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

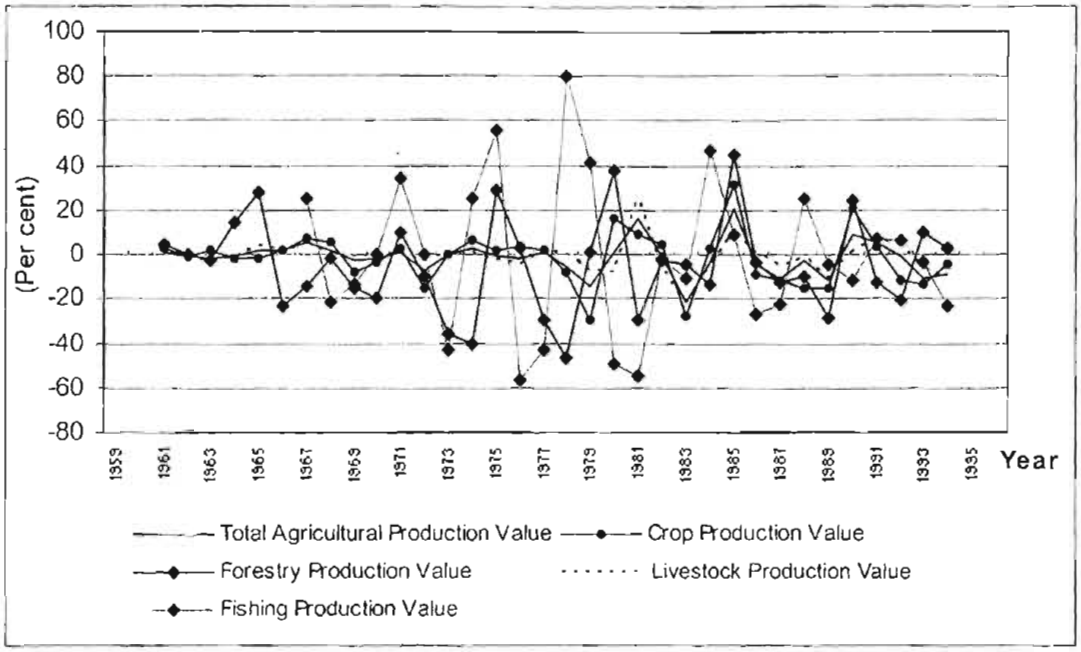

Figure 6.1: **Fluctuation in agricultural development**

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).

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.

