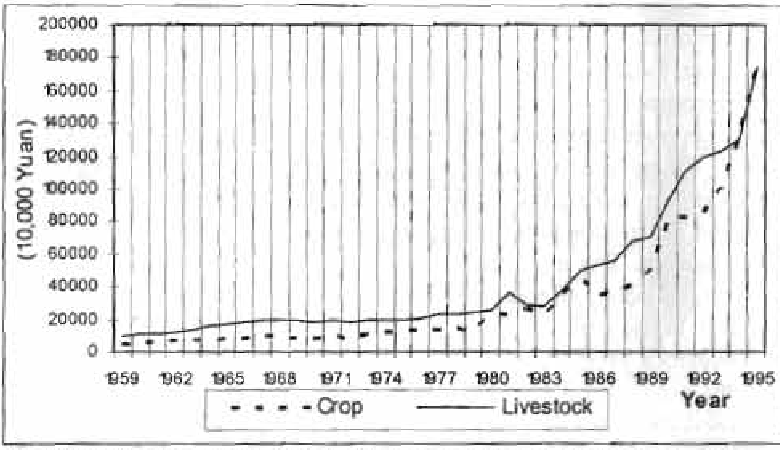


Figure 6.2: **Trends in agricultural and livestock gross production value**

Biophysical conditions affect agricultural production, but fluctuations are mainly attributed to inappropriate and frequent changes in agricultural policy. Progress in agricultural development has been made through improvement of infrastructure such as irrigation systems, technology extension, changes in the cropping system, increases in numbers of livestock, increases in agricultural input, and human resource development. Biophysically, there is potential for increased crop and livestock production, but there are also constraints in some areas. Biophysical conditions also create fluctuations in agricultural production over time. However, more drastic and long-term fluctuations have been attributed to changes in agricultural policy.

The relatively stable and constant growth in agricultural development during the 1960s and 1970s was aided by a stable policy that focused on food grain and livestock production; although the Cultural Revolution devastated culture, science, technology promotion, and economic development.

Since the 1980s, the overall policy of adopting the household responsibility system has been favourable to agricultural development . This increased food grain prices and allowed farmers to sell products in rural markets. It replaced mandatory procurement with voluntary contracts between farmers and the public, transforming the command and centralised agricultural system to a largely market-determined system. It has introduced a series of systems such as 'food grain bag responsibility' and 'vegetable basket responsibility'. This approach helped to decentralise

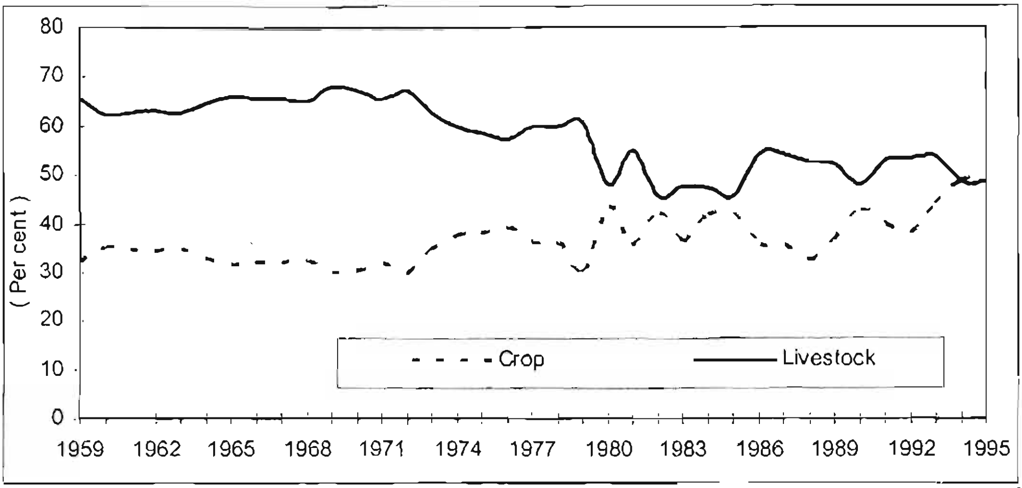


Figure 6.3: **Proportion of crop and livestock in total agricultural-production value**

agricultural management and responsibility. The outcome of these policies is that food production in China has increased rapidly. However, these policies have not made the same progress in Tibet as in central China. Although overall agricultural production has grown, the general picture of agricultural development during the 1980s is of stagnation and fluctuation when compared with other periods. The main factor was that agricultural policy changed from one focus to another. In the early 1980s, both agriculture and livestock production were given equal priority, but in 1983 a policy that focused on the livestock sector was promulgated. In 1985, the government considered both agriculture and livestock, and promoted the practice of cropping wherever suitable and livestock production wherever possible. The result of altering the policy several times was that, in an effort to fulfil each new objective, none was attained.

Trends in Production of Cereals and Oilseed

Over the last 40 years, production of cereals and oilseed has been affected by biophysical conditions and changes in policy and investment. Analysis of the trends and changes reveals the following characteristics.

Total production of cereals and oilseed has gone through five distinct development stages; now it is increasing rapidly.

Total food grain and oilseed production has had five stages: nine-year growth (1959-67), five-year stagnation (1968-73), eight-year growth (1973-80), eight-year stagnation (1981-87) and ten-year growth (1988-97). Figure 6.4 illustrates the overall trends. Table 6.4 shows the growth rates in production of cereals and oilseed and per unit yields in all stages.

During the nine-year growth from 1959-67, the total production of cereals and oilseed increased steadily year after year at rates of 6.6 and 8.9%, respectively. Per unit yield of food grain and oilseed increased at rates of 8.1 and 8.6%, respectively. The substantial growth of food grain and oilseed production in this period can be attributed to changes in the socioeconomic system as Tibetan society transformed from feudalism to democratic socialism through democratic reform and land redistribution. These changes to the socioeconomic system provided an equal opportunity for every farmer and herder to practise agriculture and to raise livestock. It also liberalised agricultural productivity and increased production incentives for farmers

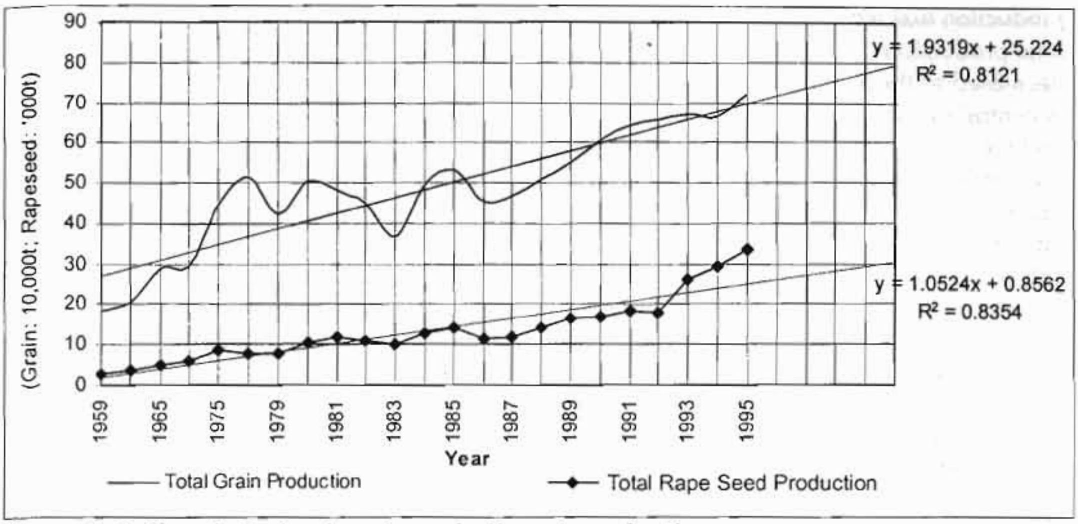


Figure 6.4: **Trends in food grain and oilseed production**

and herders. Also, changes in the agricultural system, adoption of technology and agricultural equipment, expansion of land under cultivation, irrigation and other agricultural infrastructure development, and increases in investment boosted agricultural production.

The five-year stagnation of 1967-72 resulted from the collapse of the agricultural system during the Cultural Revolution. Food grain and oilseed production growth rates were 1.4% and 1.7%, respectively. A significant factor was the decline of inputs to agricultural development, especially labour and technology.

The eight-year growth of 1973-80 resulted from developments in infrastructure; improvements in irrigation; expansion of cultivated land; increased use of fertiliser, agrochemicals and agro-machinery, and agricultural technology such as new crops and crop varieties; and improved cultivation technologies. The total production of food grain and oilseed increased at growth rates of 8.7 and 6.4%, respectively. The policy was "taking food grain as the key link and ensuring an all-round development". There was rapid expansion of winter wheat cultivation alongside a series of improvements in cultivation techniques such as the use of sowing machines, fertiliser, improved crop varieties, agrochemicals, and harvesting machines. This contributed, in 1978, to the highest per capita food grain availability yet achieved.

The eight-year stagnation of 1981-87 followed the drought of 1981-83. Agricultural

Table 6.4: **Growth rates of food grain and oilseed production**

Period	Total production				Per unit production	
	Grain crops (%)	Wheat (%)	Barley (%)	Rape seed (%)	Grain crops (%)	Rape seed (%)
Nine-year growth (1959–67)	6.63			8.96	8.15	8.68
Five-year stagnation (1968–73)	(-1.44)			(-1.70)	(-5.11)	2.00
Eight-year growth (1973–80)	8.96			6.39	6.23	1.38
Eight-year stagnation (1981–87)	0.08	(-5.19)	4.80	2.46	0.62	5.81
Ten-year growth (1988–97)	5.62	11.35	3.53	14.80	5.66	5.16

production was weakened, and, in 1983, the total production of cereals and oilseed decreased to the lowest level in 40 years. The decentralisation of agricultural management and the introduction of the household responsibility system led to a gradual deterioration of large-scale infrastructure such as irrigation systems and agro-machinery as individual households were unable to manage and use them. However, when responsibility and incentives were passed to the household level, at a later stage of this period, cereal and oilseed production gradually recovered. Total production of cereals and oilseed averaged growth rates of 0.08 and 0.6%, respectively. This was the stage of transforming the agricultural production system from one that was tightly controlled by government towards a decentralised system managed by individual farmers. Farmers gained the right to choose the type of cereals to grow. As a result, the area of barley cultivation increased rapidly and the area of winter wheat cultivation dropped. Consequently, the total production of cereals decreased because the per unit yield of barley is usually 15% lower than that of winter wheat. Another factor was the frequent and unfavourable changes in policy. Not only did agricultural policy change frequently, but the overall economic development policy was focused on tourism development.

The ten-year growth of 1988-97 resulted from a long-term development strategy. A series of measures was adopted such as the development of winter crops including winter wheat and winter barley, the introduction of maize and other high-yielding crops, improvement of per unit yield of crops, strengthening of agricultural extension and technology innovation, and farmers' training. In 1989, the government made achieving a sustainable increase in food grain and oilseed production a strategic approach to socioeconomic development. Improvement of per unit crop yield was targeted to increase total production of cereals and oilseed. Increases in the sown area of winter wheat and winter barley, increases in capital input, improvement and development of irrigation systems, and increases in fertiliser and agro-machinery application resulted in total food grain and oilseed production growth rates of 5.6 and 14.8%, respectively. The per unit yields of crops have increased by more than 5% on average in the last 10 years.

The total production of cereals and oilseed is increasing, but per capita production of cereals is stagnating.
Increases in the total production of cereals and oilseed can mainly be attributed to sustainable increases of per unit yields (Figure 6.5). The increase in per unit yields has been driven by increases in inputs, changes in cultivation techniques, improved cropping systems, adoption of improved high-yielding varieties, fertiliser, improved seed, and expansion of irrigated farm land. However, this rate of increase may be difficult to maintain. The population has been growing rapidly while the area of cultivated land is no longer expanding (Figure 6.6). Therefore, there has not been much increase in per capita production of cereals (Figure 6.7) and oilseed (Figure 6.8) in recent years. The former has stagnated at around 300 kg.

The area of cropland is stabilising, and internal restructuring and changes in the proportions of crops are occurring.
The largest increase in the area of cultivated land took place during the 1960s and 1970s. Particularly during the 1970s, the area of cropland increased at a rate of 4.5% and the sown area of food grain crops at a rate of 4%. The sown area of rape seed increased by more than 18%, and sown areas of wheat and barley increased by 18 and 5%, respectively. During the 1980s, the expansion of cultivated land slowed down and the area of cropland decreased by 0.4%. The sown area of barley and peas increased, while the wheat cropping area decreased by 4.6%. During the 1990s, the total area of cropland stabilised, and the sown area of crops tended to decrease. The sown area of barley decreased by 1.5%; and there was an apparent growth in

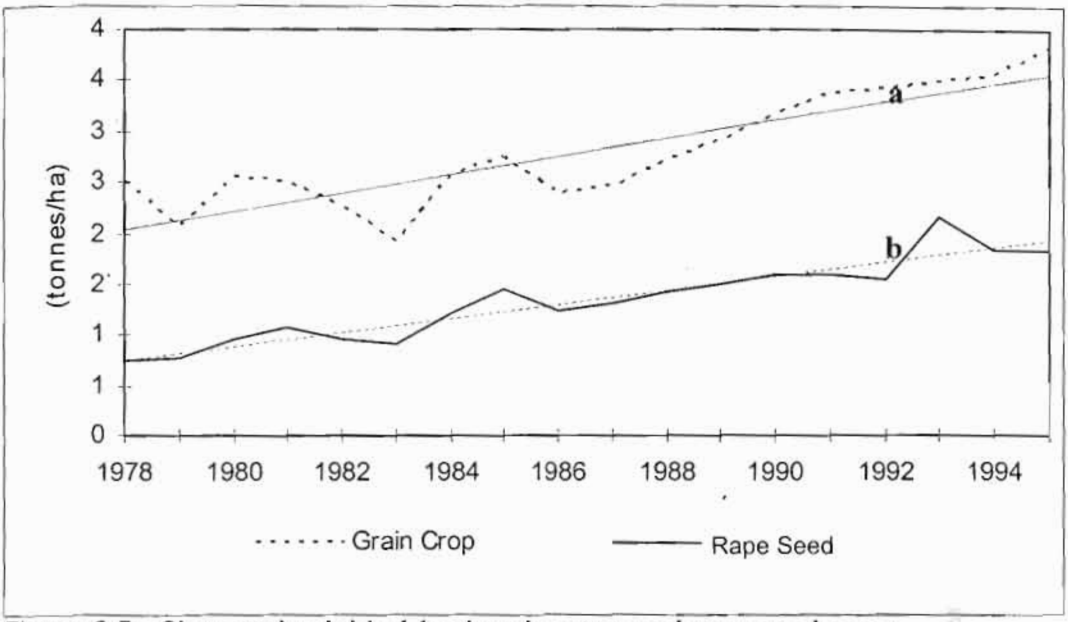


Figure 6.5: **Changes in yield of food grain crops and rape seed crops**

a) $Y = 0.0898x + 1.944$
$R^2 = 0.7682$

b) $Y = 0.0687x + 0.6851$
$R^2 = 0.8872$

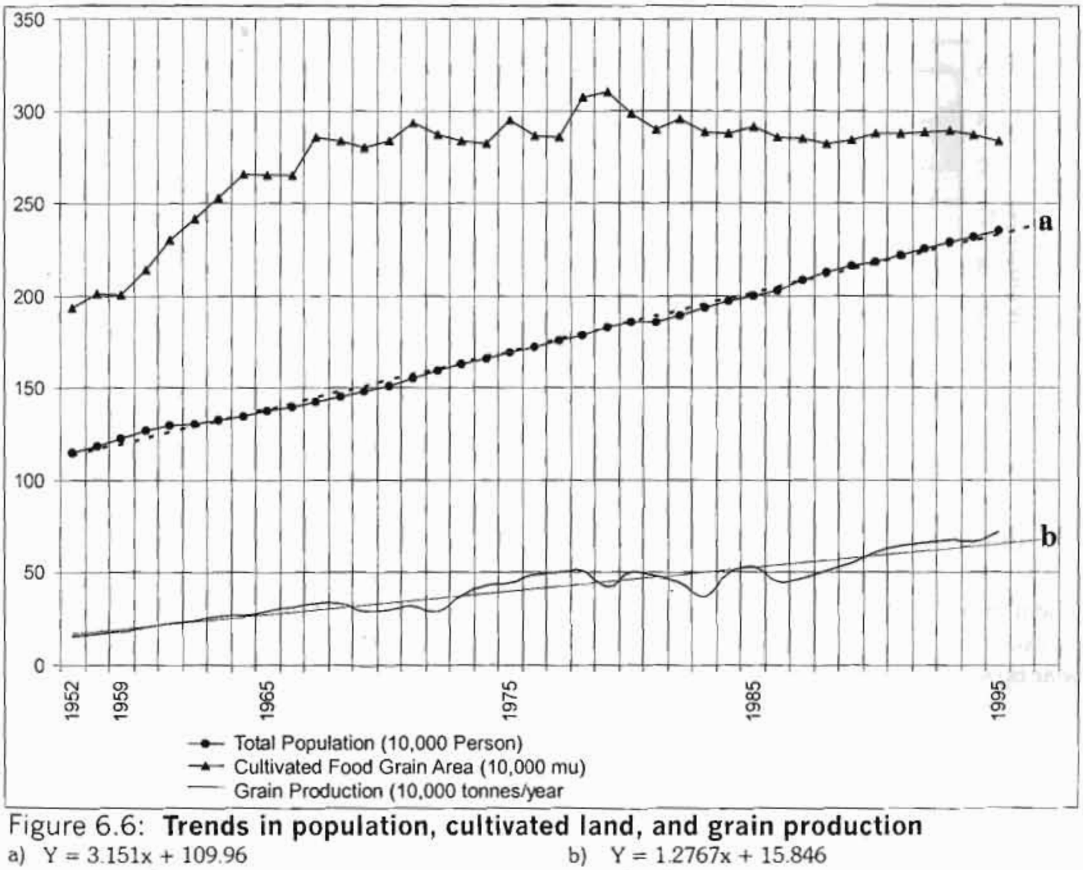


Figure 6.6: **Trends in population, cultivated land, and grain production**

a) $Y = 3.151x + 109.96$
$R^2 = 0.9968$

b) $Y = 1.2767x + 15.846$
R^2 = 0.= 9044

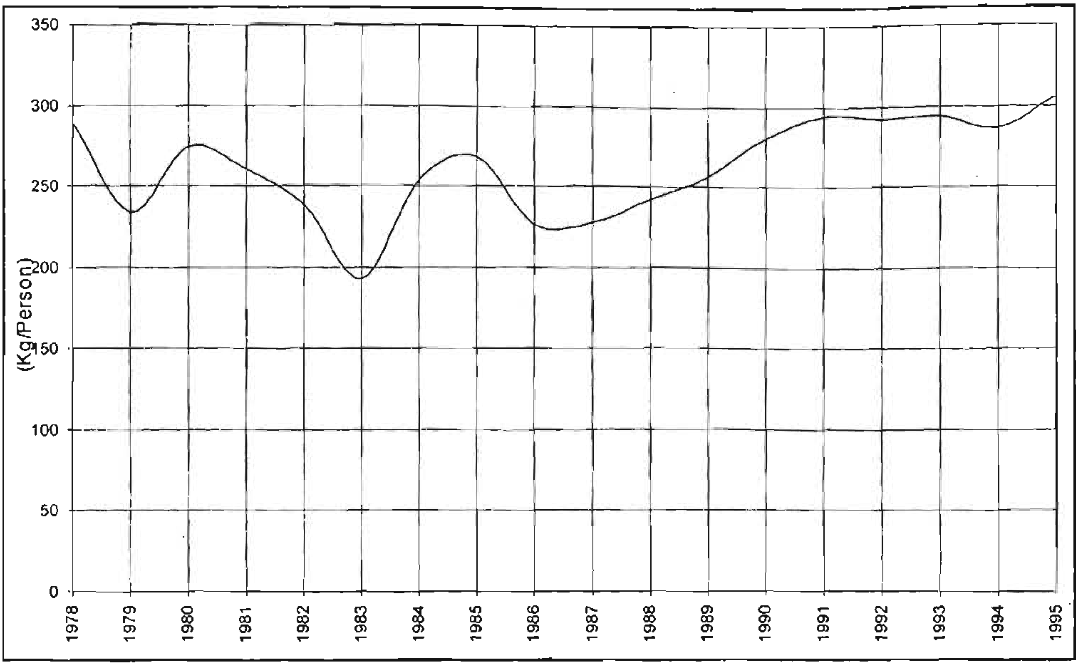


Figure 6.7: **Per capita grain production level**

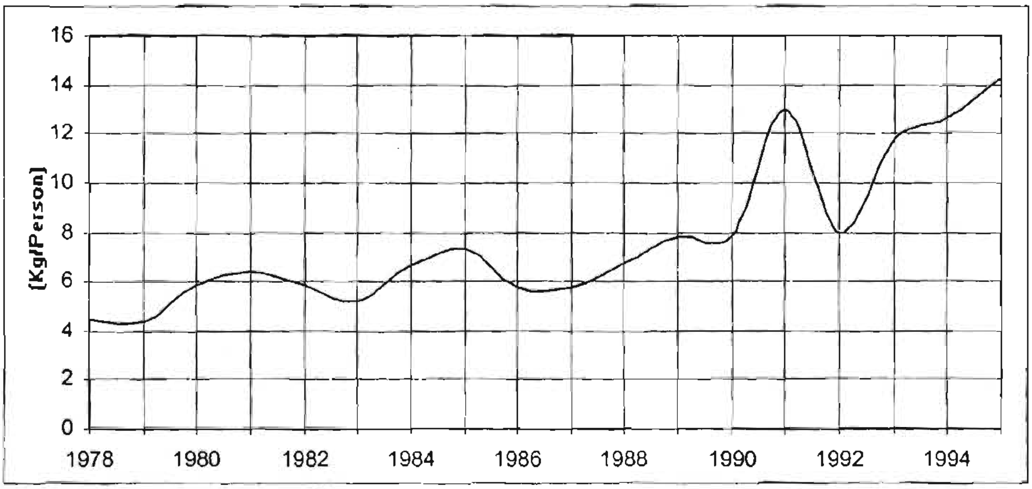


Figure 6.8: **Per capita oilseed production**

wheat of 5.8%. The area of rape seed, green manure, and potato cultivation increased year by year (Table 6.5).

Stabilisation and limitation of total cultivated area led to restructuring of crop proportions. The area of barley cultivation decreased during the 1970s, increased during the 1980s, and decreased again during the 1990s, while the area of wheat cultivation has increased in the 1990s (Figure 6.9). At present, cultivation of barley accounts for about 50% of total cropland. The proportion of pea cultivation decreased from 10% during the 1980s to 6.4% now. The proportion of rape seed cultivation increased. The main reason for these changes was the policy adopted since 1994 to achieve self-

Table 6.5: Growth in cropping areas

	1970s		1980s		1990s	
Average of cropping area and its growth rate	Average area (ha)	Growth rate (%)	Average area (ha)	Growth rate (%)	Average Area (ha)	Growth rate (%)
Total	212,530	4.51	212,980	(-0.37)	216,030	0.79
Food grain* crops	198,750	4.02	192,440	(-0.86)	191,570	(-0.04)
Barley	109,990	4.98	116,800	1.23	118,700	(-1.55)
Wheat	60,230	18.05	42,310	(-4.61)	45,490	5.81
Pulses	19,690	17.23	17,810	91.44	19,040	(-6.32)
Tuber	-	-	980	69.00	1,620	22.50
Others	8,890	47.17	10,630	238.11	3,210	(-6.21)
Cash crops	8,870	18.13	10,590	1.20	12,910	12.18
Rape seed	8,870	18.13	10,470	1.08	12,890	12.20
Peanuts	-	-	50	71.51	10	23.33
Others	4,410	35.15	9,870	32.44	9,970	(-10.39)
Vegetables	-	-	7,010	8.05	7,280	(-0.46)
Feed crops	-	-	2,690	24.16	4,030	10.20

Note: * Food grain crops include cereal crops, pulses, and tuber crops.

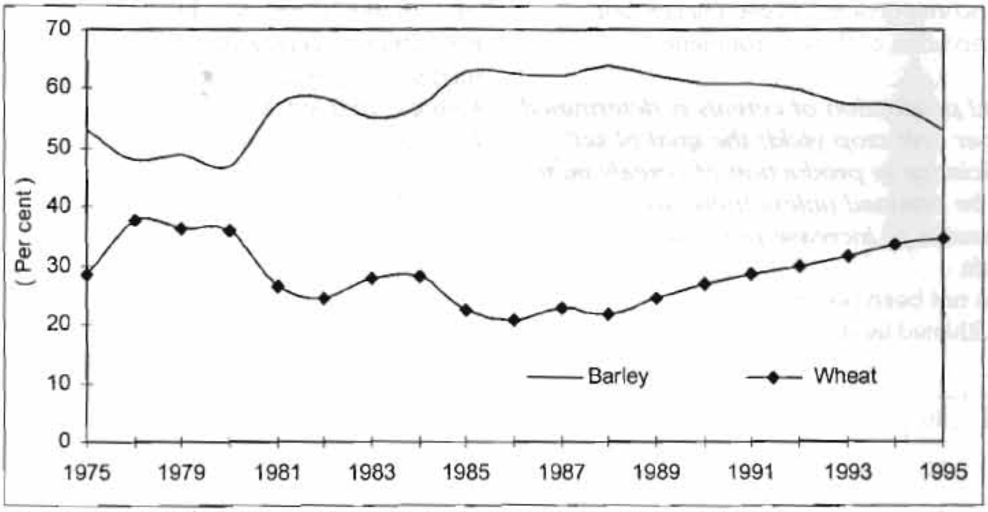


Figure 6.9: **Proportion of barley and wheat in grain production**

sufficiency in cereals and oilseed. It not only focused on improvement of per unit yield of cereals and oilseed, but also on expansion of sown area of wheat and rape seed (Table 6.6). There has also been an increase in the proportion of vegetables and green forage planted in recent years. In 1996, vegetables and green forage accounted for 4.1 and 2%, respectively, of the total sown area of cropland. This has been led by a demand for vegetables from the urban population and has provided cash income to farmers. The demand for livestock products, particularly butter and meat, has led farmers in the crop-dominated and agro-pastoral areas to raise cattle. Now farmers devote a greater area to growing green crops for production of forage and feed.

It is now important to improve the per unit yield of crops to sustain and increase the total production of food grain and oilseed, while

Table 6.6: **Cropping area by major crop by year (in percentage)**

Year	Barley	Wheat	Pulse	Tuber	Rape seed	Vegetable	Feed
1975	55.92	23.16	10.73	-	4.33	-	-
1978	48.53	29.87	9.75	-	4.79	-	-
1980	48.04	26.59	3.93	0.05	5.14	3.63	0.91
1982	54.84	19.69	1.03	0.15	5.22	3.88	0.46
1984	52.98	21.18	11.82	0.83	4.98	2.35	2.53
1986	57.60	16.95	11.96	0.81	4.41	3.99	1.36
1988	56.35	18.23	11.57	0.57	4.72	3.13	1.88
1990	56.23	19.56	10.21	0.58	5.02	3.80	1.34
1991	56.26	20.08	9.08	0.51	5.39	3.84	1.79
1993	55.82	21.69	8.61	1.52	5.60	2.85	2.10
1995	49.68	23.64	7.59	0.58	8.40	3.29	2.17
1996	53.28	23.33	6.45	0.38	8.13	4.13	2.04

promoting green forage cultivation and vegetable farming. This restructuring of crop production needs to orient towards sustainable increases of productivity, improvement of the quality of agro-products, promotion of the income-generation capabilities, and conservation of the environment.

Total production of cereals is determined by per unit crop yield; the goal of self-sufficiency in production of cereals may not be attained unless there are effective measures to increase per unit crop yields.

It has not been possible to increase the area of cultivated land at the present level of socioeconomic development. In 1997, the sown area of cereals and rape seed accounted for 84.8% of all cultivated land. Accordingly, there is little scope to increase total production of cereals and oilseed by expansion of sown area. Increases in total production of cereals and oilseed depend on increases in per unit yield. It is evident from Figure 6.10 that total production now follows fluctuations of per unit yield.

In 1994, the Tibetan Government set the goal of 1,000,000t of cereals and 50,000t of oilseed to be attained by 2000. This is the level of food grain and oilseed self-sufficiency. Taking production over the 11 years since

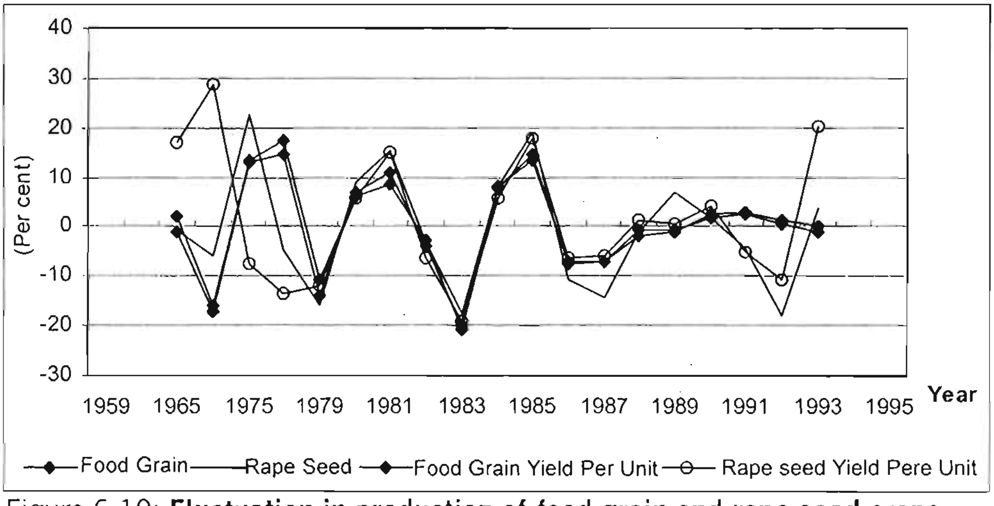


Figure 6.10: **Fluctuation in production of food grain and rape seed crops**

1987, the linear regression of cereals and rape seed production, using the formula of Y_{grain} = 3.0443x + 45.923 and Y_{rape} = 2.5117x + 8.0228, have R^2 of 0.95 and 0.92, respectively. This means that projected total production of cereals can reach 1,000,000t in 2004, and 50,000t of rape seed will be achieved in 2003 (Table 6.7). By 2000, total production of cereals and oilseed will be 885,400t and 43,200t according the current growth rate (Table 6.7 and Figure 6.11).

Therefore, the goals of 1,000,000t of cereals and 50,000t of oilseed by 2000 will not be attained unless per unit crop yields increase rapidly. At present, the per unit yields of cereals and oilseed are 4t ha^{-1} and 1.9t ha^{-1}, respectively. The goal set by the Tibetan Government can be only achieved when per unit yields of food grain and oilseed reach 5.1t ha^{-1} and 2.7t ha^{-1}, respectively.

Table 6.7: **Projection of total production of food grain and oilseed**

Years	1997	1998	1999	2000	2001	2002	2003	2004
	11	12	13	14	15	16	17	18
Total food grain production ('000 t)	794.1	824.5	855.0	885.4	915.9	946.3	976.8	1,007.2
Total rape seed production ('000 t)	35.65	38.16	40.67	43.18	45.70	48.21	50.72	53.23

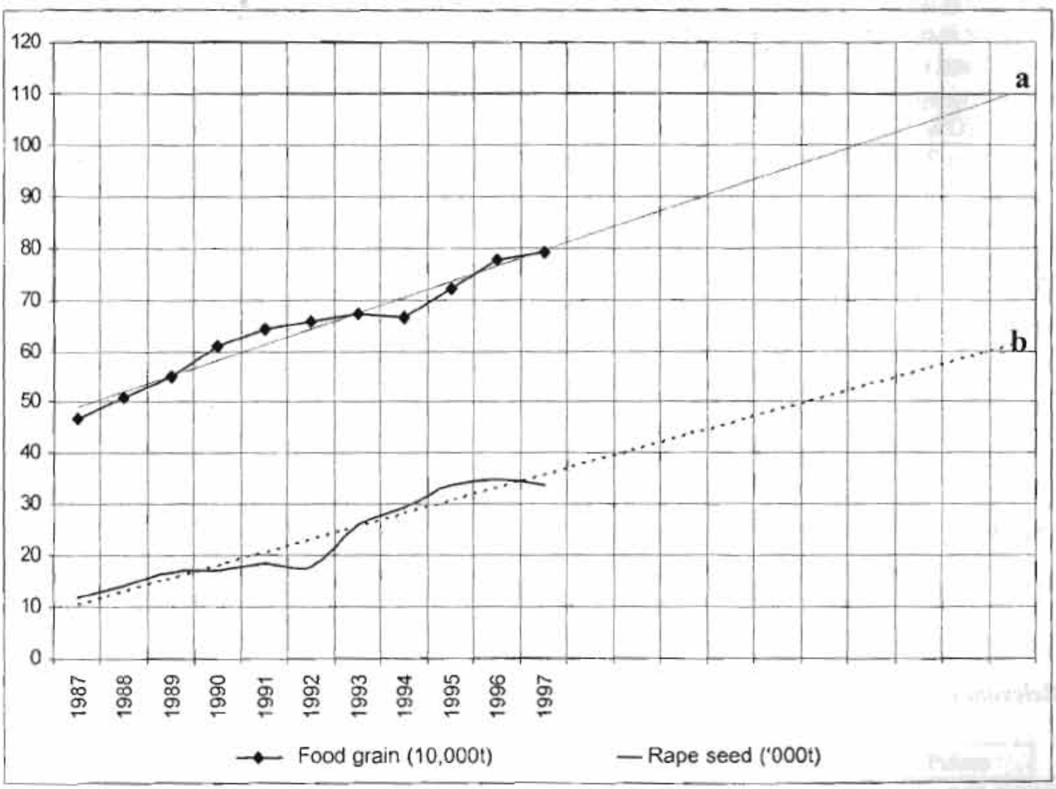


Figure 6.11: **Trends in food grain and oilseed production**

a) y = 3.0443x + 45.923 R^2 = 0.9574 b) y = 2.5117x + 8.0228 R^2 = 0.9257

Per unit crop yields cannot be increased effectively unless the production system becomes more productive and efficient. The total production of cereals and oilseed may stagnate unless per unit yield is increased, since there is little scope for large-scale cropland expansion. To improve per unit yield, food grain and oilseed production systems need to see improvements in productivity and efficiency. Currently, the agricultural production system has low productivity and efficiency. For example, during 1985-95, the gross output value of agriculture increased at a growth rate of 4.3%, while the total input increased at a rate of 9.4%. The elasticity of investment in agriculture was 0.5, which means that for each unit increase in agricultural production value, 0.5 units of investment were needed. For the last 40 years, agricultural development has depended on quantitative growth rather than qualitative growth. Thus, at present, the profitability of agricultural production is decreasing while the market for agricultural products is opening up. The contribution of agricultural science and technology in increasing agricultural production is also low at only 20%, whereas in central China it is more than 30%. The efficiency of using agricultural resources is also low. There has been great progress in developing irrigation systems, but the utilisation rate of water was only 30%, whereas in central China it is more than 40%. The rate of effectively using fertiliser is less than 15%.

