



**IGU/ LUCC North East Asia Conference, 2009**

# **The Environmental Impacts and Sustainable urbanization Strategy in Arid Areas of Northwest China**

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I Regional Characteristics of Northwest China

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# I Regional Characteristics of Northwest China

## 1.The Location and Extent of Northwest China

North Western China includes six provinces: Shaan'xi, Gansu, Xinjiang, Qinghai, Ningxia and Inner Mongolia. The area of northwest China covers 4.29 million Sq. Km, accounting for 44.69% of China's total, GDP of that is 17 million US\$, which is 7.24% of China's total.

**Location:** The hinterland of Asia-European continent, arid & semi-arid natural environment with vulnerable and sensitive characteristics

# The Location of Northwest China



## 2. Regional comparative advantages of northwest China

### 2.1 Rich Minerals and Energy Resources

□ In terms of total volume, China is a large country with rich natural resources at one time, at the same time China is a small country with the per capital possession of the most natural resources below the world's average. Even some of the vital natural resources to the national economy and people's livelihood, is less than half of the world's average.

## **2.2 The rich and colorful tourism resources**

**□ Northwest China's landforms are diverse, and the natural tourism resources are abundant, such as the scene of desert in the Northwest, lofty ridges and towering mountains in Qinghai-Tibet Plateau, and snowy scenes in highland. The long history and divers of minority peoples.**

**□ The Cradle of Chinese Civilization and CCP with the Longest history of human beings (over 8000 years).**



The majority of Chinese minorities inhabits in Western China, with the rich and unique cultures and tradition.









# **Qin Shihuang Terracotta Warriors and Horses**

**In Xi'an city, Shaan'xi province**





**Richly endowed by nature, Western China has advantages for developing tourism industry.**



### 3 Environment vulnerability, sever degradation and shortage of water

- Water and soil erosion: 80% of China's total.
- Desertification accounts for 99% of China's total.
- Grassland degradation accounts for 93.2% of China's total.
- > 25° slope cultivated land accounts for 70% of China's total.

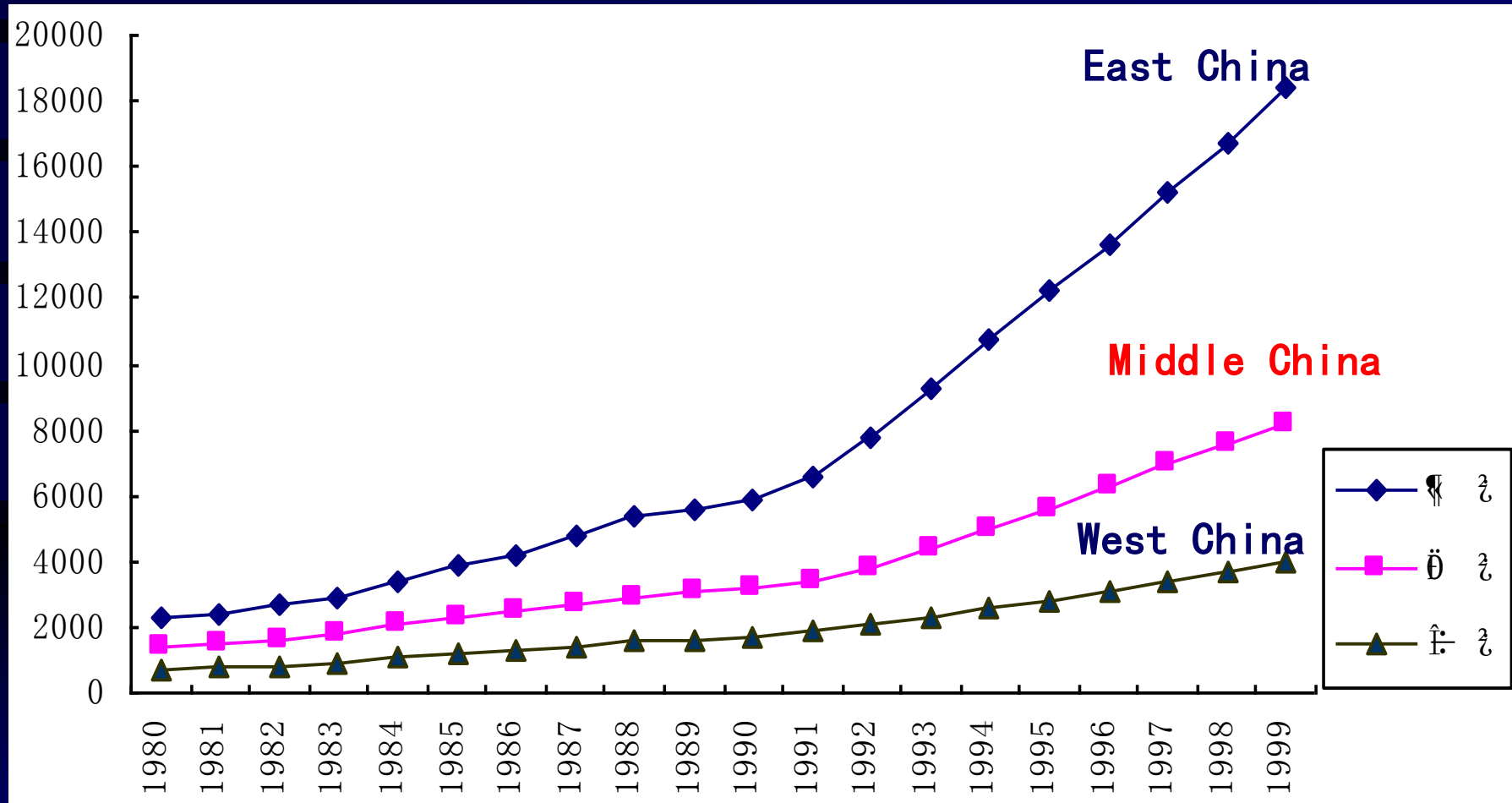


**❑ Water shortage restricts the high water demand industry and agricultural development and water saving industry is the priority choice.**

**With the heavy pressure of population increasing continuously, agricultural resources, such as water and soil, are in pressing demand, which brings about the greatly challenges to China's food security.**

