*China Climate Change Partnership Framework - Enhanced strategies for climate-proofed and environmentally sound agricultural production in the Yellow River Basin (C-PESAP)*

# Situation Analysis of Ningxia Province


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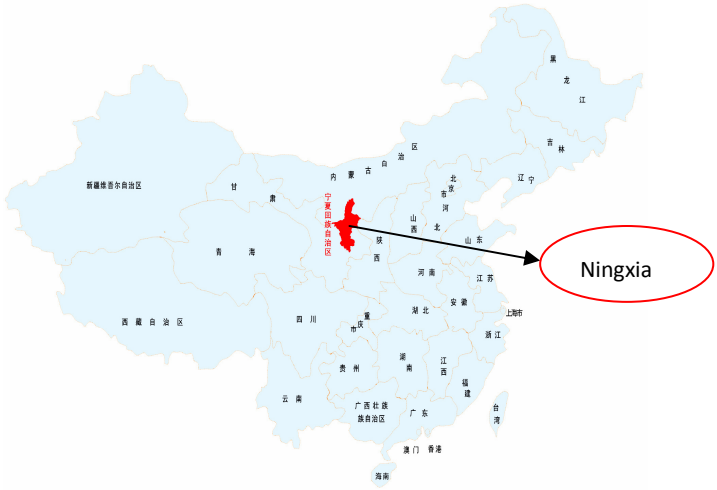
# 1. General Information about Ningxia

## 1.1 Location of Ningxia in the Yellow River Valley and Its Topography

The Ningxia Hui Autonomous Region (hereafter as Ningxia) is located at the upper and middle reaches of the Yellow River at the eastern part of northwest China. It neighbors Gansu Province at the south, Shaanxi Province at the east and the Inner Mongolia at the northeast.




The main stream of Yellow River cuts across Ningxia for 397 kilometers and runs through 12 counties of Ningxia. In Ningxia, there are 17 tributaries, big and small, of Yellow River. Among them, the biggest is Qingshuihe River, with a drainage area of 19,400 square kilometers.

Ningxia stretches 45~250 km from east to west and 465 km from south to north with a total area of 66,400 squ. km. With topography declining from south to north, Ningxia is composed of 6 geomorphic units from south to north, namely mountainous areas at Mt. Liupan, loess hills, inter-mountainous plains, Ordos Mesa, Yinchuan Plain and mountainous areas at Mt. Helan. Of the above, mountainous areas cover 8,179 squ. km (12.3%), plains cover 13,897 squ km (20.9%) and hills cover 19,679 squ. km (29.6%).

Ningxia is composed of 22 counties in 5 municipalities. By the end of 2007, the total population amounted to 6.10 million people, including 3,865,000 rural people (63.4%).

In the terms of geomorphic types and economic development, Ningxia can be divided into 3 districts, namely the Yellow River Irrigated District (YERID) at the plains at the north, dry and desertified district (DDD) at the central part and mountainous and loess hilly district (MLHD) at the south.

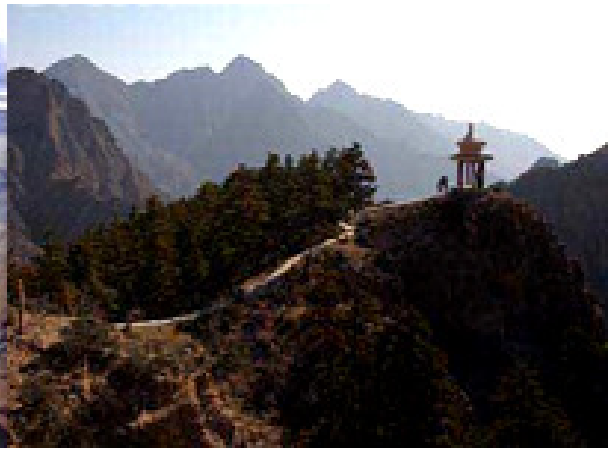
MLHD is composed of mountainous areas at Mt. Liupan and loess hills. It amounts for 31.3% of Ningxia territory. Due to high elevation, the annual precipitation at the mountainous areas at Mt. Liupan at the southern part varies from 600 to 800 mm. In spite of the fact that this is a place with the richest precipitation in Ningxia, due to high mountains, deep valleys and thin layer of infertile soils, the development of agricultural production is rather laggard. Over the loess hills of high erosion at the semi-arid areas at the northern part, slope farmland amounts to more than 70% of the cultivated land. There is also some fertile and flat farmland at valley

beds. Some of the farmland is access to irrigation by reservoirs, tube wells or rivers. This is the capital farmland. The annual precipitation here varies from 400 to 600mm, 60% of which is concentrated from July to September mostly in the forms of heavy rains. The problems of rainstorms and floods are serious and more than 90% of the land suffers from water erosion and soil loss.


DDD is at the margins of Ordos Mesa and Tenggri Desert. It covers 45.4% of Ningxia territory. Due to the limited precipitation less than 300 mm/year, this piece of land suffers from intensive evaporation and land desertification, but this place is rich in sunshine. Around 72% of Ningxia's natural grassland is distributed at this district. Due to dryness, around 88% of the land suffers from erosion. This is the most difficult place in Ningxia in ecological construction and poverty reduction. However, most of the land is relatively flat and not far from the Yellow River, it is a place very suitable for lift irrigation from the Yellow River.


YERID is the most important place of agricultural production in Ningxia. It covers 23.7% of Ningxia territory. It is composed of the alluvial plans along the Yellow River and the diluvial

piedmont of Mt. Helan. Lofty Mt Helan and its good vegetation serve as a natural protector of the irrigated plains against the cold currents and desert aggression from the northwest. The Yellow River flows 397 km through 12 counties in Ningxia. Through the development of irrigation agriculture for more than 2000 years, over 400,000 ha of productive farmland have been built. Thanks to the fertile soils, rich resources of sunshine/heat and well-developed gravity irrigation, this district has become one of the national important producers of grains. Although the farmland at this district is less than one third of Ningxia's total, its grain production and agricultural output value is above two thirds of Ningxia's total and its GDP is close to nine tenths of Ningxia's total. This is a land of honey and milk.



## 1.2 General Features of Ecological System

### 1.2.1 Ecological Types

Ningxia is located at the transitional zone between the eastern monsoon region and northwestern dry areas and between the Loess Plateau and the Ordos Plateau. There are varieties of ecological types such as forests, grasslands, deserts, water surfaces, farmlands and urban areas. Under the control of arid and semi-arid climate, deserty grassland and steppes are major ecological types. Grasslands cover around half of Ningxia's territory.

### 1.2.2 Climatic Features

Ningxia is an inland place. The climate is featured with clear division between seasons, long and cold winter, short and hot summer, plentiful sunshine, limited precipitation and short frost-free period. The annual mean temperature is -0.7~9.9℃. The mean temperature in July (hottest) is 24℃; while it is minus 9℃ in January (coldest). The temperature difference between night and daytime is 12~15℃. The frost-free period lasts around 150 days. The annual sunshine is 3000 hours, and it is one of the places in China with the most plentiful sunshine resources. The annual precipitation amounts to 289mm/year, which declines from south to north varying from 800 to 180mm. The water surface evaporation amounts to 1296 mm/year (44 times the precipitation), which increases from south to north varying from 800 to 1600 mm/year. The climate in Ningxia keeps the same tendency of the global warming-up in recent years. From 1961 to 1987, the variation of the extreme low temperature was 1.5℃, while it was 2.4℃ from 1988 to 2003. Of the 4 years' abnormal downward bias of extreme low temperature in recent 40 years, 3 years was in the periods with clear climate warming-up with frequent droughts, big winds and sandstorms.

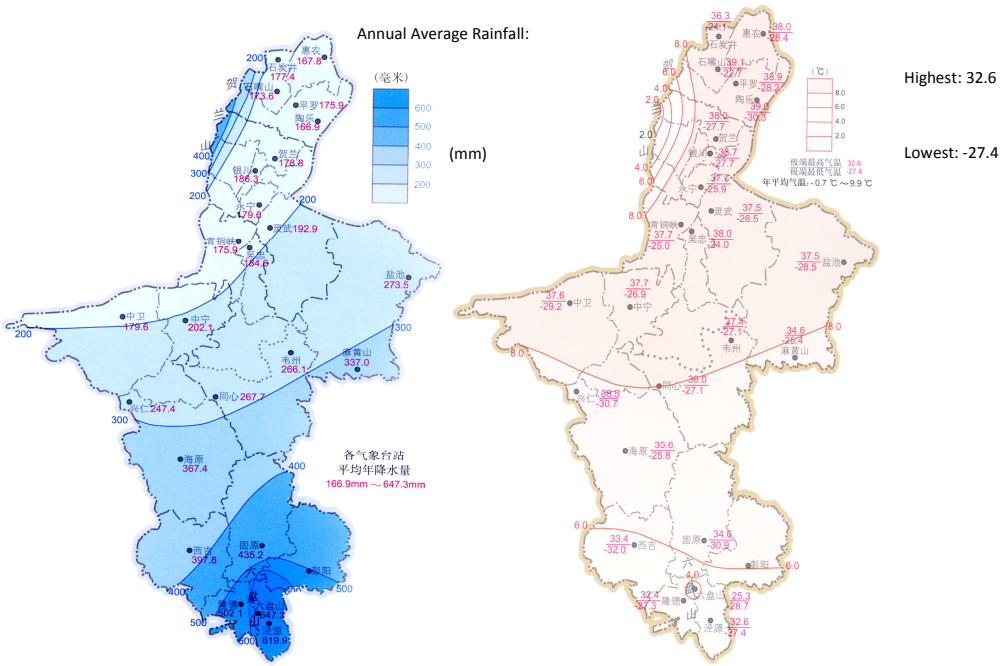



Figure 1.1. Climatic features

### 1.2.3 Present Situation of Natural Resources

Farmland: By the end of 2006, the farmland in Ningxia amounted to 1.1 million ha, including 402,000 ha of irrigated and 698,000 ha of rain-fed. The per capita farmland availability was 0.187 ha (the 4th place in China).

Soils: Ningxia's agriculture has a long history. Of the varieties of soils, grassland soil and deserty soil are the major types. With the decline of precipitation and the increase of accumulative temperature from south to north, the vegetation changes from forest grassland to steppe to deserty grassland and desert, and the eluviation and organic matter

accumulation in soils gradually declines. The soils from south to north are in an order of heilu soil, serozem soil and deserty soil. Due to the high underground water table and historic irrigated farming, the soils at northern Ningxia are fluvo-aquic soil, irrigation-silting soil, alkali soil, salty soil and swamp soil. At Mt. Liupan and Mt. Helan, there is subalpine meadow soil and grey cinnamon soil. Around 95.6% of Ningxia territory is covered by soils (or 4,949,500 ha).

Water Resources: The local water resources totals to 1163 million m3, including 949 million of surface water and 214 million of underground water. The Yellow River is the most important water source for Ningxia, irrigating the northern part. In a normal year, Ningxia is allowed to use 4 billion cubic meters of Yellow River water. In addition to the availability of 150 million cubic meters of underground water, the per capita water availability is 706 cubic meters (around one third of national average). The comprehensive quantity of water resources, the modulus of water resources and the water availability per hectare of farmland in Ningxia amounts to 0.042%, 7.1% and 2.9% of national average, respectively. Ningxia is a typical place of water shortage.

Vegetation: The natural vegetation in Ningxia is composed of that of forests, shrub-lands, meadows, grasslands and wetlands. From south to north, the distribution is forest grassland, steppe, deserty grassland and desert. Under the control of arid and semi-arid climate, grasslands cover 47.24% of Ningxia territory, and grassland vegetation amounts for 79.5% of natural vegetation. Grasslands are distributed mainly at the desertified land at central Ningxia. In 2006, Ningxia had 2,274,300 ha of grassland, including 2,198,960 ha of natural grassland. Impacted by precipitation, the grasslands from south to north are meadow grassland, steppe and deserty grassland. Deserty grassland and steppe with very low vegetation coverage amounted for 55.1% and 24.0% of the grasslands, respectively. In accordance with the survey of forest resources in 2006, Ningxia had 606,430 ha of forest land, and the natural forests were mainly distributed at Mt. Helan, Mt Luoshan and Mt. Liupan. The forested land, shrub land, young forests and nurseries covered 121,490 ha, 104,550 ha, 365,090 ha and 2800 ha, respectively.

Wetland: The wetlands in Ningxia are mainly distributed in the irrigated plains of agriculture. Ningxia has 256,000 ha of wetlands (3.85% of Ningxia territory).

# 2. Agricultural Production in Ningxia

## 2.1 Main Crops in Ningxia and Their Planting Area

The main crops in Ningxia include grains, oil plants, vegetables, pasture grass, etc. Every year, the sown area of farm crops is more than 1.4 million hectares, among which the sown area of grains is 830,000 hectares, that of oil plants 80,000 hectares, that of vegetables 90,000 hectares, and that of pasture grass 400,000 hectares.

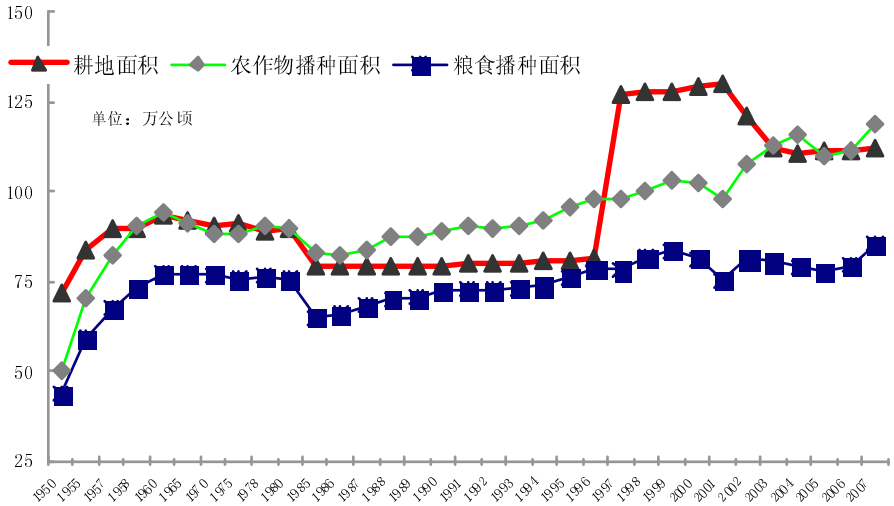



Figure 2.1. Arable land area (red), sown areas of farm crops (green) and sown areas of grains (blue) in 1950-2007

### 2.1.1 Production of Grains

In Ningxia, the crops with the largest sown area are the grain crops, mainly including wheat, rice, corn, potato, and minor cereals, whose sown area accounts for more than 80 percent of the planting area of farm crops. Especially, the Yellow River irrigation area produces 74 percent of the grains in the autonomous region with 29 percent of the arable land, and is an important commodity grain production base in Northeast China and even in the whole country.

In 1984, Ningxia took the lead in realizing food self-sufficiency with surplus in Northwest China. Thus it brought an end to the history of importing food from other places, and its food supply took a historic shift from long-term shortage to the balance of supply and marketing, and from an import province to an export province.

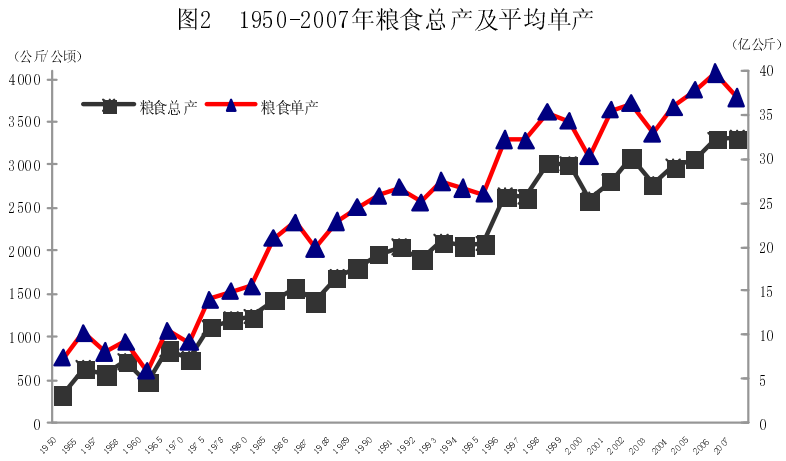



Figure 2.2 Total (black) and average (red) yield of grains in 1950-2007

In 1990, Ningxia's total grain yield exceeded 2 million tons for the first time. In 1993 – 1998, its total grain yield maintained steadily at 2.7 million tons. In 2002, it exceeded 3 million tons. Since 2004, the grain planting areas remains at about 830,000 hectares, with grain yield hitting record high for five consecutive years.

In 2008, the total grain yield in the whole autonomous region reached 3.26 million tons, doubling the figure in 1984. The per-capita share of grain reached more than 550 kilograms, ranking fifth in China. Every year, 100,000 tons of rice and 400,000 tons of corns produced in Ningxia are sold in other provinces and autonomous regions. Among the grain crops, the sown area of rice is 77,000 hectares, with an yield of 605,000 tons; the sown area of wheat is 234,000 hectares, with an yield if 616,000 tons; the sown area of corn is 206,000 hectares, with an yield of 1.466 million tons; the sown area of potato is 201,000 hectares, with an yield of 414,000 tons.

### 2.1.2 Production of Vegetables

During the past 50 years, the vegetable industry in Ningxia has undertaken tremendous change. In the 1960s, there were only 10 vegetable varieties grown in Ningxia. In the 1980s, vegetable production in vinyl houses was greatly promoted in rural areas, and the number of planted vegetable varieties rose to more than 30.

In 2005, planting areas of outdoor vegetables, mainly the vegetables grown in spring and summer, reached 884,000 *mu*, while the planting area of autumn vegetables, mainly dehydrated vegetables and vegetables grown in mountainous area for cold dishes, hit 367,000 *mu*. Among them, the vegetable planting area in protected land was 161,000 *mu*, and that in sunlight greenhouses was 114,000 *mu*. The number of vegetable varieties

exceeded 50, and the annual yield reached 3.579 million tons, with per-capita share of vegetables in Ningxia exceeding 600 kilograms.

The annual revenue reached 2.15 billion yuan, accounting for 26 percent of the total revenue of the planting industry in Ningxia. The vegetable planting industry has become the second biggest sector in the planting industry and one of Ningxia's six advantageous industries with local characteristics. Since 2006, Ningxia has accelerated the development of vegetable production by naming it as an advantageous, characteristic, leading industry for increasing farmers' income. In 2008, the planting area hit 1.3 million *mu*. Especially, Ningxia sets greenhouse vegetables as a model industry for highly efficient and modern agriculture, and gives full play to its advantages of high economic returns, high farmers' income and high land yield rate. As a result, its planting area has reached 650,000 *mu*, accounting for 50 percent of total vegetable planting area. In Ningxia, the vegetable industry has become a highlight of the planting industry that proves highly effective for farmers to increase their income.