Work is needed to develop a productive, efficient, and ecologically sound agricultural production system. The ultimate goal should be to increase per unit yields through ecologically sustainable cropping, farmer training, improvement of infrastructure, and market development. It is also important to improve the quality of other aspects such as the ecological environment, infrastructure, input, cereals, farmers' skills, seed, technology, and the quality of the agricultural development policy. The agricultural production system can then be transformed from a quantitative one to a qualitative, productive, and profitable one.

Analysis of Factors Influencing Production of Cereals and Rape Seed

To increase total production of cereals and oilseed and improve per unit yields, it is important to analyse factors that affect them. Grey relevancy analysis and co-efficiency of correlation were used for analysing the interrelationship among factors. Grey rel-

Main factor $x_0 (k),(k = 1,2\ldots,n)$

Relevant factor $x_i (k),(i = 1,2\ldots,m;\ k = 1,2,\ldots,n)$

Initial value of original data $x_i (k), x_i(k)/x_i(1),(i = 0,1\ldots,m;\ k = 1,2,\ldots,n)$

Sequence of deviation $\Delta_i(k) = \left|x_0 - x_i(k)\right|,(i = 1,2,\ldots,m; k = 1,2,\ldots,n)$

Max.& min.value $M = \frac{max}{i}\frac{max}{k}\Delta_i(k)$

$$m = \frac{min}{i}\frac{min}{k}\Delta_i(k)$$

Relevant coefficiency $\gamma_{oi}(k) = \frac{m + aM}{\Delta_i(k) + aM},(0 < a < a)$

Degree of relevancy $\gamma_{oi} = \frac{1}{n}\sum_{k=1}^{n}\gamma_{oi}9K0,(i = 1,2,\ldots,m)$

evancy analysis considers the degree of relevancy and estimates the relationship between one factor and other related factors. It determines which secondary factor most affects the main factor. Correlation analysis is used for analysing the interrelationship between one factor and another.

Grey analysis of relevancy was calculated with the following formula. (Liu Yuzhen 1997), and correlation analysis was done in MS-Excel software.

Total production of food grain

Total food grain production was the main factor under study, with sown area of food grain crops, area of irrigated cropland, per unit yield of cereals, agro-machinery, fertiliser, agrochemicals, and ranking of drought chosen as related factors (Hu Songjie 1990; 1995; Yang Gaihe 1995). The degree of grey relevancy and the co-efficiency of correlation were estimated as shown in Table 6.8. Obviously, total production of cereals also depends on the production of each individual crop. The production of barley, winter wheat, spring wheat, and pulses was therefore analysed for grey relevancy (Table 6.9).

The following inferences can be drawn from the above analysis.

- Total production is determined by the sown area of food grain crops and per unit yield, with the latter being the chief driving force. The degree of grey relevancy and the coefficiency of correlation of per unit yield with the total production of cereals are 0.97 and 0.99, respectively, whereas the corresponding figures for sown area of cereal crops are 0.91 and 0.97, respectively (Table 6.8). Because per unit yield of food-grain crops is the prime factor affecting total production of cereals, it should be the main target for agricultural development.
- The degrees of grey relevancy of agro-machinery, effective area of irrigation, fertiliser, and agrochemicals range from 0.84 to 0.86, signifying that these factors are equally important to increasing total food-grain production. There is significant

Table 6.8: **Driving forces of food grain production**

Years	Production (10,000t)	Area (10,000 ha)	Agro-machinery (10,000 kWj)	Irrigated land (10,000 ha)	Fertiliser (10,000t)	Yield (t ha^{-1})	Agro-chemicals (t)	Ranking of drought
1990(k1)	60.83	21.37	45.36	13.67	1.55	3.17	450.94	1.50
1991(k2)	64.42	21.57	48.12	11.33	2.00	3.36	438.37	1.67
1992(k3)	65.71	21.50	57.24	8.13	1.72	3.42	542.77	4.50
1993(k4)	67.22	21.56	64.32	13.67	1.22	3.49	520.00	2.33
1994(k5)	66.45	21.70	58.50	16.20	1.49	3.55	519.88	4.33
1995(k6)	71.96	22.02	68.39	14.42	1.98	3.80	594.21	2.17
1996(k7)	77.73	22.50	77.03	14.78	2.78	3.45	1236.00	1.69
Degree of relevancy		0.91	0.84	0.86	0.85	0.97	0.85	0.71
Coefficient of correlation		0.97	0.95	0.34	0.75	0.99	0.88	(-0.15)

Table 6.9: **Grey relevancy and correlation between total production of food grain and each crop**

	Spring wheat	Winter wheat	Spring barley	Pulses
Average degree of relevancy 1978–95	0.62	0.71	0.91	0.06
Coefficient of correlation	0.45	0.51	0.60	0.61

correlation between agro-machinery power and total production of cereals, and between the amount of agrochemicals used and total production. The co-efficiencies of correlation are 0.97 and 0.88, respectively. Dramatic increases in agro-machinery power used in pumping water for irrigation and ploughing of cropland, and agrochemicals used in disease control, have boosted total food-grain production. The area of effective irrigation has not increased much, and this increase had less impact on total production of cereals. Although there has been no severe drought in the past 10 years, the negative grey relevancy and correlation indicate that it has a negative effect on production and should not be ignored (Table 6.8).

- Spring barley production has a high degree of grey relevancy and is the dominant factor affecting changes in food grain production, followed by production of winter wheat (Table 6.9). Further analysis indicates that per unit yield of spring barley (for barley production) and sown area (for winter wheat production) are the main factors. Increasing per unit yield of spring barley and expanding the sown area of winter wheat may further increase total food grain production.

Table 6.10: **Factors affecting per unit yield of spring barley and winter wheat**

Crop	Relevancies	Agrochemicals (t)	Agro-machinery (10,000 kWj)	Irrigated land (10,000 ha)	Fertiliser (10,000t)	Ranking of drought
Barley	Degree of relevancy	0.83	0.82	0.86	0.85	0.70
	Coefficient of correlation	0.95	0.85	0.34	0.87	(-0.25)
Wheat	Degree of relevancy	0.95	0.88	0.87	0.87	0.69
	Coefficient of correlation	0.88	0.93	0.39	0.04	0.50

- Per unit yield of spring barley is determined primarily by area of irrigated cropland and the amount of fertiliser application, whereas per unit yield of winter wheat is affected primarily by the amount of agro-machinery and agrochemical application (Table 6.10). This suggests that increasing the area of irrigated land and fertiliser input should be considered for improving the per unit yield of barley. Disease control by application of agrochemicals is important for winter wheat production. More importantly, increasing agro-machinery power for ploughing, so that winter wheat can be sown in time, and for pumping water in spring for irrigation, will effectively improve per unit yields.

Total production of rape seed

Sown area of rape seed is the predominant factor affecting oilseed production, followed by agro-machinery and per unit yield (Table 6.11). The area of irrigated land is also a major factor. Fertiliser use has less effect on both per unit yield and total production. Further increases in both per unit yield and total production of rape seed are often restricted by drought (Table 6.12).

- Increasing the sown area and the area of irrigated land can increase total oilseed (rape seed) production. There is also a need to use improved varieties and better management to increase productivity.

Changing Trends in Meat and Milk Production

Livestock-raising comprises more than 50% of the gross agricultural output, and is fundamental to ensuring food security.

Table 6.11: **Relevancy and correlation of factors influencing rape seed production**

Year	X0	X1	x2	x3	x4	x5	x6	x7
	Production (10,000t)	Area (10,000 ha)	Agro-machinery (10,000 kWj)	Irrigated land (10,000 ha)	Fertiliser (10,000t)	Yield (kg)	Agrochemicals (t)	Ranking of drought
1990(k1)	1.71	1.07	45.36	13.67	1.55	3.17	450.94	1.50
1991(k2)	1.85	1.17	48.12	11.33	2.00	3.36	438.37	1.67
1992(k3)	1.79	1.15	57.24	8.13	1.72	3.42	542.77	4.50
1993(k4)	2.60	1.21	64.32	13.67	1.22	3.49	520.00	2.33
1994(k5)	2.94	1.62	58.50	16.20	1.49	3.55	519.88	4.33
1995(k6)	3.37	1.85	68.39	14.42	1.98	3.80	594.21	2.17
1996(k7)	3.51	1.83	77.03	14.78	2.78	4.05	1236.00	1.69
	Degree of relevancy	0.86	0.83	0.69	0.75	0.77	0.76	0.70
	Coefficient of correlation	0.95	0.89	0.69	0.46	0.92	0.67	(-0.07)

Table 6.12: **Relevancy and correlation of factors influencing rape seed yield per unit**

Years	x0	x1	x2	x3	x4	x6
	Yield	Agrochemicals (t)	Agromachinery (10,000kWj)	Irrigated land (10,000ha)	Fertiliser (10,000t)	Ranking of drought
1990(k1)	1.6	450.94	45.36	13.67	1.55	1.50
1991(k2)	1.59	438.37	48.12	11.33	2.00	1.67
1992(k3)	1.55	542.77	57.24	8.13	1.72	4.50
1993(k4)	2.15	520.00	64.32	13.67	1.22	2.33
1994(k5)	1.81	519.88	58.50	16.20	1.49	4.33
1995(k6)	1.82	594.21	68.39	14.42	1.98	2.17
1996(k7)	1.92	1236	77.03	14.77	2.78	1.69
	Degree of relevancy	0.84	0.85	0.87	0.81	0.73
	Coefficient of correlation	0.35	0.67	0.57	-0.08	(-0.15)

Historically, the total number of livestock was about 10 million head. The socioeconomic changes during the 1950s and 1960s resulted in the number of livestock increasing rapidly. The livestock-production system is in transition, driven by increasing demand for livestock products, particularly meat and milk, as the human population increases, incomes grow, and lifestyles and food preferences change.

The total number of livestock has had three distinct development stages. Presently, it is stagnating.

Livestock raising has passed through three development stages: a stage of fast growth, a stage of steady growth, and a stagnant period. Figure 6.12 and Table 6.13 show the growth rate over time.

Before 1960, livestock totalled about 10 million head. This figure increased rapidly

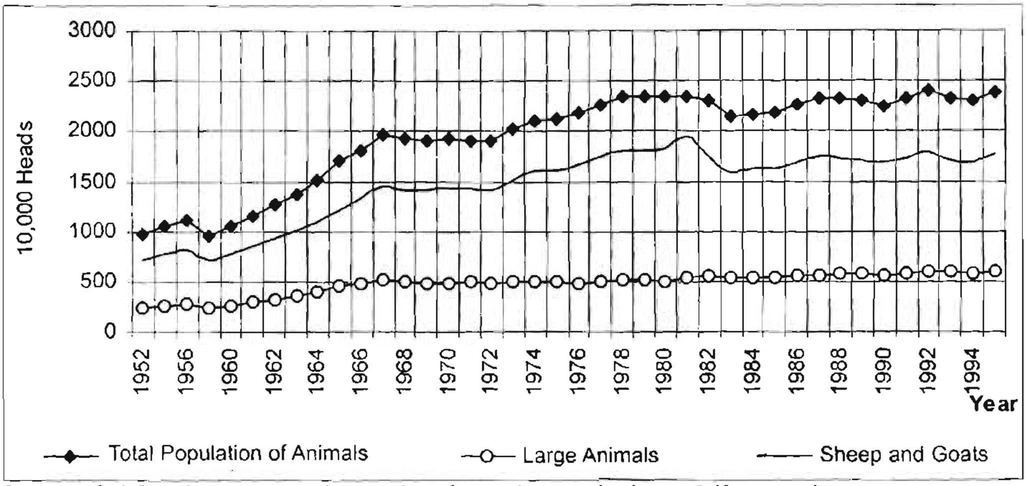


Figure 6.12: **Changes and trends of total population of livestock**

Table 6.13: **Growth rates in population of livestock (%)**

Periods	Total population	Large animals	Small animals	Sheep	Pigs
Fast growth (1960-67)	9.47	9.74	9.37	8.95	13.01
Steady growth (1968-80)	1.40	(-0.09)	1.84	2.20	5.23
Stagnant (1981-96)	0.12	1.12	(-0.11)	(-0.24)	0.19

following liberalisation, land reform, and democratic reform, and by 1967 had increased to 20 million head. The average annual growth rate was 9.4% during this period (Table 6.13).

From 1968-80, the average growth rate was only about 1.4 %, as the total number of livestock reached 23.4 million head by 1980. Although the number of livestock had increased, livestock development had been devastated, following the transformation of a large area of productive rangeland into cropland. There was greater concentration on production of cereals than on production of livestock. By the late 1970s, there was hardly any growth in numbers of livestock. Since 1980, the total number of livestock has remained between 22 million and 23.5 million, with an average growth rate of 0.1%.

During the 1960s, the average annual growth rate was more than 10%. There was a slow increase during the 1970s at an average growth rate of 2.1%. During the 1980s, there was stagnation and numbers decreased at a rate of -0.16%. In recent years, there has been a slight increase in the livestock population (Table 6.14).

In general there has not been much fluctuation in the total population of livestock (Figure 6.13). With increasing demand for pork in recent years, the population of pigs has increased at a rate of 6.6%, after a large decrease during the 1980s (Figure 6.14).

Development of rangeland has not progressed much. The off-take rate of livestock needs to be increased.

The total area of rangeland is about 82 million ha. In 1996, the useable area was about 60 million ha. Under the general situation of low carrying capacity, lack of feed during the winter and spring, and shortage of winter grazing, it is important to develop

Table 6.14: **Growth rate in livestock population over time (%)**

		Total population	Large animals	Small animals	Sheep	Pigs
1950s	1952-59	(-0.16)	0.03	(-0.32)	0.45	19.64
1960s	1960-64	9.65	10.60	9.21	8.33	22.87
	1964-69	4.81	4.05	5.17	5.51	(-1.81)
	1960-69	7.23	7.33	7.19	6.92	10.53
1970s	1970-74	2.19	0.25	2.78	2.58	8.05
	1975-79	2.52	0.70	3.06	4.14	4.67
	1970-79	2.16	0.46	2.66	3.19	7.08
1980s	1980-84	(-1.54)	0.96	(-1.99)	(-2.11)	(-11.38)
	1985-89	1.23	1.40	1.17	0.64	2.62
	1980-89	(-0.17)	1.34	(-0.50)	(-0.76)	(-4.12)
1990s	1990-95	0.60	0.39	0.63	0.52	6.66

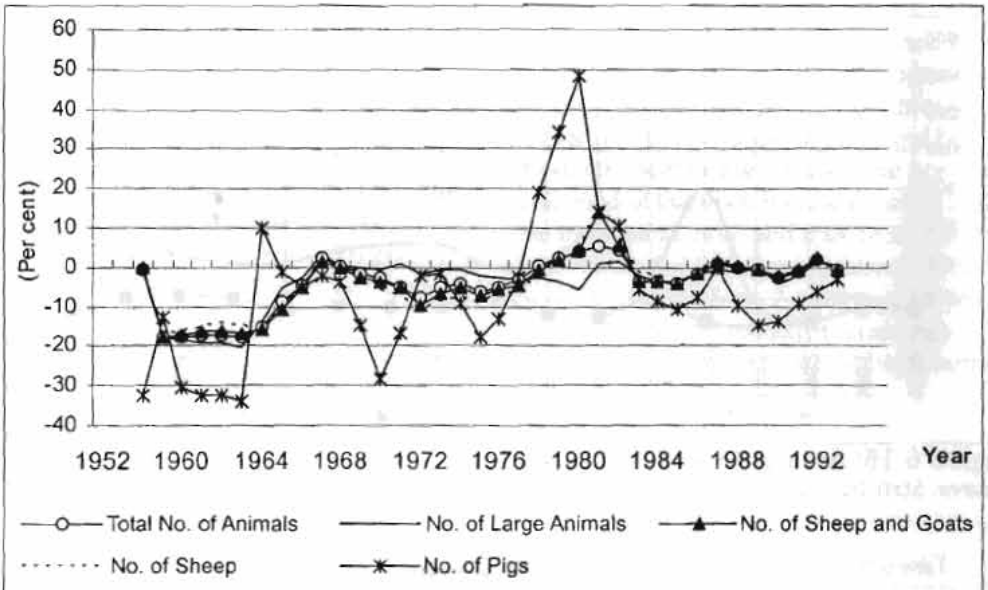


Figure 6.13: **Changes and trends in total population of livestock**

fenced and irrigated rangeland. Both fenced and irrigated rangelands are currently limited. Development has not progressed much during the past 15 years (Figure 6.15). The average area of fenced rangeland during 1980-85 was about 308,000 ha. In 1996, the total area of fenced rangeland was 546,000 ha. The average irrigated rangeland during 1980-85 was about 122,400 ha, and in 1996 it was 153,000 ha. Fenced and irrigated rangelands have increased by 144,400 ha and 30,600 ha, respectively, during the last 15 years (Table 6.15). This amount of fenced and irrigated rangeland is too small to support a productive and profitable livestock-raising effort.

As the total area of rangeland cannot be expanded and there has been not much progress in fencing and irrigation of rangeland, it is necessary to increase the off-take of livestock. Increasing the off-take rate

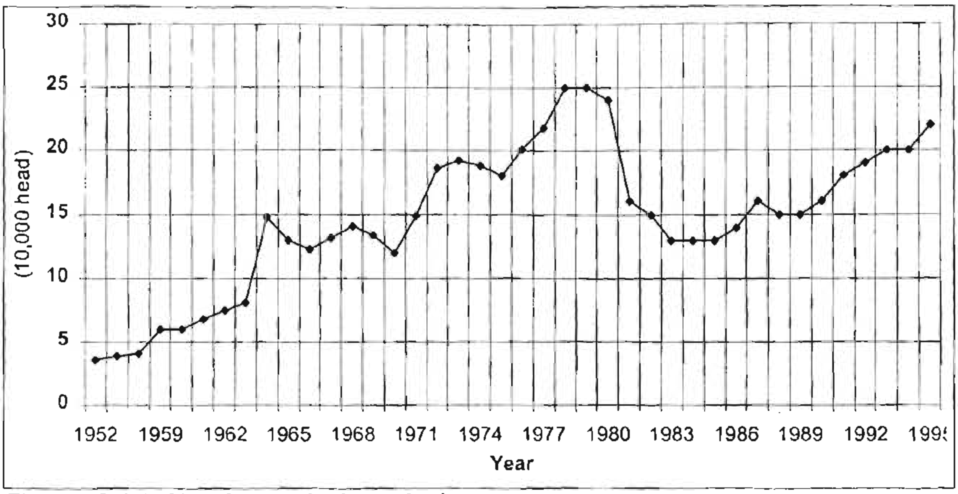


Figure 6.14: **Total population of pigs**

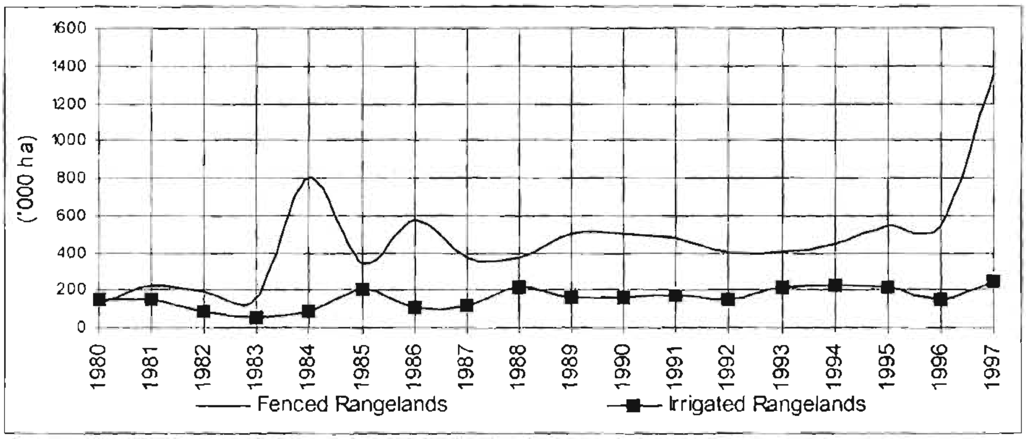


Figure 6.15: **Area of fenced and irrigated rangelands**
Source: Statistics Bureau of Tibet (1997)

Table 6.15: **Development and construction of rangelands ('000 ha)**

Year	Total area of rangeland	Total area of usable rangeland	Area of fenced rangeland	Area of irrigated rangeland
1980-85	59,875.9	32,015.2	308.6	122.4
1986-90	76,586.9	52,611.6	465.2	152.3
1991	82,150.0	41,003.3	476.7	172.0
1992	73,676.0	41,009.3	410.7	153.3
1993	73,676.0	41,009.3	410.7	213.3
1994	73,608.7	40,684.0	451.3	220.0
1995	77,382.0	55,621.3	542.0	210.0
1996	82,767.0	60,364.0	543.0	153.0
1997	131,019.0	88,427.0	13,553	247.0

Table 6.16: **Changes and trends in off-take of livestock and their growth rate**

	Yak and cattle		Pigs		Sheep and goats	
	Average taken	Average annual growth rate (%)	Average taken	Average annual growth rate (%)	Average taken	Average annual growth rate (%)
1980–84	317,200	8.72	48,900	(-1.70)	2,764,000	5.16
1985–89	411,400	5.05	71,800	5.59	3,399,800	3.54
1980–89	364,300	6.89	60,400	1.95	3,081,900	4.35
1990–96	554,900	6.50	98,400	10.14	3,543,900	0.91

will not only reduce the loss of animals during winter and spring, but also increase meat production to meet demand and increase income generation for herders. Total off-take of yak and cattle increased to an average of 554,900 head during 1990-96 from 411,400 head in the late 1980s (Table 6.16). In 1996, the total off-take of large animals was 620,000 head out of more than 6 million. Total off-take of small animals ranged from 3.4 million head to 3.8 million head out of more than 17 million head. The average rates of small animal off-take and large animal off-take were about 20 and 10%, respectively. The off-take rate of pork has rapidly increased from 30% during the 1980s to 55% in the 1990s. In general, the off-take rate of most animals has, by and large, remained the same during the past 15 years (Figure 6.16).

The demand for meat and milk has been increasing year by year, driven by population increase, income growth, and changes in lifestyles and food preferences. However, the development of rangeland in terms of expansion of fenced and irrigated areas and artificial grassland has not progressed much. There has also not been much progress in the development of feed production through forage and processing of agricultural by-products. Neither the off-take rate nor per unit yield of livestock has increased. Thus, the increase in meat and milk production has been attributed mainly to increases in the number of animals during the last 15 years. Therefore, rangeland, which is already overgrazed and degraded, has been further burdened to an alarming point.

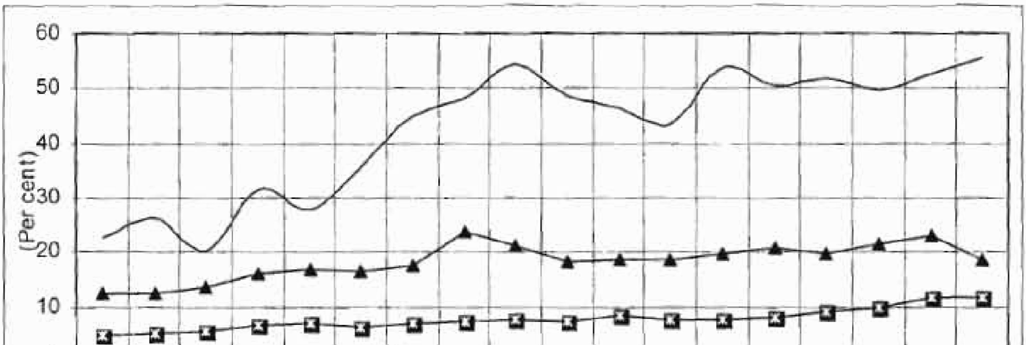


Figure 6.16: **Rate of off-take of animals (%)**
Source: Statistics Bureau of Tibet (1997)

There is a stable increase in meat production, but milk production has stagnated.

The growth of meat and milk production has been slowed by the stagnation in the raw number of animals since the 1980s. The average growth rates of meat and milk production during 1980-84 were 4.3% and 8.5%, respectively. During 1990-95, they were 3.6% and -0.3%, respectively (Table 6.17). The growth rates of per capita meat and milk production have also decreased (Figure 6.17).

In general, both total production and per capita production of meat are still increasing, while the production of milk has stagnated (Figures 5.18 and 5.19).

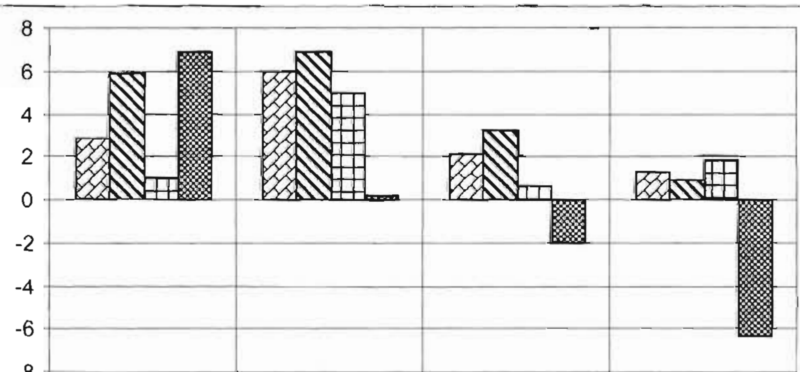
Using linear regression analysis for total production of meat and milk, with the equations $Y_m=0.3807_x+4.1349$ and $Y_{mk}=0.5158+6.172$, yields R^2 of 0.97 and 0.77, respectively. Total production of meat will be 125,000t and total production of milk will fluctuate around 180,000t.

Analysis of Factors Influencing Meat and Milk Production

Many factors affect meat production. Generally, the number of livestock and the rate of off-take are the most important. The number

Table 6.17: **Growth rates of total meat and milk production (%)**

	Meat				Milk	
	Meat	Pork	Beef	Lamb and mutton	Sheep and goat milk	Cattle and yak milk
1980–84	4.38	6.54	7.47	2.49	8.53	12.67
1985–89	7.97	11.78	8.95	6.93	10.75	9.89
1990–95	3.64	8.62	4.74	1.91	(-0.34)	(-0.20)
1995–96	2.94	17.86	1.79	2.65	(-5.62)	(-4.18)



	1980-1984	1985-1989	1990-1995	1995-1996
Meat	2.855090801	5.968513101	2.133550872	1.313320826
Beef	5.866837137	6.914853966	3.208636768	0.921658986
Mutton	1.008581561	4.952736015	0.638551691	1.876955162
Milk	6.933304125	0.196677691	-1.984533454	-6.379563996

Figure 6.17: **Growth rates of per capita meat, mutton and milk production (%)**

Source: Statistics Bureau of Tibet (1997)

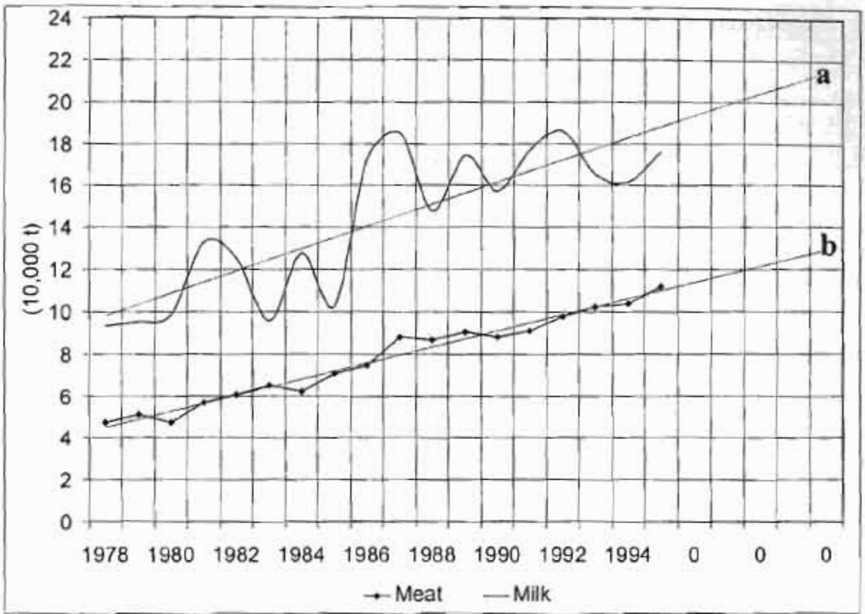


Figure 6.18: **Changes in meat and milk production**

a) $y = 0.5303x + 9.2675$ $R^2 = 0.6789$ b) $y = 0.3807x + 4.1349$ $R^2 = 0.9721$

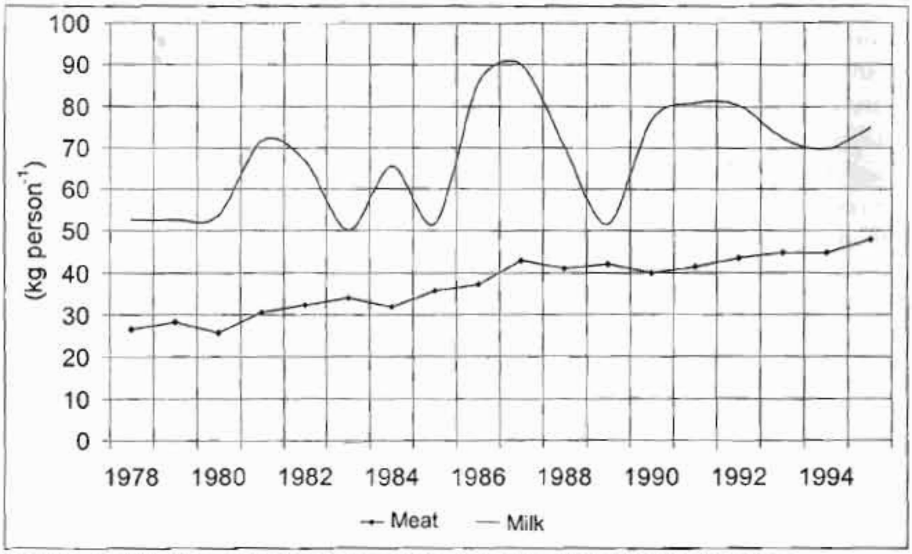


Figure 6.19: **Changes in per capita meat and milk production**

of livestock is affected by the area of rangeland, the quality of rangeland, feed production, and climatic conditions, particularly drought. However, to understand which factors are dominant, grey relevancy analysis and correlation analysis of total production of meat were carried out (Table 6.18).

The analysis shows several things.

- The off-take rate of yak and cattle is the main factor affecting meat production. Increase in the rate of off-take will facilitate an increase in meat production.

Table 6.18: **Major factors affecting the total meat production**

	Population of livestock	Food grain production	Cattle and yak off-take	Pig off-take	Sheep and goat off-take
Degree of relevancy	0.79	0.90	0.94	0.92	0.84
Coefficient of correlation	0.65	0.89	0.95	0.96	0.68
	Total area of rangeland	**Total area of usable rangeland**	**Area of fenced rangeland**	**Area of irrigated rangeland**	**Ranking of drought**
Degree of relevancy	0.90	0.85	0.68	0.80	0.70
Coefficient of correlation	0.70	0.13	0.23	0.68	(-0.39)

- Increasing the off-take rate and number of pigs have great potential to boost meat production.
- There is a close correlation between meat production and food grain production. Increase in food grain production may provide more scope for producing feed for animals. Crop-based livestock production has great potential to increase meat production in the future.
- Although the area of rangeland does not have a major effect on meat production, improvement of the rangeland has a significant effect, particularly any increase in the area of irrigated rangeland.
- The total number of livestock has not increased meat production much compared to other factors. This is because when the total population of animals is relatively stable, the rate of off-take and per unit yield are the main factors that affect meat production.
- There is a negative correlation between drought ranking and meat production. The degree of drought does not have much effect on meat production. However, drought itself has been a constraint on livestock development and meat production.

The same approach was used to analyse milk production by considering factors such as the total number of yak and cattle, the number of sheep and goats, total food grain production, total area of rangeland, total area of usable rangeland, area of fenced rangeland, area of irrigated rangeland, and ranking of drought (Table 6.19). The total number of yak and cattle has the greatest effect on milk production, followed by the total number of sheep and goats. There is a correlation between food grain production and milk production. There is less effect from the area of rangeland and area of irrigated and fenced rangeland because there has been little change in these. It is difficult to expand the area of fenced and irrigated rangeland at current levels of socio-economic development. Increases in both total number and per unit yield of cattle, yak, sheep, and goats could be achieved through development of food grain production. Milk production could be increased through developing specialised small-scale milk production in cropping areas, and improvement of feed quality and feeding strategies.

Table 6.19: **Major factors affecting milk production**

Factors	No. of cattle and yak	No. of sheep and goat	Total grain production	Total area of rangeland	Total area of usable rangeland	Area of fenced rangeland	Area of irrigated rangeland	Ranking of drought
Coefficient of correlation	0.77	0.75	0.66	0.61	0.00	0.39	0.37	-0.19
Degree of relevancy	0.86	0.85	0.91	0.91	0.86	0.64	0.76	0.75

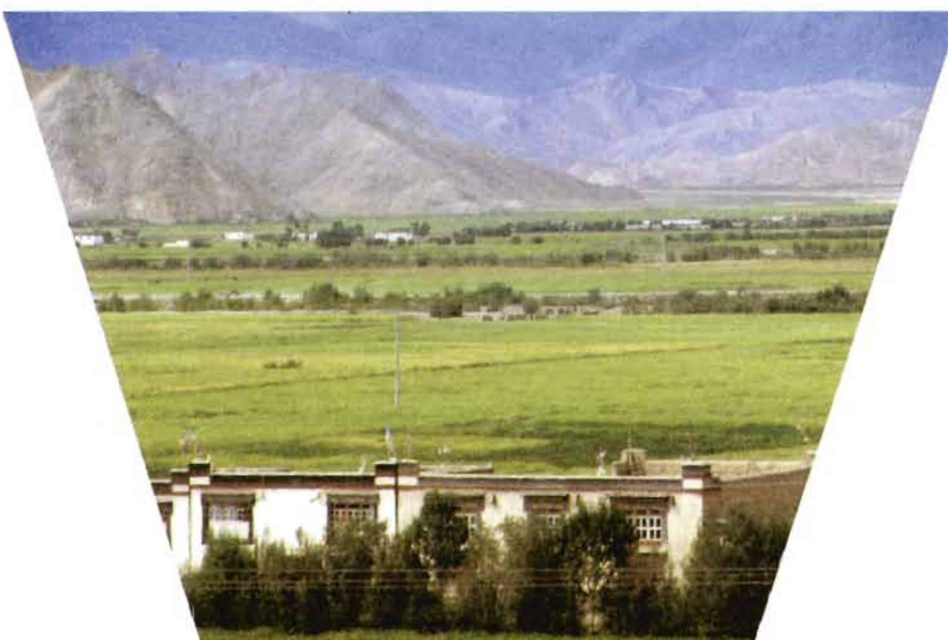
seven

changing food preferences & demands

Background: Barley crops moving higher -- perhaps global warming is facilitating expansion of farm-lands in Tibet
- *Tej Partap*

Top Inset: Harnessing water for farming major efforts have been made in the valleys to provide irrigation facilities to facilitate food production
- *Tej Partap*

Bottom inset: Maturing wheat grains ready for harvest in central Tibet- the food bowl
- *Tej Partap*



Wheat crop in central Tibet- known as the food bowl of Tibet - Tej Partap

Chapter 7
Changing Food Preferences and Demands

Two factors have the most effect on increases in food consumption and food demand. One is the population increase; when the levels of food consumption and food preferences are stable, a larger population will increase the demand for food. The other factor is income growth, which influences changes in food preferences, lifestyles, and patterns of food consumption. The higher the income, the greater the intake of calories and protein tends to be. Thus, population size and income growth are major factors affecting food consumption and food demand.