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

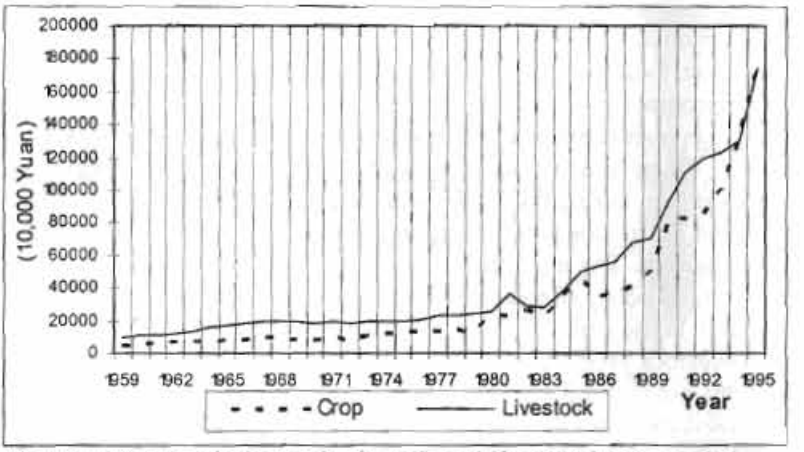

Figure 6.2: **Trends in agricultural and livestock gross production value**

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

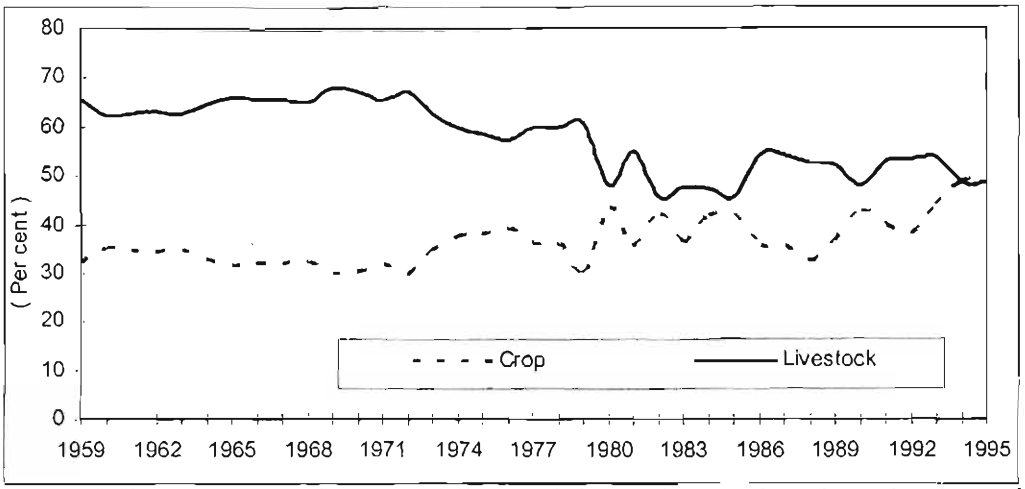

Figure 6.3: **Proportion of crop and livestock in total agricultural-production value**