### 2.1.3 Production of Pasture Grass

There are 2.40 million hectares of natural grassland available in the arid and semi-arid areas in Ningxia. Since the pasture grass industry is underdeveloped in the autonomous region, the revenue per unit area only equals to a small percentage of that in developed countries. Along with the rapid population growth, large areas of natural grassland were cultivated blindly, and domestic animals graze excessively. As a result, the productivity of the grassland drops, and ecological system and the environment are severely damaged.

To restore and build the ecological system and the environment of the grassland, Ningxia, in recent years, beefs up its efforts to sow grass artificially while closing natural grassland and banning grazing. It introduced 60 high-grade varieties of pasture grass, and formed an industry belt of high-grade pasture grass mainly characterized by planting both grain and grass in the Yellow River irrigation area, using the arid area in the middle part of the region as grassland, and converting cultivated land into grassland in southern mountainous area. The reserved planting area of pasture grass, mainly alfalfa, exceeded 6 million *mu*, with an annual yield of dried clover of 3 million tons. There are 10 pasture grass processing enterprises in the whole autonomous region, with an annual processing capability of 200,000 tons. The reserved area of perennial cultivated pasture surges by 122 percent, and the ratio of cultivated grassland and natural grassland reaches 1:6, ranking among the top in China. The autonomous region also realized stable breeding of all sheep, which had grazed in natural grassland.

### 2.1.4 Production of Oil Plants

The planting area of oil plants in Ningxia is 51,100 hectares, with an yield of 77,500 tons. The per unit area yield is 1,515 kilograms per hectare.

## 2.2 POTENTIAL AND PRESENT STATE OF PRODUCTION OF OTHER CROPS

### 2.2.1 FOREST OF ECONOMIC VALUE WITH LOCAL CHARACTERISTICS.

For many years, Ningxia brings the advantage of local resources into full play, and turns it into economic returns. It stresses characteristics when promoting development of the economic forest industry in the autonomous region, and helps the industry of characteristic economic forest grow big and strong, thus making prominent achievements. In 2008, 2.12 million *mu* of economic forest was built in the whole region, with a total yield of 800,000 tons and a total revenue of more than 5 billion yuan.

The characteristic forestry industry, mainly consisting of Chinese wolfberry, grape, red date, apple, and greenhouse fruit tress (flowers), grows rapidly in its scale and benefits, while its regional advantage becomes increasingly prominent and its structure is constantly optimized. It has been playing an important role in optimizing the agricultural structure in the autonomous region, increasing farmers' income, and boosting county economy, and becomes a new highlight of economic development in the region's rural areas and the increase of farmers' income. Four counties (or cities) have been named by the State Forestry Administration as the "Land of Famous, Characteristic and High-quality Economic Forest in China," and two counties (or cities) are awarded as "Advanced Counties in Building Economic Forest in China."

In the whole autonomous region, the net revenue per *mu* of Chinese wolfberry exceeds 3,500, and the highest net revenue per *mu* can be more than 6,000 yuan. The net revenue per *mu* of grape, apple and red date exceeds 2,000 yuan, and the highest can be more than 4,000 yuan. The net revenue per *mu* of greenhouse fruits exceeds 15,000 yuan, and the highest can be more than 30,000 yuan.

In Zhongning County, a major county producing Chinese wolfberry, the farmers' income from forestry accounts for more than 55 percent of their income, and in some major townships or villages producing Chinese wolfberry, more than 60 percent of the farmers' income comes from the economic forest industry.

At a regular meeting held in October 2008, Ningxia People's Government adopted a development program for four major characteristic economic forest industries, namely, Chinese wolfberry, grape, red date and apple. According to the program, the four major economic forest production bases in the autonomous region will be expanded by 2.47 million *mu* by 2012. Thus the total area will reach 4 million *mu*, and the annual revenue will be 11.6 billion yuan. A group of major counties of the economic forest industry will built with prominent characteristics, large scale and industrialized development, so that the farmers in these major counties of economic forest industry will get more than 40 percent of their total income from the economic forest. By 2020, the revenue will hit 25.8 billion yuan, and more than 60 percent of the farmers' total income will come from economic forest.

### 2.2.2 MINOR GRAIN CROPS

Ningxia has a long history for planting minor grain crops. The production areas are mostly in the central arid zone and the southern mountainous areas, and the main corps include peas, horse beans, haricot beans, grass peas, buckwheat, glutinous millet, millet,

hulless oat, etc. The autonomous region is a major production area of minor grain crops in Northwest China. The minor grain crops are an advantageous resource for the southern mountainous area in Ningxia, and actively boosting a minor grain crops industry with characteristics is of great significance for adjusting and optimizing the crop structure in this region, earnestly protecting and increasing the grain productivity, and promoting coordinated ad sustainable development of ecological system and economy in the poverty-stricken mountainous areas.

The climate is especially suitable for the minor grain crops' characteristics, such as short growth period, wide scope of adaptability, and resistance to drought and infertility. In the mountainous areas in Southern Ningxia, the minor grain crops can both be planted after major crops are harvested, and be suitable for maintains and hills, newly reclaimed wasteland, and some arid and barren land with poor production conditions. Since usually no pesticide or chemical fertilizers are used during their production, these grains are natural green food.

Take some products, such as buckwheat and bitter buckwheat in Yanchi and Pengyang, little haricot beans in Haiyuan and Guyuan, peas in Xiji and Haiyuan, and horse beans in Delong and Jingyuan, for example, their grains are full and round, and superior in quality. Rich in protein and vitamin, they contain high nutritive value, and generally have healthcare and food therapy effects. Favored by the public, they are the main food to adjust the diet, and also an advantageous, characteristic and traditional industry for the local region to improve the land usage rate, optimize the grain production structure, raise the agricultural returns and increase farmers' income.

In 2007, the planting area of kaoliang is 400 hectares, the output is 2,000 tons, and the per unit area yield s 15,784 kilograms per hectare. The planting area of glutinous millet is 22,800 hectares, the yield is 17,500 tons, and the per unit area yield is 767 kilograms per hectare. The planting area of buckwheat is 59,900 hectares, the yield is 46,000 tons, and the per unit area yield is 768 kilograms per hectare. The planting area of soy bean is 7,800 hectares, the yield is 6,500 tons, and the per unit area yield is 830 kilograms per hectare. In mountainous areas in southern Ningxia, a great variety of minor grain crops are planted in small areas, and are not suitable for mechanization of farm work. As labor intensive products, they generally have the problem of high production cost. However, the southern mountainous areas have rich labor resources, thus suitable for planting minor grain crops. Moreover, there are abundant coal and electricity resources, and the minor grains and their processed products have an advantage of lost cost.

## 2.3 FARMING SYSTEM AND MEASURES

The farming system includes: the cropping system (such as crop composition and distribution, intercropping, crop rotation, double/multiple cropping, etc.), the soil cultivation system, the manuring system, the irrigation system, the disease, pest, and weed prevention and control system. Ningxia has different farming systems in different areas due to their different climate.

In the Yellow River irrigation area, the farming system is mainly characterized by the rotation of wet crops and dry crops. There are three farming systems, namely, growing dry crops twice and rice once, growing dry crops once and rice once, and growing rice for

successive years. The ratio of intercropping and multiple cropping is 1:1.4. The soil cultivation system is mainly subsoiling, and the soil is deep ploughed and tedded once a year.

The manuring system is conducted by applying fertilizer in ditches dug deep in the soil, on the top of the soil, and in the planting hole. Generally, pure nitrogen is applied more than 18kg/667m$^2$ and P2O5 is applied more than 8.5kg/667m$^2$. However the usage rate of the fertilizer is less than 40 percent. There are many problems in the unreasonable use of fertilizers: imbalance of organic fertilizer and inorganic fertilizer; Imbalance of nitrogen, phosphorus and potassium in inorganic fertilizer; the basic fertilizer is usually applied too shallow, and phosphate fertilizer is seldom fully absorbed by the root system f the crops, so the fertilizer is not efficiently used; supportive study is lacking of the crops' demand for fertilizers and characteristics of different species; the ratio for straw to return to soil is low; the technology of surveying the soil and making up a formulation to apply fertilizers is not popularized, and the fertilizer is used blindly.

The disease, pest, and weed prevention and control system is mainly carried out through spraying, and pesticide is used 0.7～1.5kg/667m$^2$. In central and southern areas, the planting system is mainly dry farming for successive years. In the pumping irrigation area of Yellow River, the soil cultivation system is mainly subsoiling, and the soil is deep ploughed and tedded once a year. The manuring system is mainly conducted by applying fertilizer in ditches dug deep in the soil, on the top of the soil, and in the planting hole. The irrigation system is mainly flooding irrigation, and 400 cubic meters of water is used per *mu*. In some areas, supplementary irrigation is also carried out, and about 100 cubic meters of pumped Yellow River water is irrigated per *mu*.

In the rain-fed agricultural area, the core of the protective farming is zero or minimum tillage in the soil, using stubble of crops to cover and protect the land surface, and employing supportive agricultural techniques to protect the soil's natural functions and the land's productivity.

In view of the dry climate in recent years, in 2007, the Party branch and the government of the autonomous region made a decision to develop 1 million *mu* of dry farming and water conservation farmland to use plastic membrane, preserve soil moisture, collect rainwater, and carry out supplementary irrigation. Drought-relief techniques and measures, such as supplementary irrigation through rainwater collection, facilities, sand injection, drip irrigation under membrane, moving drip irrigation, seed dibbling under membrane, and hole irrigation by plant divisions. As a result, yield and revenue is effectively boosted even during severe drought.

Especially, for potato, watermelon and other crops planted in the mode of "rain collecting yard, water cellar, rainwater supplementary irrigation, and special crop farming techniques," their net revenue per *mu* can reach 600 – 800 yuan on average. Moreover, in the dry farming area in central and southern Ningxia, since plant diseases and insect pests rarely occur due to dry climate, only every small amount of pesticide is used. In addition, since local farmers have low income and the area is a state-level poverty-stricken area, the farmers invest little in chemical fertilizer.

In recent years, in view of dry climate, Ningxia actively carry out reform of farming system, and promote planting special crops. By adopting measures including returning straw to soil, no-tillage seeding, and surveying the soil and making up a formulation for fertilizer, the Yellow River irrigation area gradually reduces the intercropping area of wheat and corn,

stabilize the planting area of rice, vigorously promote farming patterns including transferring winter wheat to the north, wheat and corn intercropping farm with yield of one ton per *mu*, growing rice in dry land and sparsely and its simplified cultivation, planting corn only with high yield, so as to increase the yield and benefits. In the central and southern areas, the agricultural structure is adjusted promptly. The planting area of summer harvesting crops, such as spring wheat and summer harvesting minor grains, is reduced by a large margin. And the planting techniques such as using membrane to perverse soil moisture, collecting rainwater for supplementary irrigation, and detoxication of potato seeds, are also adopted to expand the planting area of autumn harvesting crops, such as potato and buckwheat.

## 2.4 Price, Income and Profit of Agricultural Produce

In 2007, the operating income of rural residents' families in the autonomous region is 3,896.23 yuan. Among it, the income from the primary industry is 3,344.32 yuan, including agricultural income of 2,081.67 yuan (including grain income of 1,305.20 yuan, oil plants income of 103.31 yuan, vegetable income of 180.95 yuan, flower and gardening income of 5.20 yuan, fruit income of 52.23 yuan, gardeon income of 112.03 yuan, and income of traditional Chinese medicinal materials of 115.46 yuan), forestry income of 8.47 yuan, animal husbandry income of 1,171.14 yuan, and fishery income of 83.04 yuan.

**Table 2.1 Comparison Sheet of Price and Revenue of Major Agricultural Produces in 2007**

| Indicator<br>Species | Total output per mu/head (unit: yuan) | Average selling price per 50 kilograms (unit: yuan) | Cash earnings per mu (unit: yuan) | Net profit per mu/head (unit: yuan) |
|---|---|---|---|---|
| Non glutinous rice | 1,072.91 | 93.29 | 646.88 | 414.22 |
| Wheat | 500.18 | 90.14 | 191.07 | 33.59 |
| Corn | 721.16 | 74.20 | 515.08 | 340.63 |
| Mulberry silkworm cocoons | 1,243.91 | 1,038.18 | 952.68 | 182.47 |
| Apple | 3,623.82 | 84.53 | 2,613.67 | 2,156.09 |
| Chinese wolfberry | 7,342.72 | 1,113.88 | 5,266.85 | 4,593.20 |
| Chinese cabbage | 1,320.77 | 10.74 | 964.07 | 722.87 |
| Free-range hog | 1,281.00 | 646.55 | | 301.97 |
| Hogs raised in small-scale farms | 1,264.68 | 624.59 | | 294.30 |
| Hogs raised in medium-scale farms | 1,419.06 | 647.60 | | 389.84 |
| Free range beef cattle | 4,816.77 | 862.92 | | 2,602.40 |
| Dairy cattle raised in small-scale farms | 11,456.93 | 96.44 | | 3,360.64 |

## 2.5 AGRICULTURAL CREDIT SYSTEM AND NON-AGRICULTURAL INCOME

### 2.5.1 RURAL CREDIT

So far, Ningxia has established a rural credit and lending system with Agriculture Development Bank, Agricultural Bank, Rural Credit Cooperatives, and Postal Savings Bank as its main channel. The rural small-amount credit loans have become the primary source of credit funds for farmers to boost production.

In 2008, Ningxia Rural Credit Cooperatives issued 430,000 “green loan notes,” accounting for 46 percent of the total number issued to farmers in Ningxia. Farmers can use the note to draw money for emergencies, and deal with matters of great urgency in their daily life. The “green loan notes” are used by the method of “examination for once, control of balance, granting the loan on demand, set record for each lean, no limitation on the number of issuance, and revolving use,” to meet farmers’ demand for loans. With the load note, farmers can apply for loans once in need, and the highest amount of the loans can be as high as 5,000 yuan.

In March 2008, the restructuring of Ningxia Rural Credit Cooperatives to a commercial bank officially started, and Yellow River Bank was officially established. In China, Ningxia is the first to restructure the provincial-level cooperatives into a bank, except for Beijing, Shanghai, and some other municipalities, where rural commercial banks had been established. Moreover, the banks at the village or township level have grown fast, and become the major form for the development of capital mutual aid organizations of farmers. Wuzhong City Binhe Village and Township Bank and Pingluosha Lake Village and Township Bank have been established, and the former has initiated a lending mode “without mortgage or guarantee for anti-poverty purpose.”

The lending institutions of small loans include commercial lending institutions of small loans, non-government lending institutions of small loans with the anti-poverty purpose (for example, Yanchi County Women’s Development Association), and the innovative small loan lending institutions which combine rural logistics, rural small loans and capital mutual aid among farmers (for example, Zhangzheng Township Rural Capital and Logistics Regulation Center). Bu August 2008, there are 23 small loan lending companies, with actual paid-in capital of 1.05 billion yuan. They have granted loans of 3.05 billion yuan to small enterprises and farmers, and the loan recovery rate is 100 percent.

### 2.5.2 AGRICULTURAL INSURANCE

Ningxia is one of the provinces and autonomous regions prone to drought, hail, sand storm, flood and other natural disasters. Since it gradually developed in the 1980s, agricultural insurance, by 2008, has been offered to 10 sectors, including greenhouse agriculture, wheat, rice, dehydrated vegetable, breeding sow, and cow, in a mode combining government’s guidance and market operation and by the means of insurance premium subsidy. Thus, it enhances farmers’ ability to withstand risks in agricultural risks.

To relief the farmers’ burdens, Ningxia government promulgated the policy that requires governments at the levels of the autonomous region, cities and counties arrange necessary funds and grant adequate insurance premium subsidy to farmers who subscribe the insurance. Take the premium of the crop farming insurance for wheat, corn and other crops

for example, fiscal subsidy by the autonomous region accounts for 40 percent of the premium, while that from the cities and counties accounts for 30 percent.

Moreover, in consideration of the interests of insurance companies, the government promulgated the following rule about the risk management of agricultural insurance: in normal harvest years , the isurance companies fulfill their responsibilities for the claims in accordance with the insurance contracts, make their own management decisions, and take full responsibility for their own profits and losses. When huge agricultural disaster occurs, the companies set a cap for the total payment of insurance claims. Namely, when the total payment for agricultural insurance in the whole autonomous region claims exceeds certain percentage, the payment is shared by the government and insurance companies.

In 2008, the written premiums of policy agricultural insurance have reached more than 9 million yuan, among which the premium of animal husbandry insurance is 8.41 million yuan, and that of farming insurance is more than 600,000 yuan. Nearly 100,000 cows and breeding sows and 11,000 *mu* of farms are covered by the insurance, and payments of farmers' claims have reached nearly 5 million yuan. Agricultural insurance has played a prominent role in dealing with natural disasters and protecting farmers' interests, and the premium income and payment of claims grow only 10 percent and 15 percent over previous years.

### 2.5.3 PRODUCTION AND OPERATION.

While sticking to rural fundamental economic systems, Ningxia is making conductive explorations about legitimate transfer of rural land. It transfers the management right of rural households' land through the land credit cooperatives, and in various land transfer forms such as subcontracting, lease, transfer, trust, swap, and buying shares with land. While making sure that farmers' land contract rights are unchanged, it concentrates the land and frees the farmers from the traditional production mode. Through intensive operation of the land, it realizes the value-added effect of scale and industrialization, and increases farmers' income.

At present, there are four modes adopted in the agricultural production and operation in Ningxia: the first is the mode of the company, the base and the farmers; the second is the mode led by the intermediary organization (or the intermediary organization, enterprises and farmers for short); the third is the mode driven by the market (or the market, the base and farmers for short); the fourth is the mode driven by the leading industry (or the leading industry, the enterprise and farmers for short).

Non-agricultural income of farmers. In 2007, the per capita net income of rural households is 3,180.8 yuan, and the annual total income is 5,245.19 yuan. Among it, the non-agricultural income is 1,631.37 yuan (including wage income of 1,021.37 yuan, transfer income of 269.5 yuan, and property income of 58.09 yuan), accounting for 31.1 percent of the farmers' total income.

## 2.6 CONTRIBUTION OF AGRICULTURE, FOOD TRANSPORTATION AND PROCESSING TO GDP

In 2008, the added value of agriculture in Ningxia is 12.01 billion yuan, and the contribution rate to the GDP reaches 10.9 percent; the added value of food transportation and processing trade is 12.2 billion yuan, and the contribution rate to the GDP reaches 11.1 percent.

