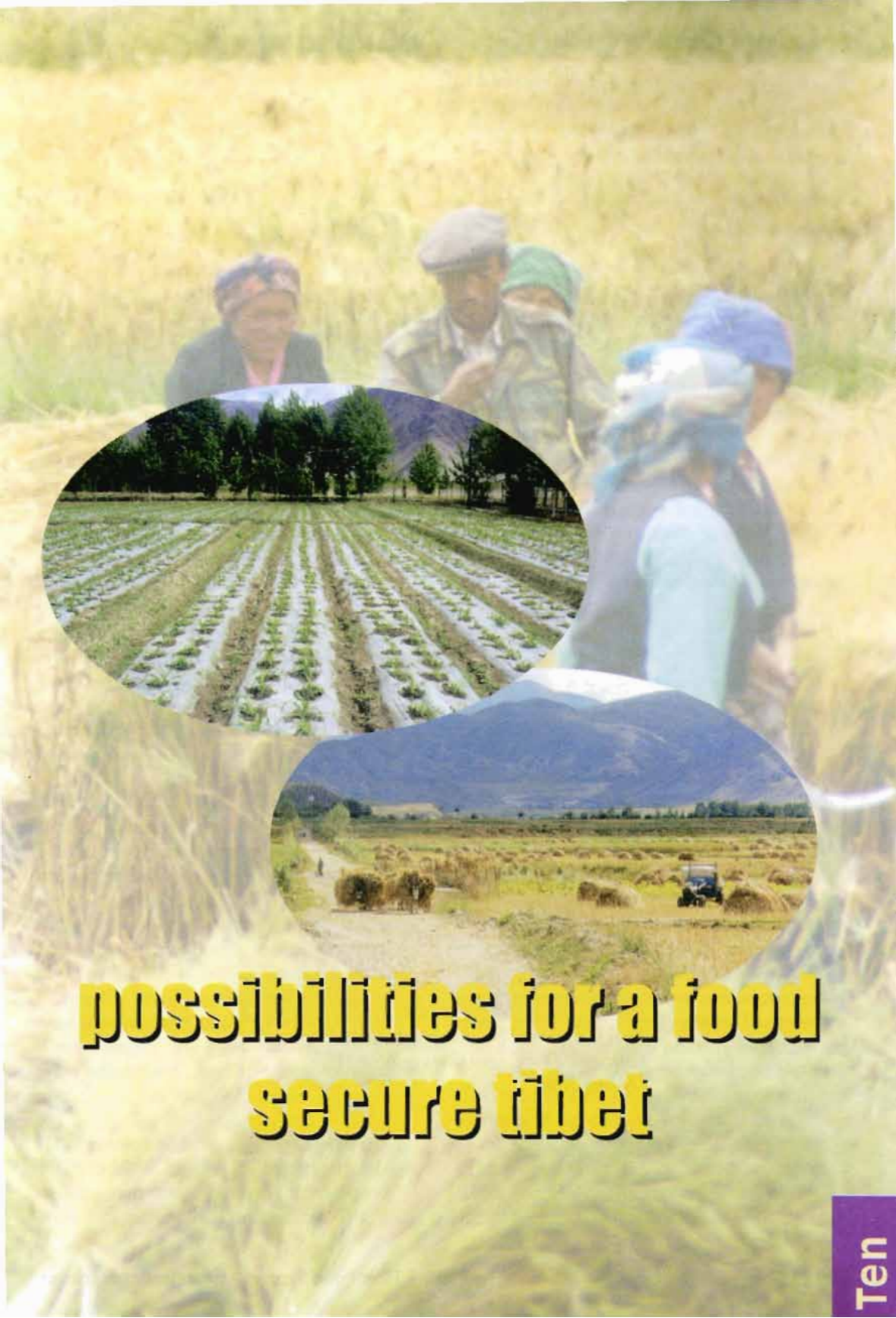

possibilities for a food secure tibet

Ten

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The commune system was abolished throughout China in 1978, and was superseded by the household responsibility system for agricultural and livestock management.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	Mapan-gyong	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