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

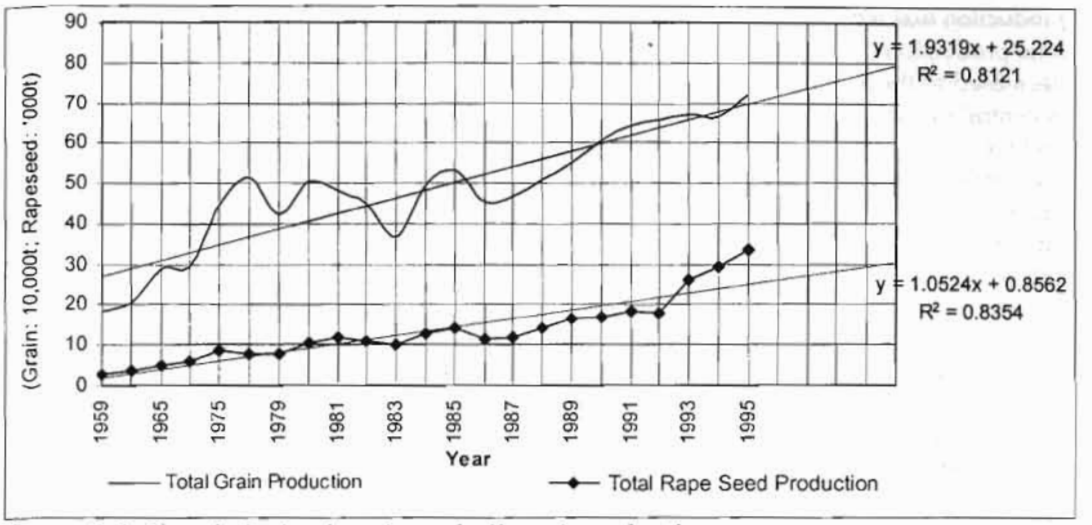

Figure 6.4: **Trends in food grain and oilseed production**

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

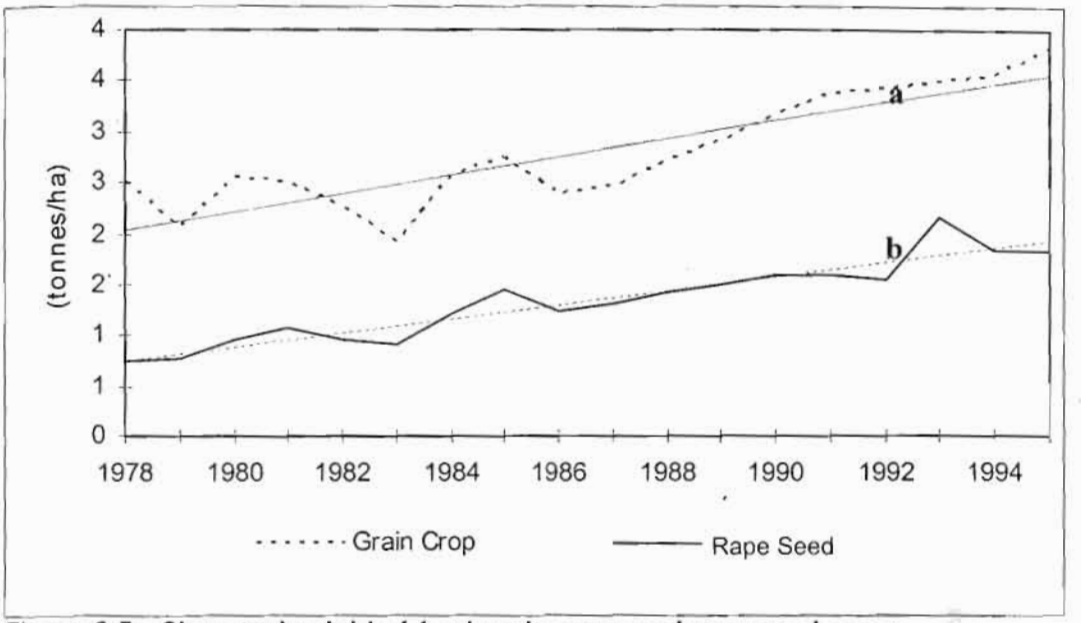

Figure 6.5: **Changes in yield of food grain crops and rape seed crops**

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

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