## 2.7 FOOD CONSUMPTION AND DEGREE OF SELF-SUFFICIENCY IN GRAIN

The Yellow River irrigation area is Ningxia is one of the large irrigation areas with advantageous flow irrigation conditions in China, and also a major production base of commodity grain in Northwest China. In 1984, Ningxia is the first to achieve self-sufficiency of food in the northwest region. In 2008, the total food yield in Ningxia reached 3.29 million tons, and the per capita share of food is 540 kilograms.

The food consumption is 202.58 kilograms per capita, among which the consumption of grain is 198.42 kilograms per capital (including wheat 146.96 kilograms per capita and rice 45.85 kilograms per capita), potatoes 3.87 kilograms per capita, beans 0.29 kilograms per capita, oil 6.28 kilograms per capita, bean products 0.51kilograms per capita, vegetables and vegetable products 76.5 kilograms per capita, melons 20.56 kilograms per capita, fruits 23.92 kilograms per capita, tea 0.25 kilograms per capita, meat and poultry 16.18 kilograms per capita (including pork 7.83 kilograms per capita, beef 1.99 kilograms per capita, lamb 2.54 kilograms per capita, poultry 3.48 kilograms per capita, and other meat 0.33 kilograms per capita), eggs and egg products 2.31 kilograms per capita, milk and dairy products 5.00 kilograms per capita, and aquatic products 0.67 kilograms per capita.

The expenditure for food consumption of rural residents is 3.496 billion yuan, accounting for 6.62 percent of the total consumption expenditure; the expenditure for food consumption of urban residents is 7.289 billion yuan, accounting for 13.81 percent of the total consumption expenditure. In 2007, the food income is 1,004.44 kilograms per capital, and the food expenditure is 871.7 kilograms per capita, and the food remainder at year-end 762.47 kilograms per capita. The food supply is self-sufficient.

## 2.8 PARTICIPANTS OF THE PROGRAM AND STAKEHOLDERS

Participants of the program include: Ningxia Development and Reform Commission, Qingtongxia City Agricultural Bureau, Tongxin County Development and Reform Bureau, and Agriculture Sciences Institute of Guyuan Region.

The stakeholders include: farmers, agents for farmers, processing enterprises of agricultural products, and rural specialized cooperatives.

The program is headed by Ningxia Development and Reform Commission. Qingtongxia City Agricultural Bureau, Tongxin County Development and Reform Bureau, and Agriculture Sciences Institute of Guyuan Region select demonstrative sites of the program. They select some techniques that can play a demonstrative and driving role in the development of local ecological agriculture, and by training local technicians, farmers, farmers' agents, processing enterprises of agricultural products, and members of rural specialized cooperatives, and village cadres, apply the selected techniques to the demonstrative sties, so as to achieve the objectives of raising the yield efficiency of resources including light, heat, water and soil, reducing the use of pesticide and chemical fertilizers, slowing down climate change, and increasing the income of farmers and processing enterprises of agricultural products.

## 2.9 CHARACTERISTICS OF FARMERS

Currently, Ningxia has an agricultural population of 3.865 million. In 2008, the farmers' net income is 3,682 yuan, the per capital living expenditure for consumption is 2,528.8 yuan, and the Engel coefficient of rural households is 40.3 percent. In the eight counties in mountainous areas, the low income population (with the annual income less than 1,067 yuan) is 248,000. Among them, the absolutely poverty-stricken population (with the annual income less than 785 yuan) is 88,000, and the poverty rate is 4.3 percent.

In the whole autonomous region, the rural residents' average educational level is below the junior secondary school level. Among rural laborers, the illiterate account for 16.3 percent, those with educational level of the primary school 30.5 percent, those with the junior secondary school level 42.1 percent, and those with the senior secondary school level or above only 11.1 percent. Among them, the average education year of rural laborers in mountainous areas is only 5.84 years, below the educational level of the primary school; the average education year of rural laborers in the plain areas is only 7.93 years, close to the educational level of the second grade in the junior secondary school. Besides, the educational level of future labor force is far from being satisfactory; the dropout rate of the population at age of 7-15 in the autonomous region is 38 percent.

The low educational level of the rural labor force directly results in their low ability to accept and master new technology, absorb new information, and participate in market competition. Among the migrant workers from the autonomous region, the proportion of the illiterates and people with primary school education is higher than the average level of the whole country, whereas the proportion of those with the education of the senior high school or technical secondary school is lower than the country's average level. More than 90 percent of the migrant workers are engaged in the occupations with low occupational skills and poor wages.

## 2.10 FARMERS' ASSOCIATION AND RELEVANT ORGANIZATIONS

In Ningxia, there are currently 892 farmers' specialized economic cooperatives, involving all sectors of rural economic development. Classified by the sectors, 657 are in the farming and animal husbandry sectors, accounting for 73.7 percent; 235 are in the fishery and agricultural machinery sectors, accounting for 26.3 percent. Classified by the service mode, 327 are mainly engaged in the technical and information service, accounting for 36.7 percent; 281 are engaged in purchase and sale service, accounting for 31.5 percent; 245 are engaged in comprehensive service, accounting for 27.5 percent; 39 are engaged in capital and other services, accounting for 4.3 percent.

Classified by the service scope, 131 operate across provinces (or autonomous regions), accounting for 14.7 percent; 115 operate across counties, accounting for 12.9 percent; 338 operates across townships, accounting for 37.9 percent; 308 operate within a township, accounting for 34.5 percent. Classified by the form of establishment, 555 are led by farmers or specialized households, accounting for 62.2 percent; 121 are led by the village community, accounting for 13.6 percent, 64 and 66 are founded by technical departments or leading enterprises, accounting for 7.2 percent and 7.4 percent respectively; 86 are established in other forms, accounting for 9.6 percent.

## 2.11 RESEARCH INSTITUTES, TECHNOLOGY APPLICATION SERVICE CENTERS, AND GOVERNMENT DEPARTMENTS RELATED TO THE FIGHT AGAINST CLIMATE CHANGE

The research institutes include: Ningxia University, Academy of Agriculture and Forestry Sciences, Academy of Social Sciences, Meteorological Research Institute, etc.

The technology application service centers include the agricultural technology application centers, forestry technology application stations, animal husbandry technology application stations, rural clean energy and technology application stations, and the grassland work stations at the autonomous region and county levels.

The government departments involved in fight against climate change include: the Development and Reform Commission, Science and Technology Department, Department of Land Resources, Department of Environmental Protection, Water Resources Department, Agriculture and Animal Husbandry Department, Meteorological Bureau, Forestry Bureau, Leading Group Office of Development-oriented Poverty Relief, etc.

## 2.12 NON-GOVERNMENT ORGANIZATIONS RELATED TO FIGHT AGAINST CLIMATE CHANGE

Ningxia CDM Center. Its primary business is to provide government departments and relevant enterprises with development plans concerning clean development mechanism (or CDM for short) projects, assist relevant enterprises in implementation of approved CDM projects, and act as the sales agency for the reduced emission quota in foreign countries.

Ningxia Poverty Relief and Environmental Improvement Center. It is in the charge of Ningxia Autonomous Region Poverty Relief Office, and is officially registered in the Department of Civil Affairs of Ningxia Hui Autonomous Region (Ningxia, Civil Affairs, No. 060081). It is a non-government organization with the mission of helping and supporting the poor and improve the environment, and also the one truly active in the most impoverished areas with the poorest natural resources in Western China. The center is a member unit of China Association for NGO Cooperation and the Social Benefit Work Committee of China Association of Social Workers.

# 3. MAJOR FACTORS AND DRIVING FORCE OF CLIMATE CHANGE

## 3.1 CLIMATE CHANGE IN YELLOW RIVER VALLEY

### 3.1.1. CHANGE IN AIR TEMPERATURE AND RAINFALL.

According to statistics, since the 1980s, the air temperature in the Yellow River Valley has risen significantly while the rainfall has decreased. The decrease of rainfall has resulted in a tendency that natural runoff volume also falls, and the fall of runoff volume is greater than that of rainfall. In the 1990s, the natural runoff volume in the Yellow River source area is 17.6 billion cubic meters, a fall of 15 percent from the average annual volume. The average annual rainfall is 447 millimeters, and declines from the southeast to the northwest. In the 1990s, the rainfall was at a record low; entering the 21st century, the rainfall shows a slight rise. However, the actual evaporation is on a rise over the years, mainly because the climate change and global warming results in the rise of water consumption for irrigation and other purposes.

Figure 3.1 Distribution of precipitation in Yellow River Basin

### 3.1.2 RAINSTORM AND FLOOD

Since the 1990s, the frequency and magnitude of the rainstorm and flood in Yellow River has fallen, while drought becomes more severe. In the 1950s, nine overbank flood occurred in the lower reaches; over the 15 years of 1986 – 2000, only three floods occurred. Since 2002, the peak flow volume is only 4,200 cubic meters per second.

### 3.1.3 Drought

Along with the climate change, drought and lack of water is the primary problem of Yellow River. According to observation data, the Yellow River Valley has experienced droughts of various degrees since the 1960s. Since the 1990s, the droughts have aggravated with its scope gradually enlarged. The decrease of water supply resulted by climate change is a major cause of the drought in the valley.

### 3.1.4 Floods

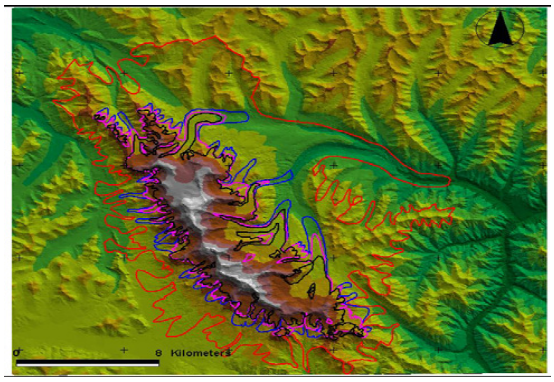
The flood disaster caused by ice blockage in Yellow River. Since the 1990s, the ice flood in Yellow River reaches in Ningxia and Inner Mongolia has shown new features due to the significant rise in winter air temperature:

① The days of the river's blockage decrease, and the dates for the ice to block the river or break up is unstable, making it hard to predict.

② The "hanging river above the ground" continue to rise, and when the river is not blocked by ice, its water level rise constantly, bringing more pressure on the dyke.

### 3.1.5 MELT OF GLACIERS

The melting of glaciers is a proof of climate change. In the past 35 years (1966 – 2000), climate warming has resulted in a 17 percent decrease of the total area of the glacier in Mount Anemaqen located in the Yellow River source area. The snow line in the mountain has risen by nearly 30 meters.




### 3.1.6 RISE OF AIR TEMPERATURE

Leading to the melt of frozen soil in the Yellow River source area. The temperature of seasonal frozen soil rises by 0.3 - 0.7℃, while that of permanent frozen soil rise by 0.1 - 0.4℃. The upper boundary of seasonal frozen oil ascends at a speed of 2 – 10 centimeters a year, while the lower boundary of permanent frozen soil goes up by 50 – 70 centimeters in decades.

### 3.1.7 LAKES AND WETLAND

Many lakes are shrinking or even have disappeared. Grassland deteriorates together with the ecological system. The area of swamp, wetland and lakes reduce by nearly 3,000 hectares compared with 1976.

### 3.1.8 RELATIONS BETWEEN WATER AND SAND

Climate change not only intensifies the problems of less water with more sand, different sources of water and sand, and the disharmony in the water and sand relations, but also brings about the fall of the water volume that goes into the sea, the severe shrink of the river course in the lower reaches of the Yellow River, and rapid development of the secondary handing river. It not only increase the possibility of the burst of the dyke, but also leads to the shrink of the wetland in the river course in lower reaches, deterioration of water quality, and damage to biodiversity.

## 3.2 CLIMATE CHANGE IN NINGXIA

### 3.2.1 CHANGE OF AIR TEMPERATURE

（1）Change of mean air temperature

In the past four decades, the mean air temperature in Ningxia rises conspicuously, and the annual mean temperature goes up at a speed of 0.35℃/10a. After 1986, the mean air temperature rises by 1.02℃, higher than the average value of China. The temperature rise in the central arid area is the most conspicuous, with the Yellow River irrigation area being the second. The southern mountainous area sees the small temperature rise.

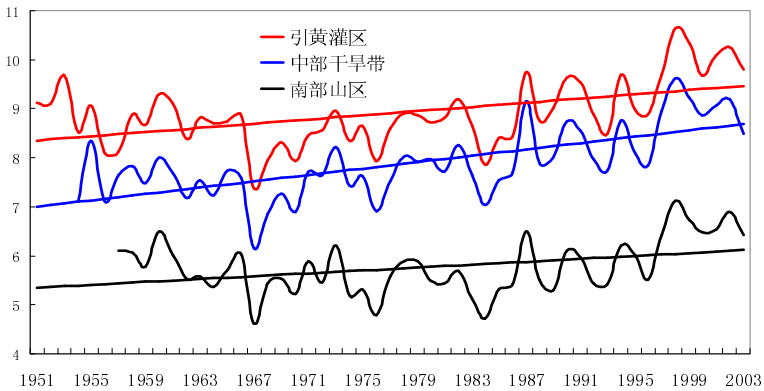



Figure 3.2 Change of mean air temperature in different areas in Ningxia (unit: ℃)

*(Yellow River Irrigated District (YERID) – RED; dry and desertified district (DDD) – BLUE; loess hilly district (MLHD) – BLACK)*

In terms of the change in different seasons, the temperature rise in winter is the biggest, while that in summer is the smallest. Those in spring and autumn are between the two.

Table 3.1. Annual and seasonal mean air temperature change in Ningxia

| Season | Year of sudden change | Mean air temperature for years | Mean temp. before sudden change | Mean temp. after sudden change | Difference between the two |
|---|---|---|---|---|---|
| spring | 1989 | 9.4 | 9.2 | 10.0 | 0.8 |
| summer | 1993 | 20.7 | 20.5 | 21.4 | 0.9 |
| autumn | 1986 | 8.0 | 7.7 | 8.6 | 0.9 |
| winter | 1985 | -5.9 | -6.6 | -4.9 | 1.7 |
| annual average | 1986 | 8.0 | 7.7 | 8.7 | 1.0 |

（2）Change of Maximum and Minimum Air Temperature

In Ningxia, the annual mean maximum air temperature rises at a speed of 0.404℃/10a. The frequency of the days with the temperature above 4℃ increases mostly, and especially the days with high temperature above 32℃ increases more conspicuously.

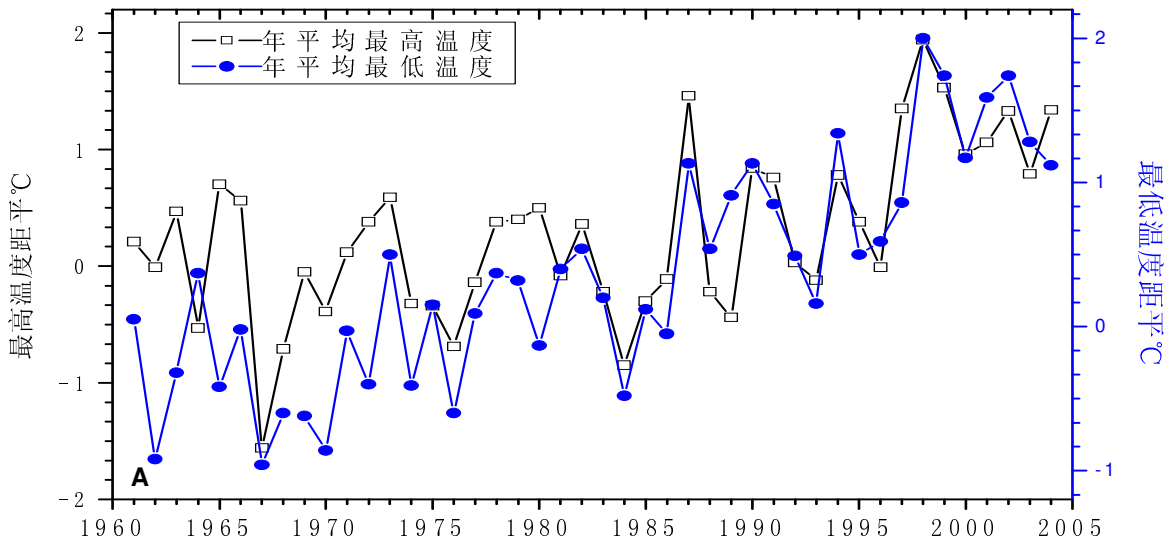



Figure 3.3. Changes of Maximum (black square) and Minimum (blue dots) Temperatures

In the past three decades, the minimum air temperature in Ningxia rises by 3℃. The frequency of days with the air temperature between -16℃～-14.1℃ in winter has shown a prominent tendency of decrease, while frequency of the days with the temperature of -26℃～-24℃ demonstrates a rising trend. Over nearly four decades, four of the five years with the extremely low temperatures happened during the periods with significant climate warming, showing that the extremely cold days are also on the rise even under the climate warming in winter.

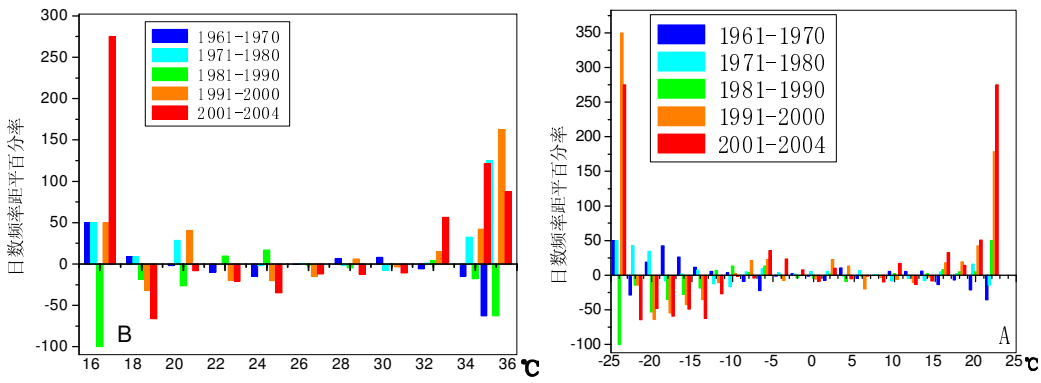



Figure 3.4: Chart of percentage comparisons between frequency of the maximum and minimum air temperature in summer season

### 3.2.2 CHANGE OF RAINFALL

The annual rainfall in Ningxia does not show a strong tendency of change, and is on a slight fall. After 1991, the seasonal change of the rainfall increases. The rainfall in winter and spring reduces prominently, and range of the change of rainfall in summer and autumn is the rise. The days with no rain and the rainfall of 2 millimeters or below increase; the days with the rainfall of 2.1 – 10 millimeters decrease at a speed of 0.9 days per decade; the days with the rainfall of 20.1 – 50 millimeters rise at the speed of 0.144 days per decade. The dates for rainstorms arrives earlier and ends later. Over nearly four decades, the date for the first soaking rain in spring in Ningxia fluctuates without conspicuous trend of rise or fall, and shows increasingly prominent changes since the mid-1980s.