Population Growth

The total population in 1997 was 2,427,000, of which 417,000 lived in urban and 2 million in rural areas. The urban population increased suddenly in 1987 and 1989 due to an administrative shift that re-classified some of the population living in or near towns and cities from rural to urban. The urban - rural balance also changed significantly relative to the total population. Overall, Tibet has kept a growth rate of more than 1.5% per annum. In recent years, however, this rate has tended to decrease. The rate of total population growth during 1996/1997 was 1.4%, down from the 1.6% during 1991-1992. The growth rates of both urban population and rural population declined at similar rates (Table 7.1). This slowing of population growth is mainly attributed to the policy of birth control. Although urban Tibetans are allowed to have two children and rural Tibetans can have up to five, privileges accrue to those having one child. In addition, many Tibetans feel that it is getting difficult to raise two children in urban areas, since both parents tend to work and the cost of living is now getting expensive. Thus, many Tibetans in urban areas are having only one child. In rural areas of Tibet, farmers are also starting to have fewer than five children because of the extension of birth control services and making those services available to farmers and herders, even in very remote areas.

The linear regression of the total population over the last 19 years ($Yp=3.4265x+173.67$, $R2=0.9962$) projected a population of 2,696,000 in year 2005; 2,868,000 by 2010; and 3,200,000 in 2020. This projection is quite close to those done by other scientists in Tibet (Sun Jinxing 1997; Yang Gaihe 1995). But this projected population in Tibet does not include people from outside of Tibet who have migrated there in recent years. It is expected that the next 15 years will see a sudden increase in the urban population of Tibet, due to continued migration from rural areas to cities and towns. Furthermore, administrative changes may change some counties into towns or even cities. Such changes, however, will not make much difference to the overall population growth rate in Tibet. The natural growth rate of the Tibetan population will remain about 1.3-1.5%. However, migration of other groups from other parts of China to the Tibet

Table 7.1: **Recent population (in millions) and growth rate (%) in Tibet**

Year	Urban population		Rural population		Total population	
	Population (million)	Growth rate (%)	Population (millions)	Growth rate (%)	Population (millions)	Growth rate (%)
1981	0.183		1.676		1.859	
1982	0.179	(-1.91)	1.713	2.17	1.892	1.77
1983	0.187	4.57	1.743	1.79	1.931	2.06
1984	0.200	6.87	1.766	1.29	1.966	1.83
1985	0.205	2.34	1.789	1.32	1.994	1.42
1986	0.205	0.29	1.819	1.65	2.024	1.51
1987	0.263	27.97	1.816	(-0.16)	2.079	2.70
1988	0.278	5.65	1.844	1.58	2.123	2.10
1989	0.360	29.63	1.798	(-2.52)	2.159	1.70
1990	0.356	(-1.14)	1.873	4.19	2.180	0.99
1991	0.362	1.63	1.855	(-0.98)	2.217	1.72
1992	0.370	2.07	1.882	1.47	2.252	1.57
1993	0.378	2.24	1.910	1.48	2.288	1.60
1994	0.384	1.69	1.935	1.29	2.319	1.35
1995	0.398	3.51	1.961	1.38	2.360	1.73
1996	0.404	1.43	1.989	1.39	2.393	1.40
1997	0.417	3.22	2.010	1.07	2.427	1.43

Autonomous Region is expected to increase gradually over the next 15 years. Previously people in central China had been worried about the high altitude of Tibet. With the improvement of infrastructure, food, housing, and transportation in Tibet, people are no longer so afraid of high altitude and bad conditions. Generally, facilities and conditions are now good enough to support the move of people from central China to the Tibet Autonomous Region. Since 1992, and particularly since 1994, the overall infrastructure, living conditions, and employment opportunities have improved considerably due to support from both the central government and sister provinces in China. These improvements have led increasing numbers of people to migrate from central China to the Tibet Autonomous Region as "floating population". These people mostly stay in urban areas where the living conditions and employment opportunities are much better than in rural areas. Very few people from central China, especially Han Chinese, have stayed in rural Tibet, except for a few Chinese Moslems. Under this scenario, the urban population is expected to increase rapidly in the near future. The provincial migration between the Tibet Autonomous Region and other provinces in China in 1991 was -2,300 people, which means that 2,300 people left Tibet for the outside, whereas in 1994, there was a net gain of 2,000 people coming into Tibet. Since that time there has been much more migration into Tibet from other provinces. With the current trend, by 2005 the urban population of Tibet will increase to 700,000, of which 500,000 will be local people. The total population of consumers is expected to be more than 3 million by year 2005 and 4 million by year 2010.

Trends in Income and Level of Consumption

Tables 7.2 and 7.3 present the data on recent changes in income and the level of consumption. Several trends are evident.

Table 7.2: **Income and expenditures in rural and urban areas of Tibet by year**

		1990	1991	1992	1993	1994	1995	1996	1997
Per Capita income (Yuan yr^{-1})	Salary of staff	3,181	3,355	3,448	4,085	7,115	7,382	11,087	10,098
	Urban	1,685	2,111	2,208	2,504	3,596	4,460	5,912	5,9130
	Rural	592	617	653	706	817	878	975	1085
	Ratio of urban to rural	2.85	3.42	3.38	3.55	4.40	5.08	6.06	5.45
Per Capita Expenditure (yuan yr^{-1})	Tibet	734	840	905	931	1,110	1,202	1,312	1,471
	Farmers	485	554	594	591	694	762	873	939
	Non-farmers	2,290	2,628	2,874	3,083	3,094	3,981	4,023	4,744
	Ratio of non-farmers to farmers	4.72	4.74	4.84	5.22	4.46	5.22	4.61	5.05

Table 7.3: **Spending on basic needs and food, and their percentage of total spending in rural areas**

Year	Total exp. (yuan)	Basic Needs		Food	
		Cost (yuan)	(%)	Cost (yuan)	(%)
1985	269	268	99.6	184	68.3
1986	257	256	99.3	179	69.6
1987	245	243	99.1	171	69.9
1988	271	268	98.7	179	66.1
1989	289	285	98.4	187	64.5
1990	346	340	98.5	252	72.9
1991	389	381	98	268	68.9
1992	544	536	98.5	387	71.1
1993	638	619	97.1	497	78
1994	788	763	96.7	552	70
1995	896	873	97.3	667	74.3

Both income and consumption have been increasing rapidly, but the growth of both in urban areas has been much faster than that in rural areas.

The differences in income and consumption between urban and rural areas have been growing significantly. The per capita income in urban areas was 2.8 times that of rural areas in 1990, while in 1995, it was 5 times. Compared to the average in China overall, the income gap between urban and rural people in Tibet was significantly higher. The gap in consumption levels was also very high. The gap of consumption level between non-farmers and farmers was 5.05 in 1997, an increase from 4.72 in 1990. This gap continues to grow (Figure 7.1).

In rural areas of Tibet most livelihood expenditures are currently on food. The total expenditure of farmers on livelihood at present is about 800 yuan/person/year, which is pretty low, but out of that 70% is spent on food, and the Engel's rate is still increasing (Figure 7.2,Table 7.3). A household survey in Dazi County near Lhasa City showed that in 1996 farmers spent 63.3% of all livelihood expenditure on food, an indication that many farmers there were still at the level of 'extreme poverty' (Liu Wei 1998). Nevertheless, Dazi County is one of the richest and best-located counties in Tibet, since it is close to Lhasa and has good land, water resources, road access, and infrastructure. Therefore, we can extrapolate that, in Tibet as a whole, the living standard remains very poor, although there has been tremendous progress in recent years.

Rural Tibetans spend a much higher percentage of their total livelihood expenditure on food than those living in other rural areas of China (58.6%). As pointed out earlier, the per capita calorie intake in Tibet is lower than that in central China. A household survey in

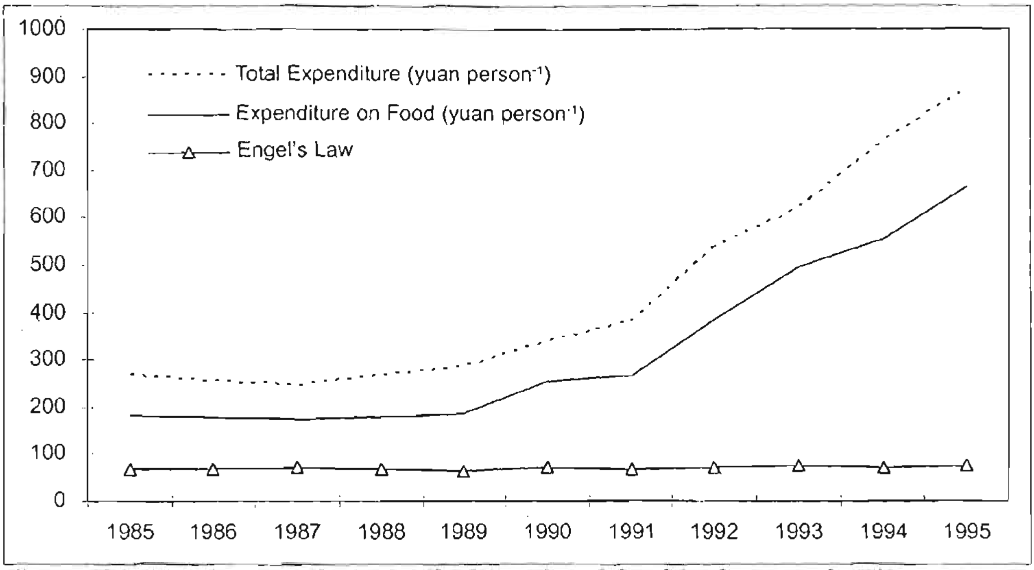


Figure 7.1: **Total expenditure on livelihood and food by farmers in Tibet**

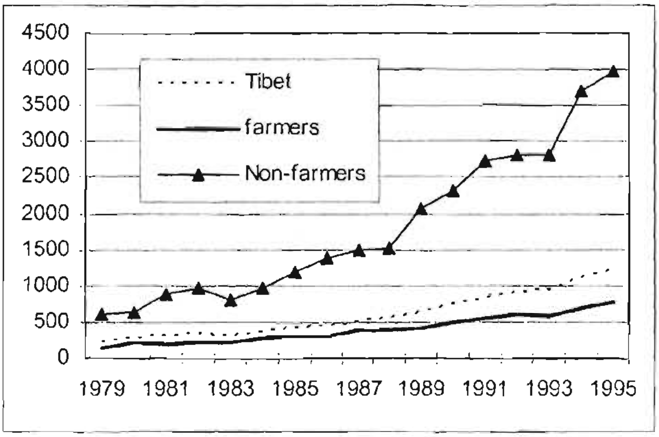


Figure 7.2: **Per capita expenditure (yuan)**

Zha'nang, Shigatse City, Linzhou, Gyantse, Dingri, and Dazi County during 1996-1998 suggested that more than 85% of the total food in farmers' diets in Tibet is tsampa. Farmers consume very little meat, milk, vegetables, or fruit . In other words, although they spend a high proportion of their money on food, farmers still consume lower priced food of poor quality and nutritional value.

In urban areas of Tibet, the average annual per capita income is about 6,000 yuan, and the average per capita annual expenditure on livelihood is about 5,000 yuan. Both are more than 5 times higher than the figures for rural Tibet. Furthermore, the 57.3% of the total expenditure on livelihood that went to food was much less than that of rural areas of Tibet. The living standard and quality of life in urban areas is much better than in rural areas in terms of food, housing, public facilities, services, transportation, and communication. With such an increasing gap between rural and urban living standards, more and more rural people can be expected to migrate to urban areas. However, the employment opportunities in urban areas are often taken by people from outside of Tibet, as most of the people from central China are more competitive and skilled than local farmers and herders. No regulations assign job priority to the indigenous population. In addition, the lack of labour-intensive industries, which absorb more population and provide more employment, mean that job growth is low. The large gap between rural and urban living standards, together with the poor employment outlook for newly urbanised farmers and herders, is likely to reduce the stability of society. Therefore institutions, the public, and decision-makers should consider providing more opportunities for farmers and herders to generate income, and give high priority to improving their well-being and living standards. Education, training, improving their competitiveness, and promoting employment for the local farmers and herders should be given high priority.

Changing Trends in Food Consumption and Preferences

All food items consumed in Tibet in the last 15 years were converted into calorie equivalents. The proportions of each food item in total calorie intake were calculated. Figure 7.3 presents the result.

Consumption of cereals has been declining among the urban population, whereas it is still increasing slightly among the rural population. In urban areas, about 78% of total calorie intake was from cereals in 1989, and 62% in 1995, whereas in rural areas, it has increased to 88% in 1995 from 80% in 1989. Both in rural and in urban areas, the consumption of barley as a staple food grain has been declining very significantly in recent years. At present, according to a survey of typical households in Lhasa, fewer and fewer young people are taking tsampa as a staple food grain. Among 20 randomly selected households in Lhasa City, barley made up only 34% of the total food grain consumed. Some of the households even did not have any tsampa. Most tsampa was eaten at breakfast, and only 25% of the households took tsampa as their staple food. Most of the households now take wheat and rice as staple food grains. But many households expressed that only 10 years ago, tsampa had been the main food grain. With this trend, by 2005, about 20% of Tibetans may take rice and wheat as their staple food grains instead of barley, and by 2010 this may increase to 30%.

Comparing urban with rural areas of Tibet, food grain and alcohol consumption in rural areas are much higher than in urban areas. The urban population eats more meat, milk, and vegetables than the rural population. It suggested that the food preferences between the two are now quite different.

In urban areas, the consumption of meat, milk, eggs, and vegetables has been increasing very rapidly since 1990, while in rural areas, it has been decreasing. This is mainly due to higher salaries and benefits gained by official staff and cadres in the early 1990s. The price of locally produced food has increased only a little while the price for exotic food has increased, thus the relative purchasing power of farmers and herders has been reduced.

In general, the urban populations of Tibet are now starting to seek low-calorie but high-protein food, while rural farmers are consuming locally produced food grain rather than meat and milk. The food consumption structure in rural areas still remains traditional, while the food preferences in urban areas of Tibet are changing very drastically towards a Chinese style.

Trends in Food Demand

Many factors, such as food preferences, income level, age, food quality, and food availability, affect demand for food. When food availability is relatively constant or fixed, population and income growth are the main influences on the growth of food demand. When the population and food availability are relatively constant, income growth is the dominating factor that raises food demand. When income is not increasing rapidly and food availability is constant, population size is the dominant factor that increases the food demand. When both income and population are increasing and food availability is improving, then the food demand and the amount of food consumed will increase very rapidly. This is exactly the case in Tibet. Assuming that food availability is improving steadily, and taking population and income as the main factors affecting food demand, the growth rate of food demand will depend on the population growth rate and per capita

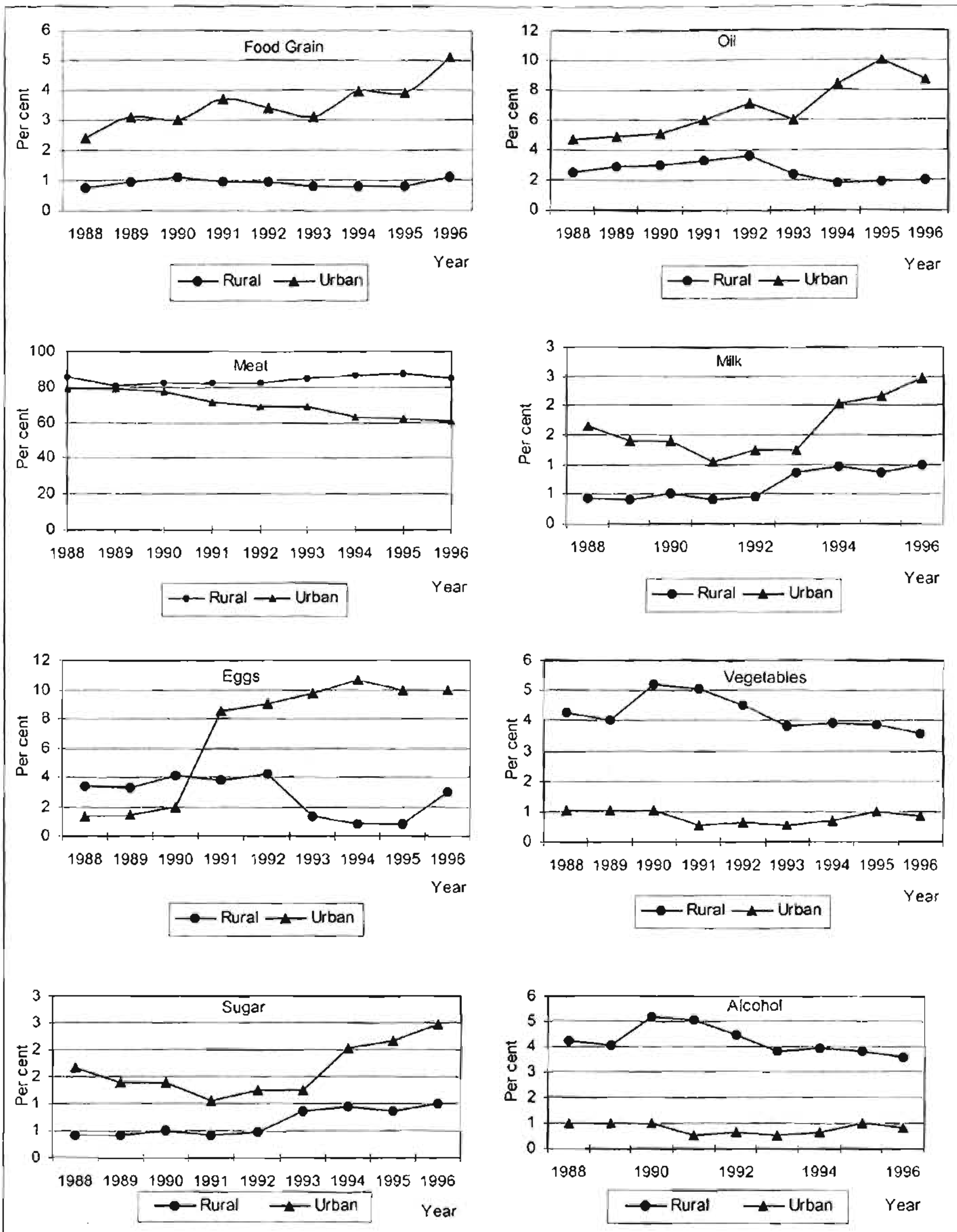


Figure 7.3: **Changes in proportion of food consumption in Tibet**

income. The increase of effective demand for food is often reflected in the growth rates of consumption of different foods, which are determined by income elasticity (Zhu Xigang 1997). Under this assumption, the growth rate in food demand can be estimated using following formula:

$$R = P + E_{dy} Y$$

Where

- R = *Growth rate in food demand*
- P = *Population growth rate,*
- Y = *Growth rate in total income*
- E_{dy} = *Income elasticity of food consumption*

Trends in food consumption

As discussed earlier, there have been dramatic changes in food preferences in both rural and urban areas of Tibet. The growth rate of food consumption during the last 10 years also suggests that consumption of livestock, poultry, and vegetables has been increasing significantly while the rate of growth of food grain and oilseed consumption have been slowing down. The speed of this change in urban areas is much faster than in rural areas. The consumption of cereals as a share of total food consumption in urban areas of Tibet is declining at a rate of 3.4% a year, while in rural areas it is increasing at a rate of 3.2%. There has been a rapid increase in the consumption of milk and eggs in both rural and urban areas of Tibet, with average growth rates of 14.2 and 13.5%, respectively (Table 7.4). But the rate of consumption of each food is mainly determined by the ratio of income elasticity to consumption of each food.

Income elasticity to food consumption

The elasticity of gross per capita income and per capita GDP to different foods consumed were estimated (Table 7.4). In urban areas, the elasticity of per capita income to milk consumption was the highest, at 2.03. Urban dwellers increase their consumption of milk (mainly in the form of butter) with increase of per capita income. The per capita income elasticity to consumption of eggs, vegetables, and meat is also very high, but the correlation to consumption of cereals and alcohol appears to be negative. All these indicate that the direct consumption of cereals is declining, while the indirect consumption of cereals is rising due to the increasing consumption of livestock products in urban areas of Tibet. The food preferences in urban areas of Tibet now have shifted towards higher protein content food and vegetable food, instead of the food-consumption structure of just 10 years ago, which was based on cereals. In rural Tibet, although the per capita income elasticity to consumption of milk, vegetables, and sugar also appears to be high, there is also positive elasticity of income to consumption of cereals, which remain the food preference in the rural areas of Tibet.

Table 7.4: **Growth rate in food consumption and income elasticity to food consumption**

Food and income	Growth rate of income and food consumption (%)				Income elasticity index of food consumption					
	Urban	Rural	Average	GDP	By Per capita GDP: Urban	By Per capita GDP: Rural	By Per capita GDP: Average	Urban	Rural	Average
Income	20.14	17.28	18.71	14.10						
Food grain	(-3.40)	3.17	(-0.11)		(-0.24)	0.22	(-0.01)	(-0.17)	0.18	0.01
Rape seed	2.73	12.33	7.53		0.19	0.87	0.53	0.14	0.71	0.42
Vegetable	11.00	8.75	9.88		0.78	0.62	0.70	0.55	1.28	0.86
Meat	8.39	1.39	4.89		0.59	0.10	0.35	0.42	0.08	0.25
Milk	18.95	9.39	14.17		2.90	1.09	1.54	2.03	1.36	1.20
Eggs	12.84	13.48	13.16		0.91	0.96	0.93	0.64	0.78	0.71
Sugar	5.61	18.96	12.28		0.40	1.34	0.87	0.28	1.10	0.69
Alcohol	(-0.46)	1.27	0.40		(-0.03)	0.09	0.03	(-0.02)	0.07	0.03

The rate of growth in food demand

Food demand, driven by population growth and increase in per capita income, appears to be significantly higher than before. The demand for milk and eggs has rapidly increased at growth rates of 18.6 and 18.3%, respectively. Vegetable and sugar consumption also increased at growth rates of 10.5 and 14.8%, respectively. The demand for cereals by the urban population has declined slightly at a rate of -0.8%, whereas the growth rate of food grain demand in rural areas will still keep to about 3% in the near future (Table 7.5). The demand for livestock-based food and vegetables in the urban areas is much higher than in rural Tibet. With this pattern of growth of food demand in Tibet, the food preferences in rural and urban areas of Tibet will soon be totally different from each other. The food preference and food consumption structure in urban areas is now getting close to the Chinese diet, while, in rural Tibet, food preferences will maintain more traditional: tsampa, yak meat, butter tea, and chang (alcohol brewed from barley).

Table 7.5: **Growth rate of food demand and food production in rural and urban areas of Tibet**

Foods		Foodgrain	Rapeseed	Vegetables	Meat	Milk	Eggs	Sugar	Alcohol
Growth rate of Per Capita Food Consumption (90-96)	Urban	(-0.81)	6.18	13.62	13.30	19.70	19.89	13.32	2.86
	Rural	6.83	12.98	7.44	0.57	10.01	16.80	23.99	0.07
	Average	3.01	9.58	10.53	6.94	18.66	18.34	14.86	1.47
Growth rate of Per Capita Food Production (90-96)		3.02	11.69	2.7	2.27	7.87	21.39	/	/

The production growths of cereals, oilseed, and eggs are currently ahead of the growth of demand. But the growth rates of demand for other food, such as meat, milk, and vegetables, are much higher than the production growth (Table 7.5).

Zonal Variations in Food Demand

Many factors affect zonal variations in food consumption and demand. Variations in per capita GDP, per capita income, the level of consumption, food preferences and structure, and the population are the major factors. Another factor is the zonal variation in food production, including both food quantity and food quality. The socioeconomic development level of different regions largely determines the level of food consumption, while the regional differences in food production affect the availability of food. However, the predominant factors affecting the zonal variations in food consumption and demand are variation of population and differentiation of per capita income.

Zonal variations in population

The analyses of population differentiation and growth among the prefectures and farming systems of Tibet were made based on the population censuses in 1982 and 1990 and the population data of 1995 (Table 7.6). The population in Tibet is unevenly distributed, and there is great variation in the population among the different prefectures and farming systems in Tibet.

Over 60% of the population is distributed in the river valleys in the upper reaches of the Yalungtsangpo River and its main tributaries, the Lhasa River and the Nyachu River. This area comprises only about 20% of Tibet. Generally, the population in the pastoral zone is sparsely distributed, particularly in Naqu and Ali prefectures. The population density is less than one person km^{-2} in these areas, while in the crop dominated and agro-pastoral zones, where the majority of the Tibetan population is concentrated, the population density can reach more than 20 persons km^{-2}. The distribution of population in Tibet, to some extent, could reflect the differentiation of biophysical conditions and the level of socioeconomic development.

The population has grown since the 1970s due to the improved health care and socio-economic status of the people in Tibet. The average population growth rate from 1952-1959 was 0.9%, while during the 1970s and 1980s, the average rate was 1.8%. At present, population growth has slowed down to 1.4%. There was faster population growth in the pastoral-dominated zone than in the crop-dominated zone of Tibet (Table 7.6). Both Naqu and Ali prefectures, which are mainly pastoral, have population growth rates of more than 2%. While in the crop-dominated zone, the population growth rate was about 1.1% during 1990-1995. The agro-pastoral-forestry mixed zone in the southern parts of Tibet has kept the lowest population growth at a rate of 0.6%.

The per capita production value of agriculture varies among the prefectures and food production systems/farming systems, and this variation is increasing . The per capita production value of agriculture in Naqu Prefecture was about 1,104 yuan, while in the Shigatse Prefecture, it was 1,894 yuan; these figures increased by 113.74% and 422.05%, respectively, from 1985. There is a huge gap between the pastoral-dominated and cropping-dominated zones. The per capita production value of agriculture in the former is not only much lower, but also increasing more slowly than that of the crop-dominated zone. The growth of crop production value is much faster than production value of livestock in different zones (Table 7.7).

Table 7.6: **Zonal variations of population in Tibet**

Prefectures and farming systems of Tibet	Total population			1982 to 1990			1990 to 1995		
	1982	1990	1995	Increased	Growth rate	Annual growth rate	Increas-ed	Growth rate	Annual growth rate
Lhasa	313,002	375,979	383,308	62,977	16.4	1.82	7,329	4.1	0.69
Changdu	444,584	500,173	530,616	55,589	13.1	1.46	30,443	6.5	1.08
Shannan	245,450	280,811	302,766	35,361	13.9	1.55	21,955	7.5	1.26
Shigatse	465,810	549,157	589,194	83,347	18.6	2.07	40,037	12.3	2.06
Nagu	245,594	293,842	330,286	48,248	19.3	2.15	36,444	12.4	2.07
Ali	494,48	616,39	686,23	12,191	24.8	2.76	6,984	10.6	1.78
Linzhi	125,424	134,422	140,387	8,998	10.1	1.13	5,965	6.1	1.03
Crop dominated	672,079	793,361	839,304	121,282	15.6	1.74	45,943	6.8	1.15
Agro-pastoral	662,055	758,930	806,773	96,875	15.6	1.73	47,843	7.6	1.27
Pastoral	327,094	396,448	442,383	69,354	22.7	2.53	45,935	11.3	1.89
Agro-pastoral-forestry	228,084	247,284	256,720	19,200	10.3	1.15	9,436	3.5	0.59
Tibet Total	1,891,294	2,198,013	234,7175	306,711	16.6	1.85	149,157	8.5	1.42

Zonal variations in per capita gross production value of agriculture

Since it is difficult to get data for per capita income for different prefectures and farming systems, the per capita agricultural production value was taken as a reflection of the per capita income, as agricultural production (include cropping, livestock, forestry production) is the predominant economic sector in Tibet.

Zonal variations in food demand

The total food demands for each zone and prefecture in Tibet were estimated on the basis of the minimum requirement of per capita calories (2,500 Kcal day^{-1}). The data suggested that the minimum annual food demand (in food grain equivalent) in Tibet had increased 8,000 tonnes from 1982-1990 and 6,000 tonnes from 1991-1995. The total food demand on the basis of growth of

Table 7.7: **Variability and growth of per capita total agricultural production value**

	Per capita gross agricultural production value (yuan)			Per capita gross crop production value (yuan)			Per capita gross livestock crop production value (yuan)		
	1995	**1985**	**Increase**	**1995**	**1985**	**Increase**	**1995**	**1985**	**Increase**
Lhasa	773.3	267	189.5	482.8	109.9	339.5	284.8	105.3	170.6
Changdu	1616.3	343.6	370.4	724.2	79.6	810.1	767.3	201.7	280.4
Shannan	1305.7	473	176	726	155	368.3	550.6	183.9	199.3
Shigatse	1894.2	362.8	422	1249.6	191.3	553.2	626.1	141.1	343.7
Nagu	1004.5	470	113.7	23.2	9.4	146.7	981.1	429.2	128.6
Ali	1871.9	5883	218.3	92.3	37.9	143.3	1779.1	517.5	243.8
Linzhi	1395.7	512.3	172.5	539	201.9	167	413.9	194.9	112.3
Crop dominated	1289.2	321.5	300.9	940.8	172.3	445.9	334.9	96.4	247.5
Agro-pastoral	1601	373.7	328.4	775.2	107.1	623.9	766.5	203.6	276.4
Pastoral	1192.7	502.9	137.2	49.7	9.8	406.3	1142.8	447.7	155.2
Agro-pastoral-forestry	1636.9	429.6	281	693.4	148.7	366.3	588.6	182.4	222.7

population has been decreasing, but, as discussed earlier, per capita food consumption is increasing steadily.

In order to better understand the demand for food grain, meat, and milk in each prefecture and zone in Tibet, the minimum level of per capita consumption of food grain (210 kg), meat (23 kg) and milk (70 kg), which together provide 2,288 Kcal day^{-1} per capita, were used for calculating the minimum demand for these foods. Then, based on the population increase during 1982-1990 and 1991-1995, the minimum amount of increased food demand over the past years was estimated (Table 7.8).

The minimum total food demand in Tibet in 1995 was estimated as 569,900 tonnes, and the actual food grain demand in 1995 was about 492,500 tonnes. The demand for meat and milk were 54,000 tonnes and 168,890 tonnes, respectively, in 1995 (Table 7.9).

Table 7.8: **Food demand increases in Tibet, 1982-1995**

	Food consumption increase 1982-1990 (t)				Food consumption increase 1991-1995 (t)			
	In Grain equivalent	Grain	Meat	Milk	In grain equivalent	Grain	Meat	Milk
Lhasa	15,303	13,225	1,448	4,534	1,781	1,539	169	528
Changdu	13,508	11,674	1,279	4,002	7,398	6,393	700	2,192
Shannan	8,593	7,426	813	2,546	5,335	4,611	505	1,581
Shigatse	20,253	17,503	1,917	6,001	9,729	8,408	921	2,883
Nagu	11,724	10,132	1,110	3,474	8,856	7,653	838	2,624
Ali	2,962	2,560	280	878	1,697	1,467	161	503
Linzhi	2,187	1,890	207	648	1,449	1,253	137	429
Crop dominated	29,472	25,469	2,789	8,732	11,164	9,648	1,057	3,308
Agro-pastoral	23,541	20,344	2,228	6,975	11,626	10,047	1,100	3,445
Pastoral	16,853	14,564	1,595	4,993	11,162	9,646	1,056	3,307
Agro-pastoral-forestry	4,666	4,032	442	1,382	2,293	1,982	217	679
Tibet Total	74,531	64,409	7,054	22,083	36,245	31,323	3,431	10,739

Table 7.9: **Food demand in Tibet (1995)**

	Population	In grain equivalent (tonnes)	Food grain (tonnes)	Meat (tonnes)	Milk (tonnes)
Lhasa	383,308	93,144	80,495	8,816	27,598
Changdu	530,616	128,940	111,429	12,204	38,204
Shannan	302,766	73,572	63,581	6,964	21,799
Shigatse	599,194	143,174	123,731	13,551	42,422
Nagu	330,286	80,259	69,360	7,597	23,781
Ali	68,623	16,675	14,411	1,578	4,941
Linzhi	140,387	34,114	29,481	3,229	10,108
Crop dominated	839,304	203,951	176,254	19,304	60,430
Agro-pastoral	806,773	196,046	169,422	18,556	58,088
Pastoral	442,383	107,499	92,900	10,175	31,852
Agro-pastoral-forestry	256,720	62,383	53,911	5,905	18,484
Tibet in total	2,347,175	569,879	492,488	53,939	168,853

Highway to Central China - Nyima Tashi

Eight

food demand-supply variations

Background:	Post harvesting of crops near Lhasa - *Nyima Tashi*
Top Inset:	Nomad settlements - *Nyima Tashi*
Bottom inset:	Fast-growing nomad town (Dangxiong town) - *Nyima Tashi*

Nomad girls - Nyima Tashi

Chapter 8

Food Demand-Supply Variations

This chapter focuses on food demand-supply gaps and their variations, the structure of food consumption, and the inter-regional balance between food production and food demand.

Total Food Production and Food Demand

The total demand for cereals over the last 40 years was calculated based on the minimum requirement of per capita annual food grain consumption, 210 kg/person, and total population. It was assumed that, for the last 40 years, the majority of the population has been self-sufficient in food grain and consuming cereals at a minimum level. Comparing the food grain demand derived from this calculation with total production, there was a shortage of cereals during the 1950s and 1960s, a reasonable balance during the late 1970s, and a drastic shortfall in the early 1980s, followed by a rapid increase in production, which led to the present considerable surplus (Figure 8.1).