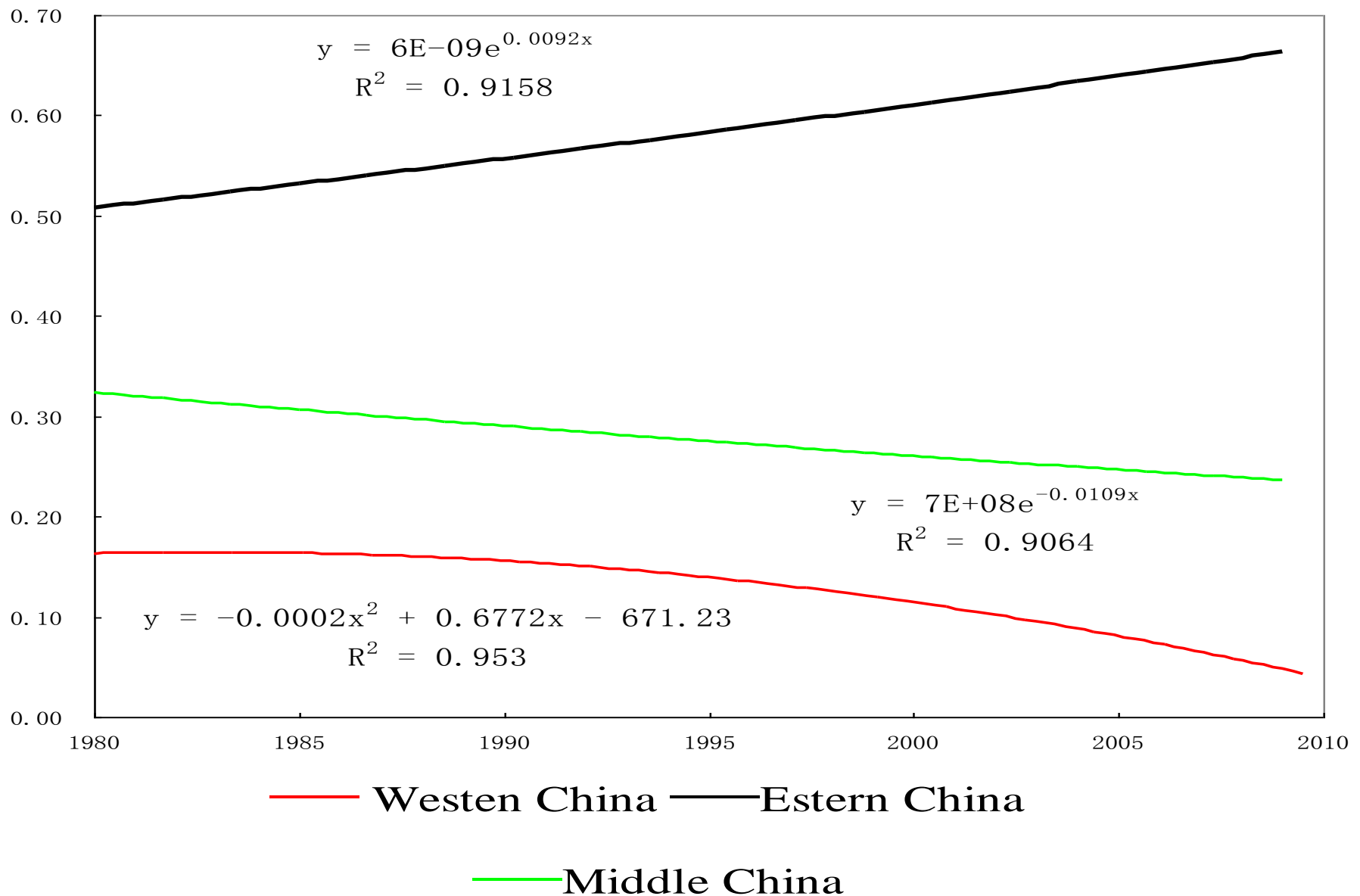
**❑ The shortage of per capita water and unmatched spatial distributions of water and arable land is one of the biggest barriers to develop the high water-demanded agricultural industries.**

## 4 Less developed and severely uneven socio-economy under the contradiction between eco-environment and socio-economic system



**Evolving tracks of per capita GDP of the Three Parts of China**

# Regressions on GDP of the Three Parts of China before the Implementation of Policy of Development of West (by the price of 1980)





# II Rapid urbanizing Era

1. Urbanization world with three trends during the next 25 years, predicted by United Nation Human Settlement Programme.

The year of 2007 marks a turning point in human history: the world's urban population for the first time equal to the world's rural population.

- In 2005, the world's urban population was 3.17 billion out of world total of 6.45 billion.

In 2030, the world's urban population will reach almost 5 billion, with an average annual growth rate of 1.78 per cent, almost twice the growth rate of the world's total population.

- Asia and Africa will host the largest urban population. Asia will host 50% of the world's urban population by 2030. Cities of developing world will absorb 95% of urban growth in the next two decades, and by 2030, will be home to almost 4 billion people, or 80% of the world's urban population. The rural population will shrink by 2015, in Asia and Africa, as the urban population growth.

- Small and intermediate cities will absorb most urban growth.

More than 53% of the world's urban population lives in cities of fewer than 500000 inhabitants, and another 22% of the world's urban population lives in cities of 1 to 5 million inhabitants. ( *UN-HABITAT, State of the world's cities report 2006/2007, page 4-5* )

## 2.China is in a rapid urbanizing stage

- In 2005, urbanization rate of China and northwest China are nearly 43 % and 38 % respectively, and per capita GDP of China is 1700 US\$. Both China and northwest China are going into a rapid urbanizing stage, urbanization ratio between 30%-70%. northwest China has 81 cities, accounting for 12.3% of China's total.

**Urbanization Rate in Different Regions of northwest China  
( 2005 ) , ( 10<sup>4</sup> persons, %)**

Region	Total Population	Urban Population	Rural Population	Urbanization Rate
Shaanxi	3718	1384	2334	37.23%
Gansu	2592	778	1814	30.02%
Qinghai	543	213	330	39.25%
Ningxia	595	252	343	42.28%
Xinjiang	2008	746	1262	37.15%
Inner Mongolia	2386	1126	1260	47.20%
Northwest China	11842	4499	7343	38.0%
China	130628	56157	74471	42.99%
Ratio of Northwest to China	9.07%	8.01%	9.86%	

**Data source: China statistics year book, by National Bureau of Statistics of China, 2006**

•During the next 25 years, the urban population of China will double than that in 2005, reaching 930 million by 2030, and the urbanization rate of China will increase to 60%, which would bring about huge transformation between urban and rural areas.

### The tendency of China's urbanization

year	1997	2010	2030	2050
National total population (100 million)	12.36	13.95	15.50	15.87
Urban population (100 million)	3.70	6.00	9.30	11.99
Urbanization rate (%)	29.9	43.0	60.0	75.6