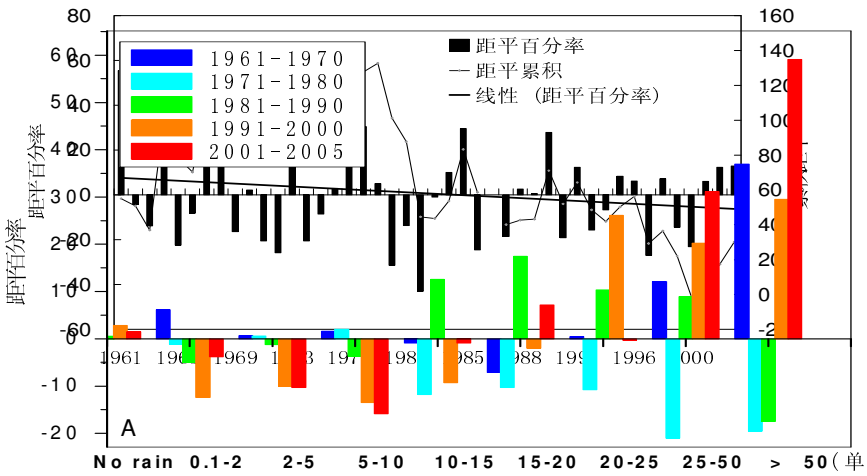



Figure 3.5. Frequency change of the days with rainfall at different levels in Ningxia

### 3.2.3 CHANGE OF AGRICULTURAL CLIMATE RESOURCES

#### (1) Heat Resource Increases

- Accumulated Temperature Rises

In Ningxia, the accu*mu*lated temperatures above 0℃ and 10℃ all show an upward tendency after 1987. In 1987 - 2005, the accumulated temperature in the northern Yellow River irrigation area rises by more than 200℃ compared with 1961 - 1986. That in southern mountainous area is mostly less than 150℃. That in the central arid area is between 150 - 200℃. The increase of the heat resource during crops' growing period is conducive to the expansion of the planting area of the thermophilous crops.

In various parts of Ningxia, the days with the accumulated temperature above 0℃ or 10℃ increase slightly after 1987. But the rise is not big, and is mostly two – six days, which means the actual days suitable for agricultural products does not increase greatly.

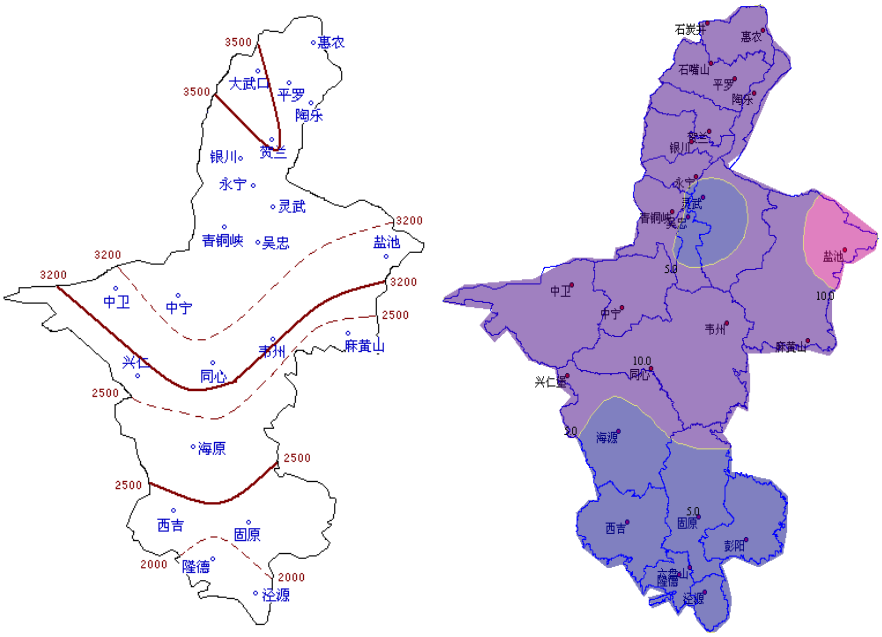



Figure 3.6. Isopleths showing change of the mean accumulated temperature above 10℃ before and after climate warming in Ningxia (left) Differential chart of the days with temperature above 10℃ before and after climate warming in Ningxia (right) (Dashed line" 1961 – 1986; real line: 1987 - 2005)

- Frost free season gets longer while the soil frozen season gets shorter

The frost free season in all parts of Ningxia shows a tendency of getting longer. It increases the most in the zone of Qingtongxia, Wuzhong and Yanchi, with that in Wuzhong reaching 0.65d/a. It increases at the slowest speed in the zone of Yinchuan, Yongan and Lingwu, Zhongning, Haiyuan and Jingyuan, with that in Lingwu being only 0.03d/a.

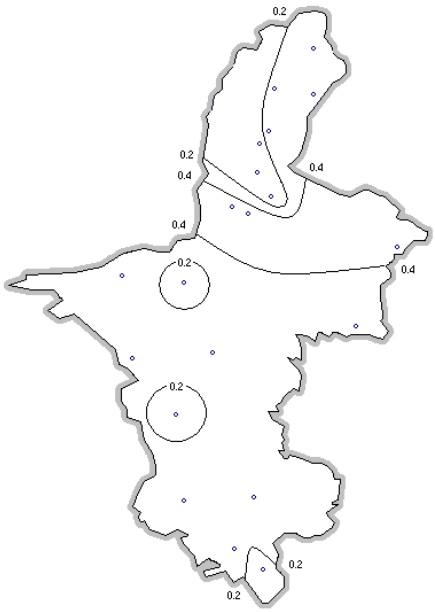



Figure 3.7. Inclination rate of climate in frost free season in all station in Ningxia（d/a）

The depth of frozen soil in Ningxia decease. The date when the soil is frozen arrives late, and the date of thawing arrives earlier, making the soil frozen period shorter.

- The temperature in the coldest month rises, but the rise is unstable

The northern edge of isotherm and the upper edge of altitude with the temperature of -8.0℃, the mean air temperature in the coldest month in Ningxia, both expands prominently. The upper boundary rises by 600 – 800 meters. In 2001 – 2005, the monthly mean air temperature in various parts of Ningxia is all above - 8.0℃. As the climate conditions are suitable for planting winter wheat, the planting area of the winter wheat has expanded northward to Luoping. But in 2008, the monthly mean air temperature is below -8.0℃ in all parts of Ningxia, and the extreme climate posed a great challenge to agricultural production.

Table 3.2 The Monthly Mean Air Temperature in the Coldest Month in Different Decades in Various Stations in Ningxia

| Station | 1960's | 1970's | 1980's | 1990's | 2001～2005 |
|---|---|---|---|---|---|
| Huinong | -9.5 | -8.9 | -8.1 | -8.2 | -6.5 |
| Luoping | -9.5 | -9.0 | -8.2 | -8.0 | -5.8 |
| Taole | -10.2 | -9.9 | -9.0 | -8.6 | -7.2 |
| Helan | -9.5 | -8.9 | -7.8 | -7.5 | -6.1 |
| Yinchuan | -9.1 | -8.6 | -7.7 | -7.6 | -6.1 |
| Yongning | -8.7 | -8.1 | -7.3 | -7.4 | -5.9 |
| Lingwu | -8.1 | -7.9 | -7.5 | -7.4 | -6.1 |
| Wuzhong | -7.7 | -7.3 | -6.5 | -6.5 | -5.0 |
| Qingtongxia | -7.7 | -7.4 | -6.6 | -6.4 | -4.7 |

| | | | | | |
|---|---|---|---|---|---|
| Zhongwei | -8.3 | -7.9 | -7.2 | -7.6 | -6.2 |
| Zhongning | -7.6 | -7.1 | -6.6 | -6.7 | -5.3 |
| Yanchi | -9.0 | -8.7 | -7.9 | -7.7 | -7.3 |
| Mahuangshan | -8.2 | -8.1 | -7.5 | -7.5 | -6.4 |
| Tongxin | -8.7 | -7.9 | -6.8 | -6.6 | -5.6 |
| Xingren | -10.3 | -9.8 | -9.2 | -9.1 | -7.8 |
| Haiyuan | -7.0 | -6.8 | -6.4 | -6.4 | -5.1 |
| Guyuan | -8.1 | -8.4 | -8.0 | -8.0 | -6.0 |
| Xiji | -9.2 | -9.2 | -8.8 | -8.8 | -7.4 |
| Delong | -8.7 | -8.4 | -7.8 | -7.9 | -6.9 |
| Jingyuan | -6.9 | -7.1 | -6.7 | -6.8 | -5.4 |

- Rainfall Decreases during Crops' Growing Period

In terms of the change of the climate inclination rate of the rainfall during crops' growing period in various parts of Ningxia, only the climate inclination rate in Luoping and Zhongwei is a positive value; all others are negative. This shows a falling tendency of rainfall during crops' growing period in most parts of Ningxia. Among them, the falling tendency is the most conspicuous in the southern mountainous area. In terms of the differentials between the mean precipitation during crops' growing period in 1991 – 2005 and that in 1961 – 1990 in various parts of Ningxia, the figure is high only in Luoping, Qingtongxia, Zhongwei and Yanchi, and low in all other places with that in the southern mountainous area being the lowest. Although the rainfall in Qingtongxia and Yanchi is high, the climate inclination rate of the rainfall is negative, showing that there is still a falling trend of the rainfall.

Table 3.3 Differentials between the mean precipitation during crops' growing period in 1991 – 2005 and that in 1961 – 1990 in various parts of Ningxia

| Station | Climate inclination rate (unit: mm/a) | Differentials of rainfall (unit: mm) |
|---|---|---|
| Huinong | -0.67 | -13.6 |
| Luoping | 0.25 | 1.7 |
| Taole | -0.21 | -8.2 |
| Helan | -0.60 | -14.5 |
| Yinchuan | -0.43 | -6.2 |
| Yongning | -0.52 | -11.0 |
| Lingwu | -0.39 | -9.5 |
| Wuzhong | -0.14 | -7.9 |
| Qingtongxia | -0.05 | 1.9 |
| Zhongwei | 0.08 | 8.6 |

| | | |
|---|---|---|
| Zhongning | -0.81 | -17.0 |
| Yanchi | -0.13 | 20.7 |
| Mahuangshan | -1.14 | -24.6 |
| Tongxin | -0.49 | -9.4 |
| Xingren | -0.61 | -3.4 |
| Haiyuan | -0.85 | -6.9 |
| Guyuan | -1.91 | -38.0 |
| Xiji | -1.39 | -39.1 |
| Delong | -1.66 | -41.1 |
| Jingyuan | -0.61 | -33.0 |

### 3.2.4 CHANGE OF AGRICULTURAL METEOROLOGICAL DISASTERS

**（1）Change of Drought**

Under the background of global warming, the number of severe dry spells increases considerably. Especially, the severe dry spell of more than 90 days without rain entered a phase of sharp increase in the nid-1990s, and is now in a high-incidence period. The Yellow River irrigation area and the central arid belt is the areas that see significant increase.

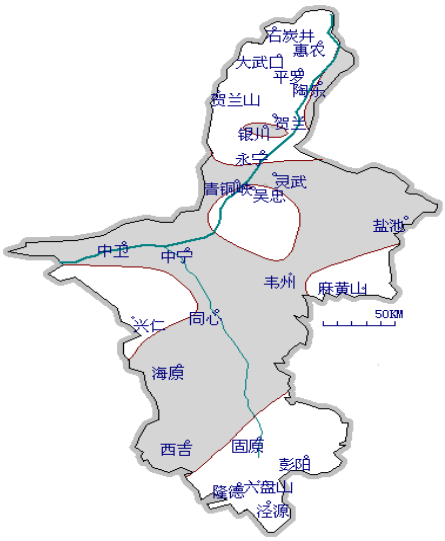



Figure 3.8 The changing trend of the frequency of extreme dry spells in 1961 - 2004 in Ningxia

**（2） Change of Frost**

Over the past four decades, the frequency of frost in Ningxia drops considerably. The possibility of spring frost is much higher than the autumn frost, and the ending date of spring

frost changes greatly. The starting and ending date of frost does not come earlier, and the damage of frost has aggravated.

**（3）Change of Wheat Dry Hot Wind**

In Ningxia, the frequency of wheat dry hot wind is on the rise. The wind occurs the most in the late June, and the area for the wind to occur shows a tendency of expansion with greater intensity. Due to warm climate, the growing period of wheat comes earlier, so the period for the wind to affect wheat also comes earlier.

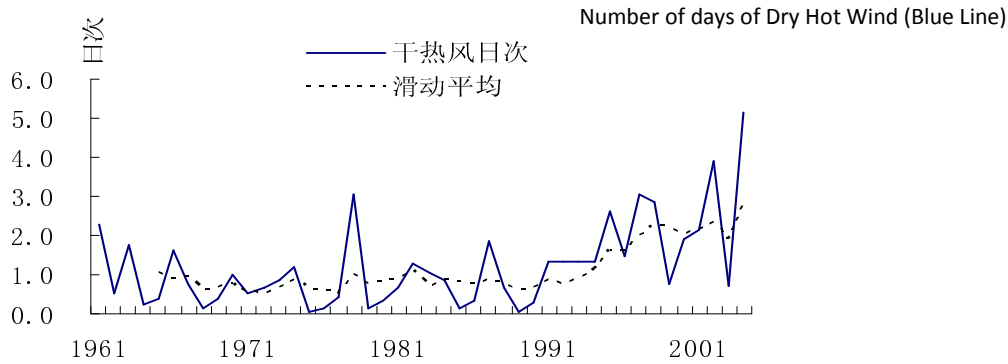



Figure 3.9 Change of Wheat Dry Hot Wind

**（4）Cold Weather Damage to Rice**

Along with climate warning, the probability for rice to suffer cold weather damage is gradually diminishing, and the risk of growing rice also declines. However, under climate warming, the intensive of the cold weather damage does not necessarily decrease, as late-ripening rice is planted in large areas. The loss of production reduction caused by cold weather does not reduce.

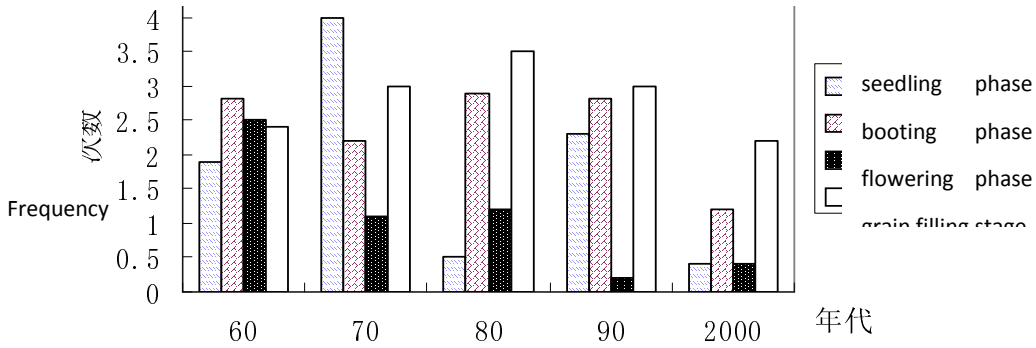



Figure 3.10. Year-to-year change of cold weather damage in different growing period of rice in 1961 - 2006

**（5）Others**

The frequency of rainstorms increases in Ningxia. The rainstorms come earlier and end late. The intensive of cold waves rises. In recent years, although the frequency of sandstorms

drops considerably, the possibility of strong sandstorms increases. Extreme hot spells occur occasionally, the warm winter occurs frequently.

### 3.2.5 FUTURE TREND OF CLIMATE CHANGE IN NINGXIA

By using PRECIS, the regional climate model of Britain's Hadley Climate Center, we have analyzed the change of surface air temperature and precipitation in Ningxia in 2071 – 2100 (2080s) compared with the climate benchmark period in 1961 – 1990, under the background of emission of greenhouse gas. The result shows the air temperature in Ningxia will continue to rise, and the high temperature of more than 40℃ may happen. The precipitation will change in wide range, but the precipitation in summer will drop considerably. The margin of the temperature's rise is much greater than that of the rise of precipitation, so drought will still the major disaster in Ningxia and shows a trend of aggravation. Extreme weather such as high temperature, drought and flood has greater possibility to occur, and will greatly affect economic and social development and life of the public.

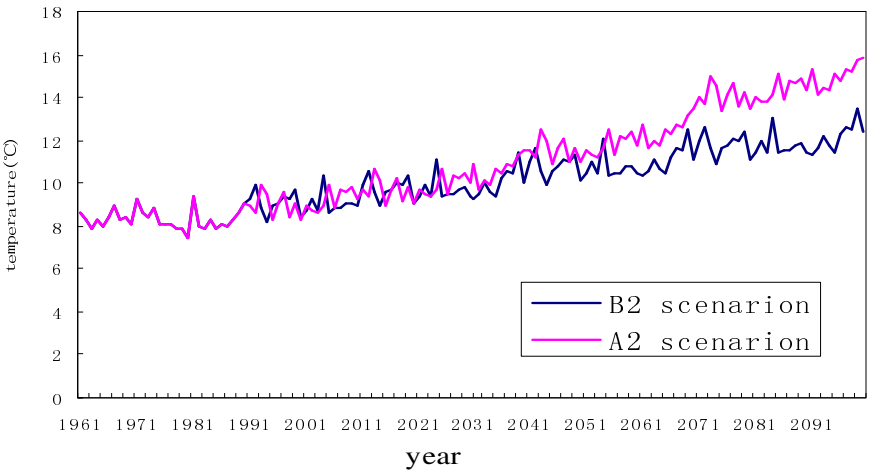



Figure 3.11 Future change of annual mean air temperature in Ningxia under climate change scenario

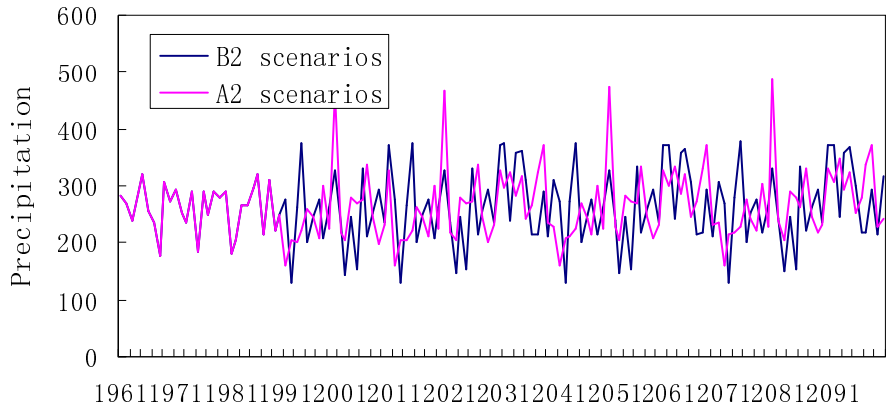



Figure 3.12. Future change of annual precipitation in Ningxia under climate change scenario

## 3.3 Other Driving Factors of Climate Change

### 3.3.1 Human activities result in climate change

Firstly, population growth, migration and urbanization lead to climate change. Since Qin and Han dynasties, Yinchuan Plain and the banks of the Yellow River have been populated by humans who were engaged in farming activities. At that time, people had small influence on the nature due to their thin population and backward technology. In Song, Western Xia, and Yuan dynasties, as a result of social and economic development, population growth, frequent wars, and large scale destruction of forest and grassland, the ecological system began to deteriorate and shortage of water resources emerged. Consequently, large areas of farms and oasis had not water to moisten them and the land laid waste and was eroded by wind and sand.