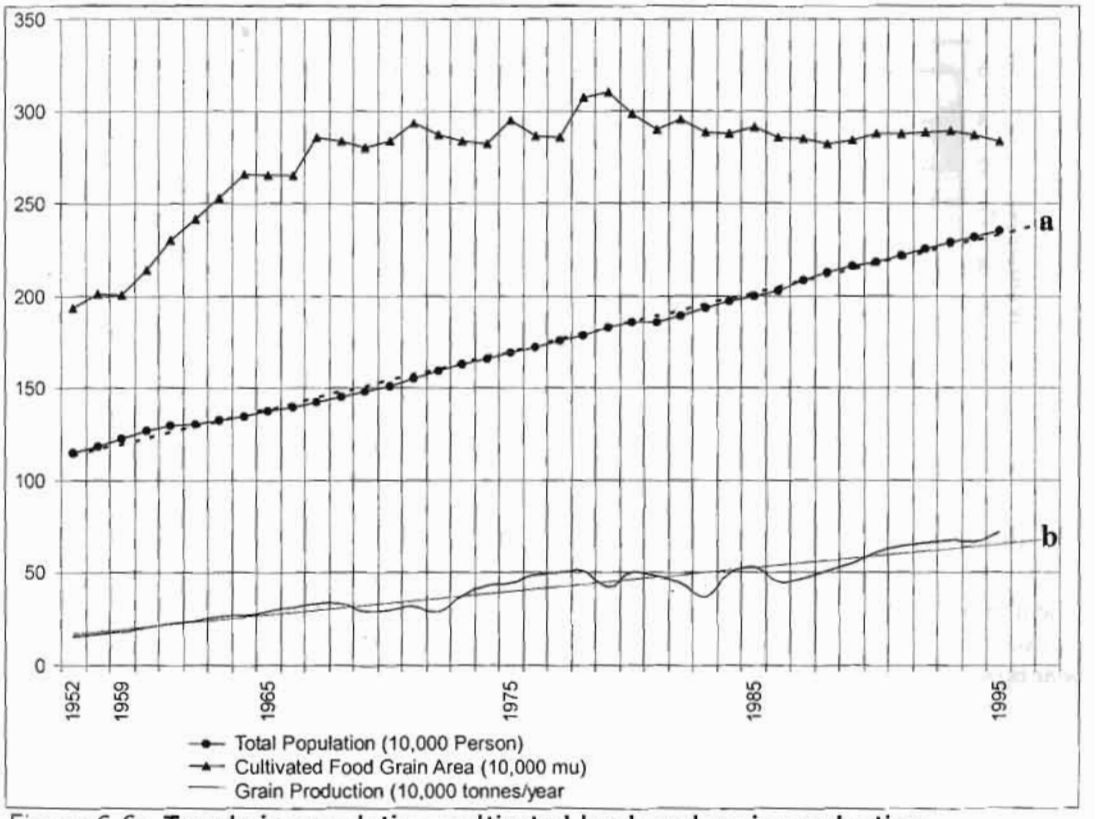

Figure 6.6: **Trends in population, cultivated land, and grain production**

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

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

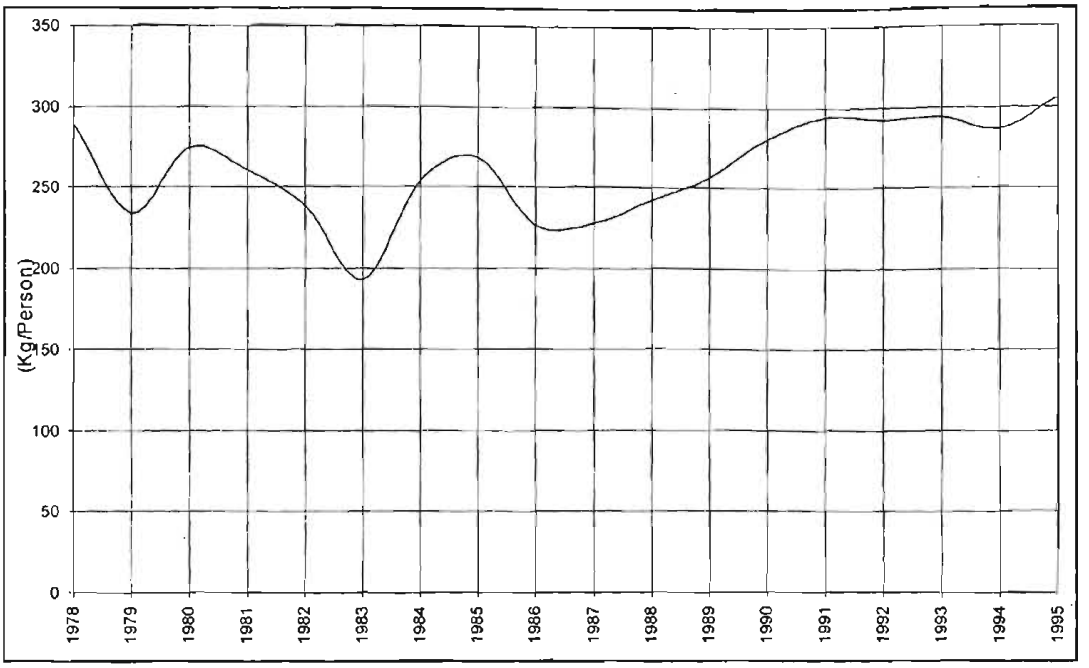

Figure 6.7: **Per capita grain production level**

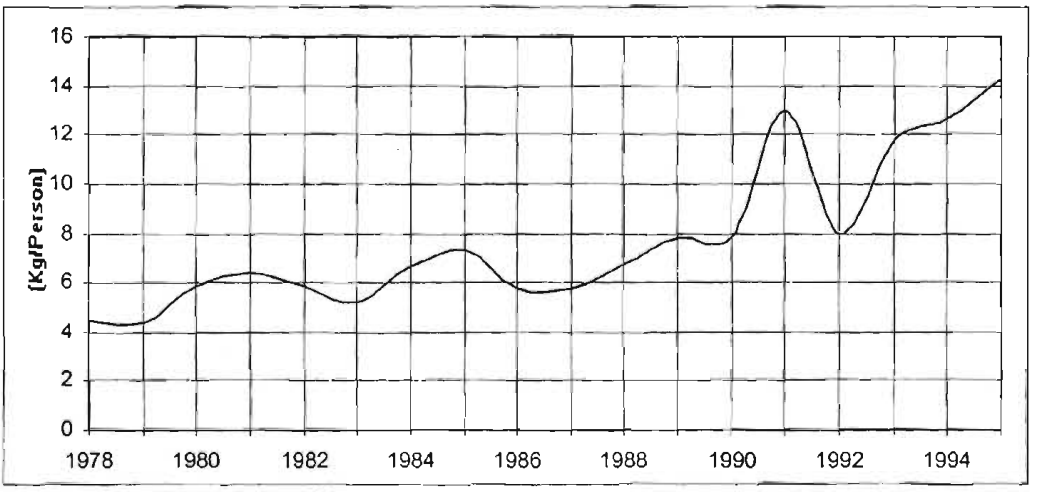

Figure 6.8: **Per capita oilseed production**

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.