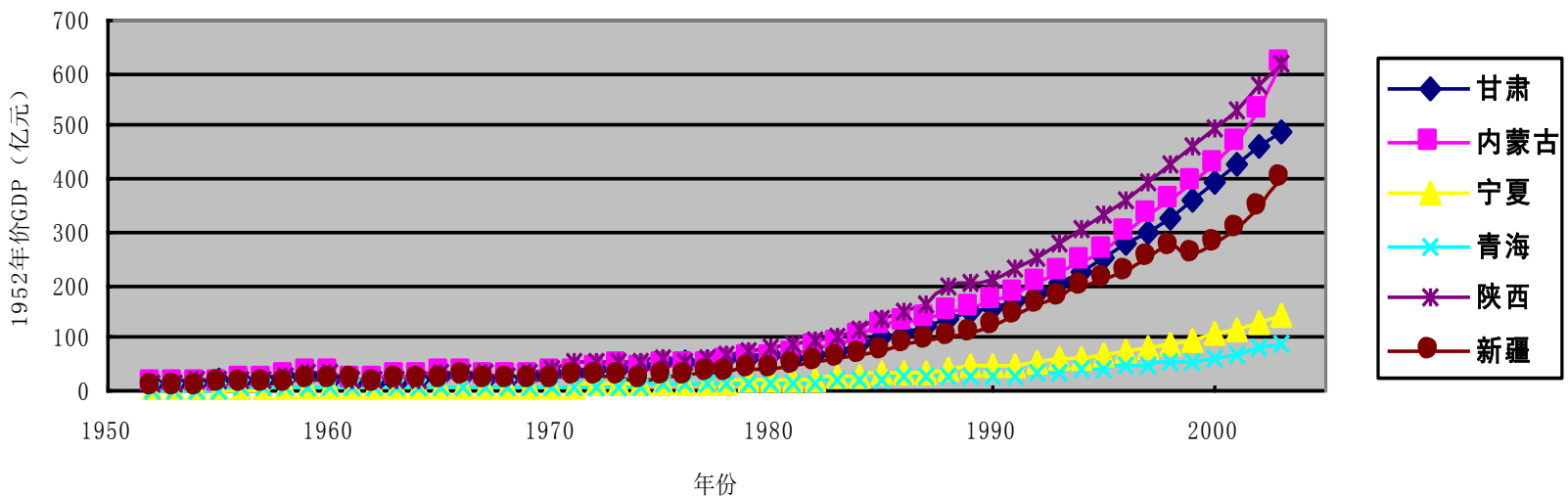


# III The Environmental Impacts of urbanization in Northwest China

We studied the land use and land cover change, environmental, urbanization and its environmental impacts, by remote sensing, ARCGIS, systematic dynamics and field survey methods, through the typical cities and regions in Loess Plateau, Oasis city in arid areas, city along river valley, and city on the plain, in northwest China. It showed the strong mutual interaction above aspects.

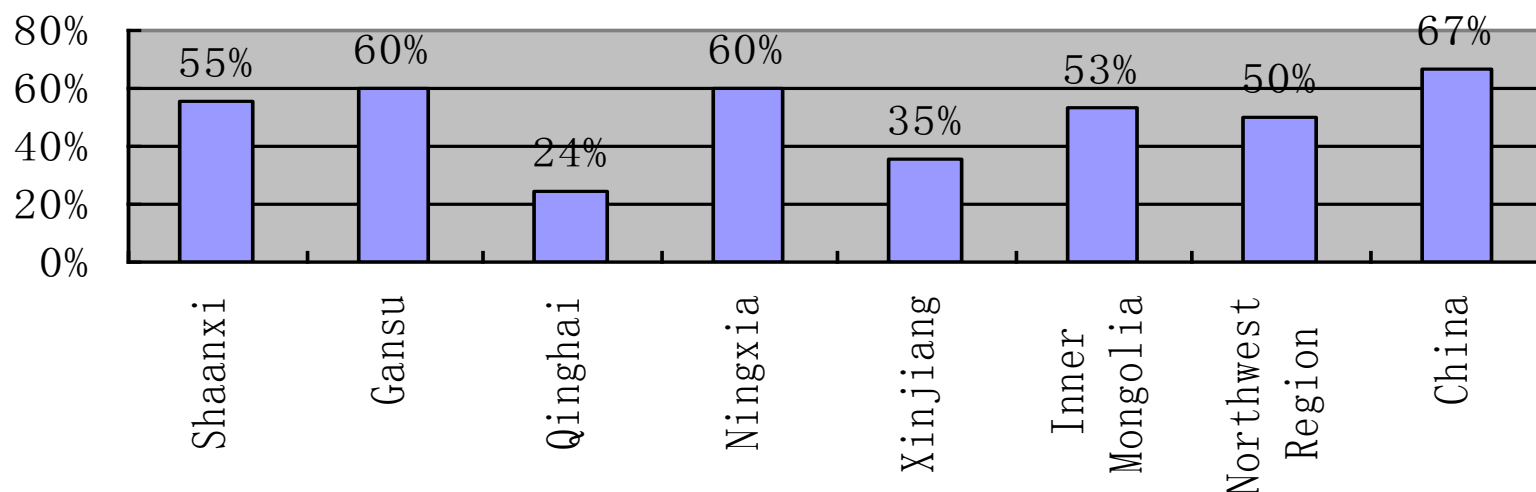
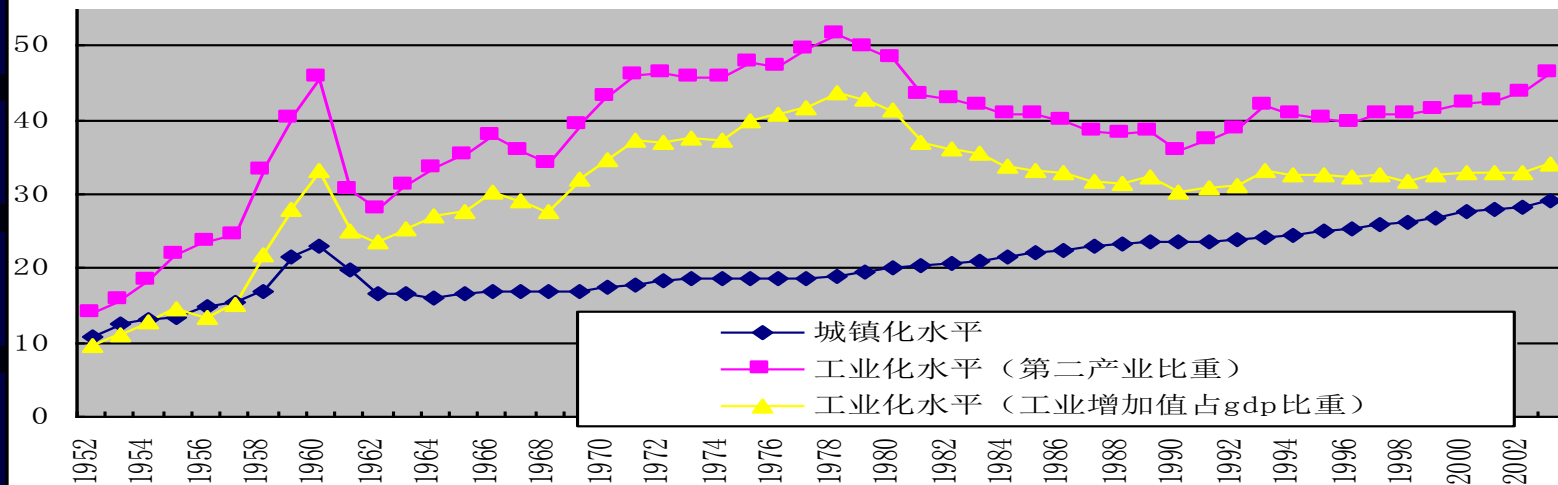
# 1. The positive affects

- Cities are significant sites of socio-economic activities, the centers of trade and destinations for rural migrants a gateway to get job opportunities in large cities.
- The agglomeration process is strengthening, population and rural land transfer to urban citizen and urban land use are accelerating, with continuous fast economic increase in northwest China.