In Ming dynasty, tens of thousands of soldiers and civilian workers flocked to Ningxia, and built barracks, cooked and warmed themselves. After years of grazing and logging, desertification occurred in the north of Ningxia. The forest deep in Liupanshan Mountains in the south also suffered destruction in large areas. The 99 springs in Helanshan Mountains, 72 springs in Xiangshan Mountains and 72 rains every year in Luoshan Mountains, which stilled existed in Western Xia Dynasty, completely disappeared at that time. Qingshuihe River, which had abundant emerald water all year long and green mountains on its banks, has become a dry seasonal river. Once it rains heavily, muddy water overflows. The Qingshuihe River Valley has become the area where water loss and soil erosion is the most serious with 50 million tons of mud and silt flowing into the Yellow River every year. In Yuanyang Lake in the east of Tongxin County and Yuanyang Lake nearby Baiji shoal in Lingwu County, the place where water could be seen by inserting a achnatherum splendens into the ground, became saline land and small dunes.

The second cause is economic growth and industrialization. Ningxia is one of the most underdeveloped province and autonomous region in terms of economy in China. In 2008, the GPD of autonomous region reached 107 billion yuan, exceeding the 100 billion yuan mark. The development of industry began in 1958. After 50 years of development, an industrial structure and system with coal and electricity as its basic industry and petrochemical, metallurgy, machinery, textile, building materials and medicine as its pillar industries, began to take shape. Since 1998, Ningxia's GDP growth rate is close to average level of the whole

county, but its aggregate economic volume remains small. In 2008, the industrial value added is only 48.51 billion yuan, and the per capita GDP legs far behind the country's average level. Moreover, because of the energy saving and emission reduction measures taken by the country in recent years, the economic growth of Ningxia's industry sees a downturn. Therefore, economic growth and industrial development have limited influence on climate change.

The third is the change of land utilization. In the year-end of 2007, the land used in Ningxia is arable land of 16.95 million *mu*, garden of 514,900 *mu*, forest of 9.0955 million *mu*, meadow of 34.0081 million *mu*, other agricultural land of 2.4274 million *mu*, land for residential area and enterprises and mining of 2.7537 million *mu*, and other land of 1.2191 million *mu*. The per capita share of the land in the autonomous region is 12.71 *mu*, and per capita share of arable land is 2.71 *mu*. Due to population growth, the per capital share of land decreased by 0.26 *mu* compared with the previous year, and the per capital share of arable land reduced by 0.04 *mu*. The occupation of arable land for construction purpose is the primary cause of the reduction of arable land.

Table 3.4 Change of All Types of Land in 2007

Unit: *mu*

| Type of land | | Area in beginning of the year | Area in end of the year | Reduction in the year | Increase in the year | Net increase or decrease |
|---|---|---|---|---|---|---|
| Agricultural land | In total | 62655834.4 | 62641007.7 | 29637.5 | 14810.8 | -14826.7 |
| | Arable land | 16502395.0 | 16595099.5 | 22421.2 | 115125.7 | +92704.5 |
| | Garden | 515540.9 | 514914.3 | 626.6 | 0.0 | -626.6 |
| | Forest | 9096484.7 | 9095509.7 | 3302.8 | 2327.8 | -975.0 |
| | Meadow | 34114753.6 | 34008060.2 | 107373.5 | 680.1 | -106693.4 |
| | Other agricultural land | 2426660.2 | 2427424.0 | 2731.0 | 3494.8 | +763.8 |
| Construction land | In total | 3079782.0 | 3128837.0 | 122.8 | 49177.8 | +49055.0 |
| | land for residential area and enterprises and mining | 2708736.4 | 2753652.1 | 391.0 | 45306.7 | +44915.7 |
| | Land for transportation | 267378.6 | 271172.3 | 41.9 | 3835.6 | +3793.7 |
| | Land of water conservancy facilities | 103667.0 | 104012.6 | 0.0 | 345.6 | +345.6 |
| Unused land | In total | 12195946.3 | 12161718.0 | 39703.9 | 5475.6 | -34228.3 |
| | Unused land | 10984696.0 | 10942570.3 | 42370.2 | 244.5 | -42125.7 |
| | Other land | 1211250.3 | 1219147.7 | 1869.2 | 9766.6 | +7897.4 |

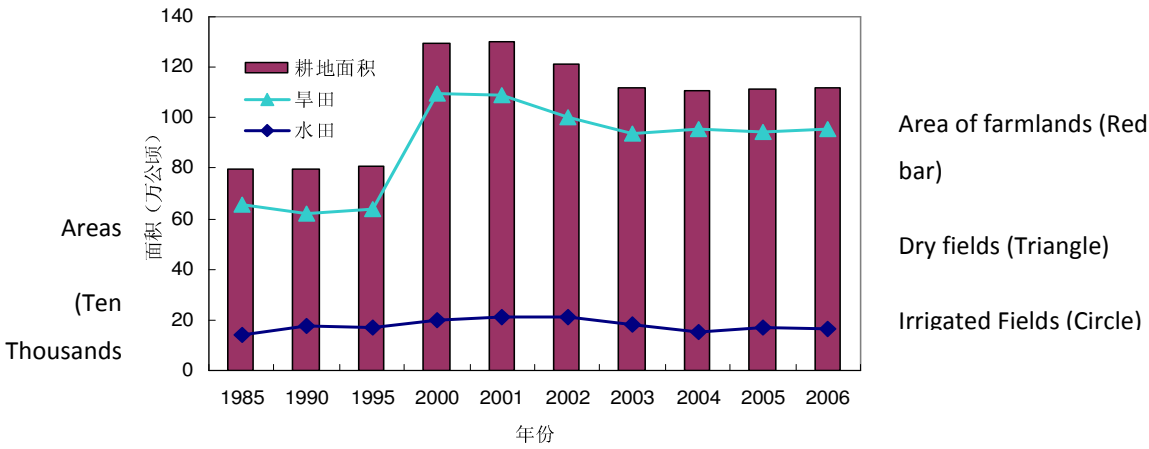



Figure 3.13. Land Use

# 4. Vulnerability of Agricultural Ecological System, and Potential Influence of Climate Change and Other Causes of Change on Agricultural Production

## 4.1 Influence on Growth of Crops

The rise of accumulated temperature is beneficial to the expansion of the planting area of thermophilous crops. The farming area of winter wheat has expanded northward to nearby Luoping.

The rise of air temperature speeds up the growth of spring wheat, shortens the growth period, and influences the accumulation of dry matter. Especially, as the air temperature in spring rises conspicuously, the shortening of the ear differentiation stage of spring wheat has great influence on the structure of grains. The rise of the occurrence of hot dry wind is generally adverse to the yield of spring wheat. The contribution rate of climate change to the per unit area yield of wheat is -2.6 percent.

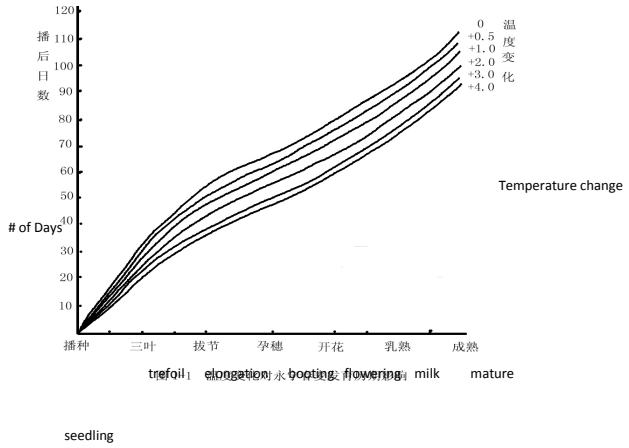



Figure 4.1 Impact of temperature change to various growth phases of wheat

The rise of air temperature provides conditions for introduction of high yielding varieties of rice, lowers the sensitivity of rice to temperature change, and reduces the change rate of the per unit area yield of rice, thus ensuring the high and stable yield of rice. The contribution rate of climate change to the per unit area yield of rice in Yellow River irrigation area in Ningxia is 2.51 percent.

Since climate change occurs, the air temperature in then Yellow River irrigation area in Ningxia has not surpassed the preferential temperature for corn, and is generally beneficial to the growth of corn. The contribution rate to the per unit area yield of corn is 4.47 percent.

Generally speaking, since climate change occurs, the air temperature in Ningxia has not surpassed the preferential temperature for wheat, corn, rice and potato. The crops' growth period comes earlier, the days of the whole growth stage shortens, and the total water demand increases. The growth of crops is under the threat of high temperature, drought and

frost. The technology's contribution to agricultural production offsets of the negative influence of climate change.

In Ningxia, vegetation is under the influence of precipitation and temperature. The former is the main factor, that is. The fluctuation of precipitation is the main cause of the fluctuation of vegetation coverage in Ningxia. In the past 20 years, the vegetation coverage in the central arid area is on the rise, and the rise is especially large in autumn. In the southern mountainous area the change is not big. In Helan Mountains and the eastern slope, it changes greatly in spring and autumn. In 2001 – 2004, the area with medium and high vegetation coverage in autumn in different areas in Ningxia was on the increase, while precipitation did not increase. Therefore, enclosure of the hillsides to prohibit grazing and facilitate afforestation and building of ecological environment has taken effect.

## 4.2 Frequency of Floods and Droughts

In the autonomous region, the agricultural activities is under the influence of drought, flood, sand storm (wind), hail, frost, heavy rain, high temperature, freezing damage and other natural disasters. In 1994 - 2000, 23 percent of the arable land has been damaged. On average, 193,500 hectares of arable land is affected by meteorological disasters every year, and 142,300 hectares was damaged. Among them, the damages caused by drought, hail and frost are the biggest, accounting for 55 percent, 21 percent and 10 percent of the total area.

## 4.3 Decrease of Available Water Resource

Located in the hinterland of northwest China, and surrounded on three sides by desert, Ningxia has typical continental climate. For years, the mean precipitation is only 289 millimeters, whereas evaporation discharge is as high as 1,250 millimeters. Therefore, the autonomous region is short of water resource. The per capital share of water resource is only 193 cubic meters. If taking into consideration of the consumption quota of 4 billion cubic meters of Yellow River's water allocated by the state, the per capita share is only 687 cubic meters, about one third of the average level of China, making it an area with severe water shortage. Besides, the impeded progress of water conservancy project construction, and poor water quality results in the simultaneous existence of water shortage caused by resource, quality and project.

Especially in recent years, high air temperature and drought has aggravated the water shortage in southern mountainous area and the central arid belt. The water resource shortage greatly affected the balanced social and economic development in Ningxia. It is mainly manifested in the lack of drinking water for human and animals in rural areas, water for grains in central arid and southern mountainous areas, seasonal irrigation water in the irrigation area, water for recovery of water ecological environment, water for construction of energy and chemical industry bases, and water for urbanization.

The total water resource in Ningxia is 1.1633 billion cubic meters. The average water generation modulus is 22,500 cubic meters per square kilometers. Among it, the surface water resource is 949.3 million cubic meters, underground water resource is 3.0733 million cubic meters, and the double counted volume is 2.8593 billion cubic meters. At present, the available water resource mainly include the volume of available Yellow River water resource and local water resource.

For many years, local available surface water resource is 447 million cubic meters on average. Among it, the available volume of local surface water in Yellow River's tributaries in Ningxia, such as Qingshuihe River, Huluhe River and Jinghe River, is 297 million cubic meters. The volume of available water resource of the difference of water infiltration of the base flow of rivers in northern Yellow River irrigation areas is 150 million cubic meters. According to the allocation plan for Yellow River's water formulated in 1987, Ningxia can consume 4 billion cubic meters of Yellow River's water resource, including the available water resource in the tributaries before the South-to-North water diversion project is put into operation. Therefore, with the allocated water of Yellow River, the volume of available water resource in Ningxia is 4.15 billion cubic meters.

## 4.4 Decrease of the Soil's Fertility and Soil Desertification

The soil in the autonomous region does not have rich natural fertility. Most of the soil has coarse texture, low organic content, and insufficient moisture. Soils with low and hard-to-use fertility, such as alluvial soil, aeolian sandy soil, skeletal soil, lithosoil, red clay, and alkaline saline soil, account for 28.6 percent of the total area of the soil.

Ningxia is located between Loess Plateau and Tengger and Mu Us deserts, and is one of the provinces and autonomous regions that suffer severe wind and sand disaster. In 1949, the area of desertified land is 24.75 million *mu*. According to results of the third nationwide survey of desertification in 2004, the area of desertified land reduced to 17.739 million *mu*, accounting for 22.8 percent of the total area of the autonomous region. The desert is distributed in 16 cities, counties and prefectures in the autonomous region. Classified by their type, the deserts include 1.92 million *mu* of migratory dunes, 1.413 million *mu* of semi fixed dunes, 1.021 million *mu* of fixed dunes, 1.727 million *mu* of Gobi desert, 30,000 *mu* of wind eroded inferior land, and 2.44 million *mu* of desert farming land.

The autonomous region has 5.355 million *mu* of land with strong desertification trend, accounting for 6.9 percent of its total area. In 1994 – 2004, the area of desertified land shows a reversal trend in Ningxia. Compared with 1999, the desert decreased by 381,000 *mu* in a total, and 75,000 *mu* every year. Compared with 1999, the area of migratory dunes reduced by 840,000 *mu*, that of semi fixed dunes by 915,000 *mu*, that of fixed dunes by 945,000 *mu*.

## 4.5 Salinization of the Soil

In Ningxia, there are 14.79 hectares of saline and alkaline land, accounting of 33.5 percent of the arable land in the irrigation area. Among it, the area of lightly saline and alkaline land is 93,900 hectares, that of moderately saline and alkaline land 34,200 hectares, and that of heavily saline and alkaline land 19,800 hectares, accounting for 21.3 percent, 7.8 percent and 4.5 percent of the arable land respectively.

## 4.6 Other Factors that Influences the Environment

Global climate warming leads to the decline of precipitation in the Yellow River Valley, and it is increasingly common that droughts are more severe than flood. In most areas, the grass and wood do not fully grow. The yield of grass and vegetation coverage declines. The land surface is dry and easy to be broken, and venerable to wind erosion and desertification

due to the frequent deflation of wind. The condition is adverse to dry farming and animal husbandry of natural grazing, and poses a threat to the stability of the ecological system.

## 4.7 Impact on Agricultural Production

Environmental pollution during agricultural production include: chemical fertilizer, pesticide, and agricultural film used during agricultural production, feces produced in animal husbandry, straws of crops, human excrement and urine, sewage by rural residents, and household garbage. And the area source pollution caused by them is increasingly prominent. Especially after enclosure of hillsides to prohibit grazing and facilitate afforestation, the animal husbandry production is increasingly concentrated, making the agricultural pollution in rural areas more conspicuous.

The increased use of chemical fertilizer and pesticide has severely affected the safety of agriculture products. The volume of feces produced by domestic animals and fowls in the whole autonomous region is more than one time of that of solid industrial waste. 98 percent of livestock and poultry farms do not have facilities for comprehensive utilization and waste water treatment. Solid waste is piled up at will, and the waste water of animal husbandry is discharge at discretion.

The ammonia and nitrogen emitted by agricultural area source account for as high as 30 percent – 55 percent of the total emission in the whole autonomous region. The eutrophication in water bodies in Ningxia is serious. The area of land irrigated by polluted water reaches 13,000 hectares, and shows a rising tendency.

# 5. ASSESSMENT OF THE INFLUENCE OF AGRICULTURAL PRODUCTION ON ENVIRONMENT

## 5.1 EMISSION OF GREEN HOUSE GASES AND CARBON FIXATION

In 2007, the total emission of green house gases in Ningxia was 88.7814 million tons of carbon dioxide equivalent. Among it, the mission of methane was 2.922 million tons of carbon dioxide equivalent, accounting for 3.27 percent, that of nitrous oxide emitted by animal husbandry was 670,500 tons, accounting for 0.76 percent; that of methane emitted by farms was 466,100 tons, accounting for 3.86 percent; that of nitrous oxide is 3.4296 million tons, accounting for 3.86 percent; the carbon dioxide absorbed by forest carbon sinks was -1.5625 million tons of carbon dioxide equivalent, accounting for -1.76 percent.

## 5.2 EXCESSIVE UTILIZATION OF WATER RESOURCE

### 5.2.1 SHORTAGE OF WATER RESOURCES IN NINGXIA

Ningxia has only Yellow River running through its territory, and have no large lakes, and the several small lakes have no practical significance for water supply for industrial and agricultural use. Historically, Yellow River did bring grandeur to Ningxia, so there is a saying that “among all the land under heaven, Yellow River brings wealthy to Ningxia.” In as early as the Qin and Han dynasties, measures were taken by stationing armies and migrating civilians to open up uncultivated land on both sides of Yellow River. Water conservancy projects were built on large scale, and canals were dug for flow irrigation, enabling agriculture to develop fast. The long history of irrigation can be seen from the names of Qin Canal, Hanyan Canal, and Tanglai Canal. But along with the change and deterioration of climate, the water of the Yellow River, in which the irrigation areas in Weining and Yinchuan take pride, is frequently in emergencies due to insufficient supply in upper stream and water interception in downstream. In 1951 - 1990, the mean runoff volume of the Yellow River in Ningxia has been more than 30 billion cubic meters, and been decreasing each year. In the high flow period of July and August in 2002, the actual water supply was only 11.1 billion cubic meters, down 61 percent over the same period in previous years.

In the first half of 2003, the highest water supply volume was 23 billion cubic meters, down by 14 billion cubic meters compared with 37 billion cubic meters in normal years. The water abstraction volume in the irrigation area relying on Yellow River was only 3.7 billion cubic meters, with a shortage of nearly 1.5 billion cubic meters. If drought aggravates, the water supply of 3.7 billion cubic meters will be reduced by 20 percent. Then 300 *mu* of crops in the irrigation area has no water for irrigation, and 100 million cubic meters of water for ecological purpose and 50 million cubic meters of water for human and animal consumption have no assured source. The imbalance of irrigation water is already acute, and will be even more severe when the peak of water consumption in the Yellow River Valley comes.