Figure 8.1 also illustrates that, although there was a deficit of cereals before 1965, that deficit was constantly being reduced. The 50% increase in production was attributed to expansion of cultivated land at a growth rate of 3.3% during that period. By 1966, the balance between total demand and production had been basically attained. However, during the early Cultural Revolution (1967-72), food grain production stagnated and the balance between production and demand was unstable. It was a time of severe food grain shortage, particularly during 1970-71

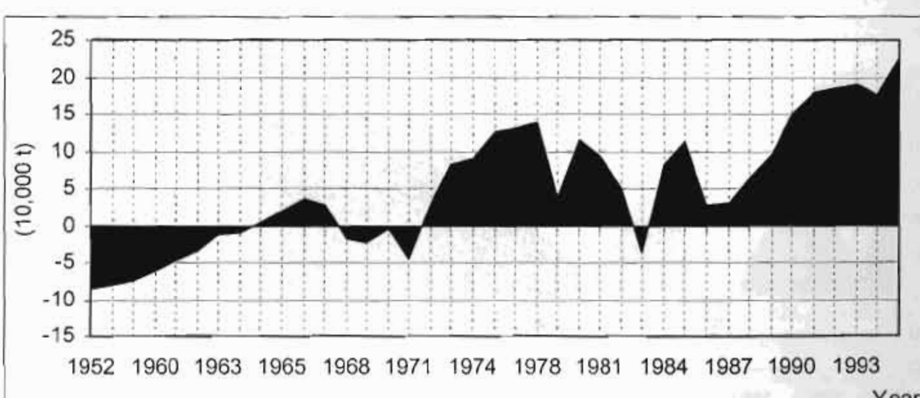


Figure 8.1: **Gaps between food grain production and demand on the basis of minimum requirement for food grain**

food shortage, which was one of the worst during the last 40 years. During 1972-80, the balance improved. Production of cereals increased quickly and reached its highest level in 1978. There was tremendous effort to improve the irrigation system, introduce new crops and new technology, change cropping systems, expand cultivated land, and introduce new cultivation techniques. During the 1980s, the overall policy of food grain production was favourable and there were incentives for farmers to produce more cereals. However, the drought of the early 1980s upset the balance and there was a shortage in 1981-83. If we use 210 kg of per capita food grain requirement per year as our definition of need, then Tibet should have had food grain surpluses since 1984.

The balance of total food demand and production was analysed for the last 20 years. Figure 8.2 shows that there have been occasional years of severe food shortages — such as during the drought of the early 1980s.

The balance between total food production and demand, based on actual consumption, was estimated by converting all the main food items into calorie equivalents. The surplus and deficit were estimated using two separate assumptions. One was that all food produced in Tibet was consumed by its people (surplus/deficit-1). The other was that a minimum of 30% of food produced was either used as seed or feed, or wasted during redistribution, processing, and consumption (deficit/surplus-2). The food balance sheet deriving from these two assumptions is illustrated in Table 8.1. Both food production and consumption have increased significantly since 1988. There has been a slight decrease in per capita calorie intake by the urban population while calorie intake by the rural population has increased. If all food produced in Tibet were eaten (surplus/deficit-1), there would be more than 1,000 kcal day^{-1} surplus per capita calories. If 30% of food were either used as seed and feed or wasted (surplus/deficit-2), there would be a surplus of less than 400 kcal day^{-1}. At present, in Tibet as a whole, the total per capita calorie production is just about self-sufficient. Further increases in food production are needed if living standards are to improve; also, population growth must be controlled. In pastoral zones, where cereals are not produced and there is rapid population increase, effective redistribution and control of population growth should be considered as strategic approaches to achieving food security and improving the well-being of people.

Production and Demand Balance of Main Food Items

Cereals, oilseed, meat, milk, eggs, and vegetables are the main food items. Estimates of the growth in demand for each food item were based on population growth rates, income, and food consumption. The growth rate of food production was based on previous food production growth trends. The food consumption structure is changing and demand is increasing rapidly, at a rate of 3% a year in Tibet as a whole.

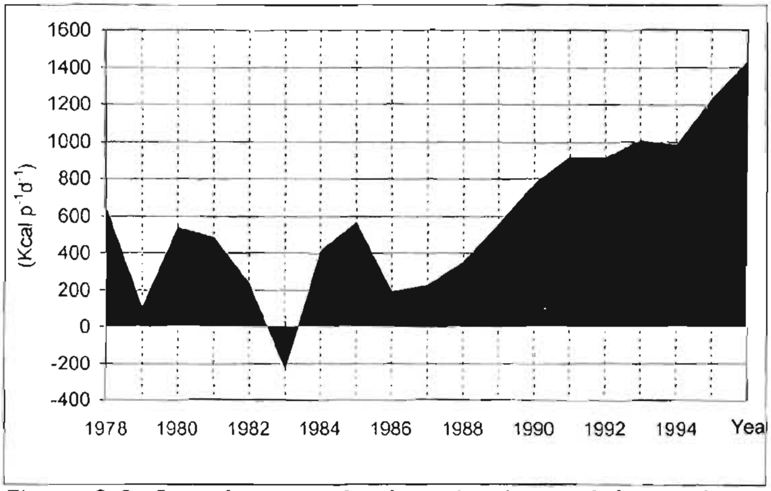


Figure 8.2: **Gaps between food production and demand**

Demand for meat, milk, vegetables, and eggs has been increasing rapidly, and the demand for milk, meat, and eggs now exceeds production (Table 8.2).

A dynamic food balance sheet was created by using the growth rates in Table 8.2. By 2000, total production of cereals will reach 877,200t. By 2005, total food grain, oilseed, meat, milk, and vegetable production will be 1.02 million tonnes; 81,200t; 184,200t; 265,000t; and 412,500t, respectively. The demand for cereals, oilseed, meat, milk, and vegetables will have reached 581,900t; 9,000t; 110,040t; 642,100t; and 370,800t, respectively. The balance sheet of vegetable production and demand indicates improvement by 2005. Gaps between production and demand for milk and eggs will increase under present growth rates. There will be considerable surplus of cereals, oilseed, and meat at current levels of consumption and production (Table 8.3).

Table 8.1: **Gaps between total per capita calorie supply and demand**

Year	Total demand			Total calorie supply	Surplus/ deficit (1)	Surplus/ deficit (2)
	Urban	Rural	Average			
1988	2,039.7	2,314.6	2,177	2,851.7	674.6	(-180.9)
1989	2,005.7	2,289.8	2,147.8	3,057.2	909.4	(-7.7)
1990	1,889.1	2,189.8	2,039.5	3,274.3	1,234.9	252.6
1991	2,173.4	2,475.8	2,324.6	3,419.9	1,095.3	69.4
1992	1,904	2,477.5	2,190.8	3,414.9	1,224.2	199.7
1993	2,096.5	2,812.7	2,454.6	3,507.6	1,052.9	0.7
1994	1,748	2,986.7	2,367.4	3,482.4	1,115	70.3
1995	1,858.4	2,947.1	2,402.7	3,728.6	1,325.9	207.3
1996	1,928.4	2,938	2,433.2	3,932.1	1,498.9	319.3

Table 8.2: **Growth rate in per capita food production and demand (%)**

	Food grain	Rape seed	Vegetables	Meat	Milk	Eggs	Sugar	Alcohol
Per capita consumption (1990–96)	3.01	9.58	10.53	6.94	14.86	18.34	18.66	1.47
Per capita production (1990–96)	3.07	9.77	14.36	5.33	5.32	7.24	/	/

However, 20% of cereals produced are either used as seed or animal feed or lost during storage and distribution. About 10% of meat, milk, vegetables, and other food items is lost during redistribution, storage, and processing. If these amounts are deducted, then Tibet is currently in food deficit. Although there has been tremendous increase in food production over the past decades, demand is still ahead of production growth, and the balance between food production and demand is not secure. Many kinds of food items are currently imported. For example, although there was no food grain deficit in Tibet during 1990-95, about 382,000t of cereals were imported from other parts of China. At present, there is more than a 200,000t surplus of cereals produced each year. However, due to its low quality, the urban population does not use locally produced winter wheat to make bread and noodles, preferring to consume imported rice and wheat. There is currently a 6,800t deficit of butter. Meat (mainly pork and poultry), vegetables, and fruit are also imported.

With the further opening up of the food market, market-oriented demand will play a greater role in food availability. The conventional way of improving availability, by subsidising food for consumption while neglecting the quality of the food produced, will put increased financial pressure on both government and individuals. It will also restrict the increase in calorie intake by the local population because of the high price of imported food. For remote and poor populations, it will make it more difficult to access food not only physically but also

Table 8.3: **Dynamics of food balance**

	Year	1996	1997	1998	1999	2000	2005	2010	2015	2020
Total supply ('000 t)	Food grain	77.72	80.11	82.57	85.11	87.72	102.04	118.69	138.07	160.61
	Rape seed	3.51	3.85	4.23	4.64	5.10	8.12	12.94	20.62	32.85
	Vegetables	12.33	14.10	16.13	18.44	21.09	41.25	80.69	157.83	308.72
	Meat	11.54	12.16	12.80	13.49	14.20	18.42	23.88	30.95	40.13
	Milk	16.62	17.50	18.43	19.42	20.45	26.50	34.33	44.49	57.64
	Eggs	0.15	0.17	0.18	0.19	0.20	0.29	0.41	0.58	0.83
Total demand ('000 t)	Food grain	44.57	45.91	47.29	48.71	50.18	58.19	67.49	78.27	90.78
	Rape seed	1.71	1.87	2.05	2.25	2.47	3.90	6.16	9.73	15.38
	Vegetables	15.05	16.64	18.39	20.33	22.47	37.08	61.17	100.93	166.52
	Meat	6.04	6.45	6.90	7.38	7.89	11.04	15.44	21.59	30.19
	Milk	18.48	21.22	24.37	27.98	32.14	64.21	128.27	256.27	511.98
	Eggs	1.13	1.34	1.58	1.87	2.21	5.14	11.92	27.68	64.24
Surplus/deficit ('000 t)	Food grain	33.16	34.20	35.28	36.40	37.54	43.84	51.20	59.80	69.83
	Rape seed	1.80	1.98	2.17	2.39	2.63	4.22	6.78	10.88	17.47
	Vegetable	(-2.72)	(-2.54)	(-2.27)	(-1.89)	(-1.38)	4.18	19.52	56.90	142.20
	Meat	5.50	5.70	5.90	6.11	6.31	7.38	8.44	9.37	9.94
	Milk	(-1.86)	(-3.71)	(-5.93)	(-8.57)	(-11.69)	(-37.71)	(-93.94)	(-211.78)	(-454.33)
	Eggs	(-0.97)	(-1.17)	(-1.40)	(-1.68)	(-2.01)	(-4.85)	(-11.51)	(-27.09)	(-63.42)

economically. It will be more difficult to maintain a good balance between supply and demand.

Thus, it will be desirable to upgrade the quality of locally produced food, improve per unit yield of cereals and livestock, optimise cropping and the livestock population structure, promote rangeland development, increase the off-take rate of livestock, enhance greenhouse vegetable cultivation, and control population growth. It is necessary to develop a strong, local food-supply system before intervening in the people's economic access to food.

Food Supply and Demand between Farming Systems and Food Production Systems

Zonal/regional variations in food production, demand, and consumption in Tibet are affected by the differences in biophysical conditions, economic development, and social background. Better understanding of the inter-zonal/regional balance of food production and demand in Tibet will be important for ensuring food security in all zones and regions.

Zonal variations in food production

Of the total production of food grain, 57.5% is produced in the crop-dominated zone and only 0.7% in the pastoral zone. More than 70% of oilseed is produced in the crop-dominated zone. The total production of cereals and oilseed in the agro-pastoral zone comprises 28.7 and 22.3%, respectively (Table 8.4). It is obvious that both cereals and oilseed are, by and large, produced by the crop-dominated zone and supplied to other areas of Tibet. This regional variation in food grain and oilseed production is created by differences in biophysical conditions among the four food-production system zones of Tibet.

Table 8.4: **Comparison of food grain and oilseed production among production systems (tonnes)**

Foods	Total Tibet	Crop-dominated zone		Agro-pastoral zone		Pastoral zone		Agro-forestry-pastoral mixed zone	
		1995	% of total	1995	% of total	1995	% of total	1995	% of total
Food grain production (t)	717,583.2	413,284.7	57.59	206,492.4	28.78	5,120.2	0.71	92,685.9	12.92
Grain	667,056.3	386,480.7	57.94	184,550.7	27.67	5,067.5	0.76	90,957.5	13.64
Pulse	45,931.5	22,710.4	49.44	21,446.6	46.69	52.7	0.11	1,721.8	3.75
Rape seed	33,578.3	23,946.9	71.32	7,505.5	22.35	12.8	0.04	2,113.0	6.29
Cultivated land (ha)	221,617.7	102,735.7	46.36	83,434.5	37.65	9,199.0	4.15	26,248.5	11.84
Dry land (ha)	219,607.9	102,736.7	46.78	83,434.5	37.99	9,199.0	4.19	24,237.7	11.04
Irrigated land (ha)	172,850.1	74,158	42.90	78,734.3	45.55	1,728.2	1.00	18,229.6	10.55
Cropping area (ha)	218,371.7	99,520.4	45.57	81,865.3	37.49	7,221.6	3.31	29,764.4	13.63
Food grain crops (ha)	187,616.8	85,389.6	45.51	71,516.0	38.12	4,514.8	2.41	26,196.4	13.96
Grain (ha)	169,883.5	77,604.9	45.68	62,377.1	36.72	4,467.1	2.63	25,434.3	14.97
Pulse (ha)	16,481.2	6,617.8	40.15	9,060.4	54.97	47.7	0.29	755.3	4.58
Rape seed (ha)	18,383.9	11,437.7	62.22	5,309.5	28.88	14.2	0.08	1,622.4	8.83

Note: Food grain includes cereals, pulses, and tuber crops.

As there are differences in biophysical conditions and socioeconomic development among the prefectures, food grain and oilseed production vary from one to another. In 1995, out of 717,600t of cereals and 33,500t of oilseed produced, 39.6% and 49.2%, respectively, were produced in Shigatse Prefecture, followed by Lhasa with 18.8% and 28.5%, respectively. These prefectures currently produce more than half of the total food grain and more than 70% of the oilseed (Table 8.5).

The agro-pastoral zone is the dominant producer of meat and milk. In 1995, the total production of meat and milk was 112,100t and 176,100t, respectively; and the agro-pastoral zone accounted for 37.8 and 40.3%, respectively, of this. In 1997, total production of meat and milk was 121,500t and 180,600t, respectively, of which the agro-pastoral zone accounted for more than 40%.

The pastoral zone produces 36 and 24.4% of meat and milk, respectively. There is also considerable meat and milk production in the crop-dominated zone; 16% of meat and 21.7% of milk. The regional variation in meat and milk is much smaller than for food grain and oilseed production. All four farming/production systems produce a certain

Table 8.5: **Total food grain and oilseed production in each prefecture (1995)**

Items		Food grain (t)	Grain (t)	Pulse (t)	Rape seed (t)
Tibet	1995	717,583	667,056	45,931	33,578
Lhasa	1995	135,165	126,442	4,967	9,581
	%	18.8	19.0	10.8	28.5
Changdu	1995	100,200	96,680	3,512	502
	%	14.0	14.5	7.6	1.5
Shannan	1995	125,318	118,784	6,533	4,873
	%	17.5	17.8	14.2	14.5
Shigatse	1995	284,207	254,411	28,964	16,527
	%	39.6	38.1	63.1	49.2
Naqu	1995	2,747	2,723	24.7	12
	%	0.4	0.4	0.1	0.0
Ali	1995	5,171	4,692	479	16
	%	0.7	0.7	1.0	0.0
Linzhi	1995	64,771	6,3321	1,449	2,063
	%	9.0	9.5	3.2	6.1

Slight differences in total sums can be accounted for by a slight difference in central (see Table 8.4) and prefecture level statistics.

amount of meat and milk (Table 8.6). Comparing prefectures, in 1997, out of 23.1 million head of small and large livestock, Naqu and Shigatse prefectures had more than 50%. Naqu and Changdu prefectures had nearly half of meat production, accounting for 27.8 and 26.7%, respectively. Naqu Prefecture produced more sheep and goat meat, while Changdu Prefecture produced more yak meat. Nearly 50% of all milk was produced by Shigatse and Changdu prefectures, while Naqu Prefecture produced 17%. Ali and Linzhi prefectures are smaller producers of meat and milk compared to the other prefectures (Table 8.7).

Table 8.6: **Livestock production among production systems (1995)**

	Total Tibet	Crop-dominated zone		Agro-pastoral zone		Pastoral zone		Agro-forestry-pastoral mixed zone	
	N	N	%	N	%	N	%	N	%
Livestock population (10,000 head)	2,379.2	379.8	15.96	720.0	30.26	1,131.4	47.55	148.0	6.22
Large animals	712.4	101.4	14.23	336.8	47.28	212.3	29.80	61.9	8.69
Sheep and goats	1,769.9	274.2	15.49	504.0	28.47	919.1	51.93	72.6	4.10
Meat production (t)	111,853.2	17,987.4	16.08	42,311.1	37.83	40,314.9	36.04	11,239.8	10.05
Beef	60,260.9	8,477.3	14.07	27,246.2	45.21	18,551.1	30.78	5,986.4	9.93
Lamb and mutton	46,093.5	7,933.4	17.21	14,460.9	31.37	21,762.3	47.21	1,936.9	4.20
Milk production (t)	176,782.9	38,504.4	21.78	71,385.7	40.38	43,155.8	24.41	23,737.0	13.43
Yak and cattle milk (t)	140,642.6	35,862.2	25.50	57,027.3	40.55	24,617.1	17.50	23,136.0	16.45
Wool production (t)	9,213.4	1,485	16.12	2,295.2	24.91	5,178.3	56.20	255.0	2.77
Sheep wool	8,253.2	1,187.1	14.38	1,974.0	23.92	4,914.0	59.54	178.0	2.16
Sheep & goat leather (10,000 pieces)	371.6	67.3	18.12	141.7	38.14	150.7	40.55	11.9	3.19
Yak & cattle leather (10,000 pieces)	68.9	9.9	14.40	34.2	49.63	19.1	27.73	5.7	8.25

To sum up, there are considerable intrazonal/regional variations in Tibet's food production. It is clearly marked by four farming/food production system zones. Cereals and oilseed are produced in central Tibet, where large amounts of meat and milk are also produced. Northern and northwestern Tibet produce meat and milk, but less food grain and oilseed; south and southeastern Tibet produce many kinds of food, but in smaller quantities than other parts. Most vegetables, fruit, and eggs are produced in central Tibet.

Zonal variation in food consumption and demand

In crop-dominated and agro-pastoral zones, cereals are the dominant source of calorie intake, accounting for more than 80% in rural areas and nearly 70% in urban areas. Most farmers in these zones currently consume little meat, milk, vegetables, or fruits. Richer households consume more rice, wheat, and vegetables. Meat and butter tea are common for them. In some households in Gyantse County, more than 40% of food grain is now rice and wheat instead of barley. However, in the same county, middle-income households depend on barley for more than 95% of their food grain. Once farmers become rich and have the economic capacity to access imported cereals, which are more palatable, locally produced barley and wheat are replaced. The majority of farmers still eat barley as the staple food. There are hardly any vegetables in a farmer's diet. In some rich families, radishes and potatoes are eaten almost all year round. However, in the poor

Table 8.7: Livestock production in Tibet (1995)

Prefectures		Animals (10,000 head)			Meat production (t)			Total dairy production (t)	
		Total	Large animals	Sheep & goats	Total	Beef	Lamb and mutton	Total	Yak and cattle milk
	Tibet	2,379.2	712.4	1,769.9	111,853.2	60,260.9	46,093.5	176,782.9	140,642.6
Lhasa	1995	168.2	66.5	99.0	10,173.4	6,408.5	3,013.9	13,181.3	11,775.7
	%	7.1	9.3	5.6	9.1	10.6	6.5	7.5	8.4
Changdu	1995	354.8	241.6	197.8	29,910.5	22,355.2	6,241.7	39,204.3	35,950.7
	%	14.9	33.9	11.2	26.7	37.1	13.5	22.2	25.6
Shannan	1995	216.2	86.5	161.3	13,209.5	6,573.2	5,396.5	30,881.7	26,616.7
	%	9.1	12.1	9.1	11.8	10.9	11.7	17.5	18.9
Shigatse	1995	563.8	98.4	465.1	17,269.9	5,518.2	11,646.3	39,854.9	27,040.7
	%	23.7	13.8	26.3	15.4	9.2	25.3	22.5	19.2
Naqu	1995	742.7	169.3	573.4	31,048.1	16,305.3	14,741.7	31,003.0	21,669.9
	%	31.2	23.8	32.4	27.8	27.1	32.0	17.5	15.4
Ali	1995	271.1	16.4	254.7	5,547.7	672.9	4,874.8	6,142.3	1,084.8
	%	11.4	2.3	14.4	5.0	1.1	10.6	3.5	0.8
Linzhi	1995	62.3	33.7	18.6	4,694.1	2,427.6	178.5	16,515.5	16,504.0
	%	2.62	4.73	1.05	4.20	4.03	0.39	9.34	11.73

families, there is only tsampa and a few spices. Barley is made into different foods and cooked with meat in different ways. In this area, tsampa is the staple food grain, butter tea and chang are the drinks, dried (or cooked) sheep or yak is the meat, and potatoes and radishes are the vegetables.

The urban population now hardly uses tsampa as a staple. Most people consume rice and wheat as food grains. Many kinds of vegetables are available. The lifestyle and food preferences in urban areas of Tibet are now similar to other provinces of China. Butter tea is now the only distinctly Tibetan food consumed in most households.

In the agro-forestry-pastoral mixed zone of the south-east, many foods are produced. Food grain, mainly wheat, makes up more than 75% of the total food intake. There is little production or consumption of barley as a staple food. A household survey in Linzhi County showed that 80% of the meat consumed is pork and 58% of the food grain is wheat. Milk is consumed in different ways. Butter tea still is the most common item.
In the pastoral zone of the north and north-west, consumption of meat and milk is much higher than in other areas. Nomads consume considerable amounts of cereals. Food grain, particularly barley, is exchanged for livestock products. Tsampa is processed locally. Nomads also receive subsidised cereals from the government, often as wheat or rice. People in the pastoral zone consume more wheat and rice than people in cropping areas. A household survey in Damshung and Naqu counties suggested that nomads worry more about food grain stock, particularly tsampa, than people from other areas of Tibet. On average, more than 77% of per capita calorie intake is food grain, and the richer the nomads, the greater the consumption of barley, wheat, and rice. Areas that are accessible by road or near to markets often have greater stocks of food grain, particularly when the people have settled down. For example, in Damshung County, which is close to Lhasa and on the Qinghai-Tibet highway, many nomad families keep more than 250 kg of barley as a reserve. More than 47% of livestock products are exchanged for cereals. Some poor families had 4-8 yaks or 20-30 sheep, over 60% of livestock products being exchanged for cereals.
It seems that when there are no subsidies of

food grain given to nomads, they must exchange more than 40% of off-taken animals for cereals. However, when there are subsidies, nomads do not need to exchange livestock products, and, to some extent, the number of off-taken animals is reduced. Not realising this, outsiders often complain about the low off-take rate of livestock in nomadic areas. With reducing subsidies, more nomads are going to cropping areas with their animals and exchanging animals or livestock products for cereals. For many nomads in remote areas, exchanging livestock for cereals is imperative; cash and other products come after cereals.

On the basis of total population and minimum per capita requirement of calories, it was estimated that, in 1995, total food demand in food grain equivalent in the crop-dominated and pastoral zones was about 220,000t for each area. In the agro-pastoral and agro-pastoral-forestry mixed zones, total food demand in food grain equivalent was 107,000t and 62,400t, respectively. The total demand for Tibet was 569,900t. On the basis of minimum requirement of per capita food grain (210 kg), per capita meat (23 kg), and per capita milk (72 kg), and the total population in 1995, the total demand for cereals was 176,300t in the crop-dominated zone and 93,000t in the pastoral zone.

Inter-zonal food balancing pattern in Tibet

The surplus and deficit of per capita calories and protein were calculated based on the minimum requirement of per capita calories (2,500 kcal day^{-1}) and protein (70g day^{-1}) and the conversion of all food production in 1995. The gaps between per capita production and the minimum requirement were mapped.

There is a larger deficit of per capita calories in northern and north-western Tibet than in other areas. Almost the entire Naqu Prefecture and the eastern parts of Ali Prefecture are highly deficient in per capita calories. The calories produced in the counties of this region meet only half of the minimum required intake. Along the Yalongzangpo River, particularly in areas of the Nyachu River and Lhasa River in central Tibet, there is a large surplus of per capita calories; 2,000 kcal day^{-1} (Figure 8.3). The distribution and pattern of surplus and deficit of per capita protein is similar. Generally, there is a deficit in northern Tibet and a surplus in the southern and central parts (Figure 8.4).

The shortfall of per capita calories in Naqu and Ali prefectures was1385 kcal day^{-1} on average. Naqu Prefecture produced less than 30% of its minimum requirement. More surprisingly, as in a pastoral zone more meat and milk are generally produced, there was also 15.6% deficit of per capita protein in Naqu Prefecture. Lhasa, Shannan, Shigatse and Linzhi prefectures have high per capita surpluses of about 2,100 kcal day^{-1}. They produce 50% more than their minimum requirements. These prefectures also produced surpluses of per capita protein, exceeding their minimum requirements by over 80% . Changdu Prefecture is a big producer of livestock and there is also considerable food grain production. However, when all food is translated into per capita calorie and protein equivalents and compared with the basic requirement of the population, this prefecture appears to be just about self-sufficient, mainly because of the large population. Comparing food-production systems, there was 75.4% deficit per capita in calories and 5.4% protein deficit in the pastoral zone. In the crop-dominated zone, there was 124.1% surplus in per capita calories and a 95.5% surplus of per capita protein. Overall in Tibet; both per capita calories and protein were in surplus: 41.1% for calories and 58.2% for protein (Table 8.8).

An overall inter-zonal balance of food production and demand in Tibet shows that there is more production than the minimum requirement of food. However, because of the long distances and limitations of transportation, and the large quantities of food that need to be moved across zones, there are

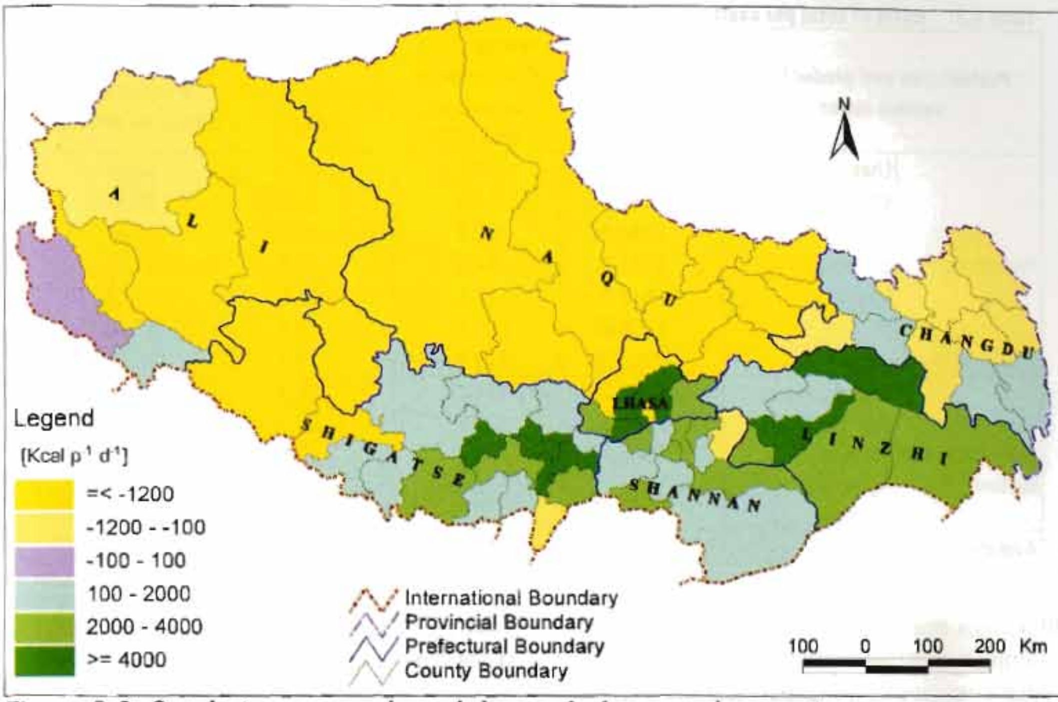


Figure 8.3: **Gap between supply and demand of energy by county**

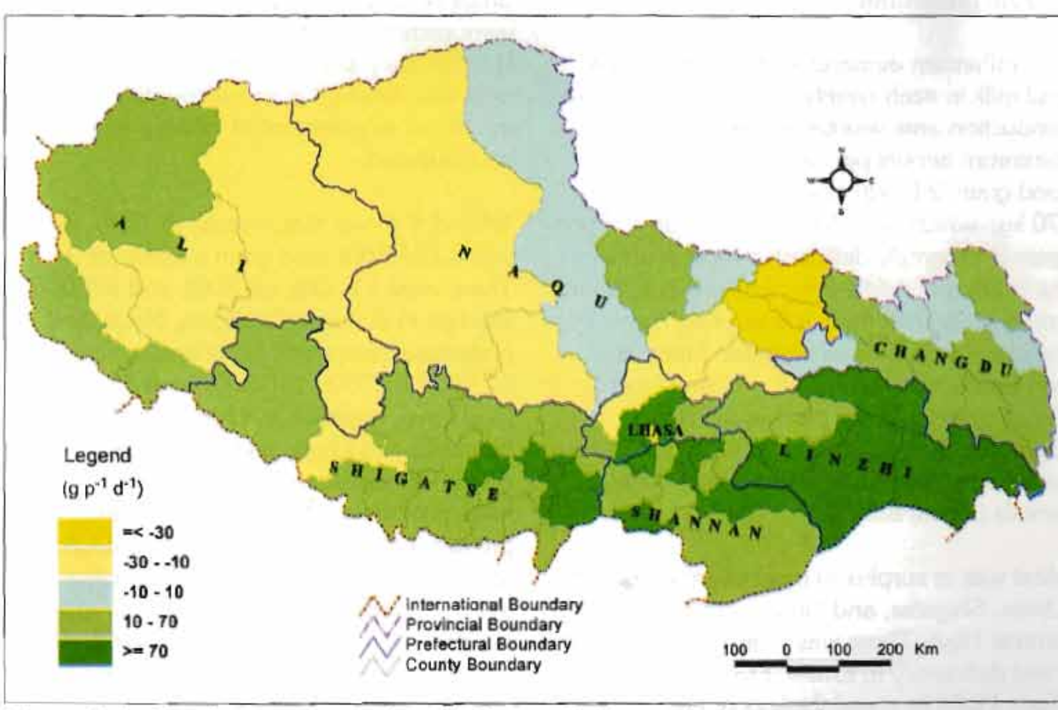


Figure 8.4: **Gap between supply and demand of protein by county**

Table 8.8: **Ratio of total per capita energy and protein supply to basic needs in Tibet**

Prefectures and production system zones		Per capita energy		Per capita protein	
		Surplus /deficit (kcal day^{-1})	Proportion of surplus or deficit (%)	Surplus / deficit (g day^{-1})	Proportion of surplus or deficit (%)
Prefecture	Lhasa	2995.22	119.8	69	98.61
	Changdu	(-185.71)	(-7.4)	14.8	21.11
	Shannan	2244.45	89.8	68.2	97.42
	Shigatse	2114.36	84.6	56.8	81.20
	Naqu	(-1819.99)	(-72.8)	(-10.9)	(-15.68)
	Ali	(-909.97)	(-36.4)	8.8	12.58
	Linzhi	2756.35	110.3	77.4	110.60
Food production system	Crop-dominated	3104.28	124.2	66.9	95.53
	Agro-pastoral	942.88	37.7	39	55.76
	Pastoral	(-1885.78)	(-75.4)	(-3.8)	(-5.43)
	Agro-pastoral-forestry	1949.37	78	60.9	87.00
Average Tibet		1027.69	41.1	40.6	58.21

difficulties and high costs involved. Consequently, it may be most practical for food-deficit counties to try to become self-sufficient. Already a policy promoting food grain self-sufficiency is in place. It promotes expansion of cultivated land and improving irrigation systems in many counties of Naqu and Ali prefectures.

The minimum demand for food grain, meat, and milk in each county, prefecture, and food-production area was calculated using a minimum annual per capita consumption of food grain (210 kg), meat (23 kg) and milk (70 kg), which provides 2,288 kcal day^{-1}. Food grain is extremely deficient in most counties in the north and north-west, whereas in southern and central Tibet there is a surplus. The majority of counties in Shigatse, Shannan, and Lhasa prefectures had sufficient food. Three counties along the Nyachu River (Shigatse, Bailang, and Gyantse counties) had heavy surpluses of more than 20,000t of cereals (Figure 8.5).

Meat was in surplus in most counties except Lhasa, Shigatse, and Gyantse counties of central Tibet. There was more than 1,000t of meat deficiency in Lhasa. Five counties in Naqu Prefecture and three counties in Changdu Prefecture had surplus meat of more than 2,000t each (Figure 8.6).

In general, Tibet is self-sufficient in milk. However, milk surpluses and deficits are distributed haphazardly (Figure 8.7). Densely populated counties such as Lhasa City, Shigatse City, and Gyantse and Dazi counties were extremely deficient by more than 40%. Even in the pastoral zone in Naqu Prefecture, milk was deficient in some counties if the minimum requirement of 72 kg person^{-1} yr^{-1} is considered.