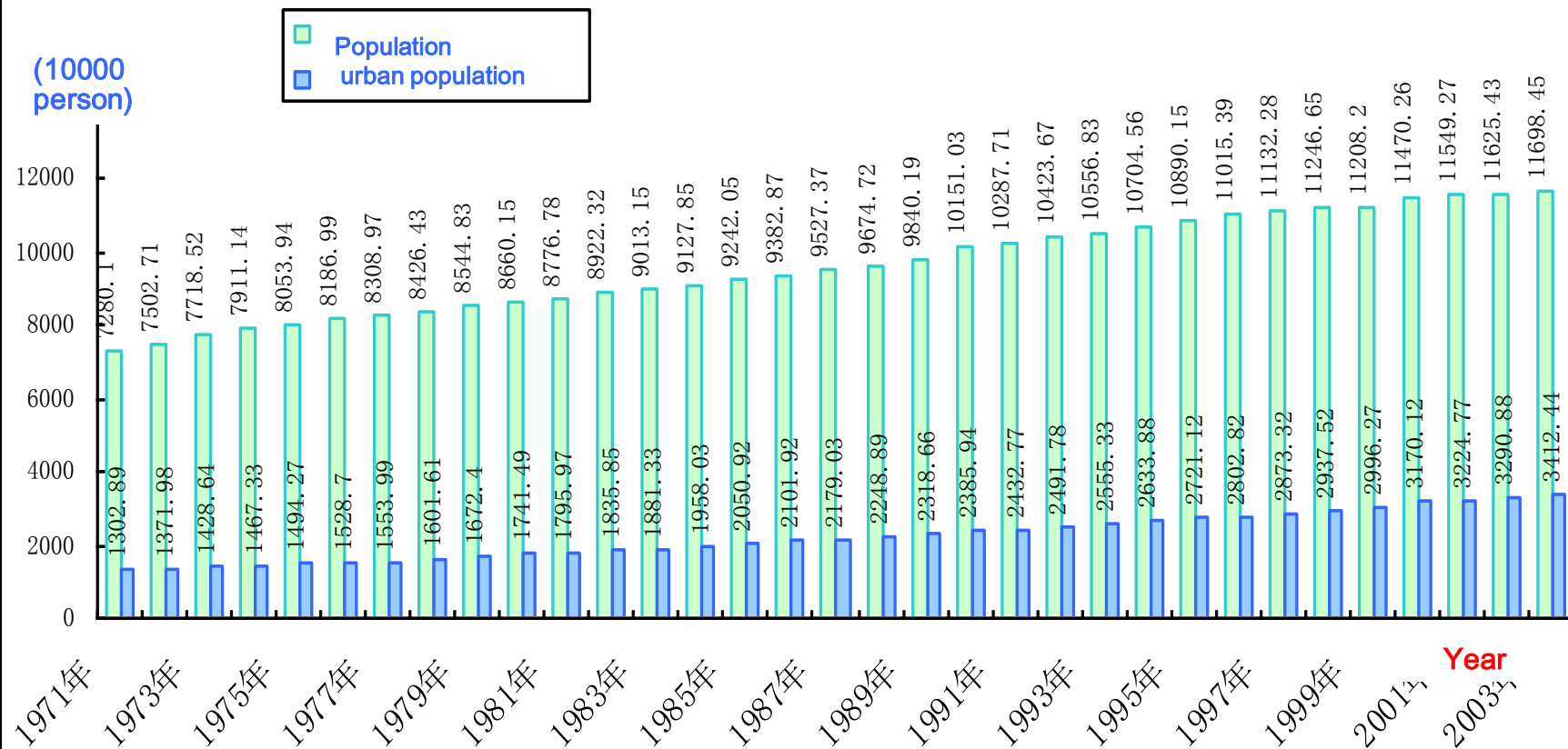
Provincial economic growth of northwest China (1950-2000)

## Industralization and urbanization of northwest China (1950-2000)

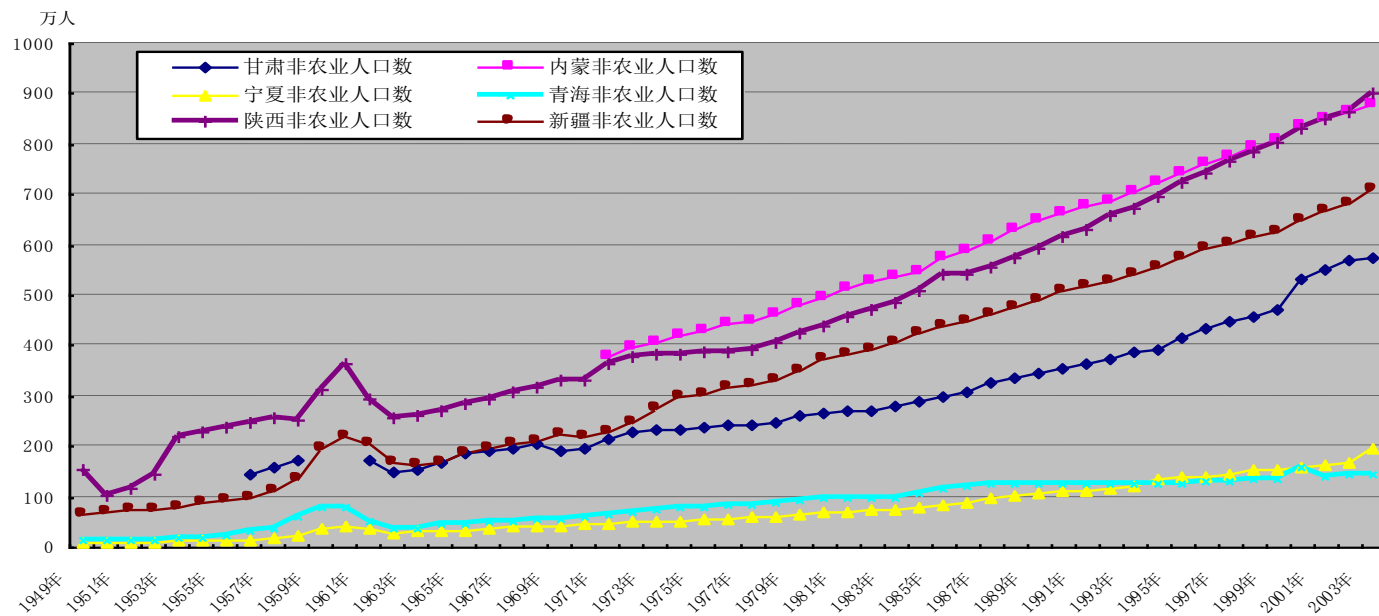


Proportion of Municipality(excluded county city) GDP to total provincial GDP in 2005