Historically, the southern area in Ningxia had 72 springs and 72 mountain rains. But along with climate change and deterioration of ecological environment, the southern

mountainous areas have no springs or mountain rains. The fall of precipitation greatly cut down the volume of surface water. Moreover, limited by geological and structural conditions, the underground water shows dotted and linear distribution, and is poor in quantity and quality. It varies greatly with the geological conditions and topography, and most of the water has a mineralization degree above 3 gram per liter. Currently, the per capita share of available water resources in southern Ningxia is only one fourth of the country's average level.

### 5.2.2 PROBLEMS OF UTILIZATION OF WATER RESOURCES IN NINGXIA.

Firstly, the acute imbalance of demand and supply of water resources and severe waste of water both exist. Historically, the irrigation area in Ningxia was only part of the Weining plain and Yinchuan plain. However, in recent years, the Yellow River irrigation area in the two plains expands by nearly one third. The large scale Yellow River water conservation projects, such as Huhai, Yanhuanding, and Hongsibao, pile the pressure on the already tense water source of Yellow River in the autonomous region. Moreover due to the difference of planeness between lateral canals, field ditches, and the ground at the terminal of the irrigation projects, canal break and leaking often occur.

The extensive farming mode aggravates waste of resources and pollution of the environment. For example, the deep flood irrigation in large plots of farm land, which is an extremely lavish farming mode, falls to produce the biggest economic benefits of the tense water resources. To solve the shortage of the 1.5 billion cubic meters of irrigation water source in Ningxia irrigation area, the government has drilled 4,000 wells for emergency use. But it only has temporary effect. In Ningxia's southern mountainous area with severe water shortage, the source of drinking water of the villagers has been solved by well-drilling and poverty-relief campaign in recent year. But the source of irrigation water for most farmland has not been solved.

With the acute imbalance of the demand and supply of water resources, the waste of the resources is still serious in the whole autonomous region. It is mainly manifested in the facts that old practice of flood irrigation is still used to irrigate the farmland, and the water conservation techniques are not applied in the autonomous region. Besides, the waste of water for industrial and urban use is also conspicuous. The reuse rate of water resources is low, and high water consumption with low output is common.

Secondly, the underground water is excessively exploited, and water resources are increasingly tense. Ningxia has underground water resources of 2.657 cubic meters per year. Among it, the volume of fresh water with mineralization degree below 1g/L is 1.47 billion cubic meters, accounting for 55 percent of the natural underground water resources in the whole autonomous region. That of brackish water with mineralization degree between 1–3g/L is 854 million cubic meters per year, accounting for 32 percent of the natural resources. That of salt water with mineralization degree above 3g/L is 334 million cubic meter per year, accounting for 13 percent of the natural resources. The exploitation resource of underground water in Ningxia is 2.17 billion cubic meters per year. Among it, the exploitation resource in Yellow River's Hetao Plain (including Yinchuan Plain and Weining Plain) is 2.059 cubic meters per year, accounting for 95 percent of the exploitation resource in the whole autonomous region.

Currently, the problems of underground water's depression cone, secondary salinization of the soil, and pollution of underground water in the use of underground water resources is

prominent. The underground water's depression cones are mainly distributed in the urban areas of Yinchuan City and Shizuishan City. In the capital city of Yinchaun, the primary pressured water bearing formation is drilled as the main off-take target for the water for living and industrial purposes. The longtime concentrated exploitation by large volume has resulted in the depression cone in the primary pressured water bearing formation.

According to statistics, Yinchaun city drilled 354 motor-pumped wells in the primary pressured water bearing formation in 2007. The exploitation volume is 105.37 million cubic meters per year, and maximum density of the wells is three - four wells per square kilometer. In Xixia district, the maximum density has reached seven wells per square kilometer. The depression cone formed by years of exploitation tends to be stable. It has a distribution area of 453.17 kilometers, and the center of the cone is located in Xixia District.

Within the big regional cone, two small cones are formed in Xingqing District and Xixia District. The cone in Xingqing District is centered nearby Xiaonanmen, and takes an oval shape with the northwest direction as its long axis. The cone in Xixia District is centered nearby the nitrogenous fertilizer plant and the timber mill, and takes an oval shape with the northeast direction as its long axis.

Shizuishan City is a heavy industry city in Ningxia. The single phreatic water in mountain front and the primary pressure water is the off-take target for water for living and industrial purposes in the city. Along with the rise of exploitation volume over the years, five depression cones are formed in Dawukou District and Huinong District of the city. According to statistics, 382 motor-pumped wells were drilled in Dawukou district in 2000, with an exploitation volume of 4819.835×104 cubic meters per year. In the single phreatic water and "double structure" phreatic water areas in Dawukou District, four regional depression cones are formed with an area of 93.78 kilometers. Currently, the development of the regional depression cones tends to be stable.

Salinization is the outcome of the imbalance of the supply, runoff and drainage of underground water. Subdued and low-lying topography in the aggraded valley plain results in slow runoff of the underground water and poor drainage conditions. As a result, a large amount of irrigation water and underground water in surrounding areas cannot be drained after flowing into the farmland. Additionally, due to the low buried depth and strong evaporation, the soil salinity accumulates gradually on the land surface, leading to secondary salinization of the soil.

For a long time, extensive irrigation methods, such as water diversion and irrigation in large volume, and irrigation from one field to another, and flood irrigation, have been adopted in agricultural production, which both waste the previous water resources and aggravate the soil salinization to some extent. The soil salinization in Ningxia is mainly distributed in the area to the north of Yinchuan in Yinchuan Plain, and has an area of 3,696.87 square kilometers.

The saline land in the north of Yinchuan Plain can be classified into three levels. The heavily saline land is mainly distributed in the area between Hongguang and Luoping and the southern area of Huinong, and covers an area of 500.75 square kilometers; the slightly saline land is mainly distributed in Yinchuan City and its northern area and the southeast of Pingluo, and covers an area of 872.14 square kilometers; the medium saline land is mainly distributed in area outside the heavily and slightly saline land, and covers an area of 2,323.98 square kilometers.

However, in the area to the south of Yinchuan, it is only distributed nearby the east of Shaogangbao, and Qin Canal and Donggan Canal in the east of Lingwu. Since the 1990s, the comprehensive agricultural development project has been launched in the Hetao irrigation area to reform the medium-and-low-yield land and increase grain output, the degree and area of soil salinization has reduced with prominent effect. The mean annual water drainage volume in the irrigation area to the north of Yinchuan has risen by 26 percent, while the desalination volume has increased by 24 percent. The desalination index has risen from 1.06 before the development project to 1.17. Thus the irrigation area is in the desalination state.

According to the Investigation Report of the Environment and Geology in Ningxia Hui Autonomous Region, by analyzing the images sent back the U.S. land TM satellite and the data of the development trend of soil salinization, the number of salting stains in land surface of the area to the north of Yinchuan is diminishing gradually, and soil salinization is on the decline in most areas.

Thirdly, the pollution of underground water is far from being satisfactory. The pollution of underground water in Ningxia is mainly caused by three industrial waste, domestic sewage, pesticide, chemical fertilizer and other pollutants seeping into the underground by various means. Especially, it is increasingly serious in Yinchuan and Dawukou areas. Since the main water extraction formation in Yinchuan is the primary pressured water-bearing formation, and 93 percent of the underground water supply comes from the leakage recharge by upper phreatic water, the pollution of the upper phreatic water will directly result in the pollution of underground water in the lower pressured water-bearing formation. Especially, in Yinchuan, Shizuishan, the Qingshuihe River Valley, and the Huluhe River Valley in southern Ningxia, combined exploitation of underground water is more serious. As a result, the water in salty and fresh water bearing formations intermingles and mixes with each other, leading to the deterioration of the quality of underground water.

## 5.3 BIODIVERSITY AND LOSS OF ECOLOGICAL FUNCTION

### 5.3.1 GENERAL

Ningxia is the place where farmland and grazing land intersect with each other. The climate change has great impact on the natural environment and development of human society in Ningxia. According to archaeological documents, the climate was warm since the Yangshao civilization to Yin Dynasty. At that time, there were many lakes and swamps and large areas of meadow. Timber forests and bushes grow along the river banks, and herds of wild donkeys, buffalos, boars, antelopes, and rhinoceros lived on riversides and shoals of lakes, while ostriches could be found in arid area.

According to the Chronicle of Western Qiang in the Book of the Later Han, southern Ningxia is a good place with “thousands kilometers of rich lands and crops.” And “with abundant water and grass, the land was suitable for grazing. The cattle and horses came one after another, and the sheep herds blocked the road.” Liupanshan Mountains “had tens of thousands of pines, which is green and beautiful.” In the Han Dynasty tombs in Zhangjiachang of Yanchi county, glutinous millet and millet seeds of yellow, red and white colors were unearthed with other cultural relics. The wild horses and their skin is special local products of Yanzhou and Lingzhou, and have been the articles of tribute by local officials to the court. In Tang dynasty, Lingzhou had developed animal husbandry industry, and a large

number of wild animals. Hunting was an important prodiction activity, and natural vegetation was still luxuriant.

Take the world famous rock painting in Helanshan Mountains for example, the people, domestic animals, birds, beasts, and the paintings of hunting, returning home after grazing, tigers and wolves chasing deer, and tigers attacking horses, are reflection of the life of the ancient people at that time. It vividly shows the natural ecological system with lush forest, rich water and grass, and numerous wild animals in Helanshan Mountains, the people's nomadic life style, and the vast scene of the vigorous, thriving grassland.

Due to accumulated human interference (including wars, deforestation and excessive grazing) through ages, the ecological system has an increasingly small proportion in the whole region, while its self-healing is deteriorating. In early Qing Dynasty (early 18$^{th}$ century), the virgin forest in Ningxia had disappeared completely, the farmland and grassland deteriorated, and the species and number of the wildlife dropped sharply.

In the past several decades, excessive population growth, predatory land utilization mode, unseasonable land use structure in the central arid wind and sand area and the southern loess hills, and extensive production mode lead to excessive farming, grazing and logging. Consequently, the problems of vegetation shrinking, land desertification, and water loss and soil erosion are out of control, and the venerable ecological system further deteriorates.

In some areas of Ningxia, the ecological system is under the influence of climate change. For example, the wild horses mentioned above disappeared in about 1000 A.D. The land in Tongxin, yanchi and Huan County in Gansu province, which was arable in Tang Dynasty, has become vast arid land spanning 350 kilometers. The biodiversity is severely damaged, which leads to deterioration of the ecological system, and aggravation of water loss and soil erosion, land desertification, and salinization.

### 5.3.2 ECOLOGICAL AND ENVIRONMENTAL PROBLEMS.

As for water loss and soil erosion, the land erosion is classified into win erosion and water erosion. The total area of water loss and soil erosion in the whole autonomous region is 36,849 square kilometers by 2000, accounting for 71.1 percent of the total area. Among it, the area of water erosion accounts for 40.3 percent, and that of wind erosion 30.8 percent. The water erosion area in Ningxia's southern mountainous area accounts for 76 percent of the total water erosion area in the autonomous region.

As for land desertification, Ningxia is one of the regions where the problem is the most serious in China. The heavily desertified land is mainly distributed in Yanchi, Lingwu, taole, Zhongwei, Tongxin and other counties in central and northern parts of Ningxia. According to a survey of desertification in Ningxia in 1995, the desertified land has an area of 12,568 square kilometers, accounting for 24.3 percent of the total area of the autonomous region. As for soil salinization, secondary salinization mostly occurs in irrigation farmland in the plain, but the brackish water irrigation area in the Qingshuihe Valley in southern mountainous area also has saline land. According to statistics by water resources authorities, the saline land in the Yellow River irrigation area (at the levels of slightly, medium and heavily salinization) covers an area of 2.216 million mu, accounting for 33.5 percent of the total arable land. In addition, there are 835,000 *mu* of saline and alkaline waste land.

### 5.3.3 ANALYSIS OF DETERIORATION OF THE ECOLOGICAL SYSTEM.

Analysis of the trend of water loss and land erosion: The southern mountainous region located in loess hills is one of the places where the water loss and land erosion is the most serious in Ningxia. For years, the Party branches and governments at all level attach great importance to control of water loss and land erosion, and have been actively exploring new ideas and methods for conservation of water and soil. They have taken measures of guiding with policy, setting examples with models and driving with technology, and taking small river basins as the unit, controlled water loss and land erosion by making breakthrough in basic farmland construction, thus achieving prominent results.

But generally speaking, the area of water loss and land erosion is still on the rise. According survey made in different times, the area of soil erosion land was 35,449 square kilometers in the 1950s, 39,175 square kilometers in the early 1980s, 38,873 square kilometers in the early 1990s, and 37,086 square kilometers in 1999. According to statistics, the accumulated area of controlled soil erosion land was 3,622 square kilometers from the 1950s to 1983, and 5,540 square kilometers in 1990, and 10,243 square kilometers in 1999.

That means although 10,000 square kilometers of soil erosion land have been controlled, the area of soil erosion land does not decrease, and instead, rises by more than 2,000 square kilometers. The causes of the aggravated soil erosion include: Firstly, human activities are the primary cause of aggravated soil erosion. Along with the population growth, development of resources, and expansion of production, some units and persons only pay attention to economic benefits, and neglect protection of ecological environment; they stress immediate interests and ignore long-term interests, and result in the man-made aggravation of water loss and soil erosion.

According to statistics of counties in Ningxia's southern mountainous area in 1990, the eight counties in the area directly destroy forest and grassland of 1,779 square kilometers by excessive reclamation, digging for herbal medicines, and grazing, and the volume of water loss and soil erosion is about 6.1 million tons. About 25 million tons of waste earth and scrap produced by mining, quarrying , and road construction is disposed in riverbed and hillside, and is flushed by water into river channels and reservoirs. According to a survey, the area of newly added soil erosion land resulting from reclamation and digging for herbal medicine is about 200 square kilometers every year, accounting for 20–40 percent of the controlled area.

Secondly, the result of control is preserved at a low rate, since the soil erosion land is damaged while it is controlled. In the 1980s, the United Nations World Food Programme aided the forest and grassland consteruction project No. 2605 in Xiji County. In five years, 104,000 hectares of forest have been built, accounting for 33 percent of the total afforestation area in Xiji County. But now, few of the forest have been preserved.

The third cause is the impact of drought on ecological environment. Ningxia is located in the arid and semi arid region. The precipitation is small, and has great interannual variations. Drought occurs frequently, and multiple droughts spanning two seasons, three seasons and years often occur. Not only the survival rate of the trees and grass planted in the year will be affected; sometimes, even the trees and grass which have survived for years die out during severe drought.

For example, a drought occurred in Ningxia's southern mountainous areas in 1999. And tens of thousands of hectares of trees and grass planted in 2000 in a program to return farmland to forestry and grassland had only a survival rate of only 20-40 percent even though

they were taken care of earnestly. These factors are all the causes of the rise of water loss and land erosion in Ningxia.

Analysis of the trend of soil salinization: Soil salinization mainly occurs in the Yellow River irrigation area in the northern plains in Ningxia, and is more serious in Yinchuan Plan than in Weining Plain. According to a survey, by the year-end of 2005, among 6.616 million *mu* of arable land in Ningxia's Yellow River irrigation area, the non- saline farmland has an area of 4.397 million *mu*, accounting for 66.46 percent of total area of farmland. The saline farmland has an area of 2.219 million *mu*, accounting for 33.54 percent of the total area. The saline farmland includes 1.409 million *mu* of slightly saline land (accounting for 21.3 percent of total arable land in the irrigation area), 513,000 *mu* of medium saline farmland (accounting for 7.75 percent), and 297,000 *mu* of heavily saline land (accounting for 4.49 percent).

Besides, there are 835,000 *mu* of saline and alkaline waste land. In comparison with relevant results and data of the soil survey in Ningxia in 1985, the arable land in Ningxia's Yellow River irrigation area had an area of 6.616 million *mu* in 2005, up by 541, 000 million *mu*. Based on it, the total area of non-saline farmland reached 4.4 million *mu*, up by 778,000 *mu*. Its proportion increased from 59.6 percent in 1985 ton 66.5 percent. The total area of saline farmland was 2.216 million *mu*, down by 237,000 *mu*. Its proportion dropped from 40.4 percent in 1985 to 33.5 percent in 2005.

Moreover, the degree of salinization was also greatly mitigated. The proportion of medium saline farmland fell from 29.6 percent to 23.1 percent; the proportion of the heavily saline land dropped from 16.2 percent to 13.4 percent. The average saline content in the soil was 1.65 g/kg in 2005, down by 23.2 percent compared with 2.15g/kg shown by the soil survey in 1985. The burial depth of underground water lowered from 184 centimeters in 1985 to 236 centimeters in 2005, falling by 52 centimeters, or 28.3 percent.

Before the spring irrigation in 2005, the average mineralization degree of underground water is 1.23g/L, reducing by 0.4g/L, or 24.5 percent, from 1.63g/L in 1985. The cause of the decrease is, firstly, the increase of water consumption for industrial, agricultural and living purpose, which leads to the drop of underground water level, and secondly, the implementation of measures to reform the saline land. It can be seen that the soil salinization in the farmland in the Yellow River irrigation area is mitigated as a whole, but aggravates in some areas. 3. Analysis of the trend of land desertification. The desertified land is mainly distributed in the central and northern areas in Ningxia, especially in Taole, tongxin, Lingwu, Yanchi and Zhongwei counties.

According to the survey and analysis of Ningxia Academy of Forestry Survey and Design, the area of desert in the whole autonomous region was 1.284 million hectares in 1949, 1.296 million hectares in 1960, 1.326 million hectares in 1970, 1.269 million hectares in 1990, and 1.257 million hectares in 1995. It shows that the land desertification in the autonomous region had a trend of aggravation before the 1990s, and shows a downward trend after the 1970s. Thus Ningxia is the only province or autonomous with reserve trend of desertification in China.

Ningxia is surrounded by Tengger Desert, Mu Su Sandy Land and Ulan Buh Desert on three sides, and has dry climate with little rainfall, sparse vegetation and severe wind erosion. These are the natural causes of land desertification. However, the more important cause is the intensified human activities, rapid population growth, long time disorder reclamation, excessive digging for liquorice and grazing, firewood, Nostoc flagelliforme, and medicine

collection without limits, which result in further deterioration of the already venerable ecological environment. Consequently, the vegetation degenerates, diminish or withered, leading to land desertification in large areas.

Although in the past two decades, Ningxia has made great achievement on control of land desertification, the speed of desertification control cannot catch up with that of the land desertification in some areas. According to surveys, the desertified land in increases by 10,000 hectares in the former Taole County, 14,700 hectares in Lingwu County, and 29,000 hectares in Tonghxin County, but decreases by 32,000 hectares in Yanchi County. Therefore, the land desertification problem is still serious in Ningxia, and control of desertification is long-term and demanding task.