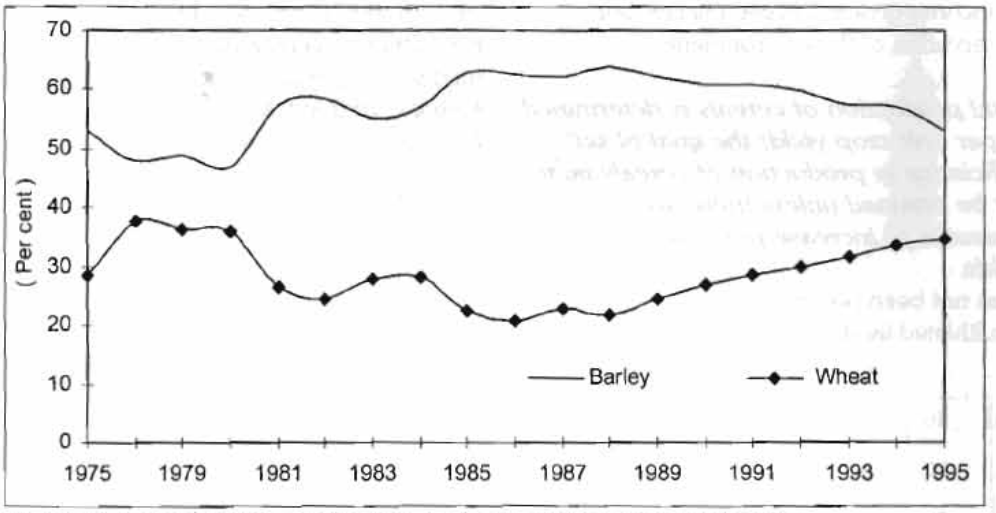

Figure 6.9: **Proportion of barley and wheat in grain production**

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

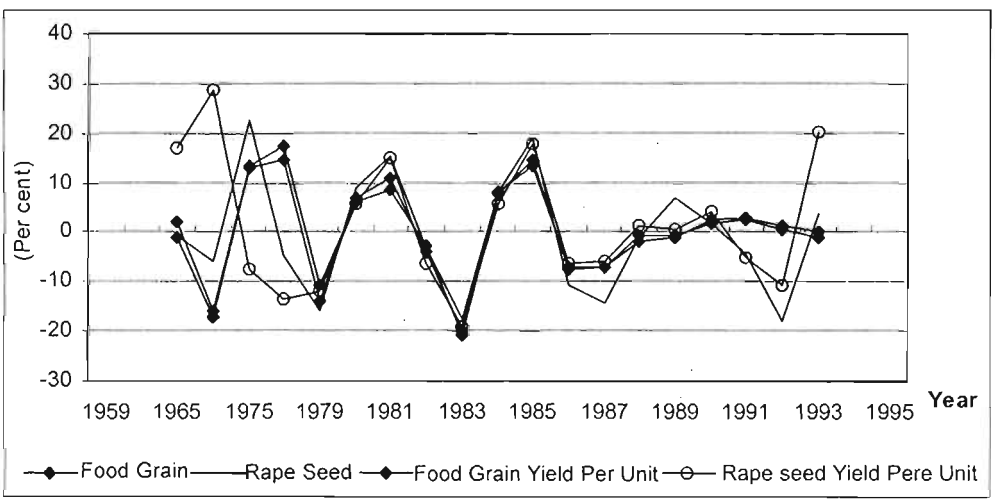

Figure 6.10: **Fluctuation in production of food grain and rape seed crops**

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

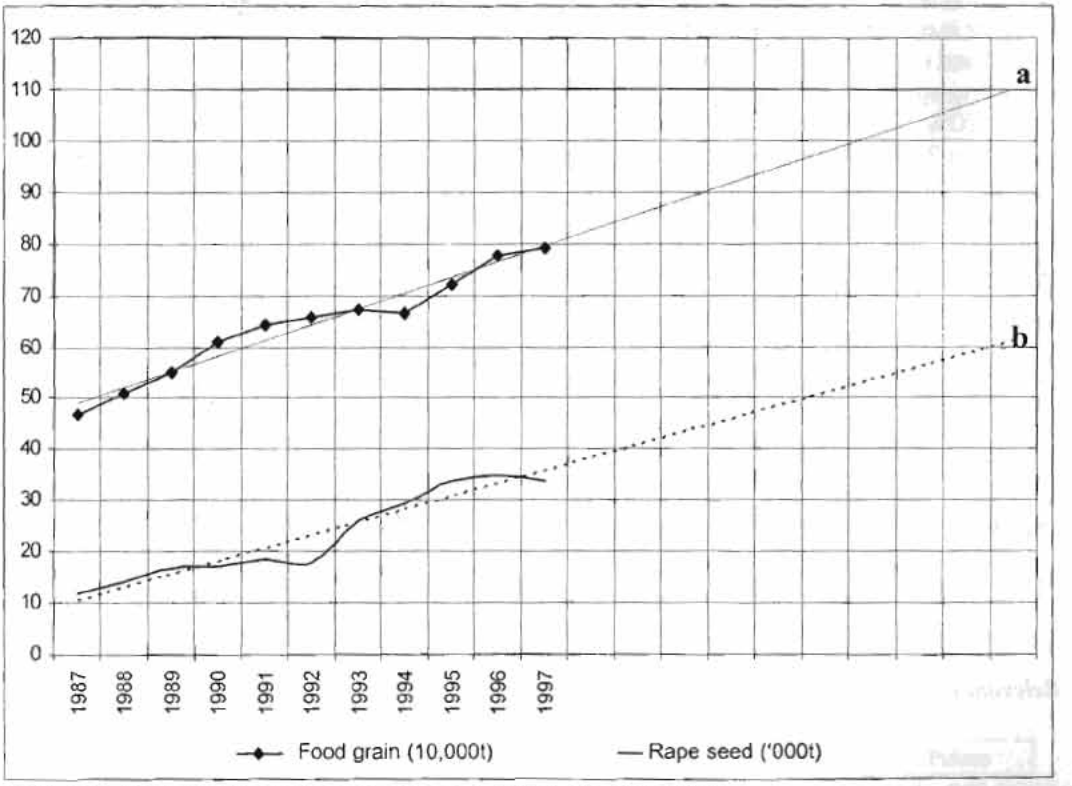

Figure 6.11: **Trends in food grain and oilseed production**
a) $y = 3.0443x + 45.923$ $R^2 = 0.9574$ b) $y = 2.5117x + 8.0228$ $R^2 = 0.9257$