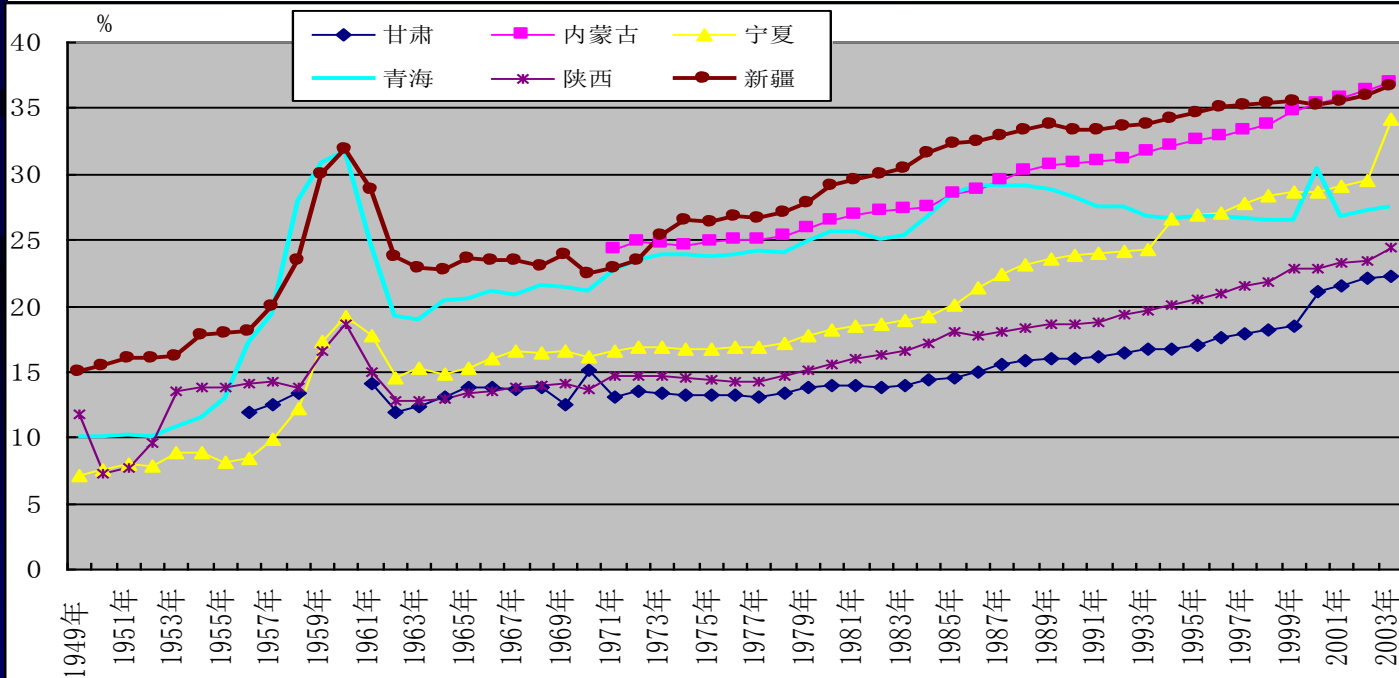




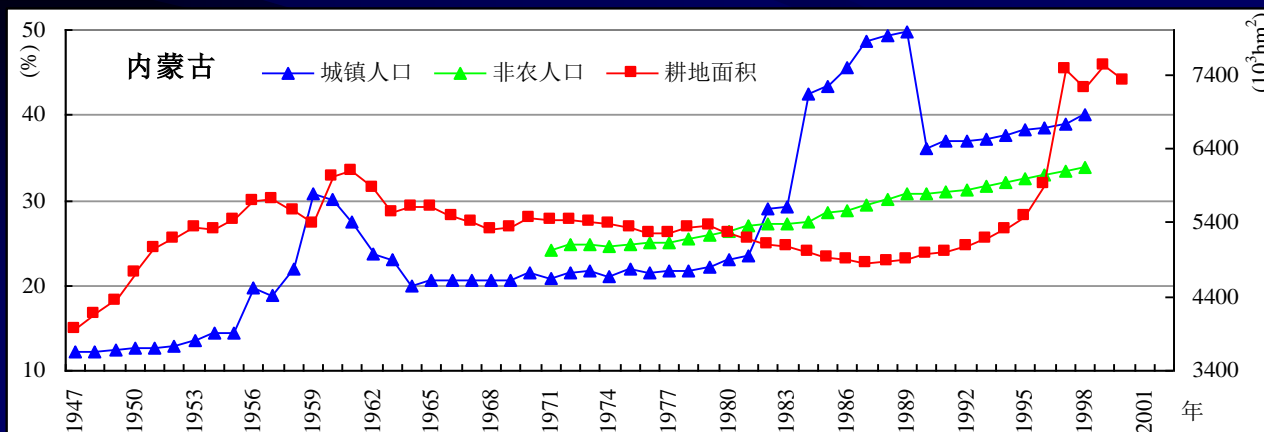
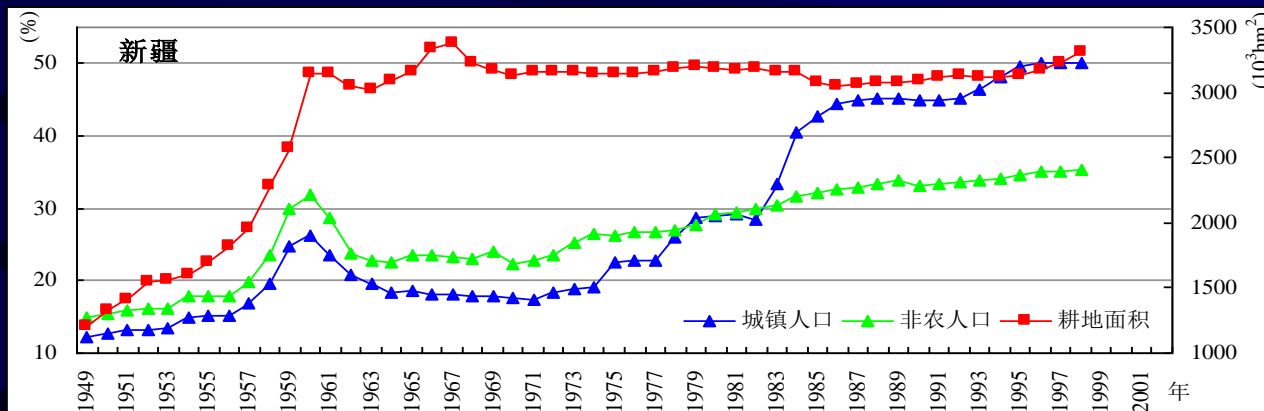
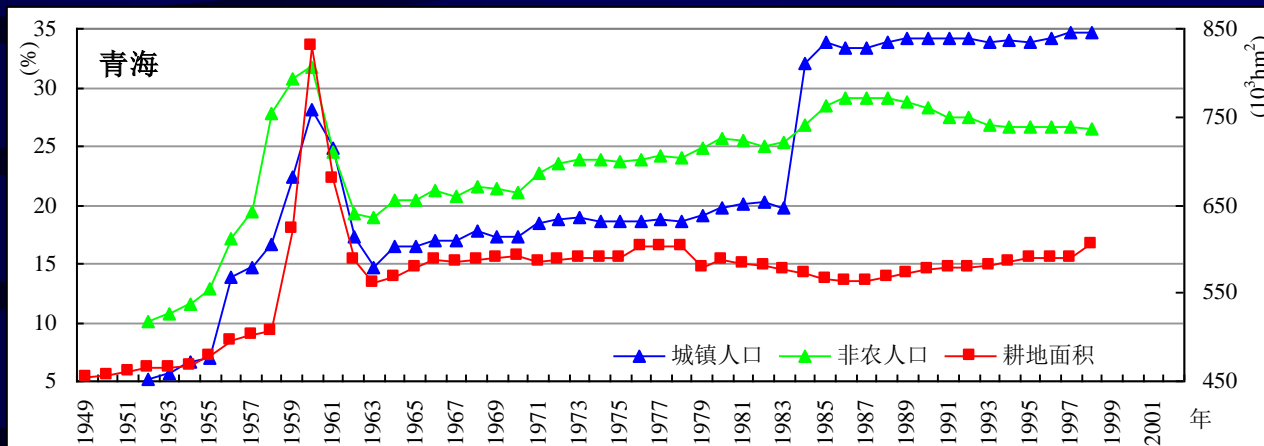
**The growth of urban population and total population of northwest China ( 1970-2003 )**