## 5.4 IMPACT OF CLIMATE CHANGE TO ECOLOGICAL ENVIRONMENT

Along with global climate change, the climate in Ningxia also undertakes conspicuous change. The rise of air temperature and decrease of precipitation aggravate the frequency and intensity of drought in Ningxia, thus leading to escalation of land desertification and grassland degradation, shrinking of wetland and forest, drop of crops' yield, and further deterioration of the living conditions of residents in mountainous areas. To meet the need for agricultural water and drinking water for humans and animals, excessive water diversion and exploitation of underground water are inevitable. These will result in exhaustion of water resources and imbalance of water, and thus the deterioration of the whole ecological environment.

Additionally, climate change will increase the frequency of meteorological disasters. Ningxia spans three climate zones, and the change of meteorological elements often causes many natural disasters, such as low temperature, frost, hail, drought, flood, strong wind, sand storm, and dry hot wind, which are greatly harmful to the crops. Located in the inland region, Ningxia has few extensive heavy rains, and few serious floods. However, local strong rainstorms in a short period of time occur occasionally, and will cause flood in local areas. Since three fourths of the autonomous region is in the arid area, drought occurs most frequently, and affects vast areas. It often takes place in several counties or even in the whole autonomous region at the same time, resulting in extremely severe agricultural loss. In the southern mountainous area, most of the farmland is dry farm. In the year of severe drought, total crop failure may occur since there is no water for irrigation, and the farmland with no harvest at all can account for more than 80 percent of the dry farm.

## 5.5 ENVIRONMENTAL POLLUTION IN RURAL AREAS

### 5.5.1 POLLUTION OF WATER ENVIRONMENT

The Yellow River enters Ningxia in Nanchangtan in Zhongwei City, and runs through four prefecture-level cities of Zhongwei, Wuzhong, Yinchuan and Shizuishan for 397 kilometers. In 2008, the water quality in the monitoring section in Xiaheyan in Zhongwei (wherer Yellow River enters Ningxia) was excellent in grade II, and the qualification rate is 91.7 percent, down 8.3 percent over the previous year. The comprehensive pollution index was 3.95, up 32.9 percent over the previous year. The rate of the main petroleum pollution agents exceeding the standard was 8.3 percent, and the maximum value was 0.311 mg/L, 5.2 times more than the national standard. Other pollution agents complied with the national standard.

The water quality in the monitoring section in the highway bridge in Yingu was good in grade III, and the qualification rate was 100 percent, up 23 percent over the previous year. The comprehensive pollution index was 4.66, down 11.6 percent over the previous year, and the pollution agents all complied with the national station in the whole year. The water quality in the monitoring section in the ferry crossing in Taole is good in grade III, and the qualification rate was 66.7 percent, up 8.4 percent over the previous year. The comprehensive pollution index was 4.86, down 6.4 percent over the previous year. The rate of ammonia and nitrogen pollution agents exceeding the standard was 33.3 percent, and the maximum value was 1.533mg/L, 0.5 times more than the national standard.

The water quality in the monitoring section in Huangmagou where Yellow River leaves Ningxia was good in grade III, and the qualification rate was 81.8 percent, up 15.1 percent over the previous year. The comprehensive pollution index was 4.68, down 7.9 percent over the previous year. The rate of ammonia and nitrogen pollution agents exceeding the standard was 16.7 percent, and the maximum value was 1.182 mg/L, 0.2 times more than the national standard. In 2008, the overall qualitative appraisal of the water in Yellow River in Ningxia was good in grade III, at the same level with the previous year. The qualification rate of the water quality in monitoring section was 83 percent, up 10.3 percent over the previous year.

The water quality in the section where Yellow River enters Ningxia was excellent in grade II, and that in the section where Yellow River leaves Ningxia was good in grade III. The primary cause of the decline of water quality from “excellent” to “good” is that the flow quantity of the Yellow River decreased in comparison with that in the previous year, which resulted in the water body’s poor capability for dilution and self-purification. The density of ammonia nitrogen was on the rise, which resulted from the industrial and domestic pollution and agricultural area source pollution. 2、

Water quality in lakes. Shahu Lake is located in the southwest of Ningxia’s Luoping County, and 56 kilometers away from Yinchuan. It covers a total area of 82 square kilometers, among which the area of water body is 22 square kilometers and that of desert is 12.7 square kilometers. The desert in the south and the lake in the north mingle with each other, and the water and the sky blend into one color. The lake is an ecological tourist attraction which combines the scenery in southern Chinese riverside towns and that in desert, and is state-level scenic area. The Western Lake is the largest wetland ecological system with complex, primitive, and intact natural ecological environment in the suburb of Yinchuan City.

It covers an area of 2,600 hectares, and is two kilometers away from the central administrative area of Yinchuan City. It has sound natural ecological system. Reeds grow extensively in the lake, and have a water purification area of 6,000 *mu*. There is an island in the lake, where tens of thousands of birds of various species inhabit every year. Three crops of reeds are grown annually in the lake, where fish springs and birds sing. According to the monitoring results of Ningxia Environmental Protection Bureau, the water in Shahu Lake and Western Lake is slightly polluted with the quality of grade IV, and is in a mesotrophic state. The various pollution agents in Western Lake all comply with the national standard, while the maximum concentration of nitrogen and phosphorus, the main pollution agents in Shahu Lake, is 1.52 mg/L and 0.088 mg/L respectively, 0.5 and 0.8 times more than the national standard.

Water quality in drainage ditches. In Ningxia, there are six major drainage ditches, namely, Si’er dry ditch, Yinxin dry ditch, No. 3 and No. 5 drainage ditches, Wuzhong clean

water ditch, Wuzhong southern dry ditch, and Lingwu eastern ditch. According to monitoring results in 2008, the water in the drainage ditches was of bad quality in grade V, and heavily polluted. The cause was that the ditches take in a large amount of industrial waste water, urban domestic sewage, and return water from farmland, and the pollutants received exceeded the self-purification capability of the water body, making water quality in the ditches unable to be self restored. Although the water quality did not show any prominent change compared with the previous year, the pollution was still serious. The task of comprehensive control of the pollution in drainage ditches is extremely urgent.

Water quality in centralized urban drinking water sources. In the 12 centralized urban drinking water sources monitored by Ningxia Environmental Protection Bureau, only the sulfate content in the water in Hejiawan Water Source in Guyuan is one times more than the national standard due to geological factors. The water quality in the water sources in other cities and prefectures all complies with the level III of the Quality Standard for Underground Water (No. GN/T14848-1993). The water is of good quality and can assure the safety of drinking water.

Main problems of pollution of water environment in Ningxia. The problem of stable qualification of Yellow River in Ningxia. Although the water quality in Yellow River in Ningxia meets level III of national standard, the qualification rate at sections is between 66.7 - 91.7 percent. Pollution of water bodies in local areas often occurs, and the index of permanganate, a major pollutant, and the mean annual concentration of ammonia nitrogen do not show a conspicuous declining trend. The concentration of ammonia nitrogen and the permanganate index exceed the standard in the section in the ferry crossing in Taole and the section in highway bridge in Yesheng respectively.

The pollution of Yellow River in Ningxia is closely linked to the water volume of yellow River. In the low water period (January - April), when Yellow River has less flow volume, slow flowing speed, and poor self-purification ability, the water quality declines at all sections, and even the heavily polluted water quality in grade V may occur. As Yellow River runs for 397 kilometers in Ningxia, the water quality declines by one grade, showing the pollution along the river contributes greatly to the deterioration of the water quality. To improve the water quality in Yellow River in Ningxia, we should not only reduce discharge of pollutants, but also ensure necessary water volume for ecological purpose. The task of maintaining Yellow River's dilution and self-purification ability and realize stable qualification of the water quality in yellow River in Ningxia remains a difficult task.

The problem of control of pollution in drainage ditches. Since the major drainage ditches have taken in a large amount of industrial waste water, domestic sewage, and animal husbandry waste water, the pollutants discharged have greatly surpassed the self-cleaning ability of the water body. The water is heavily polluted, and has been of bad quality in grade V for 10 years. In addition, since the ditches have no lining for protection, the heavily polluted water in the river and ditches not only pollutes Yellow River in Ningxia, but also seeps into and pollutes underground water, posing a threat to drinking water safety in cities. It is of great urgency to beef up the efforts to tackle pollution in drainage ditches.

Pollution of underground water. Ningxia is located in the arid and semi-arid region, and has high wind and little precipitation for years. The evaporation is 10 times of precipitation, and 98 percent of domestic and drinking water comes from the underground water source. The dynamic changes of underground water is closely linked to diversion and irrigation through canals in farmland, and 80 percent of underground water is supplied by seepage of

water in canals and irrigation water in farmland. When the water in drainage ditches, heavily polluted by industrial, domestic and rural animal husbandry pollution, runs through surface water sources, the infiltration of foul water and the leaching process of the pollutants of agricultural area sources on land surface has become the primary cause of the pollution of underground phreatic water and artesian water in Ningxia.

Moreover, a comprehensive and effective managerial system has not been established in the drinking water sources in Ningxia. The separation of facility management of water source project, allocation of water volume and water quality management, the separation of raw water management and the urban water supply system, the separation of environmental protection in water sources and the planning and management of water sources not only waste precious manpower, financial and material resources, but also severely hamper the environmental protection of domestic and drinking water sources in Ningxia. It is of great urgency to earnestly improve control of underground water pollution, protect and improve the water quality in domestic and drinking water sources in Ningxia, and safeguard drinking water safety.

Problem of pollution in lakes and wetlands. Ningxia has rich resources of lakes and wetlands. In Yinchuan City only, there are 31 lakes and five wetlands with a water-collecting area of 200 million square meters. They not only beautify the natural scenery, but also adjust climate and improve ecological environment. In recent years, the discharge of industrial waste water and the supply of return water from farmland, the water quality in 30 percent of the lakes and wetlands has gradually deteriorated to grade V or bad quality. If protection of the lakes and wetland is not improved, the area of the water with deteriorated quality will continue to expand.

### 5.5.2 POLLUTION OF SOIL

Ningxia Environmental Protection Bureau has carried out testing in five vegetable planting bases in Ningxia for 10 indices of PH value, cadmium, mercury, lead, arsenic, chrome, copper, zinc, dimethoate, and methamidophos in the soil. The results show that in the monitoring sites in the vegetable planting bases in the autonomous region, the monitoring values of copper, zinc, lead, cadmium, arsenic, chrome, dimethoate, and methamidophos all meet the criterion of “the PH value above 7.5” in the Quality Standard of Soil Environment No. GB15618-1995.

Except for the vegetable planting base in Ruiying Village, Dongyuan Township, Zhongwei City, the comprehensive pollution indices of other planting bases are between 0.29 - 0.43. The pollution is at a safe level, and the soil is clean. The comprehensive pollution index of the soil in the vegetable planting base in Ruiying Village, Dongyuan Township, Zhongwei City is 0.74. The pollution is at the warning level, and soil is basically clean. Please refer to the following table for details.

Table 5.1 Comprehensive pollution indices of the soil in vegetable planting bases in Ningxia and the evaluation

| Name of the bases | Comprehensive pollution index | Pollution grade | Pollution level |
|---|---|---|---|
| Xihe Village in Wanghong Township, Yongning County, Yinchuan City | 0.34 | Safe | Clean soil |
| Kunlun Vegetable Planting Base in Yinchuan City | 0.43 | Safe | Clean soil |
| Dongyonggu Village in Miaotai Township, Huinong district, Shizuishan city | 0.32 | Safe | Clean soil |
| Baisitan Village in Dongta Township, Litong District, Wuzhong City | 0.33 | Safe | Clean soil |
| State-level Agricultural technology Demonstration Park in Wuzhong City | 0.40 | Safe | Clean soil |
| Dongmen Vegetable Garden in Yuanzhou District, Guyuan City | 0.38 | Safe | Clean soil |
| Mayuan Village in Touying Township, Yuanzhou District, Guyuan City | 0.29 | Safe | Clean soil |
| Vegetable Planting Bases in Ruidong Village, Dongyuan Township, Zhongwei City | 0.74 | Warming | Basically clean soil |

Moreover, the soil in three foul water irrigation areas is also tested. The content of copper, zinc, lead, cadmium, arsenic, chrome, and mercury all meet the criterion of “the PH value above 7.5” in the Quality Standard of Soil Environment No. GB15618-1995. The comprehensive pollution indices are between 0.27 - 0.40. The pollution is at the safe level, and the soil is clean. Please refer to the following table for details.

Table 5.2 Comprehensive pollution indices of the soil in foul water irrigation areas and the evaluation

| Name of the foul water irrigation area | Comprehensive pollution index | Pollution grade | Pollution level |
|---|---|---|---|
| balanghu Village in Malianqu Township, Litong District, Wuzhong City | 0.35 | Safe | Clean soil |
| Foul water irrigation area nearby Shenjiahe Reservoir in Yuanzhou District, Guyuan City | 0.32 | Safe | Clean soil |
| State-run Lingwu Farm | 0.40 | Safe | Clean soil |
| Foul water irrigation area in Hetan Village, changing District, Yinchuan City | 0.27 | Safe | Clean soil |

Testing results show that the monitoring concentration values of the pollution indices in of the irrigation water in vegetable planting bases and foul water irrigation areas all meet the criterion for vegetables in the Quality Standard of Irrigation Water for Farmland. No. GB5084-92

### 5.5.3 POLLUTION OF FOOD

Ningxia Environmental Protection Bureau has carried out testing of the farm produce in Ningxia's vegetable planting bases where assure food products are produced. The results show that the concentration values of various pollutants in the produce all meet the permitted criterion, and the food safety in the vegetable bases is assured. The concentration values of various pollutants in the produce produced in foul water irrigation areas all meet the permitted criterion, which shows that the quality of agricultural produce is unaffected and the food is safety.

### 5.5.4 POLLUTION OF AIR.

Ningxia environmental Protection Bureau has carried out testing to the air quality in the environment in Ningxia's vegetable planting bases where assure food products are produced. The results show that the daily density value of the total suspended particulates in the monitoring site in Team Five of Dongyonggu Village in Miaotai Township, Huinong District, Shizuishan city is 0.112-0.378mg/m3, exceeding the standard for 40 percent. The daily density value of the total suspended particulates in three monitoring sites in the vegetable bases in Baisitan Village, Dongtai Township, Litong district, Wuzhong City is 0.10-1.10mg/m3, exceeding the standard by 33 percent. The daily density values in all monitoring sites in other bases all meet the secondary criterion of the Air Quality Standard, showing that the air quality is good in the vegetable planting bases.

### 5.5.5 MAJOR PROBLEMS OF RURAL ENVIRONMENT.

The environment in Ningxia is mainly manifested in the pollution of drinking water sources and protection of drinking water safety, comprehensive pollution of rural domestic sewage and household garbage, animal husbandry pollution, pollution by rural industrial enterprises, and other problems (such as area source pollution and pollution of white garbage).

A. Pollution of drinking water source and protection of drinking water safety.

On the one hand, the cause of the pollution of drinking water source is that Ningxia is in the arid region in Northeast China, and the underground water has the problems of high mineralization degree and fluoride content by itself. On the other hand, some water sources are located around farms. The use of chemical fertilizer and pesticide, especially highly toxic and persistent pesticide, in a large amount pollutes the soil in water sources. And water loss and soil erosion formed during rainy seasons help the residue of chemical fertilizer and pesticide in the soil pollute underground water and surface water through surface runoff and infiltration.

Domestic animals and fowls are raised in some protection zones of water sources. The untreated feces is discharged continuously into water bodies or infiltrated into underground thorough eluviations by rain and surface runoff and pollutes the underground

and surface water bodies. There are some industrial enterprises in some protection zones of water sources. For example, the starch processing plant in Guyuan City in southern Ningxia discharges waste water at will and causes a serious problem of drinking water safety.

However, water quality monitoring and evaluation activities are carried out only in the urban drinking water sources. In the vast rural areas, however, it is difficult to carry out regular monitoring work due to scattered distribution of small-sized water sources, and unstable water quality and quantity. Currently, necessary conditions were absent for monitoring drinking water safety in rural areas. According to a survey, there are still more than 1.5 million people having problems of rural drinking water safety in the whole autonomous region. Among them, more than 800,000 people have the problems of unqualified water quality, such as high fluorine and arsenic content, brackish water, excessive amounts of bacteria, and water pollution; more than 770,000 people have the problem that the assured rate of water resources, quantity of domestic water and convenience in water use do not meet the standard.

In Lingwu, Yanchi, Tongxin, Guyuan counties, a total of 331,600 people drink high fluoride water; in Luoping, Yongning, Xixia District, and Qingtongxia, 20,000 people drink high arsenic water; in Luoluo, Huinong, and southern mountainous areas, 622,200 people drink brackish water and 68,500 people drink polluted water.

B. Comprehensive pollution of village domestic sewage and household garbage.

Along with the rapid development of Ningxia's economy, the living standard of rural residents rises constantly. Modern commodities and new lifestyle is rapidly spreading to rural areas, and various production and domestic garbage, which cannot be simply disposed in landfill, also emerge quickly. The garbage has complex composition, and includes plastic foam and bags; broken asbestos shingle, class and wine bottles; and even industrial waste, expired drugs, and other toxic and harmful substances. It severely damages the soil and natural scenery, affected agricultural production and rural environment, and becomes the infection sources of diseases, thus doing harm to human health and disrupting residents' living environment.

Besides, there is no sewage collecting system in rural areas, and domestic sewage is discharged at will. The phenomenon of "disposing garbage by wind blow and sewage by evaporation" is commonly seen, which results in poor rural environment. According to statistics, nearly 2,696 tons of domestic garbage and 120,000 tons of sewage are disposed all over the rural areas every day in the whole autonomous region. Most of them are not effectively treated, and disposed at will along the roads, around farmland, and in ponds and canals. They seriously pollute the living environment in rural areas, and directly threaten the living environment and physical health of rural residents.

C. Pollution caused by livestock

Ningxia is one of the provinces and autonomous regions with developed animal husbandry industry in West China. In 2007, 320,000 cows, 1.5 million heads of beef cattle, 10.55 million lamb sheep, 2.6 million hogs, and 30 million domestic fowls were raised in the autonomous region, and they produced 19.282 million tons of feces every year, which

surpasses the quantity of solid industrial waste. Most farms have unreasonable layout by being located in the center, on the side and in houses of the village, and close to villagers' houses around. Although a few farms are built outside the village, they are in the upwind direction of the village. In the simply constructed houses, the feces of the animals and fowls are piled up at will. Since more than 90 percent of the large scale poultry and animals farms have no sewage treatment facility, the random discharge and stacking of the waste water and solid waste have severe negative impact on the surrounding environment and the water body in Yellow River, with the problems of stink and flies being relatively more serious.