Table 8.9 shows that, overall in 1995, there was a 222,800t food grain surplus, or 34.8%. There were 11,300t; 68,800t; and 9300t of food grain deficit in Changdu, Naqu, and Ali prefectures, respectively, whereas there were 54,700t; 61,700t; 160,500t; and 35,300t of food grain surpluses in Lhasa, Shannan, Shigatse, and Linzhi prefectures, respectively. All prefectures are more or less surplus in meat production; Changdu and Naqu prefectures produced 17,700t and 23,200t, respectively. There was a large deficit of milk in Lhasa and Shigatse; 52.2% more milk was needed in Lhasa to meet minimum demand and 6% more in Shigatse Prefecture. Linzhi Prefecture had the highest surplus of milk

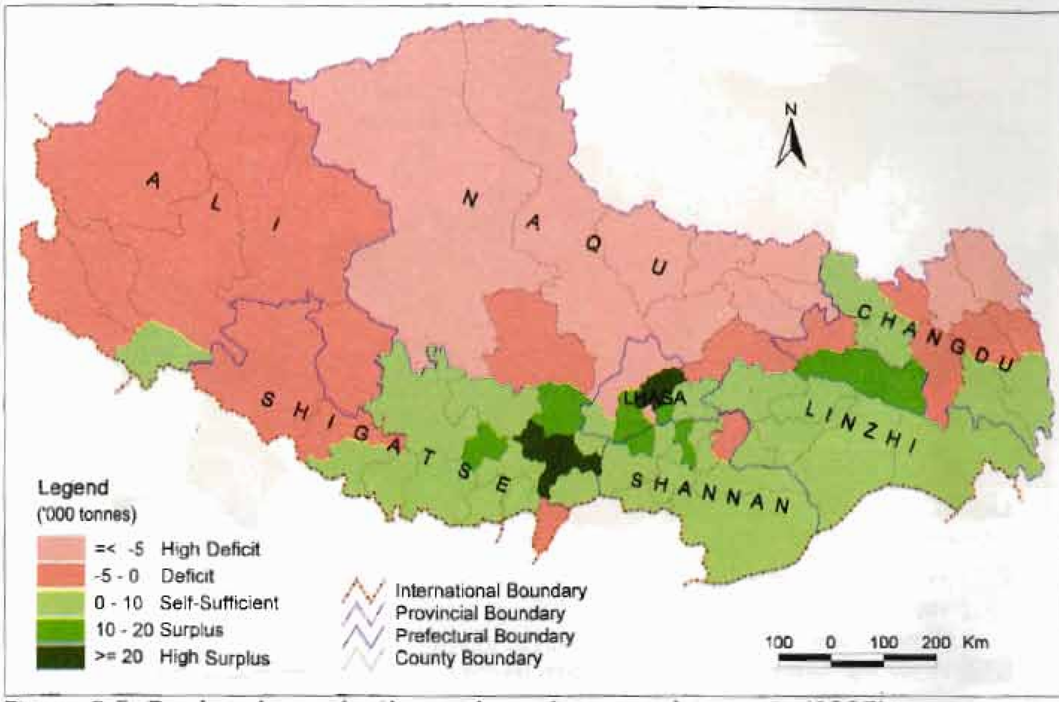


Figure 8.5: **Food grain production and requirements by county (1995)**

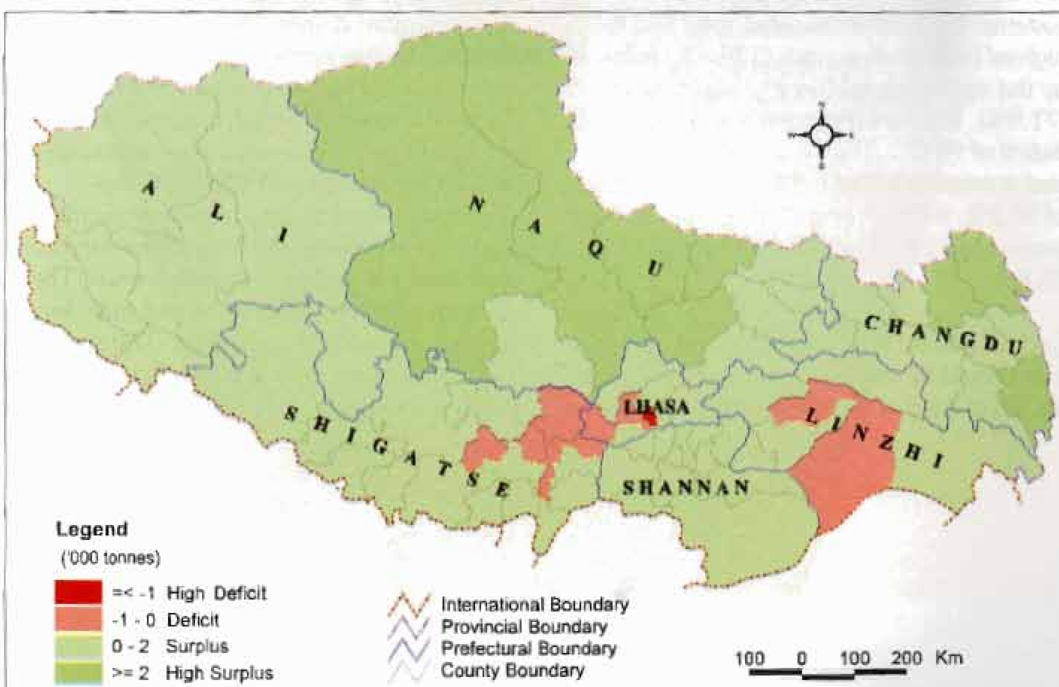


Figure 8.6: **Gap between meat production and requirements by county (1995)**

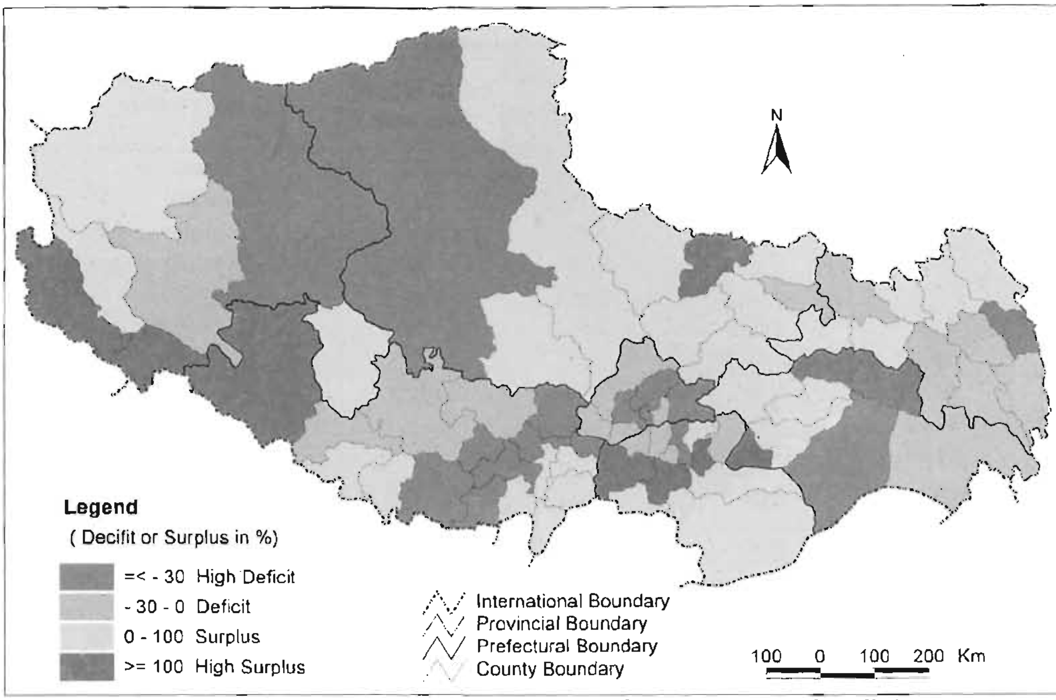


Figure 8.7: **State of milk production in Tibet, 1995, surplus and deficit**

(63.3%) followed by Shannan Prefecture (41.6%). Comparing food-production systems, the crop-dominated zone had the highest food grain surplus (134.4%) followed by the agro-pastoral-forestry mixed zone (71.9%). The pastoral zone had a food grain deficit of 94.6%. The crop-dominated zone had a meat deficit of 6.8% and a milk deficit of 36.2%. In Tibet overall, there was a meat surplus of 124.3% and a milk surplus of 15.8%.

Lack of precise data meant that no adjustment could be made of gross production figures of food grain, meat, and milk for seed, feed, and losses in storage, redistribution, and processing. The gap between production and minimum demand therefore may be higher than this estimate. However, general trends in food balance among regions and within the counties and prefectures are shown. In general, cereals, vegetables, and oilseed are transported from the crop-dominated zone to other zones, while meat and milk are sent to the crop-dominated zone from pastoral and agro-pastoral zones. The pastoral zone produces meat and milk, but imports cereals and vegetables. The agro-pastoral-forestry zone is self-sufficient in these foods at present.

Table 8.9: Major food supply-demand gaps by zone and prefecture

	Food grain		Meat		Milk	
	Surplus (deficit)(t)	Proportion of surplus (deficit) (%)	Surplus (deficit) (t)	Proportion of surplus (deficit) (%)	Surplus (deficit) (t)	Proportion of surplus (deficit) (%)
Lhasa	54,671.1	67.92	1,357.4	15.40	(-14,416.9)	(-52.24)
Changdu	(-11,228.6)	(-10.08)	17,706.3	145.08	999.9	2.62
Shannan	61,737.3	97.10	6,245.7	89.69	9,082.5	41.66
Shigatse	160,476.9	129.70	3,718.4	27.44	(-2,567)	(-6.05)
Naqu	(-68,776.7)	(-96.16	23,202.7	296.19	5,605.8	22.86
Ali	(-9,239)	(-64.11	3,969.3	251.49	1,907.7	38.61
Linzhi	35,290	119.70	1,465.2	45.38	6,407.7	63.39
Crop-dominated zone	237,030.9	134.48	(-1,316.6)	(-6.82)	(-21,925.5)	(-36.28)
Agro-pastoral zone	37,070	21.88	23,755.4	128.02	14,004.3	24.11
Pastoral zone	(-89944.6)	(-94.61)	29891.3	287.09	9687.6	29.72
Agro-pastoral-forestry zone	38774.7	71.92	5335.2	90.36	5253.1	28.42
Total Tibet	222931	34.87	57665.3	124.38	7019.6	15.84

Farmland near a village - Nyima Tashi

potential to enhance food production

Nine

Background:	Sheep grazing on pastoral land, Naqu - *Nyima Tashi*
Top Inset:	Winter wheat field in Dailong County - *Nyima Tashi*
Bottom inset:	Crop production in Central Tibet (Nimu County) - *Nyima Tashi*


Yaks grazing near Namtso - Nyima Tashi

Chapter 9

Potential to Enhance Food Production

The potential to enhance food production is an important aspect of regional food availability and food security. It can be defined as the maximum amount of food produced from cropping and animal husbandry in ideal conditions, or the potential ability of cropland and rangeland to produce food in a particular eco-region or administrative region. Analysis of the potential for enhancing food production is necessary to plan for food production and food security.

Meticulous and thorough studies of the potential of food production have been undertaken from various perspectives—land productivity, crop productivity, climatic productivity, and carrying capacity of land resources—on different scales, in different regions, and by different methodologies. For several decades, great attention has been paid to the capacity of land resources to support a population. Regardless of the approach, it is important to know what production can be achieved to meet the future demands of an increasing population. Keeping this in mind, analysis of maximum food grain production, maximum yields; carrying capacity of rangeland, and productivity of livestock was performed.

Several studies of potential food production in Tibet have been carried out. Liu Yanghua's (1991) study on potential productivity of cropland and rangeland in the middle reaches of the Yalongzangpo River, where the majority of the Tibetan population is concentrated, looked at the maximum potential yields of crops such as barley and wheat, the potential productivity of cropland, the carrying capacity of rangeland, and the interdependence of land resources, food production, and population. This research became the guideline for integrated development of agriculture in this region. As part of a study of the whole of China, Shang Jiali (1989) estimated the carrying capacity of land resources and estimated the maximum yield of crops in Tibet. The productivity of Tibetan agriculture (Du Jun 1995), the potential productivity of climatic resources for food grain (Wang Xianming 1996), and the potential increase in production from agricultural technology (Deng He 1996) have been discussed. Yang Gaihe (1995) focused on the potential productivity of cropland and rangeland, and the supporting capacity of food production based on the existing area of cultivated land and pastureland. Yu Zhijian (1997) studied the potential of greenhouses in food production and the potential distribution of food produced in them. Other studies focused on resource management and assessment of agricultural productivity and the potential productivity of technology innovation and dissemination (Nyima Tashi 1998a; Yang Yichou 1995).

This study will focus on the spatial differentiation of potential productivity of cropland, potential yields, and rangeland carrying capacity. It aims to identify potential areas for food grain and oilseed production, areas with scope for livestock development, gaps between actual and potential yields for various crops, and constraints to increasing food productivity.

Potential Productivity of Cropland

Potential productivity of cropland has been estimated by a number of scientists using different methods (Dang Anrong 1997; Liu Yanghua 1992). Based on these estimates and county administrative-based data, a GIS was used to map and reclassify the potential productivity of cropland (Figure 9.1).

Figure 9.1 shows the spatial distribution of potential productivity of cropland. Four regions can be identified.

- *High-potential productivity*. This includes three counties along the Nyachu River, four counties in the watershed of the Lhasa River, and three counties in the middle reaches of the Yalongzangpo River. Potential productivity of cropland in these counties is more than 15t ha^{-1} on average. It is the grain bowl of Tibet, producing over 40% of the total grain.
- *Mid-potential productivity*. This includes five counties in Shigatse Prefecture and most of Linzhi Prefecture. Potential productivity of cropland ranges from 10-15t ha^{-1}.
- *Low-potential productivity*. This area includes some counties in eastern Tibet, south-western parts of Shigatse Prefecture, and southern parts of Shannan Prefecture: twenty-six counties in total. Potential productivity is about 5-10t ha^{-1}.
- *Non-cropping area or slight potential*. This includes all of northern Tibet where the average altitude exceeds 4400m. Counties in the southern parts of this region may have land suitable for cropping, but the plots are often extremely small. Most parts have either cropland of less than 5t ha^{-1} of potential productivity or no cropland at all.

All the data were analysed according to food-production systems (Table 9.1) and adminis-

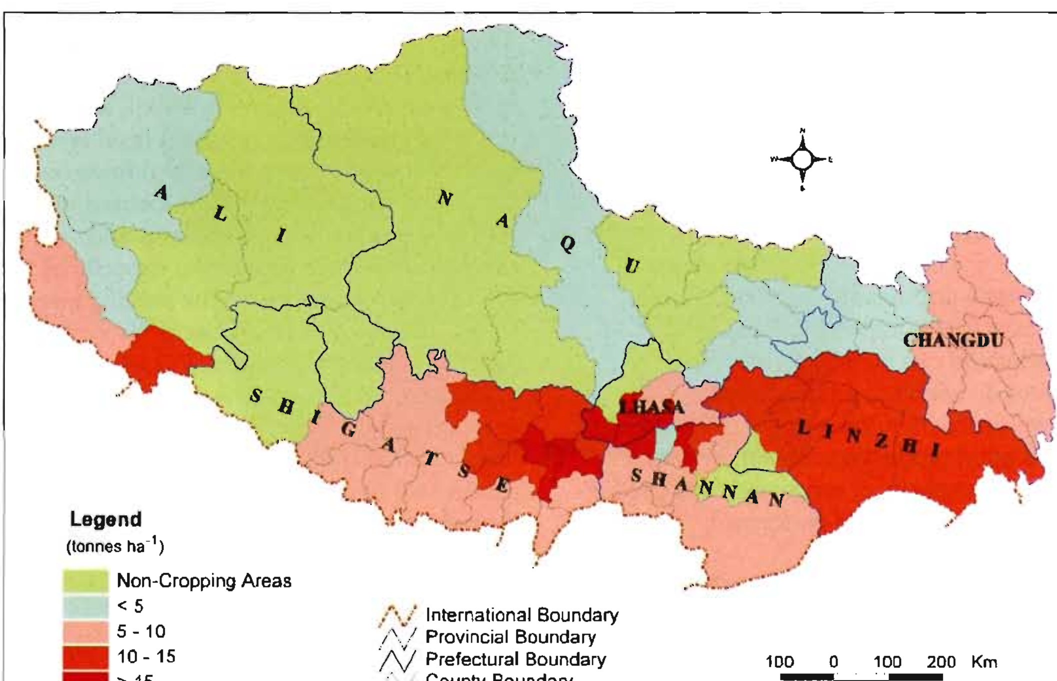


Figure 9.1: **Potential productivity of cropland**

trative prefectures (Table 9.2). The potential productivity of climate (light, temperature, and water) and the potential productivity of cropland (light, temperature, water, and land) were calculated and compared to actual yields.

Table 9.1 suggests that the potential productivity of cropland varies greatly among food-production systems. Crop-dominated zones have greatest potential productivity of both climate and cropland: 24.63t ha^{-1} of potential productivity of climate and 13.35t ha^{-1} of potential productivity of cropland. These figures are 53.2 and 62.6% higher, respectively, than the average. The potential of the pastoral production system zone is 56.5 and 77.9% lower, respectively, than the average.

Actual yields in the crop-dominated production system zone (3.23t ha^{-1}) are 56.7% higher than the average. In the pastoral production system zones, where cropping is practised, yields are only 0.75t ha^{-1}, which is 63.5% lower than the average (Table 9.1 and Figure 9.2).

There is great variation in potential productivity of both climate and cropland among the seven prefectures (Table 9.2). Lhasa Municipality possesses the highest, with potential productivity of both climate and cropland at 24.5t ha^{-1} and 13.4t ha^{-1}, respectively. However, there is hardly any potentially productive cropland in Naqu and Ali prefectures, although some counties, such as Pulan County and Suoxian County, have considerable potential. Shigatse Prefecture could become the future grain bowl of Tibet, with its vast area of cultivated land and reasonably good biophysical conditions for crop production, although water is scarce in

Table 9.1: **Potential productivity (t ha^{-1}) of climate and cropland in food-production systems and comparison with average of Tibet (%)**

	Crop-dominated production system		Agro-pastoral production system		Pastoral production system		Agro-forestry-pastoral mixed production system		Total Tibet
	t ha^{-1}	% from average	t ha^{-1}	% from average	t ha^{-1}	% from average	t ha^{-1}	% from average	t ha^{-1}
Potential productivity of climate	24.63	53.2	12.59	(-21.6)	9.66	(-56.5)	15.79	(-1.7)	16.07
Potential productivity of cropland	13.35	62.6	5.56	(-32.2)	1.81	(-77.9)	9.50	15.7	8.21
Actual yield	3.23	56.7	1.91	(-7.2)	0.75	(-63.5)	2.36	14.5	2.06

Table 9.2: **Potential productivity (t ha^{-1}) of climate and cropland in prefectures and comparison with average of Tibet (%)**

	Lhasa		Changdu		Shannan		Shigatse		Naqu		Ali		Linzhi		Tibet
	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}	% from ave.	t ha^{-1}
Potential productivity of climate	24.54	52.7	13.48	(-16.1)	18.24	13.5	19.01	18.2	5.92	(-63.1)	11.59	(-27.8)	18.35	14.1	16.07
Potential productivity of cropland	13.43	63.5	5.64	(-31.3)	10.35	26.0	9.62	17.1	2.19	(-73.3)	3.99	(-51.4)	12.06	46.8	8.21
Actual yield	2.59	27.5	1.53	(-24.6)	3.09	52.2	2.43	19.7	0.38	(-81.2)	0.93	(-54.1)	2.68	32.0	2.03

Note: The actual yield is calculated based on the standard measurement of area.

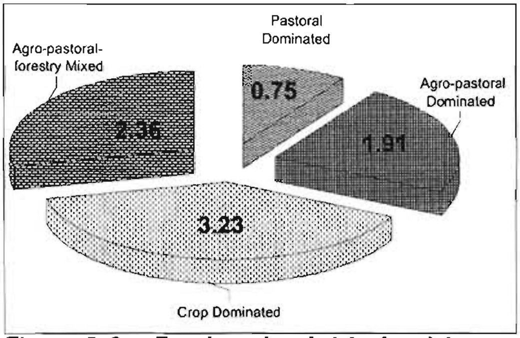


Figure 9.2: **Food grain yield of cultivated land (t ha^{-1})**

some areas. The potential productivity of both climate and cropland are 19t ha^{-1} and 9.6t ha^{-1}, respectively. This is over 17% higher than the average. The so-called grain bowl of Tibet, Shannan Prefecture, produces the highest yield, 52.5% higher than the average. The potential productivity of cropland in this prefecture is 10.35t ha^{-1}, but there is not much room to expand cropland.

Lhasa Municipality possesses the highest potential productivity of cropland, 63.5% higher than the average. Linzhi Prefecture, where there is high potential productivity of the climate, comes second but is confined by a sloping topography that lowers the potential productivity. The rank-order of other prefectures is Shannan, Shigatse, Changdu, Ali, and Naqu. Despite different levels of input on farm land and different crop management, the ranking of actual yield is similar

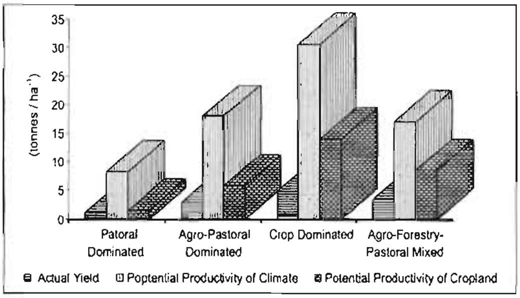


Figure 9.3: **Potential productivity and actual yield of cultivated land in Tibet (t ha^{-1})**

Note: The actual yield is calculated based on the standard measurement of area.

to the ranking of potential productivity, except that Shannan Prefecture is highest and Lhasa Municipality drops to third. This indicates that actual yield is controlled by both potential productivity of cropland and management of the land, including irrigation, inputs, and agronomic practices. There is an obvious need to improve the managerial skills of farmers. If this is accomplished, food grain self-sufficiency could be achieved.

In order to understand the differences between potential productivity of climate and cropland, and actual yield (and the constraints to production), gaps in productivity were calculated for each food-production system. There is a huge gap between potential productivity of climate and cropland, and between potential productivity of cropland and actual yield. It is clear from Figure 9.3 that there are not only big differences among food-production systems but also among parameters.

Table 9.3 elaborates upon this in more detail. It shows that in the crop-dominated production system, the yield gap P1 (the gap between potential productivity of climate and cropland) and the yield gap P2 (the gap between potential productivity of cropland and actual yield) are both high and quite close. This indicates that both land suitability and management constrain food grain production. In the agro-pastoral-forestry mixed production system, yield gap P2 is higher than yield gap P1; this means there is greater potential to increase food grain yield by improving management than by improving land suitability. In the pastoral production system, there is low potential productivity of cropland, and the actual yield is heading towards maximum cropland productivity. In the agro-pastoral production system, yield gap P1 is higher than yield gap P2; this means that land productivity has a greater impact on potential than management. On average, both yield gaps are considerable, signifying that improvement of land suitability, land fertility, and farming management are crucial for increasing food grain production.

Table 9.3: **Productivity and gaps in food-production systems (t ha^{-1})**

Yields and yield gaps	Crop-dominated production system	Agro-pastoral production system	Pastoral production system	Agro-forestry-pastoral mixed production system	Tibet
Potential productivity of climate	24.6	12.6	9.7	15.8	16
Potential productivity of cropland	13.4	5.6	1.8	9.5	8.2
Actual yield	3.2	1.9	0.8	2.4	2.1
Yield gap P1	11.3	7	7.9	6.3	7.9
Yield gap P2	10.1	3.7	1	7.1	6.2

Note: Yield gap P1 = potential productivity of climate minus potential productivity of cropland; yield gap P2 = potential productivity of cropland minus actual yield.

Yield gaps are also estimated for prefectures. Yield gap P2 in Lhasa and Linzhi prefectures is high at 10.8t ha^{-1} and 9.3t ha^{-1}, respectively. In Naqu and Ali prefectures, it is 1.8t ha^{-1} and 3.1t ha^{-1}, respectively. Shannan and Shigatse prefectures are quite similar and yield gap P2 is about 7t ha^{-1} in each case (Table 9.4).

To summarise, Tibet possesses a substantial potential productivity of on average 8.2t ha^{-1}. Estimating from the existing cultivated land, total food grain production could reach 2.67 million tonnes. The total production of food grain in 2,000 was about 1 million tonnes, less than 40% of the estimated potential production of cropland. There is a tremendous gap between the theoretical yield of cropland and the actual production.

Potential Productivity of Crops

The gap between the potential productivity of cropland and the actual average yield is tremendous. Is there any possibility of using more of the potential productivity of climate and cropland? What is the theoretical maximum yield? Which crops can use the potential land productivity most effectively? What are the gaps between managerial levels of cropping? What are the constraints to further increasing food grain production to meet future demands?

Potentially attainable crop yields

In most cropping areas, there is great potential to increase the productivity of land. For the last few decades, agricultural scientists have endeavoured to improve crop yields through innovative technologies, cropping systems, introducing new crop varieties, improvement and application of improved seed and fertiliser, and crop protection. Two important factors have to be considered. One is biological productivity, which is different for different crops and varieties. The other one is the managerial level or economic and technological capability for crop farming, determined by farmers' knowledge, technological innovation, agricultural infrastructure, level of agricultural input, and related policies.

Table 9.4: **Productivity and gaps by prefecture (t ha^{-1})**

	Lhasa	Changdu	Shannan	Shigatse	Naqu	Ali	Linzhi	Total Tibet
Potential productivity of climate	24.5	13.5	18.2	19	5.9	11.6	18.4	16.1
Potential productivity of cropland	13.4	5.6	10.4	9.6	2.2	4	12.1	8.2
Actual yield	2.6	1.5	3.1	2.4	0.4	1.	2.7	2.1
Yield gap P1	11.1	7.8	7.9	9.4	3.7	7.6	6.3	7.9
Yield gap P2	10.8	4.1	7.3	7.2	1.8	3.1	9.4	6.2

Note: Yield gap P1 = potential productivity of climate minus potential productivity of cropland; yield gap P2 = potential productivity of cropland minus actual yield.

In the late 1970s and early 1980s, experiments on high-yielding crop varieties investigated the maximum yield under various management options. Many of the experiments were successful in producing high yields in selected small areas. A few experiments were also carried out on a larger scale or in farmers' fields. For example, Feimai, the high-yielding variety of winter wheat, produced 13t ha^{-1} in a 0.11 ha field in Shigatse at the altitude of 3836m in 1978. Similarly, a variety of spring barley, Ximalaya No 6, yielded 12t ha^{-1} in Shigatse in 1982. Likewise, Oral, a rape seed variety introduced to Tibet from Canada, produced 6t ha^{-1} in Lhasa in 1979 in an experimental plot of 0.08 ha. These experiences suggested that higher yields could be attained through better management and use of high-yielding crop varieties. In the late 1980s and early 1990s, these methods were replicated on a larger scale. High-yielding varieties of spring and winter barley, spring and winter wheat, and rape seed were tested. The main approach was to package the technologies that were already available and demonstrate them to farmers. This work was limited to the middle reaches of the Yalongzangpo River where farm size is relatively large and there are adequate water resources and production conditions.

Regional co-operation for testing newly released varieties of crops such as barley, spring wheat, and rape seed was undertaken in high-altitude regions of the agro-pastoral production system zone and lower altitudes of the agro-pastoral-forestry mixed production system zone. These experiments suggested that crop yields could be increased by using high-yielding varieties and better management.

For the purpose of this study, all data on high-yielding crops in different eco-regions and levels of agronomic management were collected: historical record of highest yield[1], highest yield in experimental plot[2], highest yield in ideal farm land[3], actual yield in 1997[4], and average yield in recent five-year period[5] (Table 9.5).

These data were collected from different sources and may not be truly comparable. However, it is still meaningful to compare them to see in what circumstances a particular crop could produce the highest yield.

In the crop-dominated production system zone, the average historical record of highest yields for grain and rape seed are 12t ha^{-1} and 6.6t ha^{-1}, respectively. The highest yield in experimental plots for grain was 7.7t ha^{-1}, and for rape seed 3.4t ha^{-1}. Actual average yields of grain and rape seed in 1997 were 3.3t ha^{-1} and 1.4t ha^{-1}, respectively. This indicates a yield gap. Similar situations can also be seen in the agro-pastoral production system zone and agro-pastoral-forestry mixed production system zone. In addition, there are big differences between food-production systems influenced by different management and biophysical conditions. All yields in the crop-dominated production system are much

[1] Historical record of highest yield is the yield of a crop variety produced in one plot under best conditions and management in each zone. The minimum experimental area was 30 m^2.

[2] Highest yield in an experimental plot is the average yield of a crop variety produced in a minimum of three plots under best conditions and management in each zone. Different crops were tested in each zone. Each crop was planted in a plot of 30 m^2 in replicates of three. All varieties used were newly released cultivars.

[3] Highest yield in ideal farm land is the yield of a crop variety produced under ideal farm land and management conditions in each zone. The result was obtained by the farmer's own management supervised by a scientist. The minimum area was over 666.66 m^2. The ideal farm land was located on flat river-bank with fertile soil and access to irrigation.

[4] Actual yield was the yield of a crop in 1997 in each zone with the farmer's normal level of management.

[5] Average yield in recent five-year period is the average crop yield in recent five-year period in each zone using the farmer's management.

higher than the average in Tibet, while the agro-pastoral production system has much lower yields than the average (Table 9.5).

To summarise, maximum crop yields have been attained in various circumstances. Compared with actual crop yields, there is great potential to attain much higher yields and to increase grain and rape seed production. To attain potential maximum yields in practice, it is important to see why there is a gap, what the constraints are, and how to close the gap.

Potential for increasing crop yields

Generally, there are three possibilities for increasing production. The first is to expand cropping land or the sown area of crops, the second is to increase cropping intensity, and the third is to improve the per unit crop yield. At present, there is little scope for expanding cropping land because of poor economic capability. Intensification of cropping is also not possible on a large scale at the moment owing to low temperatures, technological limitations, and financial incapability. Increasing the per unit yield is possible and has great potential.

If it is assumed that potentially attainable crop yields can be obtained, then the yield gaps between different levels of management and the maximum potential can be defined as the potential for increasing crop yields, as illustrated by Figure 9.4. The yield gaps derived in Table 9.6 were based on the approach of Figure 9.4.

Yield Gap 2 for both food grain and oilseed production is highest in the crop-dominated production system: 4.3t ha^{-1} and 3.2t ha^{-1}, respectively (Table 9.6). This indicates that

Table 9.5: **Yield changes at different management levels (potentially attainable yields) food-production system ($t\ ha^{-1}$)**

Productivity	Average grain yield							Average rape seed yield						
	Crop-dominated production system		Agro-pastoral production system		Agro-forestry-pastoral mixed production system		Average	Crop-dominated production system		Agro-pastoral production system		Agro-forestry-pastoral mixed production system		Average
	Crop yield ($t\ ha^{-1}$)	Compare with average (%)	Crop yield ($t\ ha^{-1}$)	Compare with average (%)	Crop yield ($t\ ha^{-1}$)	Compare with average (%)		Crop yield ($t\ ha^{-1}$)	Compare with average (%)	Crop yield ($t\ ha^{-1}$)	Compare with average (%)	Crop yield ($t\ ha^{-1}$)	Compare with average (%)	
Potential productivity of cropland	14.1	4.6	5.9	(-3.6)	8.6	(-0.9)	9.5							
Historical record of highest yield	12	3.5	5.8	(-2.7)	7.6	(-0.9)	8.5	6.6	1.4	3.6	(-1.4)	4.8	-0.2	5.0
Highest yield in experimental plot	7.7	1.3	4.9	(-1.5)	6.5	0.1	6.4	3.4	0.5	2.2	(-0.7)	3.2	0.3	2.9
Highest yield in ideal farmland	6.2	0.5	4.7	(-1)	6.2	0.5	5.7	2.4	0.3	1.9	(-0.2)	2.1	0	2.1
Average yield in 1997	3.3	0.1	2.8	(-0.5)	3.3	0.2	3.1	1.4	0.2	1.2	(-0.1)	1.4	0.1	1.3
Average yield in recent five-year period	3.1	0.3	2.1	(-1.0)	3.1	0.3	2.8	1.3	0.1	1.1	(-0.1)	1.2	0.0	1.2

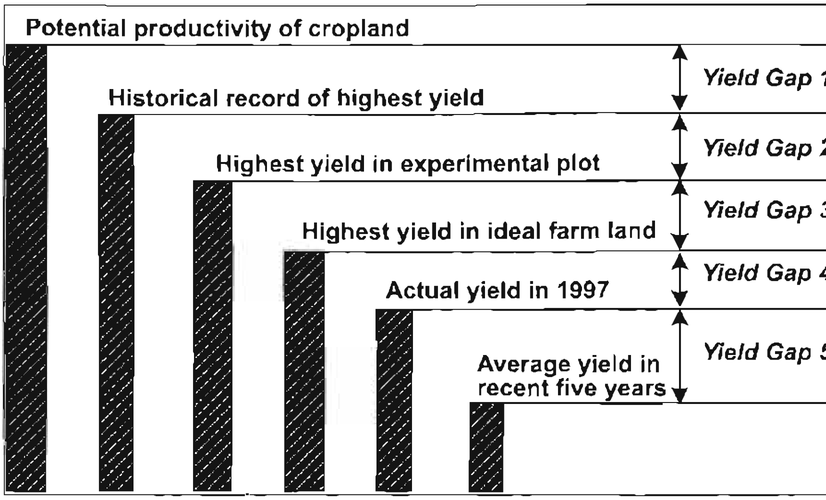


Figure 9.4: **Yield gaps**

breeding for high-yielding varieties or using high-yielding varieties with the best possible crop practices has great potential to boost crop yields in this area. Yield Gap 4 (the yield gap between the highest yield in ideal farm land and the actual yield in 1997) is high in all three food-production areas. This indicates that improvements in farm management and the quality of farm land are keys for increasing per unit yield of crops.

The yield gaps can be analysed as constraints to increasing yield. Yield Gap1 can be seen as the biological constraint, Yield Gap 2 as the technological constraint, Yield Gap 3 as the result of cultivation limitations and varietal selection, and Yield Gap 4 as farm-management constraint and poor quality of farm land. Yield Gap 5 is affected by the agricultural production level over time. In Tibet, poor management and poor quality of cropland are the most crucial factors that constrain increases in food grain and oilseed production.

Attainable crop yields
Attainable yields and yield gaps for crops in each food-production system were analysed. The yield that is attainable differs not only among food-production systems but also among crops.

Table 9.6: **Potentially increasable yields of food grain and oilseed (t ha^{-1})**

	Average food grain yield				Average oilseed yield			
	Crop-dominated production system	Agro-pastoral production system	Agro-pastoral-forestry mixed production system	Average in Tibet	Crop-dominated production system	Agro-pastoral production system	Agro-pastoral-forestry mixed production system	Average in Tibet
Yield gap 1	2.1	0.1	1	1				
Yield gap 2	4.3	0.9	1.1	2.1	3.2	1.4	1.6	2.1
Yield gap 3	1.5	0.2	0.3	0.7	1	0.3	1.1	0.8
Yield gap 4	2.9	1.9	2.9	2.6	1	0.7	0.7	0.8
Yield gap 5	0.2	0.7	0.2	0.3	0.1	0.1	0.2	0.1

In the crop-dominated production system, potential productivity of cropland is about 14.1t ha^{-1}. The historical record of highest yield of food grain crops is about 12t ha^{-1}, of which 9.5t ha^{-1} was for spring barley, 9.8t ha^{-1} for winter barley, 14.1t ha^{-1} for spring wheat, and 14.8t ha^{-1} for winter wheat. The historical record of highest yield for rape seed is 6.6t ha^{-1} from a variety of canola from Canada. Over 7t ha^{-1} is commonly attained in experimental plots of barley and wheat. With promotion of standardised cultivation, more than 6t ha^{-1} of barley and wheat, and 2.4t ha^{-1} of rape seed are produced in many areas. However, the actual average yields of cereals and rape seed in 1997 were only 3.3t ha^{-1} and 1.4t ha^{-1}, respectively (Table 9.7).