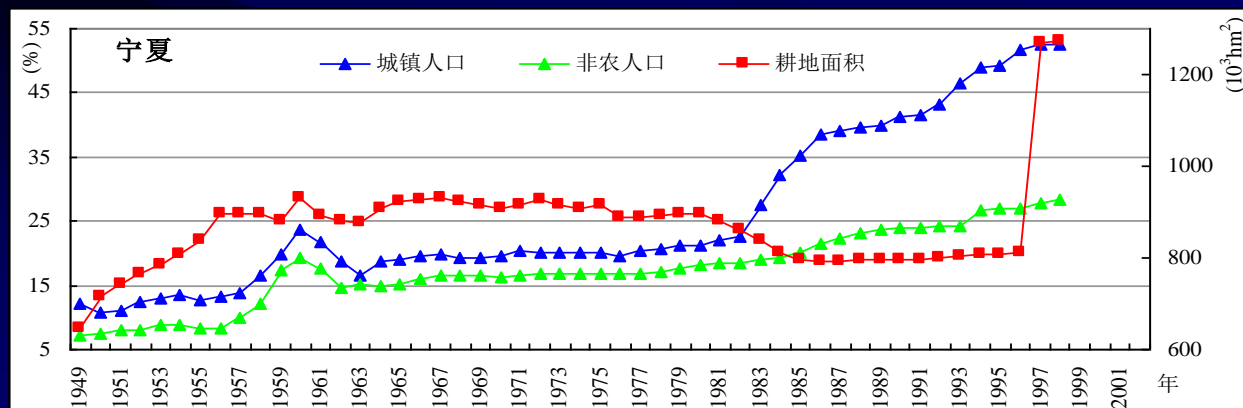
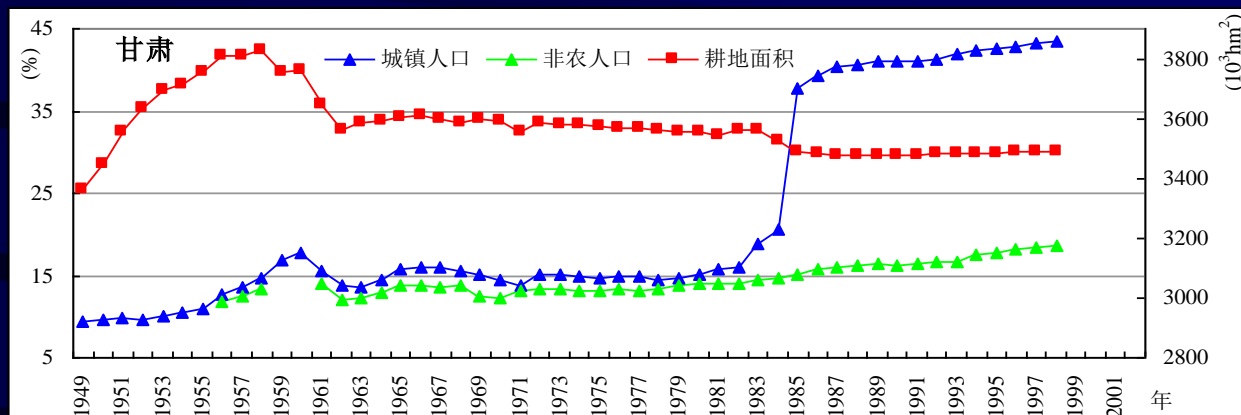
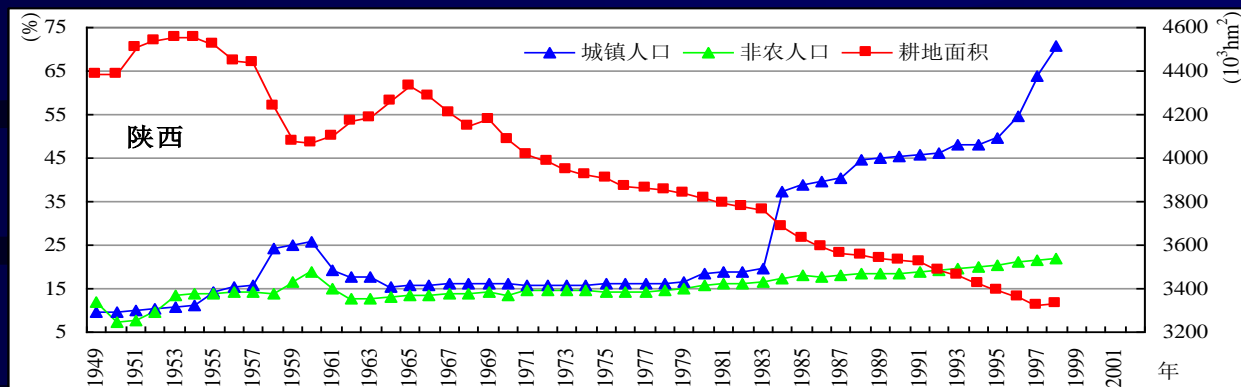