D. Pollution by rural industrial enterprises.

Rural enterprises are located in the residential area of towns and townships, as well as the rural-urban fringe zone. They have unreasonable layout, backward management methods, and extensive operation mode. Some have small size, backward production technology, and the techniques with huge energy consumption and heavy environmental pollution; some have poor environmental protection equipment and technology, and the sewage disposal facilities are incomplete or cannot function normally. The enterprises, some of which have no sewage disposal facilities, discharged a large amount of sewage and waste, and seriously the rural environment.

These problems are mainly shown in the irrigation area and around the industrial parks in the central arid area, and the pollution caused by high energy consumption enterprises in Shizuichan City and starch plants in Guyuan City is the most serious. They pose a severe threat to rural environment. 5. Pollution of agricultural chemicals. In Ningxia, pesticide, chemical fertilizer and mulching films are used heavily, and ammonia and nitrogen discharged by agricultural area source accounts for 30 percent of the total amount discharged in the whole autonomous region. Please refer to the flowing table for the amount of chemical fertilizer and agricultural films used.

Table 5.3 Amount of chemical fertilizer in Ningxia (Unit: 10,000 tons)

| Year<br>Fertilizer | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Chemical fertilizer | 76.9 | 78.4 | 79.5 | 80.4 | 82.8 | 86.9 | 90.6 | |
| Nitrogenous fertilizer | 46.9 | 48.2 | 48.8 | 46.9 | 47.9 | 46.0 | 48.2 | |
| Phosphate fertilizer | 18.3 | 17.8 | 17.9 | 19.6 | 19.5 | 20.2 | 21.4 | |
| Potassic fertilizer | 0.5 | 0.8 | 0.9 | 1.1 | 1.6 | 1.8 | 1.9 | |
| Compound fertilizer | 11.1 | 11.6 | 11.8 | 12.5 | 15.2 | 18.9 | 18.8 | |

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Table 5.4 Statistical table of mulching film used in Ningxia's Yellow River irrigation area in 2000 – 2006 Unit: ton, hectare

| Area | 2000 -2006 | | Area of polluted farmland | Percentage of the area of farmland |
|---|---|---|---|---|
| | Amount | Area | | |
| In a total in whole autonomous region | 24453 | 516512 | 215213.3 | 19.4 |
| Yellow River irrigation area | 10562 | 224745 | 93643.8 | 22.4 |
| Percentage of the Yellow River irrigation area to the whole autonomous region | 43.2% | 43.5% | 43.5% | 8.5 |

# 6. CURRENT STATUS AND GAP OF ADDRESSING CLIMATE CHANGE AND REDUCING UNSUSTAINABLE LAND USE

## 6.1 THE PUBLIC IS AWARE OF CLIMATE CHANGE, BUT HAS INSUFFICIENT CAPACITY

Through our field investigation, we found that farmers, especially those who have experienced the “good old days,” felt more keenly about climate change. The primary reason is the Chinese lunar calendar. In this climate-oriented calendar, all the 24 days marking the division of seasons are related to climate. The days are accurately predicted, and are about 15 days apart from each other, and the names of the days tell people what is going to happen.

When the prediction of the old calendar does not comply with actual conditions, it shows that “the climate is changing.” Farmers rely on good climate for good harvest, and use their observation of the weather to judge whether they will live a comfortable live. Therefore, they feel keenly about climate change.

About easing climate change, there is a traditional concept. Most people aged above 50, who have experience the great environmental changes in the 1950s and 1960s, believe the politics in man's world can affect the function of weather, and sometimes can results in the “reverse of destiny.” As the climate change results from the impact of human activities on the nature, they can also adjust the structure of crops according to their feeling about climate change. But they do not fully understand what measures should be taken to mitigate climate change, and have weak ability to cut down pollution and protection environment. Therefore, they need the guidance by the government.

Our survey shows that many officials and technicians have superficial understanding of the climate change issue. They misunderstand the global climate change caused by the green house gases emitted by human as global warming, and do not know that the change of hot and cold, dry and wet weather is more harmful to life activities. Especially among the provincial decision makers, although they have some knowledge about the negotiations, long-term impact, need for adaptability, and environmental protection related to climate change through some media reports about the trend of climate change, they seldom realize the influence of their decisions on global climate. Instead, they just hope for more precipitation, less wind and sand, and faster economic development.

## 6.2 COUNTERMEASURES NEED TO BE FURTHER REINFORCED.

In face of the grave situation of climate change, especially under the threat of natural disasters with drought being the most frequent one, Ningxia has adopted a series of countermeasures, such as development of greenhouse agriculture and special disaster resistant agriculture, moving winter wheat growing area northward, enclosure of hillsides to prohibit grazing and grow grass and trees, growing livestock in pens, energy conservation and emission reduction, comprehensive environmental control, weather modification, and development of clean resources. But strong technical support and capital investment is

lacking in implementation of these measures. Thus, these measures can hardly function in a quick and sound manner.

### 6.3 THE TASK OF REDUCING UNSUSTAINABLE LAND SSE IS DIFFICULT.

Ningxia is surrounded by Mu Su, Tengger, and Ulan Buh deserts, and is one of the provinces and autonomous regions with the most serious water loss and soil erosion in China. More than 3 million people in 13 counties in Ningxia has long suffered from the encroachments by sandstorms, while more than 3 million people in eight counties has long suffered from water loss and soil erosion. Over the years, Ningxia beefs up its efforts to control land desertification, and strengthens the construction of ecological projects, such as returning farmland to forest, and grazing ground to grassland, protection of natural forest, planting shelter forests in northeast, north and northwest China, restoration and protection of wetland, and comprehensive control of small river valley, so as to improve sustainable land use.

In the northern area, it intensifies the construction of such projects as comprehensive land control and reform of medium- and low-yield fields in the irrigation area; in the central area, it expands the irrigation area of Yellow River; in the southern hilly area, it makes great efforts in building high-standard dry farmland, by turning hillsides into terraced fields and building flood irrigation field and dyke field. In the central area, it realizes the historic breakthrough in making the speed of control faster than that of desertification, and promotes five psammophyte industries with characteristics of Ningxia, including fresh grapes, greenhouse gardens, and pulpwood in sandy land. More than 6 million *mu* of sandy land have been controlled, and the farmers' per capita income has increased from more than 200 yuan to 2,623 yuan.

In the southern area, it builds more than 3 million *mu* of high-standard dry farmland, and greatly reduces the area of unsustainably used land. However, due to disparity of the distribution of water and land resources in Ningxia, and restricted by water resources, the flat land easy to be cultivated lacks the assured water resources. In the southern area, although the precipitation exceeds 400 millimeters, the soil is barren in high mountains and deep valleys, and is unsuitable for cropping.

Currently, Ningxia still has 20,200 square kilometers of soil erosion land, and 1.183 million hectares of sandy land to be controlled, accounting for 39 percent and 22.8 percent of its territory respectively. In the northern irrigation area, it also has 200,000 hectares of saline land. Moreover, the industrial structure mainly composed by heavy industry put great pressure in environmental protection. Additionally, the excessive use of pesticide, chemical fertilizer and other agricultural chemicals in agricultural product, and lack of facilities for non-polluting disposal of animal husbandry waste, domestic sewage, and garbage, result in rural environmental pollution, which allows no optimism and is influencing the sustainable development of land resources.

# 7. Strategy of Environment-friendly Ecological Agriculture to Counter Climate Change, Scenario after the Implementation of the Strategy, and Cost Analysis

## 7.1 Optimize the Allocation of Water Resources to Improve the Utilization Efficiency of Water Resources

### 7.1.1 Intensify the water conservation efforts in the northern irrigation area.

The Yellow River irrigation area has an irrigation area of 6.9 million *mu*. The consumption of Yellow River water for agricultural purpose accounts for 93 percent of the total water consumption, and the medium and low-yield fields, mostly the saline and infertile land, account for more than 70 percent of the total area. Therefore, there is huge potential for conserving water and increasing production. With water conservation as the focus, we should intensify the efforts on water conservation reform in the irrigation area and water supply and drainage facilities in farmland, increase the fertility of the land, and raise the standard for construction of farmland shelter forest. In this way, we should strive to saving water by 30 percent and increasing the yield by 30 percent, so as to increase the effective supply of agricultural production in Ningxia and boost the sustainable development of ecological agriculture.

### 7.1.2 Accelerate the constriction of water sources project in the central area

The central dry, windy and sandy area is one of the areas where the drought and water shortage are the most serious in China. In this area, water shortage is caused by the lack of both resources and projects. With water diversion as the focus, we should reinforce the water supply capability, expand the water supply scope of the four water pumping projects of Guhai, Hongsibao, Guhai expanded irrigation project, and Yanhuan's Dingsi. Focusing on meeting poor farmers' demand for domestic and production water and protecting ecological

environment, we should accelerate the construction of water supply projects in the central area, innovate the mode of water transmission, irrigation and farming, lower the irrigation quota, and raise irrigation efficiency. In addition to ensure the safety of drinking water for human and animals, we should stabilize the area of the Yellow River irrigation, and boost the development of highly efficient agriculture of water conservation and supplementary irrigation.

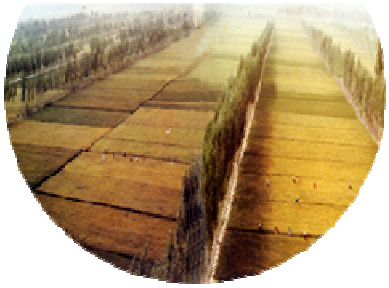

### 7.1.3 SPEED UP CONSTRUCTION OF THE PROJECTS TO HOLD RAIN AND FLOOD IN THE SOUTHERN SOIL EROSION AREA.

Water loss and soil erosion is serious in the southern loess hilly area. We should give priority to water preservation, and in addition to ecological construction and water and soil conservation projects, build a batch of high-standard rain collecting and rain and flood holding projects, to improve the ability to hold rain and flood resources in dry farmland. We should also intensify the coordination of ponds, dykes, wells, cellars and reservoirs, and in accordance with the natural law, greatly oust advantageous, characteristic agriculture that comply with the precipitation law in the dry farming area. Thus we should strive to raise the utilization rate of rain and flood to more than 60 percent, and put more than 70 percent of the soil erosion land into control.

## 7.2 Optimize the Allocation of Land Resources and Improve the Capability for Sustainable Utilization of Land Resources

### 7.2.1 Expand the area of forest.

In view of the conditions in different regions, we should carry out a ecological compensation system, and build a forestry supporting system including a farm sheltering forest in the Yellow River irrigation area, the desertification prevention and control forest in the central arid area, and the water and soil conservation forest in the southern loess hilly area, through the construction of natural protective forest, protection of forest resources, comprehensive control of Mu Su Sandy Land, protection of wetland, construction of natural reserves, protection forest along Yellow River and roads, return of farmland to forest, and consolidation of the outcome.



### 7.2.2 Recover the vegetation in natural grassland

Enclosure of grassland to prohibit grazing is an effective measure for ecological recovery in the semi-arid desert steppe. We should take a series of comprehensive measures such as enclosure, grassland reform, construction of artificial grassland, scientific breeding, livestock improvement, and prohibition, suspension and rotation of grazing, and strive to make the grassland green, improve the animal husbandry industry in the grassland, and help farmers and herdsmen to become rich. In this way, we can relieve the overburden on the grassland, and improve the ecological system's capability for self-organization and adjustment.

### 7.2.3 ESTABLISH THE ECOLOGICAL FUNCTION OF THE WETLAND IN YELLOW RIVER.

We should return farmland to lakes, launch projects to protect, restore and control wetland, and expand the area of lakes and wetlands, so as to fully recover the function of wetland.

### 7.2.4 LOWER THE LAND RECLAMATION RATE

We should promote the balance of the construction land and the compensation of the arable land through farmland cultivation, intensify the efforts on land arrangement and development in the central and northern areas. Land in contiguous stretches should be arranged and reclaimed to increase arable land. We should carry out comprehensive control of ditches, canals, farmland, forest and roads, boost the “rich soil” project, the project of testing the soil’s composition and applying fertilizer accordingly, and the project of the control of the low-lying saline and alkaline land, and reform the medium and low-yield fields in the Yellow River irrigation area. We should also make more efforts in dry farmland capital construction, with the focus on the areas with precipitation above 400 millimeters.

We should also cultivate high-standard dry farmland including terraced fields, flood irrigation field and dyke field, and grain-ration farmland for returning farmland to forest, so as to earnestly improve farmland quality, and guarantee the prohibition of disordered reclamation and damage to the environment.

#### 7.2.5 EARNESTLY PROTECT FARMLAND

In the Yellow River irrigation area, extensive afforestation on farmland, growing perennial pasture grass, digging for fish ponds, and other production and operation activities that will damage the topsoil are prohibited. Unused and waste land should be used for urban construction land. The farmland whch has not been used for a long time, should be returned to farmland to restore agricultural production. The discarded villages and residential areas should be reclaimed to promote the balance of the construction land and the compensation of the arable land.

## 7.3 OPTIMIZE AGRICULTURAL PRODUCTION STRUCTURE AND RAISE THE OUTPUT AND BENEFIT

#### 7.3.1 GREATLY BOOST CHARACTERISTIC INDUSTRIES WITH REGIONAL ADVANTAGE

In line with the strategy of “giving full play to advantage, highlighting characteristics and promoting industrialized operation of agriculture,” we should consider the climate characteristics and resources in the Yellow River irrigation area, the central arid area, and the southern mountainous area, and focus on the resources, environment in different areas, and the region advantage and potential. We should earnestly implement the industrialization strategy of agriculture, give priority t the five strategic pillar industries including Chinese wolfberry, beef and mutton, cows, potatoes, and fruits and vegetables, and the six regional advantageous and characteristics industries including high grade grain, freshwater fish, grapes, red date, seed production, and high quality pasture grass.

In this way, we can gradually form a localized and specialized production pattern with advantages in geography, culture, species, resources and processing, and help advantageous and characteristic agriculture become an important pillar industry for increase of farmers’ income and rural economic development.

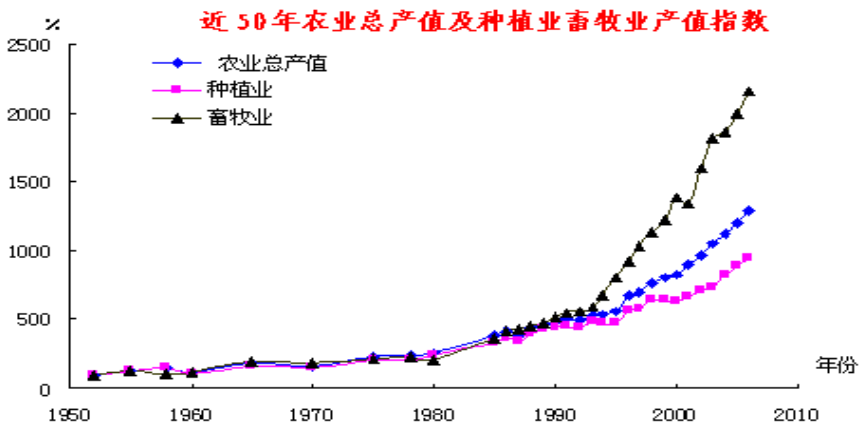



Figure 7.1. Index of production output of overall agricultural industry (blue), farming (pink) and animal husbandry (black) in the last 50 years

### 7.3.2 Popularize the technology for ecological agriculture

We should consider the characteristics of climate in different regions, and comply with the law of nature and agricultural production structure. We should also make full use of the heat, light, water and land resources, and promote quality, efficient, water conservation, ecological, and disaster resistant agricultural production technology focusing on high yield with fewer seeds, and boost the development of environment-friendly ecological agriculture.

## 7.4 Strictly Control Agricultural Pollution and Protect Agricultural Ecological Environment

We should extensively apply the practical agricultural production technology and scientific agricultural production management methods which can both meet the need for agricultural production and rationally use resources and protect environment. Especially, during agricultural production process we should produce and use environment-friendly “green” chemical fertilizer, pesticide, mulching film and other agricultural chemicals, improve

agricultural technology, reduce generation of agricultural pollution source, lower the risk of environmental pollution agricultural production and service, and ensure the ecological safety of agricultural chemicals.

Moreover, we should apply the key technology of returning straws to the field, ammonification of straws, cultivation of edible fungi on straws, straw gasification, use of the resources of waste in large livestock and poultry farms, comprehensive prevention and control of diseases and pests, replacement of pesticide and chemical fertilizer with the slurry and dregs in the methane tank, testing the soil's composition and applying fertilizer accordingly, and dry crops and their cultivation. In addition, we should establish the policy, law and regulation, and management system on rural pollution and intensify the prevention and control of agricultural pollution.

## 7.5 Popularize Clean Energy in Rural Areas to Reduce Damage to Environment

We should adopt the policy of "acting according to circumstances, adopting a balanced energy mix, comprehensive utilization and laying stress on both conservation and development," and aim at changing the farmers' traditional way of production and living. We should use agricultural waste, solar energy, wind energy, and other resources, and optimize and combine various energy development and utilization technology and highly efficient courtyard agricultural technology. More efforts should be made on the clean energy projects such as methane tanks and solar cookers, to promote virtuous circle between rural households' production and their living, farmland and courtyard. In this way, we can achieve cleanness in households, high efficiency of courtyard economy, and no harm of agricultural production, and reduce disordered logging and digging due to lack of fuel.

## 7.6 Improve the Public's Capability for and Awareness of Handling Climate Change

### 7.6.1 Give full play to the driving role of the government

We should further improve the awareness of climate change among government officials at all levels, and decision makers in enterprises and public institutions, and gradually foster a contingent of cadres who have better understanding of global climate change. People from all sectors of society should be called upon to publicize the policies to counter climate change and raise the public's awareness of climate change.

### 7.6.2 Reinforce the publicizing, education and training work

Mass media of communication, including books, newspapers, and audio-visual products, should be used to be used to publicize climate change to people from all social sectors, encourage sustainable lifestyle, advocate conservation of electricity and water, and raise the self-consciousness f0r recycling use and classification of garbage. We should also hold various training courses with special themes, carry out special training activities to different trainees, and organize science seminars on climate change. Information technology should be fully used to further improve the content and functions of websites on climate change and make them a prompt and effective platform for information sharing and communications.

### 7.6.3 Encourage the participation of the public

We should establish an incentive mechanism for the participation of the public and enterprises, and give full play to the role of the enterprises' participation and the monitoring of the public. We should improve the channel and system to release information related to climate change, expand the channels for the public to participate or supervise, and bring the supervision and guiding function of the news media into full play. Transparency in making decisions related to climate change should be improved, to make the management of climate change issues more scientific and democratic. We should also bring the role of civil societies and non-government organizations into full play, and encourage the general public and people from all social sectors to participate in the actions to mitigate global climate change.

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