Yield Gap 2 is the largest: 4.3t ha^{-1} on average for barley and wheat, and 3.3t ha^{-1} for rape seed. Yield Gap 4 is high in all situations. Therefore, improvements in crop variety selection, level of farm management, and quality of farm land can potentially increase crop yields.

In the agro-pastoral production system zone, there is hardly any winter barley or winter wheat. Spring barley is the predominant crop. In the lower valleys, spring wheat is also cultivated. Rape seed is often grown with peas. The potential attainable yield is much lower than in the crop-dominated production system zone. Historically, spring barley and spring wheat have produced maximum yields of 5.4t ha^{-1} and 6.2t ha^{-1}, respectively. Rape seed has yielded about 3.6t ha^{-1} in some areas in certain conditions. However, the actual average yields in 1997 were low: 2.8t ha^{-1} for food grain and 1.2t ha^{-1} for rape seed (Table 9.8).

The yield gap between the highest yield from ideal farm land and the actual average yield in 1997 (Yield Gap 4) is the largest. Relatively poor management and quality of farm land are the dominating factors that constrain increases in yield in this area. Land levelling, improving soil fertility, technology extension, such as improved varieties, fertiliser, and promotion of irrigation systems, are crucial for improving per unit yields. Biologically, there is considerable potential for both food grain and oilseed production. Using improved varieties and the package approach of technology extension will substantially improve per unit yield.

In the agro-pastoral-forestry mixed production system, it is possible to grow all food grain and oilseed crops. Winter wheat and winter barley are the dominant crops. Spring wheat and spring barley are distributed in either high altitude areas or low altitude areas

Table 9.7: **Crop yields, attainable yields, and yield gaps in the crop-dominated production system (t ha^{-1})**

Yields and yield gaps	Grain crops				Grain crop on average	Rape seed
	Spring barley	Winter barley	Spring wheat	Winter wheat		
Potential crop productivity					14.1	
Historical record	9.5	9.8	14.0	14.8	12.0	6.6
Highest yield from experimental plot	7.2	7.3	7.1	9.0	7.7	3.4
Highest yield from ideal farmland	5.8	5.3	5.4	8.4	6.2	2.4
Average yield in 1997	2.9	3.1	2.9	4.1	3.3	1.4
Average yield in recent five-year period	2.6	2.9	2.9	4.1	3.1	1.3
Yield gap 1					2.1	
Yield gap 2	2.3	2.5	6.9	5.8	4.3	3.2
Yield gap 3	1.4	2.0	1.7	0.6	1.5	1.0
Yield gap 4	2.9	2.2	2.5	4.3	2.9	1.0
Yield gap 5	0.3	0.2	0.0	0.0	0.2	0.1

Table 9.8: **Crop yields, attainable yields, and yield gaps in the agro-pastoral production system (t ha^{-1})**

Yields and yields gaps	Grain crop		Grain crop on average	Rape seed
	Spring barley	Spring wheat		
Potential crop productivity			5.9	
Historical record of highest yield	5.4	6.2	5.8	3.6
Highest yield in experimental plot	4.7	5.1	4.9	2.2
Highest yield in ideal farmland	4.5	4.9	4.7	1.9
Average yield in 1997	2.6	3.0	2.8	1.2
Average yield in recent five-year period	2.0	2.3	2.1	1.1
Yield gap 1			0.1	
Yield gap 2	0.7	1.1	0.9	1.4
Yield gap 3	0.2	0.2	0.2	0.2
Yield gap 4	1.9	1.9	1.9	0.7
Yield gap 5	0.6	0.7	0.7	0.1

where it is possible to harvest two or three crops a year. Rape seed is grown in most of the region, but over limited areas. Maize and rice are also grown in some parts. Out of a total sown area of 1,000 ha of rice and 3,100 ha of maize in Tibet, over 99 and 90%, respectively, are concentrated in this area.

There is promising scope for increasing cropping intensity. Three crops in two years in many regions and two crops in one year in some parts can be achieved with sufficient heat and water resources. However, crop production potential through increasing cropping intensity has not been fully utilised. The magnitude of cropping intensity is relatively low compared with other parts of China with similar biophysical conditions. In recent years, there has been some progress in establishing two-crop systems (winter barley and maize). The fundamental approach to promoting this is to train and mobilise local farmers to adopt multiple cropping systems through demonstration and 'know-how' training activities. However, this is unlikely to become widespread in the near future. Currently, the most effective way of increasing food grain and oilseed production is to focus on improvements of per unit crop yields.

The potential productivity of cropland in this area is on average 8.6t ha^{-1} for cereals. Historically, winter wheat has yielded 9.2t ha^{-1}. On ideal farm land, food grain and oilseed crops have yielded 6.2t ha^{-1} and 2.1t ha^{-1}, respectively. However, the actual average yields of cereals and rape seed in 1997 were only 3.3t ha^{-1} and 1.4t ha^{-1}, respectively.

The difference between the highest theoretical yield from ideal farm land and the actual yield in 1997 is large. Sloping and poor topographic conditions are factors that constrain an increase in yield. Unfortunately, it is not easy to change topographic conditions. Farming on flat areas and land levelling would help to increase crop yields. Poor technology application and management also constrain improvements in crop yield. Breeding and choice of new varieties of food grain and oilseed crops, improvements in cultivation techniques and cropping systems, strengthening of crop protection, and effective and efficient use of fertiliser and manure could boost per unit yields.

To summarise, increasing per unit crop yields is a useful approach to increasing production of cereals and oilseed. Potential cropland productivity has a distinct spatial distribution. The potential productivity of cropland in central Tibet around Lhasa and Shigatse is much higher than other parts. Percentage of potential productivity currently used is low. The total potential production of cereals based on potential productivity of cropland would be 2.6 million tonnes. However, total food grain production in 1997 was only 0.8 million tonnes, 30% of potential. If this could reach 50%, the total production of cereals would be 1.3 million tonnes yr^{-1}, which is sufficient to meet the demands of 2.5 million people.

Potentially attainable crop yields are promising, and there is considerable potential for increasing yield. To increase per unit crop yields, it is desirable to improve cultivation technologies, strengthen land levelling and quality improvement, improve the varieties of crops and application of improved cultivars, and train farmers through packaged technologies.

Prospects and Potential of Various Crops

Over 30 crops are grown in Tibet, including barley (mainly naked barley), wheat, rape seed, broad beans, beans, corn, millet, soy beans, peanuts, beans, hyacinth beans, soldier beans, white beans, red beans, potatoes, sweet potatoes, rice, sesame, flax, hemp, broom, corn, millet, oats, buckwheat, amaranth, and quinoa (Gu Maozhi 1995; Wang Baohai 1997). Barley and wheat are the predominant food grain crops, peas and broad beans the most important pulse crops, potatoes dominate tuber crops, and rape seed dominates oilseed crops. With the development of greenhouse technologies, many vegetable crops are now available.

Naked barley is the staple food grain crop. Traditional varieties usually yield about 1.5t ha^{-1}. With progress in varietal breeding and improvement of cultivation techniques, 3.5t ha^{-1} is now common, and on fertile soil where improved agricultural techniques are used, 6t ha^{-1} is possible with high-yielding varieties. There is potential to increase barley production through further use of high-yielding varieties and appropriate farming techniques. The greatest potential is in semi-arid and high-altitude frigid areas. Improved varieties produce 3t ha^{-1} in these areas, 20% higher than traditional varieties. Assuming that 60% of this area could attain the same rate of increase, total production could be doubled. Barley also possesses high value for processing into products that are increasingly demanded by outside markets, such as qingkelu (a soft drink), zangxiangchun (a kind of whisky), and tsampa. Moreover, barley straw is an important source of animal feed; more than 500,000t of barley straw are produced each year. However, only about 30% is used as feed. Assuming that this percentage could be increased to 50%, that would be equivalent to feed production from 400,000 ha of rangeland. Ammoniating and fermenting barley straw is a recent development. Further development and popularisation of this technique will improve the feed quality and benefit livestock-raising. Barley is one of the crops most tolerant of frigid environmental conditions and poor soil; its

Table 9.9: **Crop yields, attainable yield, and yield gaps in the agro-pastoral-forestry mixed production system (t ha^{-1})**

Yields and yield gaps	Grain crops				Grain crop on average	Rape seed
	Spring barley	Winter barley	Spring wheat	Winter wheat		
Potential productivity of cropland					8.6	
Historical record of highest yield	6.4	7.3	7.7	9.2	7.6	4.8
Highest yield from experimental plot	5.5	5.9	7.0	7.5	6.5	3.2
Highest yield from ideal farmland	5.2	5.6	6.7	7.3	6.2	2.1
Average yield in 1997	3.2	3.4	3.2	3.7	3.3	1.4
Average yield in recent five-year period	2.7	3.3	3.2	3.5	3.1	1.2
Yield gap 1					1.0	
Yield gap 2	0.9	1.4	0.7	1.7	1.1	1.6
Yield gap 3	0.3	0.3	0.3	0.2	0.3	1.1
Yield gap 4	2.0	2.2	3.5	3.6	2.9	0.7
Yield gap 5	0.5	0.1	0.0	0.2	0.2	0.2

further promotion as a forage crop in the high-altitude pastoral production system may propel livestock development (Wang Baohai 1998). Winter barley possesses much potential. In the lower river valleys of the Lhasa River and the Yalongzangpo River, yields are over 10% higher than for spring barley. Since it matures earlier than spring barley, it is also possible to grow one forage crop, usually 2t ha^{-1} of fresh peas, rape seed, or turnip. The area of winter barley cultivation is limited, and if expanded, will increase total barley production substantially.

Wheat is a traditional Tibetan crop. Previously, only spring wheat was grown in areas above 3,000m. Since 1960, winter wheat has been successfully introduced to high-altitude areas. By 1978, the total area of winter wheat cultivation had reached 52,000 ha; currently, it is about 45,000 ha. Regardless of type, in normal conditions wheat produces 4.5t ha^{-1}. However, with improved cultivation techniques and improved varieties, yields of more than 6t ha^{-1} on a large scale are possible, and winter wheat can produce more than 7.5t ha^{-1} (Hu Songjie 1995). Replacement of spring wheat by winter wheat has great potential to increase production. One of the key constraints to expansion of winter wheat is poor grain quality, manifested as low protein and gluten content, which hinders bread- and noodle-making. Nearly 100,000t of wheat flour is imported from central China every year to meet this demand. Furthermore, development of early-maturing winter wheat will provide an opportunity to grow forage after harvesting the wheat in early autumn. Improvement of wheat straw for animal feed will also make a positive impact on livestock development in the crop-dominated production system areas.

Pulse crops are dominated by peas and broad beans. Soybeans and lentils are grown in southern Tibet but only in small areas. Peas are predominantly cultivated in the agro-pastoral production system, and are mostly grown along with barley and rape seed. The yield is 2-4t ha^{-1}. On some high-productivity land, yields can reach 4.5t ha^{-1} (Hu Songjie 1995). Pea greenery is often used for forage, and the grain is also used as a concentrate for animal feed. Only about 0.1% of human food derives from peas. The protein content is 20-24.6%. Peas are usually mixed with barley and made into tsampa to improve nutritional value. Tsampa made from pure pea grain is often taken as breakfast and it is more common in western Tibet. Peas are an important crop for nitrogen fixation and help to maintain soil fertility. However, the area of pea crop is shrinking owing to the increasing area given to wheat and barley. Improving the varieties of peas sown is increasingly important for recovery of the area of the pea crop. Broad beans are commonly cultivated in river valleys. However, the area of broad bean cultivation is less than 1% of the total cropping area. About 2.5t ha^{-1} is the common yield for broad beans, but some experiments show that yield can reach 4.2t ha^{-1}. Total crude protein content is 28% (Hu Songjie 1995). With improvement in the varieties used, broad bean yields can reach 7.5t ha^{-1}. Broad beans are also a good source of forage and concentrated feed for livestock. Processing broad beans for snacks has started recently, and demand is increasing.

Potatoes are mainly used as vegetables, and are widely cultivated. The total sown area of potatoes is about 8,700 ha, comprising about 0.4% of the total sown area. On average, yield is about 30t ha^{-1}. With improved varieties, yield can be over 35t ha^{-1} and up to 45t ha^{-1} on highly productive farm land using technologies such as better seed, protection from disease, application of manure, and better management during the growing period. Extension of improved varieties, enhancement of cultivation and cropping management, better seed choice, promotion of intercropping with maize, application of plastic-film technology, introduction and development of processing technologies, and improvement of storage technology for the winter are keys for promoting and increasing production.

Rape seed is the primary oilseed crop. All three types of *Brassica* (rape seed) are grown. The total area of rape seed cultivation is around 34,000 ha, which accounts for 10% of the total sown area. Traditionally, rape seed was grown with barley and peas. In the early 1980s, the yield was about 1.2t ha^{-1}; now it is about 2t ha^{-1}. In many demonstration fields, high-yielding varieties of *Brassica napus* and *Brassica junipus* can yield 5.1t ha^{-1} and 6.1t ha^{-1}, respectively. Low erucic acid and low glucosinolate varieties, mainly introduced from Canada and known as canola, are well adapted to the Tibetan environment. Some improved rape seed varieties have now become dominant in central Tibet, where the residue after oil extraction is used for animal-feed concentrate. Extension of canola varieties, changes in cultivation techniques, and promotion of oil-processing could boost oilseed production.

Rice, peanuts, gingeli lentils, and soybeans are also well adapted to southern Tibet. Maize is a new crop in central Tibet following the introduction and development of plastic-film technology and introduction of new varieties. It is a potential crop for developing silage feed for livestock.

Vegetable and Fruit Production Potential

The total area of vegetable cultivation is 9570 ha, and average yield is about 13t ha^{-1}. The traditional vegetables are dominated by earthnut and tuber types such as potatoes, turnips, radishes, garlic, and green Chinese onions. There are few fruits or leaf-vegetables (Hu Songjie 1995). All these vegetables have the common characteristics of tolerance to cold, long storage life, high yields, and multiple uses. They have played an important role in ensuring food security. However, with changes in vegetable consumption, other varieties are demanded. With the introduction of greenhouses, it is possible to diversify the varieties of vegetables grown to include tomatoes, eggplant, capsicum, and cucumbers, which are now grown in greenhouses even at 4,200m. With further enhancement of economic capability, larger areas and more productive greenhouse-vegetable production can be developed. At present, there are 200 ha of greenhouse vegetables sown, only 2.1% of the total area of vegetable cultivation. In most cases, greenhouses can increase yields by one to two times of those achieved outside. The average yield of eggplant, cucumbers, capsicum, and tuber crops is usually about 45t ha^{-1}, 125-200% more than outside. Assuming that the percentage of greenhouse-vegetable cultivation reaches 5% of the total area of vegetable cultivation, total production of vegetables could be around 140,000t.

The total area of fruit trees cultivated is about 1860 ha, the average yield is around 3.2t ha^{-1}, and the total production is about 6,000t. There are small areas of tea (about 200 ha) with yields of about 0.4t ha^{-1}. Apples and plums were hardly available above 3,600m before 1960. Introduction of fruit trees and development of orchards took place during the 1960s and 1970s. New varieties and species of fruit such as apple, peach, Chinese plum, and watermelon (in greenhouses) were introduced to areas of 3,600-4,000m. Many state-owned farms established orchards and produced considerable amounts. In the early 1980s, the responsibility system was introduced. Most state-owned farms were dismantled and many orchards were contracted to individuals. The fast development of horticulture in central China has meant more, better, and cheaper fruit exports to the Tibetan market. Owing to the low quality and poor taste of apples and plums produced in Tibet, and poor facilities for storing fruit off-season, local fruit cannot compete with imported fruit. Without a market, orchards are no longer sustainable. Almost all orchards around Lhasa and Shigatse have now been abandoned or are seriously degraded in terms of production and fruit quality. Other factors that restrict development of horticulture above 3,600m are frost-damage to flowering in fruit trees and early frost-damage to fruit. It is highly risky to grow fruit in this area. In some seasons, there used to be great loss from late frost damage. However, new varieties of fruit trees now effectively avoid frost damage. Another problem is fruit quality. Introduction of high-quality, early-maturing species and varieties should be given high priority. If high-quality fruit trees are grown, better quality and more marketable fruit can be produced. It has been the same with tea production. Tibet could produce high quality tea, but it is limited by variety.

Potential Food Production from Wild Plants

Tibet is rich in edible wild plants — including many kinds of mushrooms, toadstools, pine mushrooms, troma (an earthnut), Tibet rhodiola, and aweto (a fungus).

Yellow mushrooms commonly grow in high-altitude alpine-meadow rangeland. With a total production of over 1 million kg, this is the favourite mushroom of herders and farmers. It can be eaten raw or cooked, and it grows naturally. Toadstools are popular in China. They are nutritious, with total crude protein content of about 24.5%, and contain 18 amino acids and vitamins. They are important for local people as a source of protein.

In the forest area of south-eastern Tibet, pine mushrooms are widely distributed. In recent years, they have been collected by local people and exported to Japan. In the county of Gongbujianda of Linzhi Prefecture, collecting pine mushrooms has become an important activity for additional income. Locally, pine mushrooms are dried and packed, and then sold in the market.

Troma, an earthnut, is widely distributed in most pastoral and river valleys. Tromadesi (mixed boiled troma with boiled rice and sugar) is prepared during festivals and for special occasions. The crude protein content in troma is more than 19.2%, and it contains many kinds of amino acids, micro-elements, and vitamins. There is potential to make infant food from troma, and the guess is that that it will have good market prospects.

Tibetan rhodiola is made into soft drinks and other products that have a market in other parts of China and abroad. Its main medicinal property is to enhance the body's capability to absorb oxygen, and it is good for reducing altitude sickness. It is widely distributed in the rangeland.

Aweto, *Cordyceps sinensis* or Chinese caterpillar fungus, is highly valued, selling for about US$2,000 per kg in both domestic and international markets. It is a food supplement with a total protein content of about 25% and a fat content of 8.4%.

Wild peach and walnut are also widely distributed. Wild peach is processed into canned fruit for the Chinese market.

Realising Production Potentials through Technological Inputs

Using improved crop varieties

The productivity of a crop variety can be improved by breeding and selection, and during the last 40 years over 100 improved varieties have been released. With direct improvement of biological productivity and modified cultivation techniques, per unit yield had doubled by 1998. It has been estimated that 14% of the increase in production of cereals and oilseed has been contributed by improved crop varieties (Hu Songjie 1995). In some areas, replacement of varieties has taken place three or four times, and on average there has been a 14% yield increase after each replacement. Spring barley yield has increased by 20% and spring wheat by 8.5%. The introduction of winter wheat and its improved varieties has increased food grain production by 82.6%. Extension of new varieties or replacement of old varieties often requires improvements or changes in cultivation techniques. With improved cultivation techniques, the whole production system is more productive. Over the last 30 years, extension of new varieties with modified cultivation techniques has resulted in a 60-70% increase in food grain and oilseed production, With the new varieties responsible for 36.6 and 8.5% of the increases, respectively (Hu Songjie 1995). The cost-benefit ratio of replacing of crop varieties and modifying cultivation techniques was estimated as 1:5. In general, extension of improved varieties and modification of cultivation techniques possess great potential for increasing production and contribute to increasing food grain and oilseed production substantially.

However, in most of the agro-pastoral and crop-dominated production systems, improved varieties have not replaced local races. Also, changes in cultivation techniques have not taken place. Breeding for a new variety needs over eight years. Breeding programmes for high-altitude and non-irrigated areas have not been undertaken. Production of cereals and oilseed will increase rapidly if improved varieties are developed.

Using improved cropping system and cultivation techniques

Over the last 40 years, five agricultural technologies were successfully introduced to farmers in Tibet: agro-machines, fertiliser, green-manure crops, winter wheat, and agro-chemicals. Application of agro-machines such as sowing machines, modified ploughs, and threshing machines for wheat and barley caused a revolution in crop production and transformed farming in Tibet. Crop production increased by 30-50% because of application of agro-machines for ploughing and sowing. Application of fertiliser, green-manure technology, and agro-chemicals increased per unit yield by 8.8% on average (Hu Songjie 1995). Similar gains may now be possible in the crop-dominated production system zone following large-scale campaigns using the package approach. Integrated improvement of low-yield cultivated land in Linzhou County of Lhasa and integrated management of cropping system land in Qushui County of Lhasa have increased food grain production by over 66%. Work on increasing crop production is now aimed at improving the total system rather than single crops or techniques. By doing this, the cost-benefit ratio of agricultural production is about 1:5 on average. Introduction and modification of local dry land agricultural technology increased the productivity of food grain crops more than 15% (Hu Songjie 1995). Appropriate application of agro-chemicals is reducing the loss of cereals from damage by diseases and insects by more than 20,000t each year. Using plastic-film technology for cultivation of maize is now common in central Tibet and is showing great potential for producing silage for livestock development. Technology introduction, innovation, and extension have been given high priority by local governments and will further boost crop production.

Livestock Production Potential

Livestock production is the predominant sector of the Tibetan economy. Meat and milk are the main products. The carrying capacity of rangeland has been studied from different perspectives (Liu Yanghua 1992; Tibetan Bureau of Land Planning 1992b; Yang Gaihe 1995). The supporting capacity of crop straw as animal feed has also been analysed (Tibetan Bureau of Land Planning 1992b; Yang Gaihe 1995). Xiao Huaiyuan (1994) attempted to analyse the capacity of agricultural by-products to support livestock production. However, livestock production potential and quantities of meat and milk production still remain unknown. In this report, production potentials for meat and milk were calculated based on an analysis of carrying capacity of rangeland, potential capacity of raising livestock using crop straw as animal feed, and supporting capacity of agricultural by-products.

Potential carrying capacity of rangeland

Over the last 30 years, there has been much development in raising livestock, with the total number of animals increasing from 17 million in 1965 to 23.8 million in 1995, an increase of 39%. Total production of meat and milk have reached 103,000t and 185,000t, respectively (Zhang Xiaopin 1997). However, growth has been at a cost in terms of rangeland overgrazing, in particular, and degradation of livestock productivity, in general. There has been a lack of input to the rangeland; output has always exceeded input. This lack of sustainable use has caused overgrazing (57% overstocking in Naqu Prefecture), degeneration (49% of Naqu), and declining productivity (20% since the 1980s), and the situation is becoming worse (Ling Hui 1998). Carrying capacity has decreased by 20-40% compared to the 1970s (Bai Tao 1995), and desertification, alkalisation, increases in poisonous plants, and increasing damage from mice and insects are common. They lead to degradation of the rangeland environment and lowering of productivity (Bai Tao 1995; Ling Hui 1998).

Sustainable use of potential carrying capacity is crucial to livestock development. In the early 1990s, the total carrying capacity of rangeland was 40-60 million sheep-equivalent units[1] (SEU; Bai Tao 1995; Liu Yanghua 1992). More recently, total carrying capacity has dropped to 34.2 million SEU (Yang Gaihe 1995). It is now estimated that carrying capacity is less than 30 million SEU at about 40 SEU 100 ha^{-1}.

The potential carrying capacity is not only low but also unevenly distributed. In the vast pastoral land of northern Tibet, the average potential carrying capacity is about 15-40 SEU 100 ha^{-1}; in the wider valleys of central Tibet around 41-70 SEU 100 ha^{-1}; in south-eastern Tibet 71-300 SEU 100 ha^{-1}; and in some areas it reaches 300-520 SEU 100 ha^{-1} (Figure 9.5. In practice, however, this area has a sloping topography and is wet and unfavourable for livestock development.

The spatial distribution of potential carrying capacity is exactly the opposite of the distribution of rangeland and is limited by biophysical conditions and socioeconomic development. In the pastoral production system zone, where livestock is given high priority, there is little capacity to increase numbers of livestock and livestock production. On the other hand, in southern Tibet, where carrying capacity is considerably higher, increases in livestock are limited by lack of grazing land, sloping topography, and the low priority given to livestock development.

Moreover, carrying capacity is not only unevenly distributed spatially but also between seasons. The difference in potential carrying capacity between summer and winter is about 50 sheep units per hectare (Bai Tao 1995). There are tremendous differences in stocking rate between cold and warm seasons. In the warm season, most of Tibet is understocked and there is potential to raise more animals (Figure 9.6), whereas in the cold season, almost all areas are overstocked; only a few counties in the far south possess limited potential to raise more livestock (Figure 9.7). On average, large parts of the north and centre are overgrazed by existing numbers of animals (Figure 9.8).

Comparison of food-production systems shows that the stocking rate in the cold season is high in all systems. In the pastoral production system zone, there is great overstocking in the cold season and slight overstocking in the warm season. In the crop-dominated production system zone, there is substantial overstocking in both warm and cold seasons (Figure 9.9).

The ratio of carrying capacity in warm season to cold season is more than 2.7 overall, while the ratio of numbers of livestock in warm to cold season is only 1.1. There is great potential to raise more livestock in the warm season (about 13 million

[1] A sheep-equivalent unit is a measure used for counting animals. For example, one yak is five sheep-equivalent units; this means that one yak has the same impact as five sheep.

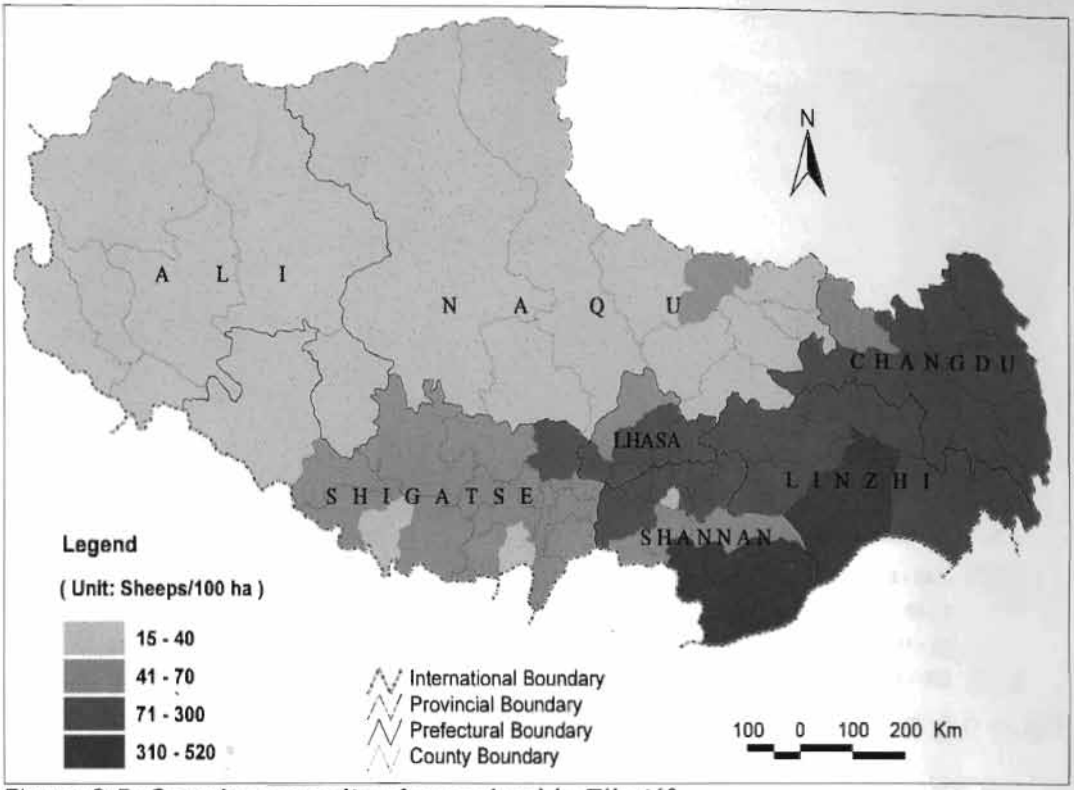


Figure 9.5: **Carrying capacity of rangeland in Tibet**[2]

SEU), but in the cold season there is already 15.5 million SEU of overstocking (Table 9.10).

Overstocking is exacerbated by the following conditions.

- Conservation and rehabilitation of rangeland are largely ignored. Over the past several decades, improvement and development of artificial grassland has not made much progress. Currently the total area of rehabilitated rangeland — re-seeding, irrigation, fencing, and artificial grassland — makes up only 0.02% of the total rangeland area. (In the USA, it accounts for over 20%.)
- Degradation of rangeland and decline in the capability to withstand natural disasters is becoming an increasing problem in pastoral production system zones. Over 20%of rangeland in Naqu and 18.8% of pasture in Shannan are seriously degraded. There is a lack of effort in developing appropriate fencing, irrigation systems, controls for disease and mice damage, eradication of poisonous plants, and replanting and fertilising of grassland. The proportion of poisonous plants has increased from 15 to 45% in some areas. The area of grass-cutting and winter grazing is decreasing year by year alongside an increase in animals. Production of grass has decreased by 60% since 1960. There is no established forage reserve in the form of stored hay to reduce livestock loss and preserve body weight during the winter.

[2] The estimate of the carrying capacity of rangeland is linked to county administrative boundaries. The basic data for potential carrying capacity were provided by Dr Liu Yanghua, Director and Professor at the Institute of Geography, Chinese Academy of Sciences, in 1996

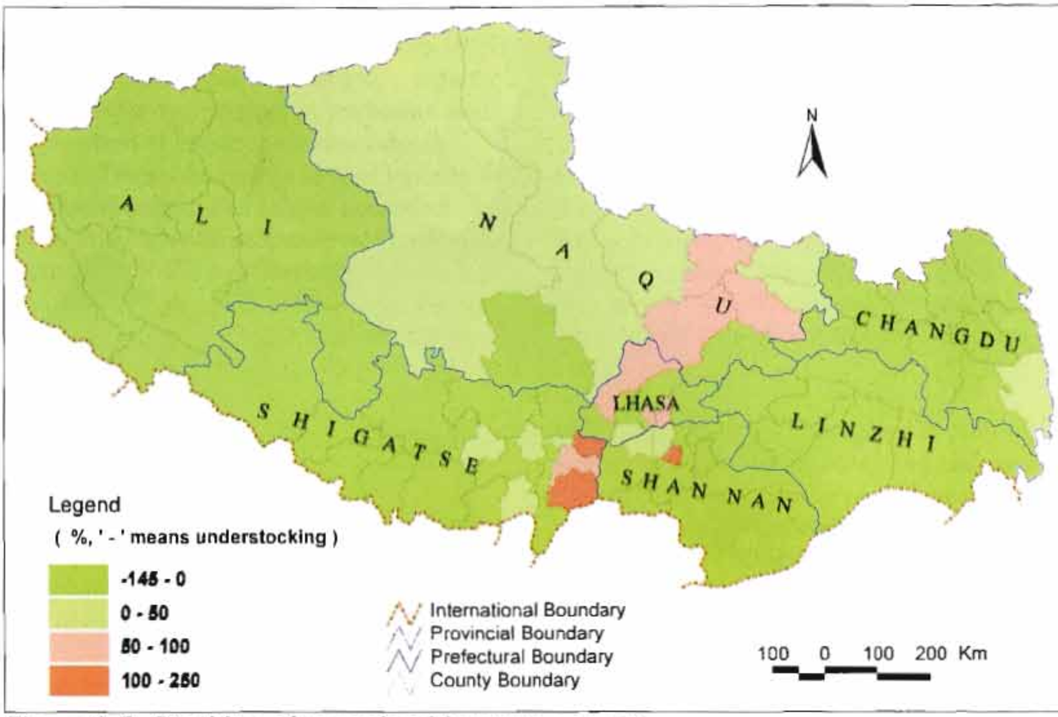


Figure 9.6: **Stocking of rangeland in warm season**

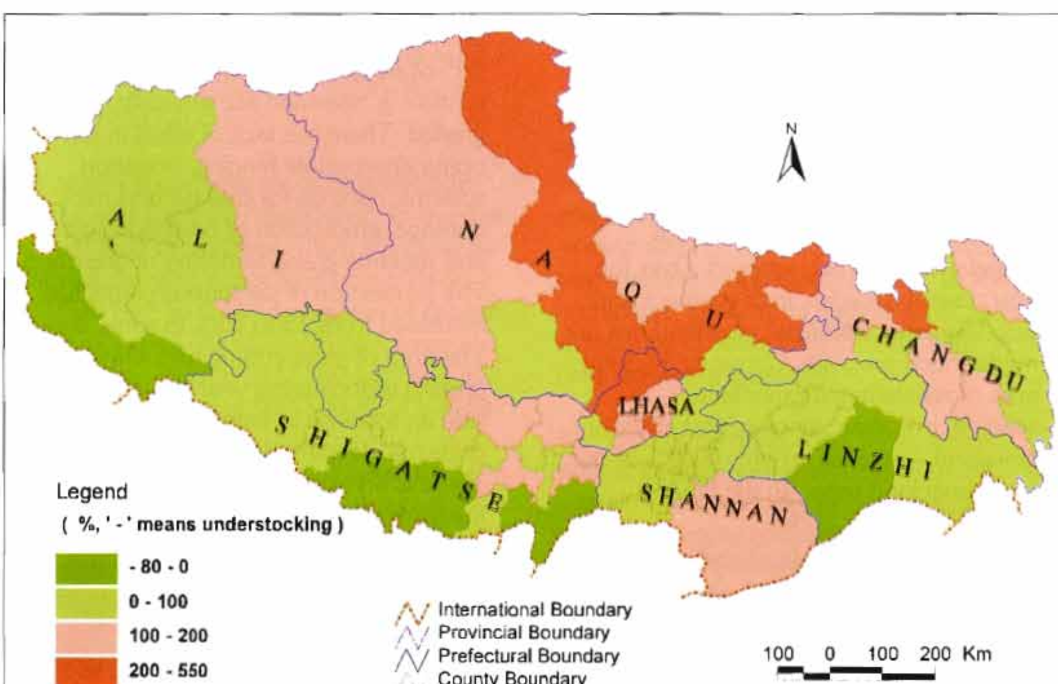


Figure 9.7: **Stocking of rangeland in cold season**

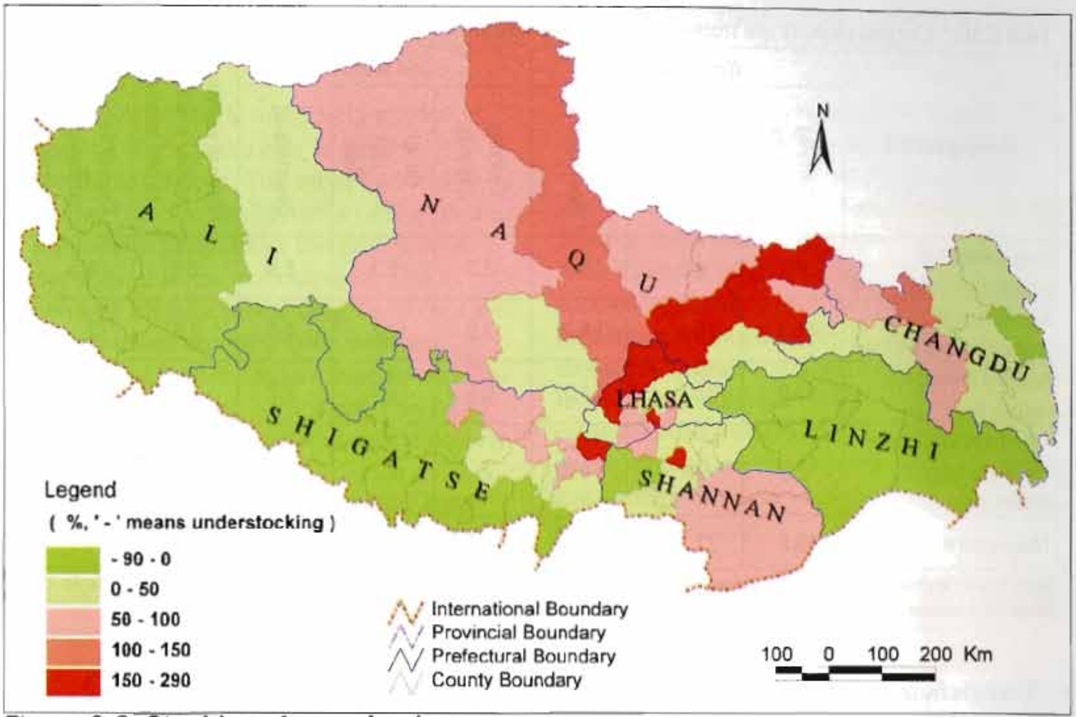


Figure 9.8: **Stocking of rangeland on average**

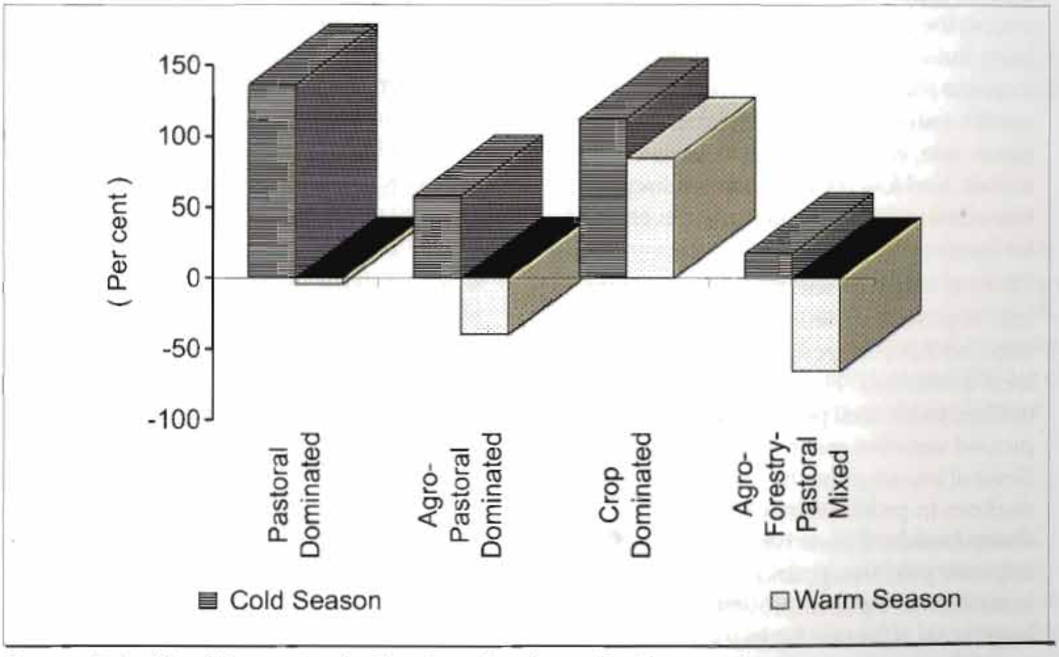


Figure 9.9: **Stocking rates in the four food-production systems**

Table 9.10: Carrying capacity and stocking status of rangeland (million SEU)