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 $M = \max_i \max_k \Delta_i(k)$

$$m = \min_i \min_k \Delta_i(k)$$

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

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

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

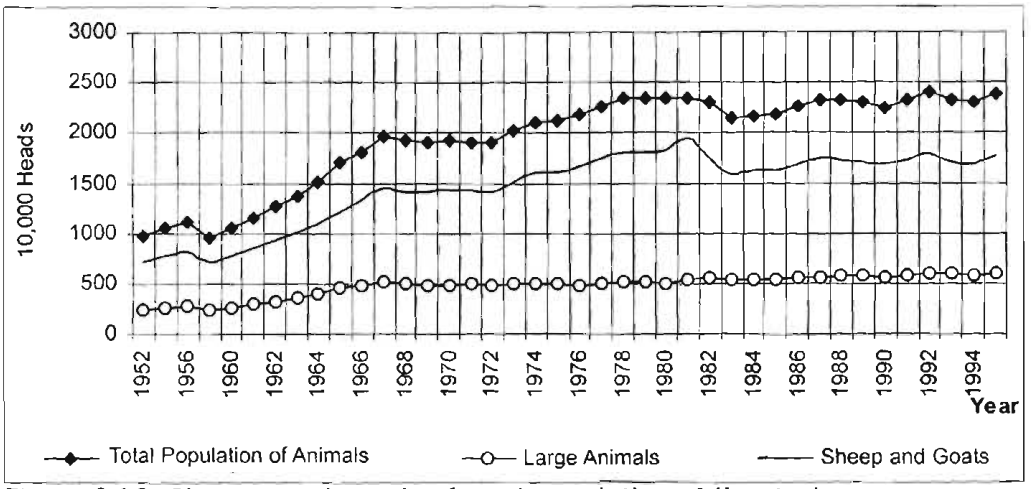

Figure 6.12: **Changes and trends of total population of livestock**

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

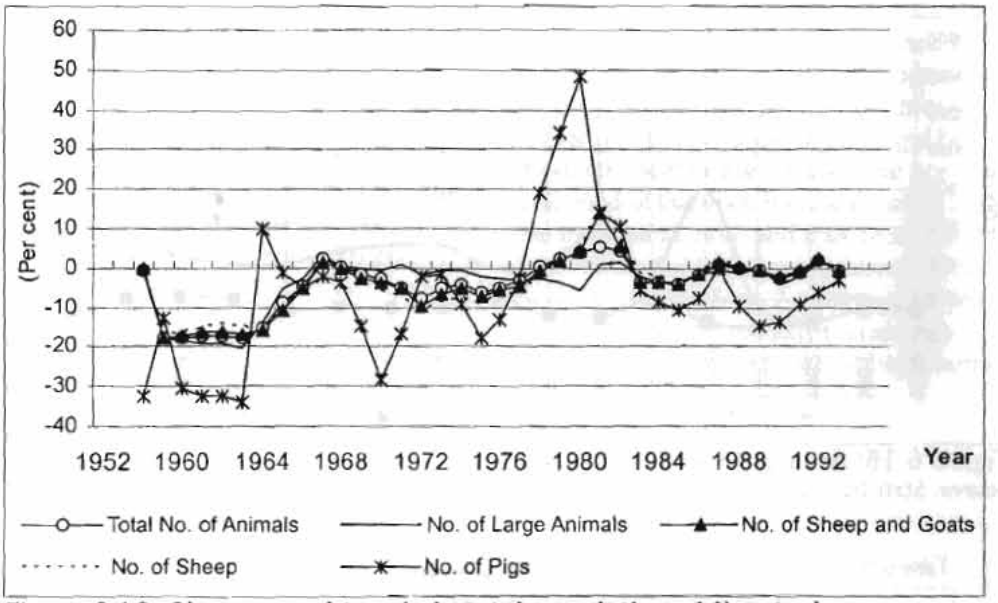

Figure 6.13: **Changes and trends in total population of livestock**