The growth of provincial urban population of northwest China, 1949-2003

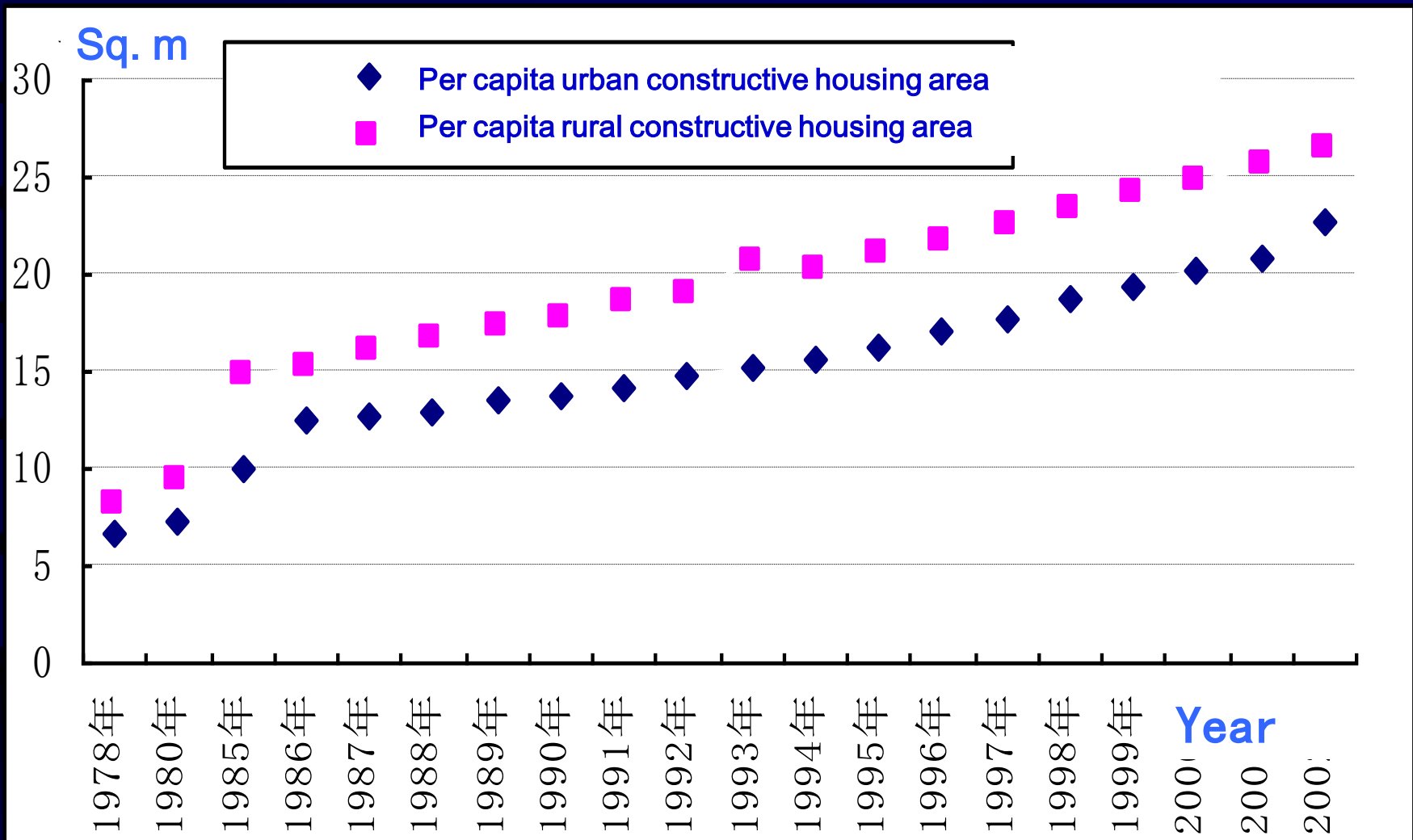


The change of urbanization rate of northwest China, 1949-2003







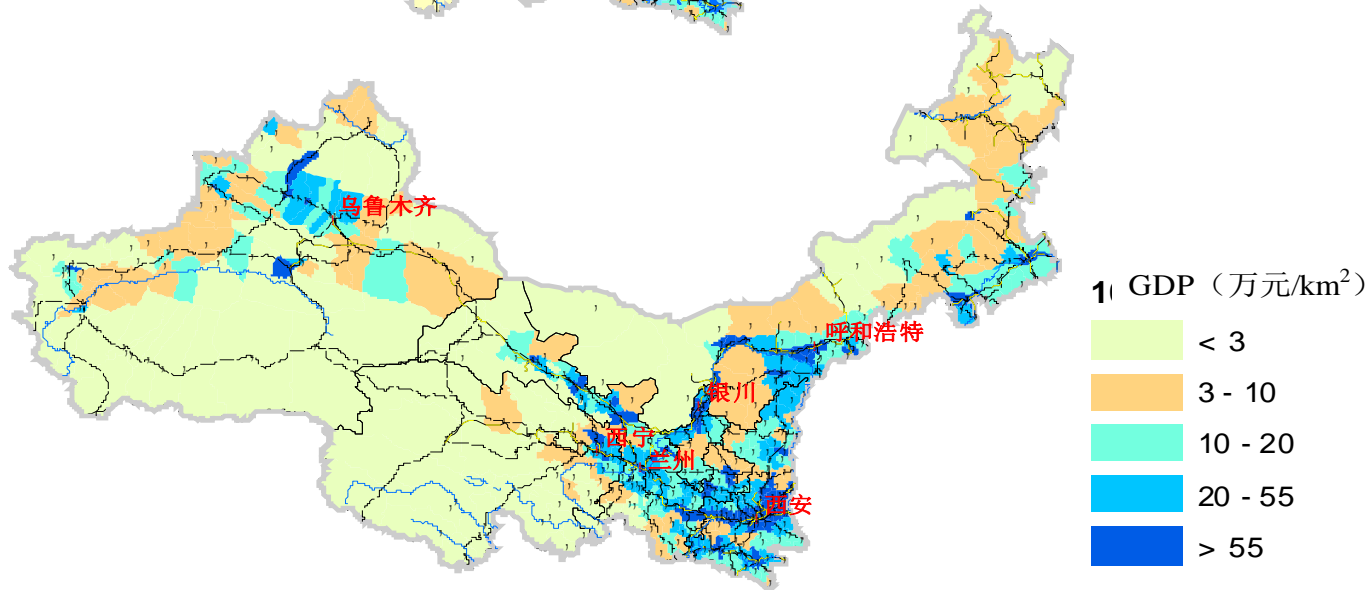
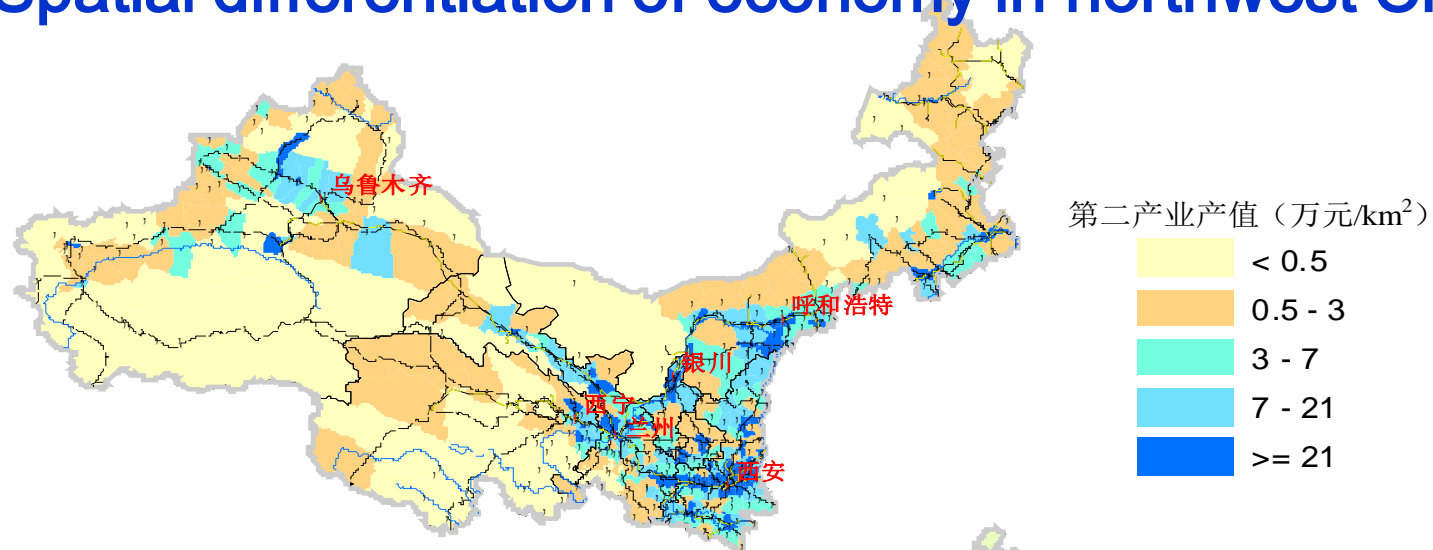