Farming system	Warm season			Cold season			Ratio of carrying capacity in warm to cold season	Ratio of livestock numbers in warm to cold season
	Carrying capacity	No. of livestock in July	Overstocking	Carrying capacity	No. of livestock in Dec.	Overstocking		
Crop-dominated production system zone	6.4	8.5	2.1	2.8	5.7	2.9	2.3	1.5
Agro-pastoral production system zone	22.3	13	(-9.2)	7.9	12.7	4.8	2.8	1
Pastoral production system zone	13.9	12.7	(-1.2)	5.5	12.7	7.2	2.5	1
Agro-forestry-pastoral mixed production system zone	7.2	2.7	(-4.4)	2	2.7	0.7	3.6	1
Tibet in total	49.8	37	(-12.8)	18.2	33.8	15.6	2.7	1.1

Note: Dr Liu Yanghua of the Institute of Geography, Chinese Academy of Sciences provided data for the carrying capacity of rangelands. The Bureau of Statistics of Tibet Autonomous Region, China, provided the number of livestock.

- There is frequently an inappropriate livestock-population structure with a large proportion of small, old, unproductive animals in the flock. The proportion of productive animals for milk and meat is 23% on average. The reason herders give for this is the high death rate of animals during the winter, which compels them to keep more livestock. They feel they cannot increase the off-take rate. The production system exhibits a vicious cycle of high death rate, more livestock to keep over winter, and low off-take rate leading to low economic benefit and poor livelihoods for herders.
- There is a lack of scientific management and improved varieties. Traditional varieties have a strong capacity to adapt to local conditions. However, at present, neither traditional pure breeds nor improved varieties are increasing production. Several investigators have reported declines in productivity of local yak and sheep breeds. Efforts have been made to improve yak, sheep, and cow breeds, but extension of these improved breeds on a large scale is limited by low economic capability and the biological adaptability of the animal. Per area and per animal production of milk and meat still remain the lowest in China, mainly because of lack of good-quality feed, particularly over the winter, lack of proper veterinary services, and poor feeding strategies. With growth in the human population and the need to sustain the livelihoods of nomads, more livestock products are required. However, the low productivity of individual animals means that this can only be attained by increasing the number of livestock. Without improvement in the carrying capacity of rangeland, this leads to overgrazing.
- Contradictions between livestock ownership and rangeland tenure still remain unsolved. The commune system ended and implementation of the responsibility system of agricultural and livestock management began in 1980. Each person was allocated a fixed number of animals so that everyone had equal assets. However, the rangeland was not allocated to individuals and still belongs to the government. When livestock are owned privately and rangeland is public, there is no incentive for individual herders to conserve,

serve, improve, or institute sustainable use of rangeland. This leads to overgrazing and degradation.

- Livestock products are poorly marketed, and the commodity rate of livestock production is low. The more livestock a herder has, the wealthier he or she feels in nomadic society. Over the past several decades, this has not changed. The average off-take rate is only 18-30%. Of the off-taken animals, over 50% are consumed by the herders themselves. Few livestock products, particularly meat and milk, are sold outside the nomadic society.

Potential of crop straw as animal feed

Crop straw is one of the most important sources of feed in traditional livestock-production systems. In the crop-dominated and agro-pastoral production system zones, crop straw is the only feed available for livestock in winter and spring. In Linzhou County of Lhasa in 1996, over 85% of the feed in winter and spring was crop straw. A similar situation was found in Shigatse County. Over 89% of crop straw used as feed is barley. Barley straw has on average 48% total digestible nutrients (TDN) and 4.3% crude protein (CP) compared to wheat straw's 41 and 3.6%, respectively (Christensen 1999). Pea straw is also an important source of animal feed in the agro-pastoral production system zone. In many areas where the altitude is high and the crop may not mature for grain, it is cultivated with barley for forage. One promising trend is the growing of alfalfa and other green forage crops in central Tibet. Many herders plant oats and barley for feed. Nevertheless, crop straw is an irreplaceable source of animal feed.

The total amount of cereal straw produced was estimated at 960,000t in 1997, based on 800,000t of food grain production. The ratio of food grain production to cereal straw is 1:1.2. Cereal straw also includes pea straw; rape seed straw is hardly used as feed. Barley straw accounts for 76% of total production. In the crop-dominated production system zones, winter wheat straw accounts for more than 50%.

Current use of crop straw is not optimal. The rate of using cereal straw for feed is about 26%. Farmers often do not manage crop straw properly. In most cases, farmers simply pile the straw beside the house or on the roof. There is rarely any further processing — such as application of ammonia and micro-organisms to ferment the straw so that digestible nutrients are increased. Moreover, there is no facility for feeding straw to animals, such as troughs or racks; straw is simply spread on the ground. Large amounts are wasted. In some villages, straw is used as fuel for cooking.

In recent years, the introduction of fermentation of straw, together with troughs and chopping of straw, has been successful in fully using straw for animal feed. In Tsetang Township and Gongga County of Shannan Prefecture in 1997 and 1998, many farmers adopted the combined package of fermentation of straw, chopping, and feeding with troughs. Local extension staff and farmers feel that this approach could enhance the utilisation rate by up to 60%. Another approach adopted by farmers in Dazi County of Lhasa is mixing chopped barley straw with wheat or corn flour as well as forage from alfalfa. In this way, additional energy and protein were provided so that livestock obtained a higher ration of total digestible nutrients and crude protein. The total utilisation rate improved by up to 62%. Assuming that the utilisation rate of straw reaches 60%, more than 2 million SEU can be additionally supported, based on an estimate of 200 kg of barley straw for one sheep as a supplement to grazing.

Feed-production potential

In addition to crop straw as feed for animals, forage, fodder, hay, silage, and concentrated feed are important for raising livestock productivity. To increase livestock yields by promoting improved and intensive production, high-quality animal feed will be required.

Currently, over 173,000 ha of wasteland are available for developing forage and silage production. If 40,000 ha of this land were cultivated for forage and grass, then, after three years, an additional 1.5 million SEU could be supported (Hu Songjie 1995).

Alfalfa, clover, peas, turnips, radishes, and rye grass are well adapted to conditions in Tibet. Promoting these feed crops and adequately using solar energy and water resources in lower river valleys would substantially boost overall livestock development. It is advisable to first increase the per unit yield of cereals and oilseed, and then devote larger areas to forage or maize production for silage by using plastic-film technology. The total biomass production of maize in the Lhasa River Valley could reach 4-5t ha^{-1} without plastic film; with plastic film, production could be 9t ha^{-1}. Four kg of silage fed to cows can increase milk production by 1 kg (Hu Songjie 1995).

Expansion of the sown area of winter barley is now possible in central Tibet through multiple-cropping systems. One harvest of green forage of alfalfa, turnip, or rape seed can be produced after harvesting winter barley. About 30-60t ha^{-1} of fresh forage are produced with this multiple-cropping system. Expansion of winter barley to 10,000 ha would allow more than 35,000 grazing SEU to be supported.

Besides these opportunities, with an increase in food grain and oilseed production, more than 100,000t of food grain could be used for processing into livestock feed. There are over 243,000t of agricultural by-products such as wheat bran, oilseed meal, and lees. They are not properly used as animal feed and are wasted.

Given the existing carrying capacity of rangeland, full use of barley and pea straw for feed, substantial use of wasteland to produce feed, development of forage and silage, and adequate use of agricultural by-products, 30% more livestock could be sustained. Based on this assumption, total carrying capacity in Tibet was estimated at 38.6 million SEU at current production levels (Table 9.11). Comparing this capacity with existing numbers of animals, the threshold has been reached. At the existing level of livestock production, population structure, and rate of off-take, 140,000t of meat and 230,000t of milk can be produced. Further increases in meat and milk production will depend not only on improved livestock productivity by breeding, but also on improving rangeland, increasing the utilisation

Table 9.11: **Total potential supporting capacity and stocking status of rangeland (10,000 SEU)**

Farming systems	Total capacity			Capacity of natural rangeland		
	Total supporting capacity	Ratio of overstocking in warm season	Ratio of overstocking in cold season	Supporting capacity of natural rangelands	Ratio of overstocking in warm season	Ratio of overstocking in cold season
Crop-dominated production system	9.5	13.3	45.5	3.4	32.6	49.5
Agro-pastoral production system	13.4	(-68.7)	35.7	12.2	(-41.5)	60.4
Pastoral production system	11.8	(-14)	81.4	10	(-8.9)	319.3
Agro-forestry-pastoral mixed production system	3.9	(-89.6)	14.9	3	(-61.8)	11.9
Total Tibet	38.7	(-34)	41.3	28.6	(-25.7)	85.3

Notes: Dr Lui at the Institute of Geography, Chinese Academy of Sciences provided data for the carrying capacity of rangelands. The author estimated the total supporting capacity of livestock production in Tibet.
SEU = sheep equivalent units

rate of crop straw, developing forage, processing agricultural by-products for feed, restructuring the livestock population, and increasing rate of off-take.

Potential for improving livestock breeds

In 1995, the number of sheep and goats was 17.6 million head and the number of yak and cattle was 5.4 million head. The average off-take rate of sheep and goats was 23% and of yak and cattle 12%. The total production of meat and milk was 120,000t and 178,000t, respectively. Average per capita consumption of meat and milk was 13.1 kg and 48.1 kg, respectively.

The total number of livestock is now almost equal to the total capacity for raising them. Control of the number of livestock is now underway, and local governments are looking at increasing per animal productivity as a way to increase livestock production. The potential productivity of improved breeds is crucial to increasing livestock production.

In terms of new breeds, in most areas the milk and meat production of yak can be increased 30% through cross-breeding among the main breeds of Pali Yak, Sibu Yak, Jiali Yak, and Dandxiong Yak. Local breeds of cattle are well adapted to the harsh conditions; most are tolerant to crude feed and have a high capability for grazing the pastoral land. However, milk and meat productivity are low. Improvement through cross-breeding between local cows and exotic large-framed cows has succeeded in increasing milk production more than five times and increasing body weight by 46-57% (Hu Songjie 1995). These improved cow breeds need better quality and larger quantities of feed. A 40% increase of wool, meat, and milk production of sheep was also achieved by similar cross-breeding. However, as of 1996, there were only 15,000 head of improved yak, 15,000 head of crossbred sheep, 40,000 head of improved cows, and 35,000 head of improved goats in Tibet. The proportion of these improved and crossbred livestock in the total is still small. In general, there is a large proportion of old and small yak and sheep. In the crop-dominated production system, promotion should focus on cow and zo, while in the agro-pastoral and pastoral production system zone, yak, sheep, and goats predominate. In the low agro-pastoral-forestry mixed production system, pig and poultry production would be more profitable. Commercialised poultry production and pig-raising in suburban areas holds much potential. Many farmers from central China raise poultry such as chicken and duck, and combine that activity effectively with greenhouse vegetable production by using residues of vegetable farming as feed for poultry and pigs. More local people are also starting to raise chickens. Young chickens, pigs, and ducks are brought from China; after about one year, they are ready for off-take. Urban-based livestock development is promising because of the huge market. However, farmers in suburban areas would need training to raise poultry and pigs. Increase of female yak (dri) and sheep to proportions of 50 and 60%, respectively, would increase milk production (Hu Songjie 1995). In general, livestock production can only be sustained when it fits local biophysical conditions and there is a market for livestock products.

Potential Fishing Production

There is great potential for developing a fishing industry, as most rivers and lakes of Tibet have great reserves of fish. It was estimated that total fish reserves are about 200,000-300,000t. Scientists estimated that 6653t of fish can be harvested per year (Yu Yungui 1994). Nevertheless, the fishing industry is constrained by cultural background. Many lakes are considered holy. However, local people in the Yangdroyongcuo area have started fishing, and it is a source of additional income for local herders.

Food Processing and Adding Value

At present, food-processing techniques for grain, oil, meat, milk, sugar, beverages, tinned food, fermented food, and puffed food are applied extensively. There is increasing demand for foods produced in pollution-free regions such as Tibet. But the food-processing industry in Tibet is still primitive, and there have been few efforts to develop it. Traditional food has not been improved by application of modern food-processing technologies. During the last several decades, 35 food-processing plants have been established; there are now about 720 people involved in food processing (Statistic Bureau of Tibet 1997). By 1995, total output value of the food industry was about 35.1 million yuan, comprising 1% of the total agricultural production value. By contrast, in central China, the food industry's production totalled 18.9% of the total agricultural production value (Lu Liangsu 1993).

Ten

possibilities for a food secure tibet

Background:	Harvesting season - *Nyima Tashi*
Top Inset:	Plastic film technology used to grow corn at 3,680m near Lhasa - *Nyima Tashi*
Bottom inset:	Harvesting season in Central Tibet - *Nyima Tashi*

Tibet is accessible to the world: plane from Kathmandu landing at Gongga Airport
- Nyima Tashi

Chapter 10
Possibilities for a Food Secure Tibet

Rural economic reform was initiated in China in 1978, and brought rapid food production and economic growth to rural areas. It also assisted the nation in achieving food security for its huge population. As one of China's provinces, Tibet has also experienced these changes. This chapter will sum up the changes in policy, investment, institutions, and peoples' perceptions of development that have brought both negative and positive impacts on overall agricultural development and on the achievement of food security for Tibet.

Rural Reforms and Agricultural Development Policies

Reforms of the rural economic system and agricultural policies in China overall

The commune system was abolished throughout China in 1978, and was superseded by the household responsibility system for agricultural and livestock management. Since then, agricultural production has decentralised to individual farm households. During the last 23 years, rural and agricultural development passed through three distinct stages: 'the great breakthrough', 'the great adjustment', and 'the great transformation'.

'The great breakthrough' stage lasted from 1978 to 1984. Before 1978, agricultural development strategies had focused on increasing agricultural production. The government maintained tight control over agricultural production, marketing, and trade through setting procurement prices and through its highly centralised state power. This depressed farmers' incentives to increase production, which stagnated. Under this situation, some households began to make private agricultural production contracts although this practice was not allowed in China at that time. Food production increased. Recognising the value of this practice, the central government adopted the household production responsibility system. Under the responsibility system, farmers had the right to use farm land as they wished. Incentives for agricultural development and food production were raised. Farmers were mobilised to enhance agricultural production. By 1984, almost all households had adopted this system and agricultural production had increased enormously. Shortages of food and agricultural products had decreased, and, for the first time since 1958, there was a food grain surplus. However, new problems emerged. Farmers faced difficulties in selling cereals owing to the unfavourable procurement policy and trading system. The market and pricing system was not suitable to the increasing growth of agricultural production. This led to a new phase of reform of economic and agricultural policies.

'The great adjustment' occurred between 1985 and 1992. The second phase of reforms focused on liberalising the pricing and marketing of agricultural products. It was aimed at solving problems in selling agricultural products. In 1985, mandatory procurement was replaced by voluntary contracts between farmers and the government. The agricultural and rural development policy was modified to favour farmers. The government introduced a market economy and liberalised the food grain market. Food grain rationing was abolished, and Chinese agriculture was transformed from a controlled system to a largely market-oriented system. This was a period of adjustment in agricultural policy on pricing, production structure and market system, adjustment in production, resource allocation, and farmers' perceptions of agricultural production. As a result of liberalisation of rural labour and incentives for developing industries at the village and town level, cottage industries, owned privately and collectively, grew enormously. They took the centre stage and became important in overall economic development. The rise of cottage industries not only improved farmers' livelihoods significantly, but also forced agricultural development policy to become more suited to a market economy. In this process, new problems emerged, such as the widening gap between urban and rural incomes, imbalances in regional development speed, low comparative benefit of agricultural production, and increasing contradiction between small-scale farming and the large markets. Serious environmental problems and resource pressures became new concerns with fast economic growth. These problems compelled changes in Chinese agricultural development policy towards improving growth and management patterns of agricultural production.

'The great transformation stage' started in 1992 and continues to the present. With the development of a market economy, more farmers shifted to cash crops for income generation, and production of cereals is stagnating. Therefore, to reverse this trend, government policy favoured incentives to farmers to grow more cereals. To do so the government increased the food grain procurement price above the international price. Meanwhile, new schemes were launched to balance the supply and demand of food grain, vegetables, and livestock products, and to stabilise prices for agricultural products in the provinces. Since 1995 key steps have included the local governor's grain-bag responsibility system and the local vegetable-basket (and meat and oilseed) responsibility system. There have been problems as well. The small-scale, household-based production system deterred increases in profits and restricted commercialisation. The government's aim was to form a profitable, market-oriented household responsibility system and a technology-directed agricultural development pattern. This was expected to transform the high-cost, low-profit, and low-efficiency production system into a systematic, commercialised, and mechanised agricultural production system. To achieve these goals, in 1998 the central government announced the continuation of the household responsibility system and land management by farmers for another 30 years. Redistribution and the permission to transfer landholding rights among farmers were reformed so that large-scale farming could be developed. In addition, reformation of food grain procurement, food grain pricing, and landholding is under way.

Reform of rural and agricultural policies in Tibet

Overall reform of the rural economy and agricultural development policies in Tibet proceeded similarly to the reforms in other parts of China. In 1979, the household responsibility system was introduced. A series of rural economy and agricultural development policies aimed at rehabilitation and improvement of farmers' livelihoods was formulated in the First Central Government Symposium on Tibetan Development in 1980. The main policies were: (1) relaxation and loosening of policies for providing self-determination of agricultural production; (2) tax exemption for agricultural production for several years; (3) reduction of farmers' and nomads' financial burdens through abolishing various apportionments of costs; and (4) ensuring livelihood necessities for urban and rural populations alike. Later in this phase, the two 'long-term steadiness' policies were introduced. One was long-term steadiness of cultivated land allocated to household use and self-determination of management; the second was long-term steadiness of animals allocated to households for raising and owning privately, and self-determination of management.

In 1984, the Second Central Government Symposium on Tibetan Development was held. New policies focused on liberalisation of thinking, transformation of the economy from closed to open and from planned to market-orientated, and promotion of the household responsibility system of production. Tourism was considered central to economic development. However, political unrest in the late 1980s disrupted the development of tourism. By 1984, overall rural economic reform and agricultural development policies in Tibet were linked with the overall framework of reformation in China.

The Third Central Government Symposium on Tibetan Development was held in 1994. Policies were developed for providing Tibet with support from well-developed provinces in China. Provinces on the coast and in central China, which are well developed, were paired with prefectures in Tibet to assist economic development and to provide cadres and staff. The central government also provided support for infrastructural development.

There have been two leaps in rural economic and agricultural development in Tibet. One was during the 1960s after democratic and landholding reform. Tibetans obtained social equity and equal rights to sharing agricultural resources at the household level. Landholding was changed from the manor system to the collective system. By 1967, Tibet had balanced its food grain supply and demand. The second advance came in 1980 with the introduction of the long-term steadiness policies. The landholding system was changed from communes to household responsibility. By 1993, for the first time, there was a significant surplus of barley and wheat in some areas. Investment in agricultural development by means of infrastructural development, technology innovation and extension, and human resource development also pushed agricultural development forward.

Comparing rural economic and agricultural developments in central China with those of Tibet, Tibet has experienced less development, and responses to new policies are often two to three years late. In central China, the first reform in 1979 was attributed to farmers' challenging existing policies and the government's responding by introducing the household responsibility system. The second reform was attributed to market demand for changes in pricing and procurement systems. The third reform was carried out to develop a market-based and profitable agricultural production system. The developing market economy challenged small farming and inefficient production, and instead favoured commercialised and intensified farming systems. This process has not yet occurred on the same scale in Tibet as in other provinces of China.

Key achievements and gaps in food security and rural development reform

Food production has increased steadily and enhanced food security. By 1998, total production of cereals, oilseed, meat, milk, and vegetables reached 850,000t; 38,000t; 127,000t; 190,000t; and 820,000t, respectively. Since 1978, food grain production has increased by 65.5%, and oilseed, meat, milk, and vegetable production has nearly doubled. Cereals are now in surplus and there are reserves for nearly two years. Total production of fish reached 1800t in 1998. Locally produced vegetables account for over 50% of the market. In general, food availability has improved substantially.

The livelihood of the local population has improved. In 1998, net per capita income reached 1,150 yuan, an increase of 550% since 1978. More than 75% of nomads have been semi-settled or settled. The total population of poor has been reduced from 770,000 in 1978 to 210,000 in 1998. More than 90% of the population is now able to earn enough to feed and dress themselves adequately, and over 50% are well-off.

There have been improvements in infrastructure and production conditions for agriculture, and enhancement in agricultural productivity. By 1998, the total area of improved varieties of crops reached 156,200 ha, making up more than 70% of total sown area. The 127,000 ha of irrigated land comprises about 60% of the total. Use of agro-machinery is increasing and application of fertiliser has doubled since 1978. By 1998, the total area of fenced and artificial grassland had increased to 546,600 ha and 56,600 ha, respectively. Disaster relief and prevention have been enhanced through establishment of production bases for food grain and livestock products, technology extension, improvement of housing and roads, and human resource development. The contribution of science and technology to increases in agricultural production has risen from 15-20% in the late 1970s to 30% now. There have been improvements in processing and marketing agricultural products. The total output value of cottage industries reached 0.5 billion yuan in 1998, increasing the capability of farmers and herders to access more and better food and livelihood necessities.

Nevertheless, there are widening gaps between Tibet and other parts of China. In socioeconomic structure, Tibet now corresponds to the 1950s level of China; more than 40 years behind the national average. The structure of employment is over 20 years behind the national average. Socioeconomic development is about 30 years behind the national average. In 1998, the proportion of rural population in Tibet was 90%, while the national average was 70%. There is 40% illiteracy in Tibet, while the national average is 12%. In 1996, the average per capita income in rural Tibet was 975 yuan, while in central China it was 1,926 yuan. The average per capita GDP in Tibet was about US$370, while it is more than US$600 on average in central China, and in some developed areas of the coast it is more than US$20,000. Socioeconomic development is behind in terms of income, social welfare, science and technology, infrastructural development, education, and livelihood. Tibet is now one of the poorest provinces of China, and it is economically the weakest. It depends, by and large, on subsidies and assistance from other parts of China.

Emerging Issues in Agricultural Development

Economic transfusion is a trap from which the Tibetan agro-economy has not been able to extricate itself

For the last 20 years, there has been fast economic growth throughout China and also in Tibet. However, growth in Tibet has been attributed to subsidies, enhanced aid from the central government, support from other provinces, and tax exemption rather than the creation of a self-developing and self-sustaining agrarian system. If economic development in Tibet cannot sustain itself and depends on external support, then there will be no capital accumulation to support expansion and enhance productivity. Neglecting local capacity-building processes will not bring long-term prosperity but diminish capability for self-development.

Changes in thinking and perceptions have been slow

Since 1992, Chinese economic policy has been directed at "seizing the opportunity, widening the open-door policy, accelerating development, and maintaining stability". The central government has mobilised the people and renewed the focus on development. Tibet has been isolated and has not opened up to the outside world. Industries such as tourism have had limited success. Some decision-makers have tried to imitate the fast economic growth and large-scale enterprises of central China, but without successfully changing the attitudes of local people. There is a gap between the thinking of decision-makers and the activities of the local population. More people from central China are migrating to Tibet. Farmers and business people bring not only new information and technologies but also new perceptions and attitudes. The majority of the local population, to some extent, lack the awareness and spirit to compete with outsiders in developing themselves. Most locals are conservative and are disinclined to improve their livelihoods and living standards. They also lack an awareness of how to protect their resources for sustainable future use.

Food shortages are the manifestation of low farm productivity and a fragile agroecosystem in Tibet.

With the exception of large-scale production of low-quality wheat, much of Tibet is a region of food deficit. With the increasing financial burden of subsidising food supply, conflicts between supply and demand of particular foods and among regions are increasing.

The supply-demand imbalance of some foods is increasing. The growth in demand for meat, milk, vegetables, and eggs is way ahead of the growth in production. At present, 50,000-70,000t of cereals are imported. In 1997, there were deficits of 25,400t of vegetables, 18,600t of milk, and 11,700t of eggs. The butter and other dairy products produced accounted for less than 66% of demand. Imported vegetables, fruit, and pork accounted for nearly 40% of the local market. These trends will increase as lifestyle and food preferences of local people change. Food preferences are moving towards those of the Han nationality, and livelihood perceptions are also beginning to resemble those of Han people. At present, there is a contradiction between what food is produced and what food the local population prefers. This contradiction may create problems in both marketing local agro-products and food supply to the local population. Meanwhile, there is also an increasing gap between zones. Inter-zonal imbalances of supply and demand may become more severe in the next few decades. Particularly, access to food in remote areas will become an important issue. There is a limit to food production in the ecologically fragile, nomadic zone. With 2% population growth in this zone, the challenge for institutions will be to create an adequate food supply for this zone.

Underdeveloped and low capacity markets are obstacles to developing the farm economy and commercialisation processes in Tibet.

When the market economy was introduced to Tibet, the government set about developing a local-resource-based, market-oriented, high-profit, and sustainable agro-economic system. However, it failed to be either market-oriented or profitable. The main constraints are as follow.

With a population of only 2.4 million in an area of 1.2 million sq.km, the sparsely distributed population makes it difficult to develop market-orientation and commercialisation. The market is fragmented. The largest city has fewer than 200,000 people, including the floating population. In addition, 90% of the population are subsistence farmers with little purchasing power. The rural population currently spends 70% of total expenditure on food, and accordingly their living standard is poor. Farmers lack the economic capacity to purchase other products they need. In addition farmers add little value to the farm products they produce; most even face food deficits. Only a few agro-products such as wool and leather are exported, and those are in the form of raw materials. Under these circumstances, it is hard to develop a market-oriented and profitable farm system.

Farmers and herders have a limited desire to take part in the market economy. This is mainly attributed to their low level of education and high rate of illiteracy. They may be rich in terms of family property (number of animals, area of land, traditional jewellery, housing, etc) and experience of living in a harsh environment, but in the context of a market economy, they lack the competitive spirit and capability to market their products. In contrast, most of the population who are better educated and have a higher living standard live in cities and towns. Their food preferences, consumption patterns, and lifestyles are different from those of the rural population. There is now a large gap between farm production in rural areas and the consumption of farm products in urban areas.

A market-oriented, high-profit agro-economy should be supported by a good marketing and services' system. However, formulation of policies in terms of pricing, property rights, investment, and environmental concerns is still ongoing.

The economic capability of a region is determined by its leading industries, resources, and location. Tibet's comparative advantage in natural resources has not been developed into any economic advantage. With the constraints of inaccessibility, lack of rural markets, and lack of marketable agro-products, it is difficult to develop a market-oriented, commercialised, and profitable agro-economy.

Tibet has a poor capacity to use science and technology to maximise its agricultural potential

For the last 40 years, there has been tremendous progress in agricultural research and development. The contribution of science and technology to increasing agricultural production has risen to 30% from almost zero 40 years ago. The number of agricultural scientists, extension staff, research institutions, and extension institutions has increased. Each prefecture has an agricultural research institute, and each county has an extension station, in addition to provincial-level research and extension institutions. Farmers in most of central Tibet have adopted improved crop varieties and improved livestock breeds. Traditional cultivation technologies have been modified. New crops, such as winter wheat, maize, and all kinds of vegetables, have been introduced. Introduction, innovation, improvement, and extension of technologies at the farm level have contributed to major changes in the agricultural production system. However, compared with other provinces in central China, the innovative and extensive application of agricultural sciences and technologies in Tibet has been limited by poor agricultural research facilities, lack of funding, low qualification of researchers and extension staff, and an underdeveloped research and development system.

There are gaps between appropriate and available inputs from science and technology. The demand for appropriate technology is rising with increasing liberalisation and education, and the change to a market economy. Despite this, only 10-20% of research outputs are actually adopted by farmers. This is mainly because of poor accessibility to information as well as lack of skills to process information on agricultural technologies in ways that farmers can use. There is limited financial support from government for appropriate research and training of farmers. International support is available, but accountability is poor. Moreover, identification of emerging trends and challenges to initiating problem-solving research are not performed.

The existing agricultural research institutes were established under a planned economy. Research programmes were planned to meet set targets, mainly for production of cereals and breeding of livestock. Scientists were trained according to targets set by the command programme. In this system, scientists concentrated on technological research without giving much consideration to its relevance to the farming environment and market situation. With the recent policy changes, government support to research and technology institutions has been frozen. This has put pressure on research institutions to either become dynamic in their performance and prove relevance to farmers' needs or face institutional failure and collapse. This, along with the poor working conditions, remote location, and harsh environmental conditions, has meant that many scientists have moved to other work. Research institutions, especially at the prefecture level, have gradually collapsed.

The education level in rural areas is low (illiteracy in Tibet ranges from 56 to 68%). This has limited the adoption of new farming initiatives. In addition, technological know-how for and dissemination of appropriate technologies is poor because of gaps between plains' oriented research and actual needs of highland farmers in Tibet.

Challenges for Sustainable Food Security

Increasing food demand and limited cropland

The proportion of arable land to total land area is about 0.3%. Of this, more than 60% is arid and classified as mid- to low-quality. Currently, there is little scope for expansion of cropland. Possibilities for expansion of cultivated land are limited by poor economic capacity and harsh biophysical conditions. The population is increasing at an average rate of 1.4% each year, and up to 2% in some regions. The rates of growth of per capita food grain and oilseed demand are 3 and 9.5%, respectively. This is in step with the rate of growth of production. It is predicted that food grain and oilseed demand and supply cannot be balanced unless per unit yields are improved rapidly. A sustainable increase of per unit yields is the key to food grain and oilseed self-sufficiency.

Increasing demand for livestock products from low-carrying-capacity rangelands

The total usable area of rangeland is about 80 million ha, comprising about 54% of Tibet. Tibet is one of the five largest animal-husbandry provinces in China, but, because of low carrying capacity, it produces the least overall. At present, the livestock population has reached the rangelands' threshold of support. With overgrazing and overstocking, the rangelands are now degrading. The proportion of degraded rangelands in some regions has reached more than 40%. There is little potential to increase livestock population. However, demand for livestock products is increasing rapidly. The growth rate of demand for meat is 6.9%, compared with a production growth rate of 2.2%. The rate of growth of milk demand is even higher at 18.6%, while the growth rate of production is about 7.8%. The challenge is how to increase livestock production without aggravating the overgrazing and degradation of fragile rangelands.

Increasing natural disasters in a fragile ecosystem

The Tibetan highland is fragile and therefore sensitive to any major biophysical changes. On the other hand, the infrastructural development for agriculture is still weak. Water is a key resource and an irrigation system is a lifeline for agricultural production, but such a system is not well developed. Theoretically, the proportion of irrigated land in Tibet is about 60%, but, in reality, many irrigation systems have fallen into disrepair. Currently, more than 10% have been discarded as useless, and more than 50% are running below optimum capacity. Large areas of farm land are short of irrigation (Gu Maozhi 1995). The situation for rangelands is even worse. Only 0.2% of rangeland is irrigated. More than 300,000 people and 7 million livestock face water shortages each year. Institutions and people in Tibet are not yet capable of managing drought disaster, and losses are practically unavoidable.