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

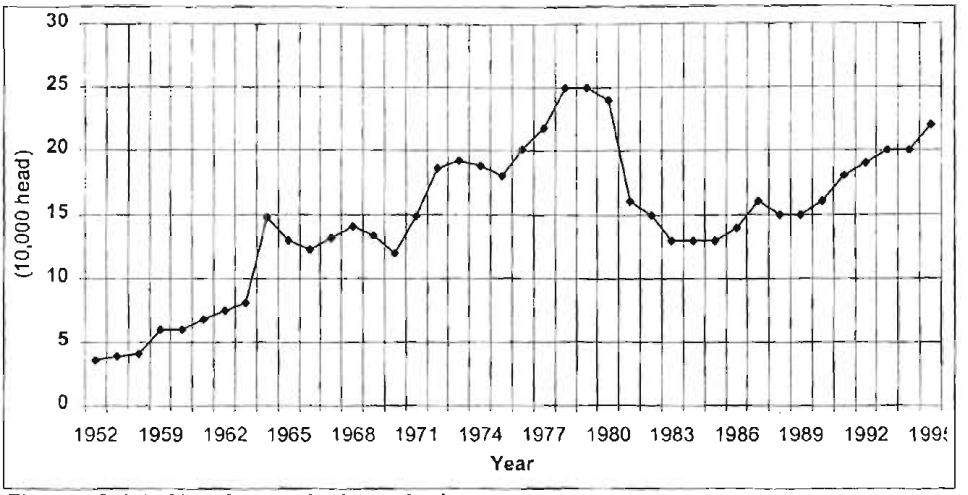

Figure 6.14: **Total population of pigs**

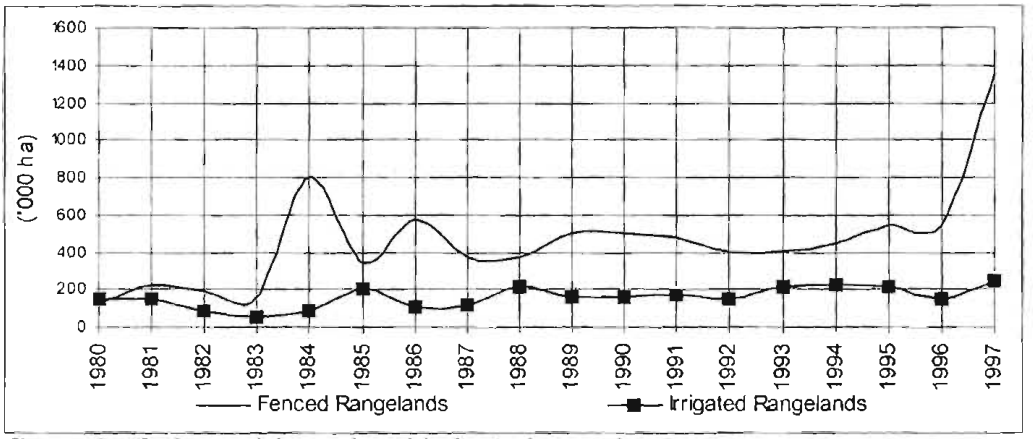

Figure 6.15: **Area of fenced and irrigated rangelands**
Source: Statistics Bureau of Tibet (1997)

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.

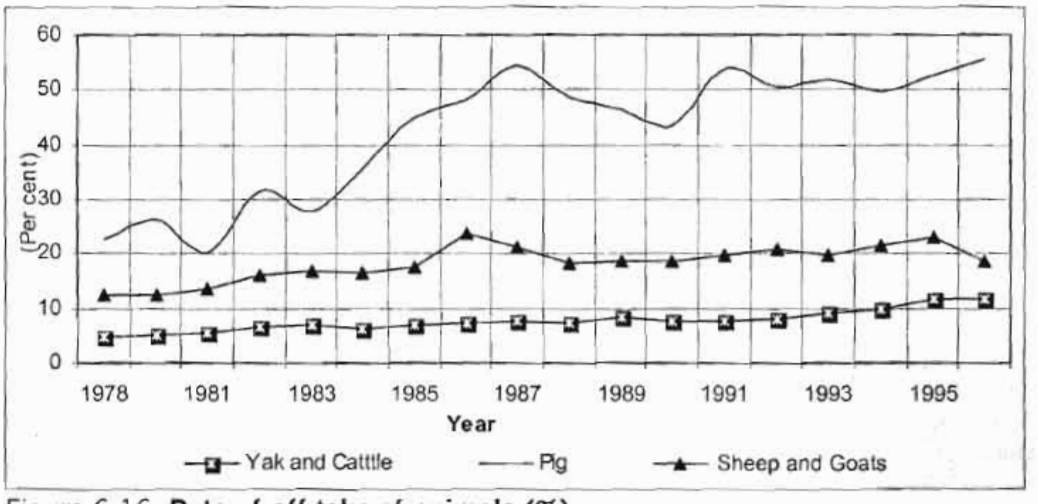

Figure 6.16: **Rate of off-take of animals (%)**
Source: Statistics Bureau of Tibet (1997)

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)