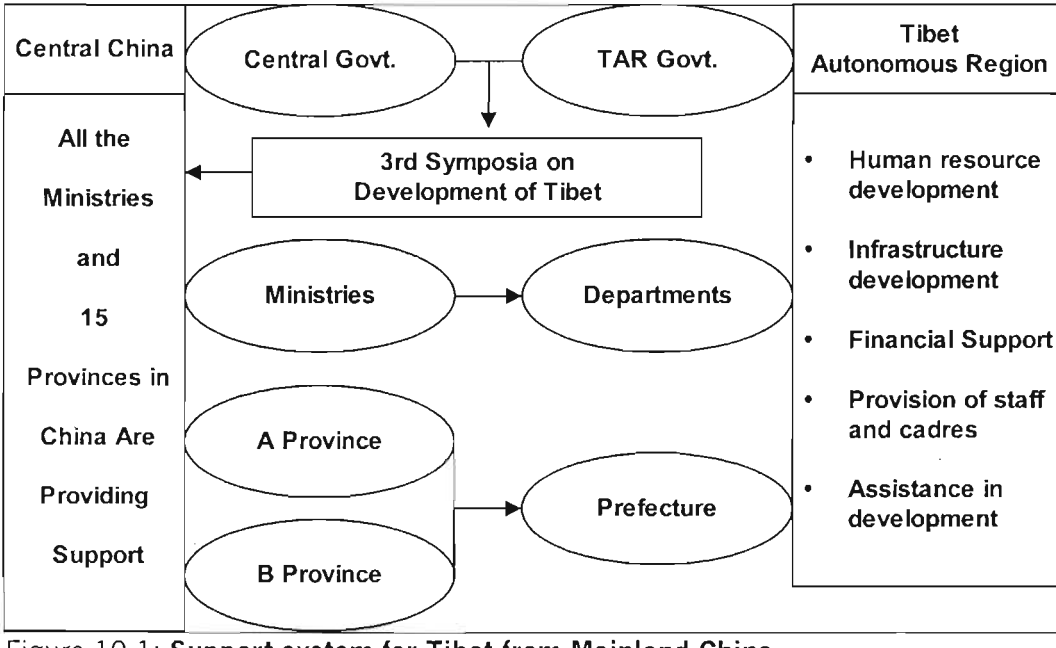

Figure 10.1: **Support system for Tibet from Mainland China**

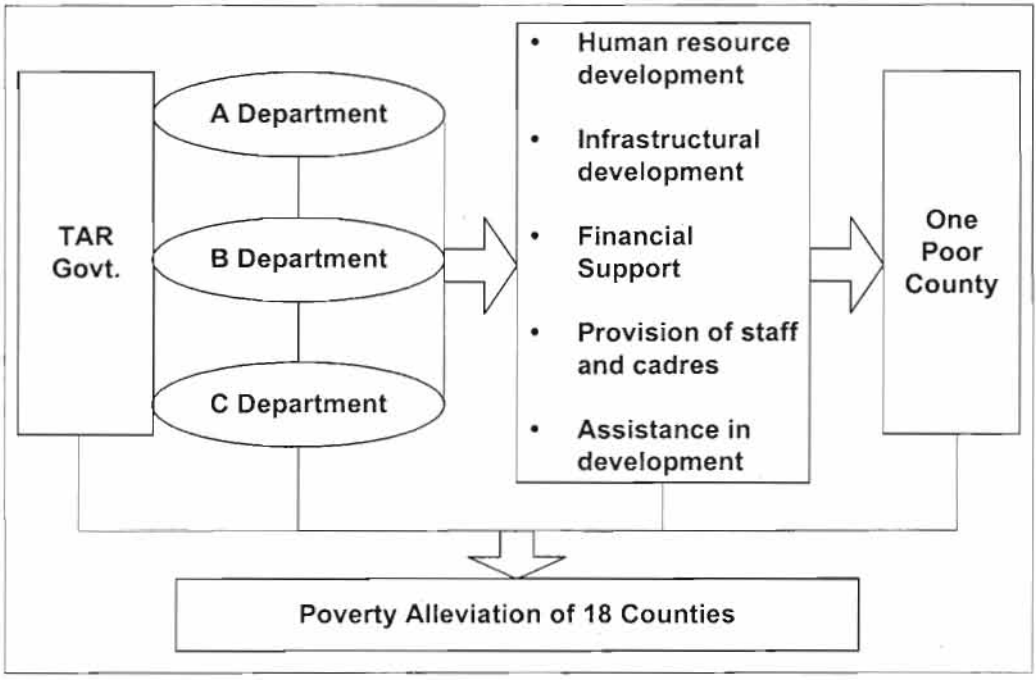

Figure 10.2: **Poverty alleviation system**

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