The household responsibility system has boosted agricultural production, but it has also fragmented land resources. Leasing of land among farmers is not well established. Most of the large agro-machines that were used during the commune era have become useless. By 1996, the areas mechanically ploughed and seeded dropped to 28.8 and 35.1%, respectively. With fragmentation of landholdings, other services such as agricultural technology extension, veterinary services, and provision of improved seed have almost collapsed. Currently, the agricultural production system has low productivity, poor management, low efficiency, poor profits, poor technological options, and poor human resource development.

The overall infrastructure for improved livestock production, particularly in the rangelands, is even worse. In 1996, the total area of fenced rangelands was about 543,000 ha and the area of irrigated rangelands was about 153,000 ha, accounting for only 0.66 and 0.18% of the total, respectively. Although over 15 bases have been established for disaster prevention and management in the pastoral zone, they have proven largely ineffective because of their limited capacity and the long periods of snow. The government has made efforts to establish veterinary service stations in most counties, but these stations often face shortages of medicine and transportation facilities. Both provincial and local governments have given considerable attention to producing livestock feed for the winter and spring period. However, low productivity and poor economic capability make meeting the demand difficult.

The institutional capacity of the agricultural research extension system is unable to help transform traditional farming systems into competitive and commercialised production systems

For the last 40 years, the traditional farming systems of Tibet have been adjusting the use of traditional practices with some infusion of modern technological options. The arrangement has worked reasonably well because both population and demand pressures were low. However, social and economic development patterns are now changing. Traditional agriculture is no longer profitable in today's context. It must be modified to match market competition so that farmers can improve their livelihoods in a rapidly changing society.

Agricultural research and education are fundamental to improving traditional agricultural systems. However, both are limited. Tibet not only has the highest rate of illiteracy in China, but also the lowest rate of using modern technology in agriculture. The rate of agricultural technology transferred to real production is about 35%, and its contribution to agricultural production increases is about 30%. The research system is also weak at promoting appropriate highland agricultural development approaches since it has been set up on the pattern of the institutions of China that serve the plains. In addition, the users of technology are poor, people are poorly educated, and untrained. In this situation, it is difficult to change traditional farming systems to more productive and profitable levels.

The fragile and marginal agro-ecosystem is challenged by large-scale investments from outside for accelerating faster economic growth in Tibet

Physical and economic fragility and marginality are highly characteristic of the agro-economic system of Tibet. Ambitious and large-scale development programmes should be difficult to implement because of their negative impact on both the socioeconomic fabric of the society and the stability of the environment. The Tibetan highland is highly sensitive to human intervention. Poor regeneration of resources attributed to the high altitude and frigid climate means that the region is prone to faster land degradation. Nonetheless, both extensive and intensive development interventions aimed at achieving faster economic growth are now under way. The main question is how long can this growth be sustained in face of destructive consequences to both the local economy and environment.

Opportunities for Making Tibet Food Secure

Harnessing the comparative advantage of Tibet's natural resources

The comparative advantage of Tibet's natural resources holds promise for developing a sustainable agricultural production system. The uniqueness of and highly valuable biodiversity, abundance of solar energy, advantageous tourism environment, and rich water and hydropower resources are the comparative advantages of Tibet. They need to be integrated into the development of sustainable agricultural production systems.

Biodiversity

Tibet has a rich and unique biodiversity that has several comparative advantages. It is rich in endemic species. There are 955 endemic plant species, comprising 18% of the total plant species in Tibet (Luobsang Linzhiduojee 1995; Nyima Tashi 1998a). Over 30 crops have unique and endemic varieties. There are 563 varieties of barley found only in Tibet (Wang Baohai 1997). There are over 126 mammalian species, of which 36 are endemic. Of over 4,000 species of insects, more than one-fourth are endemic (Wang Baohai 1997). Tibet has an abundance of threatened species. Among the 1009 species of higher plants listed as endangered in China, more than 170 are distributed on the Qinghai-Tibet Plateau, and most can be found in Tibet (Luobasang Linzhiduojee 1995). Ninety-five species of threatened vertebrates are reported in Tibet, and 23 are listed as first-level protected animals (Sun Shangzhi 1994).

This unique ecosystem has given rise to abundant biodiversity that has a high value for income generation. There are more than 1,000 species of herbs, of which more than 300 are used in Tibetan medicine (Zhang Tianhua 1997). Rare and valuable medicinal materials such as saffron, aweto (*Cordyceps sinensis,* a fungus), lotus flower, musk, and pilose antler of deer are not only sold to the international market but the production of medicine from them is one of Tibet's leading industries. Collection of some of this material from the wild may be inappropriate, but other possibilities for increasing the available quantities could be developed. Development of soft drinks and foods with medicinal properties made from resources such as Tibet *Rhodiola*, aweto, barley, and yak is being boosted through the establishment of joint ventures and processing plants. In addition, taking advantage of the clean environment to grow food that is free from pollution may also have great potential.

However, the comparative advantage of local plants and animal resources has not been recognised as allowing development of niche-based farming/agricultural production systems. As a matter of fact, harvesting of these items has historically been a part of farmers' off-farm activities from which they derived minor, supplementary income. Local people have developed effective ways to protect the land where these products exist. Harvesting is carried out in the spare time between barley cultivation and yak husbandry. In this way, the advantage of the resources is shared among local people. However, things have changed; local government has industrialised and commercialised the harvesting of these valuable products into the 'Tibetan Rhodiola Industry' and the 'Tibetan Yatsa Gunbu Industry'. These are highly profitable, but often the benefits have been taken away from local people. Another example is the integrated use of yak products such as wool, meat, and milk. Highland barley is also recognised as a promising crop that is attractive to people from coastal China. These two can be developed into a 'Tibetan Yak Industry' and a 'Tibetan Barley Industry'. Tibetan traditional medicine, which has largely depended on local herbs, has become a leading industry in Tibet, Qinghai, and Gansu. There is also horticultural production of green food or pollution-free food for marketing to central China. The wider and effective marketing of these opportunities could bring added prosperity to rural Tibet. It is desirable to develop niche-based agro-economic systems with wider partnership among all stakeholders.

Solar-energy and water resources

Solar energy is an important requirement for crop-based food production. Solar radiation, is 50-100% higher in Tibet than in other areas in the middle reaches of the Yangtze River with the same latitude. Annual sunshine during the crop-growing period is in the range of 2,315-2,417 hrs; this is 71-82% of the total sunshine hours (Hu Songjie 1995). Solar-energy resources — long sunshine hours and high effective radiation — provide the greatest advantage for agricultural development and food production in Tibet.

Potential productivity of cereal crops through photosynthesis is 127.5-180t ha^{-1}. Taking the harvest index of grain production as 0.4, grain production from photosynthesis is 51-72t ha^{-1} (Liu Yanghua 1992). Compared to actual per unit yield of grain production, photosynthetic productivity is 6-8 times greater, and it is much higher in Tibet than the average for China (Yang Gaihe 1995). This indicates that solar-energy resources provide scope for increasing crop production. However, limited by poor adoption of technologies, the rate of using solar energy is less than 0.3% at present (Hu Songjie 1995). The highest rate is about 0.8% if calculated on the highest yield of winter wheat, 14.8t ha^{-1} in Lhasa (Liu Yanghua 1992). The main reason for this is that low temperatures during the growing season restrict multiple cropping and the use of solar energy throughout the year (Yang Gaihe 1995). The development of greenhouse-based agriculture has great potential (Yu Zhijian 1997).

Solar energy not only possesses great potential in food production, but also has distinct value in mitigating pressures for fuelwood and so helping to conserve the fragile ecosystem. Stable and sustainable ecosystems and socioeconomic development are fundamental preconditions for ensuring food security and are crucial for sustainable development of agriculture. Shortages of rural energy, particularly a lack of fuelwood, have long been a problem in Tibet. It is common for people to use crop straw and animal dung as fuel. This reduces the return of organic material to cropland, which may lead to a reduction of soil fertility and land productivity. Moreover, the severe shortage of alternative energy sources means that farmers cut shrubs and other vegetation for fuel. In such a fragile ecosystem, loss of vegetation on slopes may cause soil erosion, degradation, and desertification of rangeland. Using solar energy as an alternative to biomass-based energy has been showing positive impacts on fuelwood shortages and natural vegetation. In the Changsuo Agricultural Development Zone, 60% of fuel (40% shrubs and 20% animal dung) was saved by using a solar stove for cooking in each household. Solar energy also has the advantage of being non-polluting.

Water resources refer not only to water for drinking and irrigation but also include hydrology, fresh water, mineral water, aquatic food, underground water, and surface water in both liquid and solid forms (Bai Tao 1995). Hydrology and hydropower have great potential. Tibet has a hydro-energy store of 0.2 billion kW and ranks highest in China. Total usable hydropower is estimated at 56.6 million kW and ranks third in China (Sun Shangzhi 1994). In the grand canyon of Yalongzangpo, potential water power is estimated at 0.1 billion kW, the highest in the world (Yang Yichou 1995).

Fresh water is vital for human livelihoods and agricultural development, and Tibet is rich in fresh-water resources. It is regarded as the water tower of Asia. It is well endowed with glaciers, lakes, and rivers (Bai Tao 1995). It has glaciers with a total area of 26,200 sq.km, comprising almost half the total glacier area of China (Sun Shangzhi 1994). Six fresh water lakes have areas of over 250 sq.km. The capacity of water flow is about 395.9 billion m^3, which makes up 12% of China's total (Sun Shangzhi 1994). Mineral water and hot springs are also abundant. In recent years, several mineral-water enterprises have been established. Since the Tibetan plateau is almost free of industrial pollution, mineral water possesses great potential. Aquatic food products are highly appreciated in the Chinese market. Many lakes hold great stores of fish (Table 10.1).

Table 10.1: **Estimated reserves of fish in Tibetan lakes**

Lake	Mapangyong	Bang Gong	Na Mu	Ang la	Yangzhuo yong	La ang	Se ling
Area (sq.km)	412	413	1,940	560	678	269	1,640
Estimated reserves (t)	462	465	2,183	630	763	303	1,845

Source: Yu Yungui (1994)

Scientists and planners are interested in "poverty alleviation through water conservancy and development of irrigation" (Bai Tao 1995). There is a close relationship between water resources and food security.
Solar energy and hydropower are plentiful, renewable energy resources that could resolve the rural energy shortage that constrains agro-economic development. Currently, the lack of energy available in rural areas means that animal dung and crop straw are used as fuel, robbing the agricultural production systems. Promoting the use of solar energy and hydropower in rural areas could change the status of rural energy. The use of the solar energy for cooking, pumping water, and lighting and heating houses is becoming popular. Micro-hydropower is developing fast and will provide wider scope for irrigating land, processing agro-products, and cottage-industry development. Low temperature is a major constraint to agricultural production. It prevents crop farming in large areas of Tibet. However, solar energy is plentiful and has potential for development of durable and cost-effective greenhouses to produce food and animal feed. With enhancement of economic capability, large-scale greenhouses have become popular in central Tibet, and they could be developed in northern and western Tibet.

Tourism environment

With its unique natural and cultural resources, Tibet possesses great attractiveness for developing tourism. Limited by poor infrastructural development, low qualification of cadres and staff, poor capability for managing tourism, and isolation from the outside world, tourism resources have not been adequately developed.

The rational and sustainable use of tourism resources will have the following effects on making Tibet food secure. First, it will provide opportunities for employment and will strengthen the economic capacity of people to enhance food accessibility locally. Second, it will facilitate the promotion of cottage industries and thereby enhance income generation and purchasing power of local people. Third, it will generate capital for local government to support food production and promote food availability locally. Fourth, as a result of producing food for tourists, local food production and processing systems and the quality of local food products will be improved. Ultimately, food usability will be upgraded.

Therefore, if there is social stability and the political situation is favourable, tourism is also a promising industry that could help the agricultural production system and enhance economic capability. The government is considering promoting tourism as a leading industry in its Tenth Five-Year Plan. Considerable investment in developing infrastructure and liberalising tourism at the local level and in the private sector is currently under way. It provides an opportunity for the local agro-production system to produce agro-products and services in demand from tourists. Once the tourism industry demands more local agro-products, farmers will benefit. However, if local farmers are unable to take part in developing tourism, then it will be a burden on them causing environmental degradation driven by demand for local resources and increases in prices of livelihood necessities.

Mineral resources

Mining has been designated as one of the five backbone-industries of economic development. Currently, 90 kinds of minerals are found in Tibet, and, among them, 30 have considerable reserves. The reserves of 11 minerals such as chromium, iron, lithium, copper, boron, magnesium, and barite rank fifth in China (Luobsang Linzhiduojee 1995). Factors such as small-scale mining, few high-value mines, few irreplaceable mines, uneven distribution, difficulty in mining, and so on constrain the promotion of mining into a leading industry. However, with strengthening of economic capacity, mineral resources will have greater effect in promotion of a second-sector industry and enhancement of economic development. Ultimately, this may lead to improvement in livelihoods and food security, if it is harnessed in an environmentally-friendly and local-use based way.

Land resources

Cultivated land: The area of cultivated land, its fertility, and the intensity of cultivation directly affect the production of cereals, livestock feed, and oilseed, and, therefore, food security. On a per capita basis, the availability of cultivated land in Tibet is much higher than in the rest of China, and most of the highest crop yields from experimental plots have been recorded in Tibet. In practice, however, crop yields in farmers' fields are much lower than in other parts of China. There is a great potential to increase the yield of crops through technological dissemination from the experimental plot to the farmers' field.

The total area of cultivated land in Tibet is 360,533 ha (Tibetan Bureau of Land Planning 1992a). In 1996, the per capita cultivated land was 0.15 ha — twice the average in China. Each farmer had 0.3 ha on average, more than in any other province (Tibetan Bureau of Land Planning 1992a). In 1996, food grain production was 777,300t (Statistic Bureau of Tibet 1997). Based on these figures, the actual average yield of cultivated land was 2156 kg ha^{-1}, much lower than the average yield in central China of 4245 kg ha^{-1} (Liu Zhongyi 1997). Cultivated land in Tibet has been poorly managed and currently it has poor production for several reasons.

The abundant solar energy for photosynthesis by crops provides great potential productivity for cereal crops such as barley and wheat, averaging more than 15t ha^{-1}; this is 2.5-4 times higher than the actual yield (Tibetan Bureau of Land Planning 1992a). There is great potential to develop greenhouse-based agriculture. Studies on the comparison of vegetable production in greenhouse and non-greenhouse systems have shown that average production in the greenhouse is twice that of the non-greenhouse (Li Xiaozhong 1998). The area under greenhouse-vegetable production is only 2.3% of the total area of vegetable production. However, greenhouse production accounts for over 40% of total output (Hu Songjie 1995; Li Xiaozhong 1998). The technology of using plastic membranes in maize and potato cultivation also has shown promising results. There is also great potential to develop pollution-free food (Luobsang Linzhiduojee 1995; Nyima Tashi 1998b; Yu Zhijian 1997). In general, the high potential productivity of crop photosynthesis, the potential of greenhouse agriculture, and the opportunity for producing pollution-free food are the comparative advantages for crop production.

Rangelands: Increases in livestock production cannot be sustained unless there is productive and sustainable use of rangeland. The area available, soil quality, production of grass and its quality, regeneration, and environmental conditions directly affect the development of healthy and productive livestock.

The total area of rangeland is about 80 million ha, making up 71% of Tibet and over 20% of the rangeland in China (Tibetan Bureau of Land Planning 1992a). Rangeland yielding 3.3 kg ha^{-1} of grass in dry matter accounts for 49% of usable rangeland, and that yielding 3.3-6.6 kg ha^{-1} of grass in dry matter accounts for 28% of usable rangeland. The area yielding 20 kg ha^{-1} of grass in dry matter comprises only 1% of usable rangeland, and is mostly distributed in non-livestock-dominated areas in south-eastern Tibet (Tibetan Bureau of Land Planning 1992a). Mid- and low-grade rangeland account for 44% (Tibetan Bureau of Land Planning 1992a). In Tibet, the carrying capacity of rangeland is one sheep equivalent unit (SEU) to 2.13 ha of rangeland, compared to 0.7 ha in Qinghai Province, 0.75 ha in Inner Mongolia, and 0.41 ha in the USA. Production per animal unit is extremely low. For example, production of sheep wool in Tibet is about 0.5 kg $head^{-1}$, three times less than in Qinghai and eight times less than in the USA.

The Tibetan Plateau has been recognised as the water tower of Asia, providing almost one-fifth of fresh-water resources. It has been called the ecological fountain or riverhead of the region (Luobsang Linzhiduojee 1995). Destruction and degradation of the environment, particularly of the rangeland, has a direct impact downstream. Legislation for compensation of loss of rangeland or mountain externalities will provide local people with a greater financial capacity for conservation and rehabilitation of the rangeland. However, the fragility and marginality of the rangeland ecosystem will limit development and increase the cost of rehabilitation and livestock production.

Biodiversity in the rangeland is unique and of high value. There are over 3,100 species of plants (Sun Shangzhi 1994), of which about 2670 are edible (Tibetan Bureau of Land Planning 1992a). Collection of high-value plants such as saffron, aweto, and lotus flower is a major source of income for local people, although care must be taken that such resources are not exploited beyond the natural replacement capacity, and that their habitats are conserved. Vast areas of rangeland provide habitat for many rare and endangered species of animals such as musk deer, wild yak, black-necked crane, and giyang (wild ass). The nutrient quality of grass on the rangeland is also reasonable. Many indigenous grass species have high protein and fat content, and low fibre (Tibetan Bureau of Land Planning 1992a). However, productivity is low.

Forest land and forest resources : Complexity of landscape, diversity of forest types, and richness of species are characteristics of the forest resources (Liu Wulin 1993). There are about 30 forestry areas with a total area of 7.6 million ha and 2.08 billion m^3 of mature trees (Liu Wulin 1993), accounting for 13% of the total in China (Sun Shangzhi 1994). However, the proportion of forestry-production value in total agricultural-production value is less than 3%. This is because forestry resources are mostly distributed on sloping and inaccessible mountains and gorges. With current economic and technological capabilities, it is difficult to develop a forestry industry (Yu Yungui 1994). Economic forestry only accounts for 0.01% of the total area of forest in Tibet, thus overall economic benefit is limited (Duojee Caidan 1995).

Most forest land is distributed in the mountains and gorges of south-eastern Tibet. The use of over 600,000 ha of forestland in central Tibet is limited by scarcity of water and low economic capability (Duojee Caidan 1995). In recent years, there has been progress in planting trees and development of a forestry industry. However, in general, a profitable forestry industry has not been developed.

Integrating the use of the comparative advantages of natural resources

Solar-energy resources, biodiversity, and tourism have great comparative advantages that could help ensure food security in Tibet. These resources are unique, regenerative, and easy to use. Water and hydrological resources, and mining resources, also have great potential, but Tibet presently lacks the economic capacity to develop them. Land resources such as cultivated land, rangeland, and forest land have the advantage of large areas but the disadvantage of low quality.

In the past, Tibet largely depended upon land resources to achieve food security. Future food security will be dependant upon an effective combination of the advantages of the available resources, integrated management, and sustainable use.

Solar energy, water resources, biodiversity, and land resources are fundamental to food production. Integrating these resources and using them sustainably can only ensure food security. One ambitious approach could be to develop greenhouse-based food-production systems. Low temperatures constrain food production, but solar energy is abundant. The development of durable and cost-effective greenhouses for food and animal-feed production using the unique biodiversity of Tibet can enhance food security. With promotion of economic capability, large-scale greenhouse development can be implemented combined with biogas production, livestock-raising, and cropping.

Development of the tourism industry should integrate tourism with other industries. Tourism has so far been developed in an insular way that has not had much impact on overall economic development. Tourism should be developed into an industry that is centred on local resources, incorporates biodiversity and land resources, and provides employment opportunities for the local population. If it can be developed to target local food and livelihood security, and to aim at sustainable and integrated use of natural resources, then it can play an important role in the overall socioeconomic development of Tibet.

Promoting highland agricultural products

There is an increasing demand for highland agricultural products. The 21st century has been recognised as the 'century of the mountains', and there will be greater attention paid to the development of mountain areas. Not only will there be larger external investment from central China, but the demand for agricultural products from Tibet will rise as the uniqueness and value of such products becomes increasingly known to people in other parts of China. Another reason is that the gap between demand and supply of food in the plains will become larger with population growth and improving livelihoods, thus making agricultural production in areas such as Tibet more necessary. This has been occurring in Qinghai and Sichuan provinces where farmers supply vegetables and food grain to coastal areas of China. Improvements in transportation now mean Tibet is less remote from central China than previously. The agricultural production system in Tibet is changing to meet the demand for its products from the plains.

Strengthening the application of agricultural technology

There is great potential to improve the yields of crops and livestock through the proper use of technologies. Currently, Tibet has poor technology extension and transfer at the farm level. After 40 years of research in Tibet, knowledge of appropriate technological options is no longer a problem. There are plenty of opportunities for local people to use these technologies. They include improved varieties of crops and animals, improved cultivation techniques, artificial grassland development and forage production technology, improving fertility, intercropping and multiple cropping, and small-scale poultry and pig-raising. The investments from the central government and other provinces of China are facilitating improvement of large-scale irrigation systems, cropping management promotion, expansion of cultivated land, and expansion of greenhouse vegetable farming at a faster pace.

Accepting new policies and sizable external investments

New policies and sizable external investments are opening up opportunities to economically productive agriculture. The focus of development policy in Tibet is on ensuring fast economic development to improve people's livelihoods while maintaining the social fabric and stability.

The Third Central Government Symposium on Tibetan Development held in 1994 propounded the policy of "central government concerns and nationwide support". Fifteen provinces in central China were paired with prefectures in Tibet to provide support in terms of assigning staff and cadres, training staff, and providing financial and technical support (Figure 10.1).

Up to now, more than 700 staff and cadres from various ministries have been sent to Tibet, and related projects have been implemented. Over 60 projects, mainly for infrastructural development, have been implemented, amounting to more than 6 billion yuan. In addition, more than 660 projects covering other aspects of development and amounting to almost one billion yuan have been supported. The upper reaches of the Yalongzangpo River and its two tributaries, the Nyachu and Lhasa rivers, have been designated as a development zone and allocated more than 1 billion yuan within the last 10 years. In addition, a poverty-alleviation responsibility system has been established within Tibet (Figure 10.2). Most investments have gone to infrastructural development, particularly for agricultural production. Although maintaining the infrastructure (such as an irrigation system, hydropower station, roads, or telecommunications) can be burdensome, better infrastructure has provided a great opportunity to improve agricultural production and food security. Eventually, a local responsibility system for maintaining infrastructure needs to be established.

There is ample opportunity for local farmers and herders to increase their application of technologies. Since 1998, the government has had a policy of leasing land to households for 30-year periods, and has focused on developing commercialised agriculture, encouraging farmers to lease from each other. Farmers now have the opportunity to invest in land for the future and to lease or rent for large-scale or intensive production. With the improvement of infrastructure and availability of technology options, crop and livestock production potential can gradually

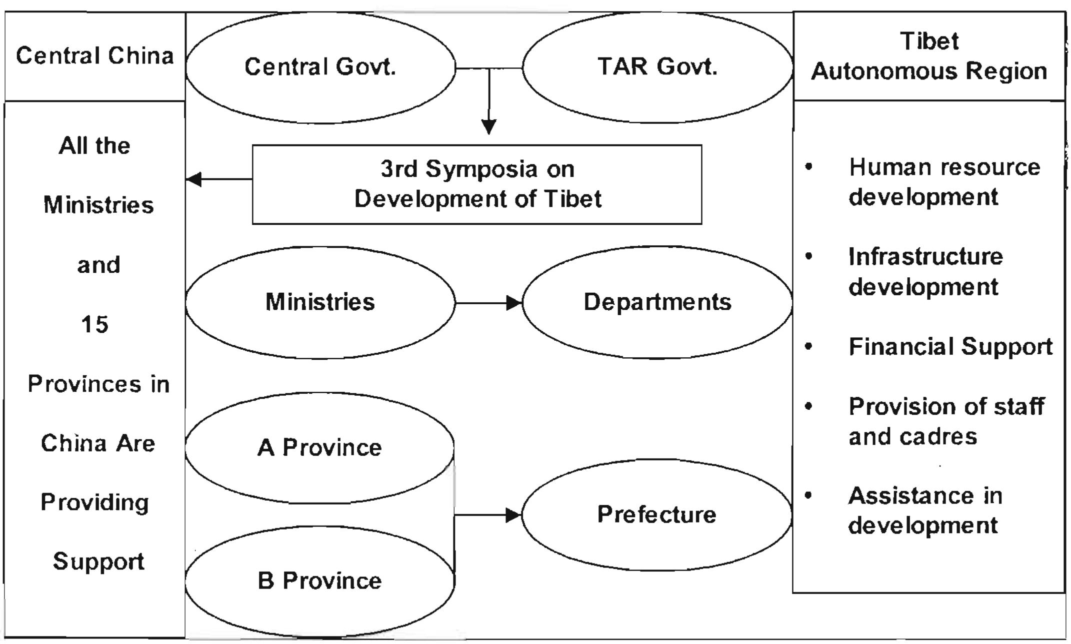


Figure 10.1: **Support system for Tibet from Mainland China**

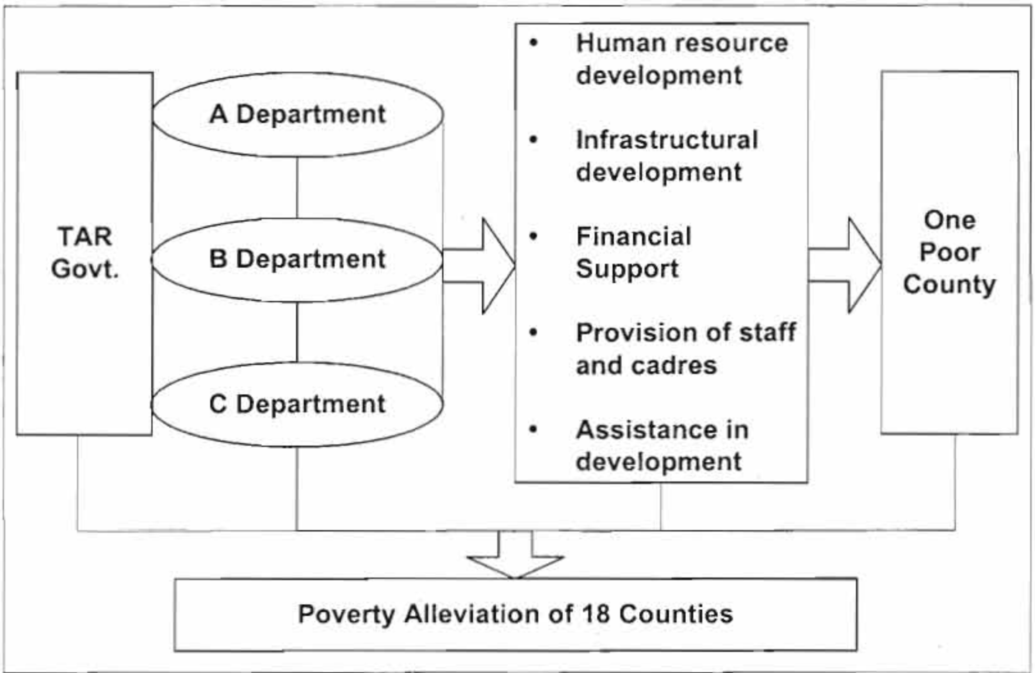


Figure 10.2: **Poverty alleviation system**

be developed. Local governments also have the opportunity to restructure agricultural production so that it is market oriented and profitable. Recently, Chinese investment and development policy have shifted towards western China, in which Tibet is included, and more and larger-scale investment may occur in the future. Meanwhile, the government has paid increasing attention to environmental conservation and the rehabilitation of degraded natural environments, particularly in mountain regions.

Harnessing the potential for increasing production of cereals

To achieve sustainable increases in food grain production, focus will have to shift to use of improved crop varieties, improvement of cropland, promotion of irrigation systems, and extension of water-saving technologies in rain-fed areas.

Over the last 40 years, there has been progress in crop breeding and using new varieties in crop-dominated areas in central Tibet. However, little attention has been paid to developing crop varieties for agro-pastoral areas in high-altitude zones. Breeding programmes to develop high-yield, early-maturing, and cold-resistant varieties of barley should be established. Increases of per unit yield of barley in agro-pastoral areas will not only contribute to increasing total food grain production, as cropping areas in agro-pastoral areas are large, but also increase livestock production through the use of grain for feed and crop residues for animal feed. Breeding programmes to improve the quality of winter wheat and extension programmes to introduce high quality wheat varieties are needed. Poor quality winter wheat is a major constraint to marketing. Improved crop varieties should be promoted in a complete technology package comprising high-yielding and good quality improved varieties, irrigation or controlled water supply technology, cultivation techniques, fertilisers and pesticides, and associated management skills.

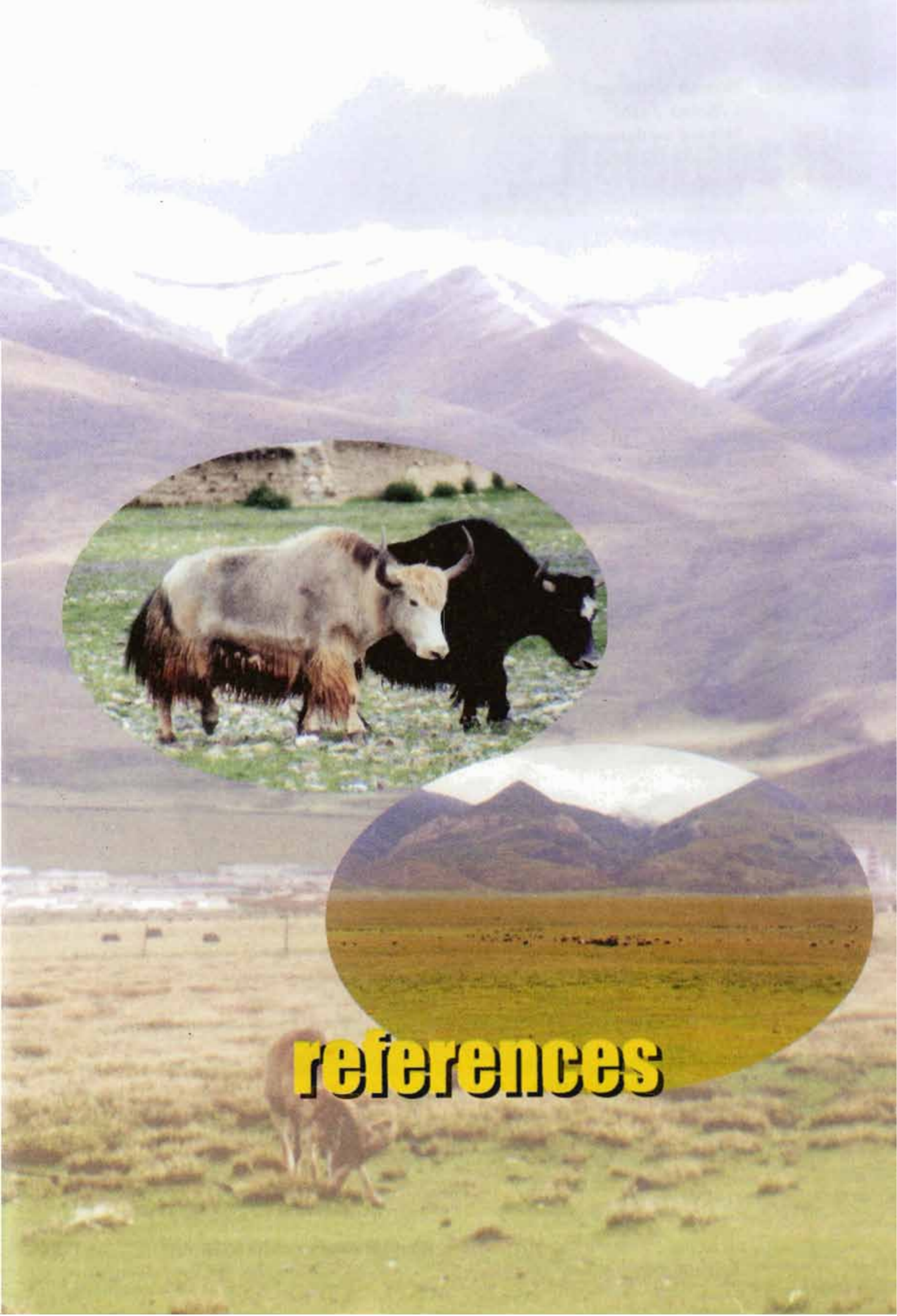
The yield of cultivated land should be improved. Over 60% of cultivated land is low-yielding or marginal, yielding about 2t ha^{-1} on average. By 1995, 22,500 ha had been improved, comprising 18% of the total marginal cropland. The main factor for low yields is a lack of fertility and moisture-holding capacity. Soil is often degraded because animal dung is used as fuel instead of being used as fertiliser. The severe lack of organic matter makes it difficult for the soil to hold water. Two measures can be taken. The first is to find alternatives through developing hydropower and using solar energy to provide more energy to rural areas. The second is to improve the irrigation and drainage system and to introduce water-saving technologies in rain-fed areas where most of the low-yielding land is distributed.

Developing the livestock production of the crop-dominated farming systems zone

Overstocking is leading to degradation of rangelands and to production stagnation in the pastoral zone. In the crop-dominated zone, increasing fodder production, livestock improvement, and marketing of livestock products can be given equal priority with increasing food grain production. Farmers in this zone need improved forage production technologies associated with cropland, such as seeding, irrigating, and harvesting forage. The use of forage crops such as oats, peas, and alfalfa should also be encouraged. Multiple cropping systems for forage production and the use of barley and wheat straw for livestock feed are yet to be fully promoted, but there is potential. Increased crop production and improved per unit yield of food grain crops also provide opportunities to derive livestock feed from agricultural by-products and production of hay. Sufficient food grain means sufficient concentrated feed. Productive cropland means that marginal land can be devoted to the development of artificial grasslands and the cultivation of perennial forage crops. Feed production and the development of a market for livestock products should receive priority in the crop-dominated zone to facilitate livestock production.

Highway on the roof of the world - Nyima Tashi

Cattle grazing in the summer season on a mountain side near Lhasa - Nyima Tashi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Background:	Nomad settlement - *Nyima Tashi*
Top Inset:	Nomad settlement - *Nyima Tashi*
Bottom inset:	Pastoral land in Dangxiong county - *Nyima Tashi*

Highway to Qinghai from Lhasa - Nyima Tashi

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