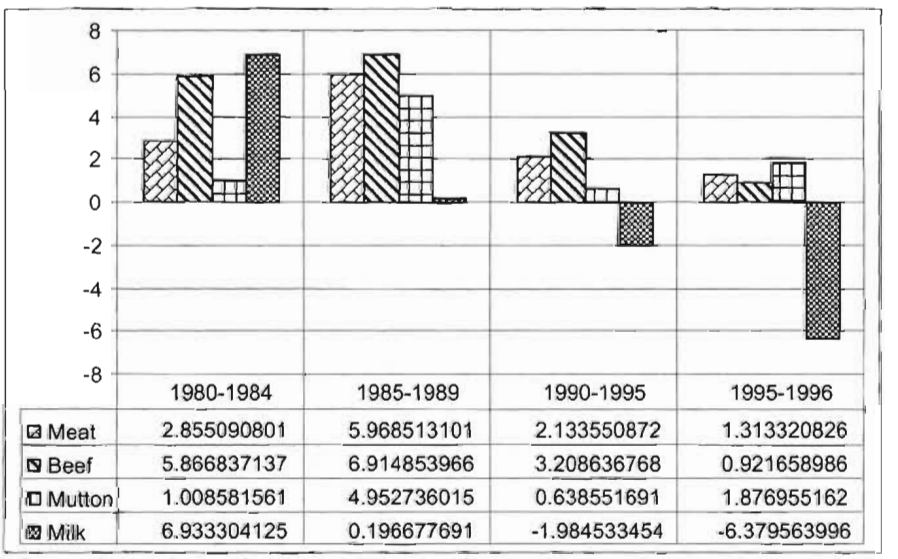

Figure 6.17: **Growth rates of per capita meat, mutton and milk production (%)**

Source: Statistics Bureau of Tibet (1997)

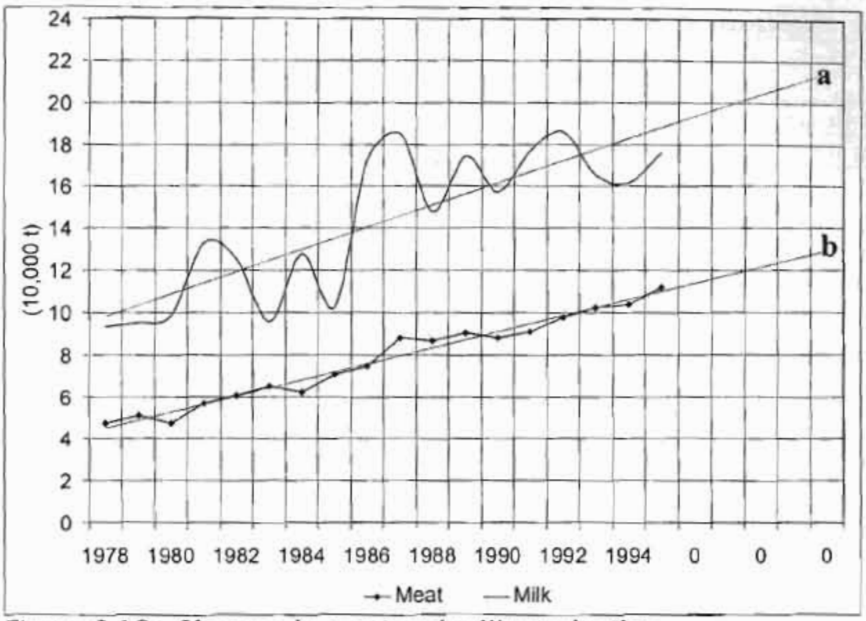

Figure 6.18: **Changes in meat and milk production**
a) $y = 0.5303x + 9.2675$ $R^2 = 0.6789$ b) $y = 0.3807x + 4.1349$ $R^2 = 0.9721$

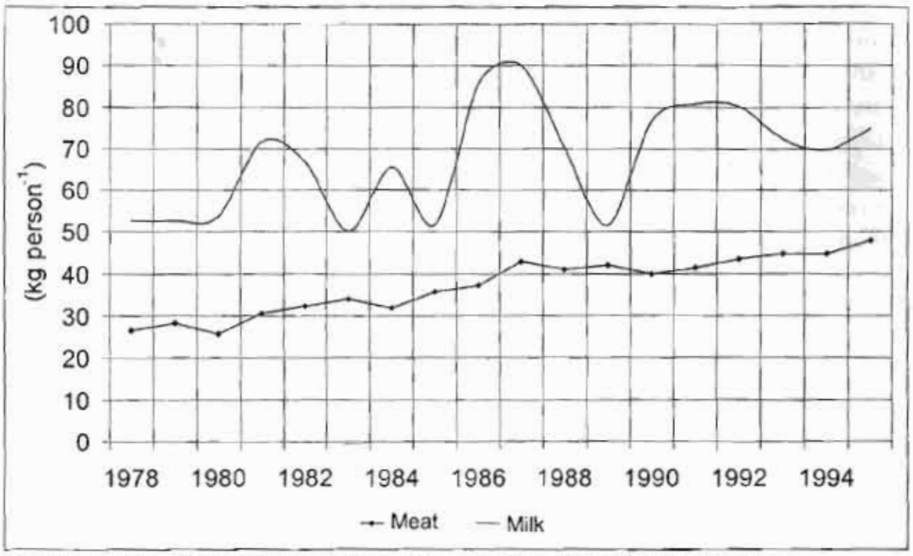

Figure 6.19: **Changes in per capita meat and milk production**

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