Per capita urban and rural housing  
area of China , 1978-2003



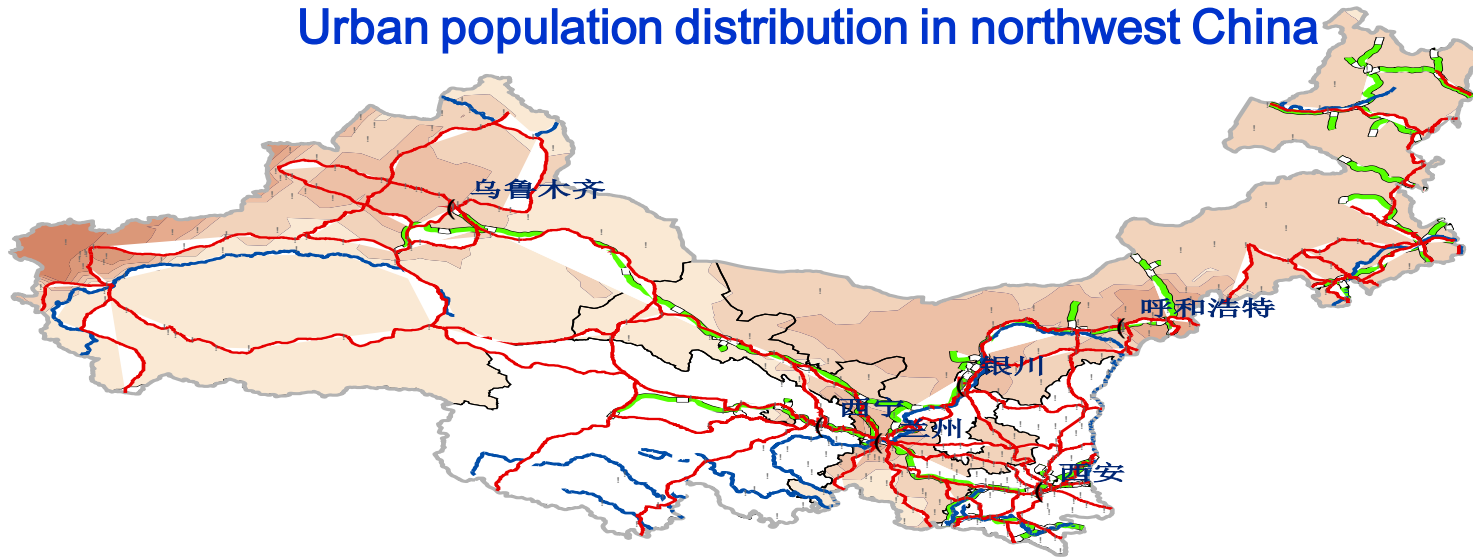
**2. The spatial differentiation of urbanization shaped in point-axis-zone and center-periphery structures, extended along the national railway , highway and large river. The provincial capital cities play the role of regional growth poles. But the urbanization rate of the rural areas is 10% less than the central areas. High increase of rural population laid much pressure on the environment, which is the obstacle of sustainable development in northwest China.**

# Spatial differentiation of economy in northwest China



县市 省会 区界 省界 河流 铁路 公路

## Urban population distribution in northwest China

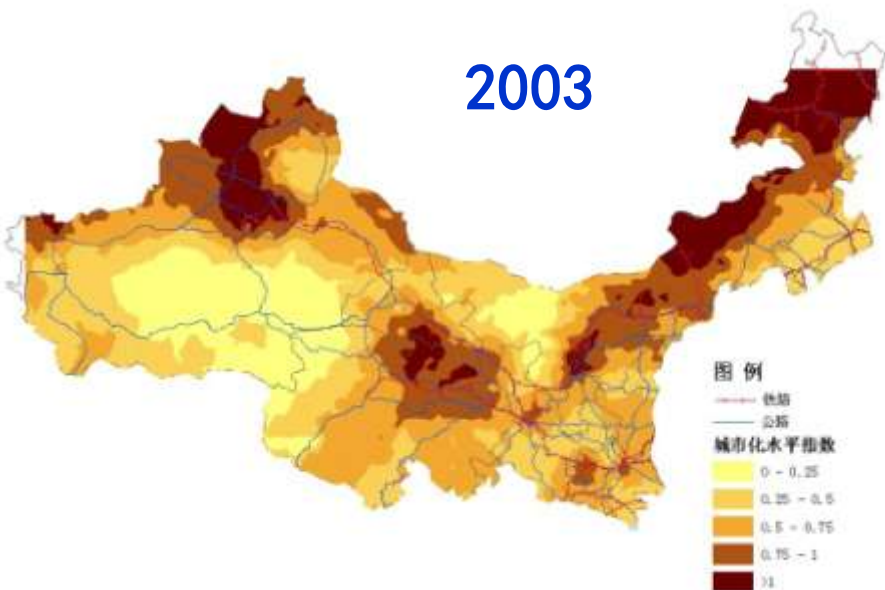


## Distribution of Urban land use for industry and traffic in northwest China

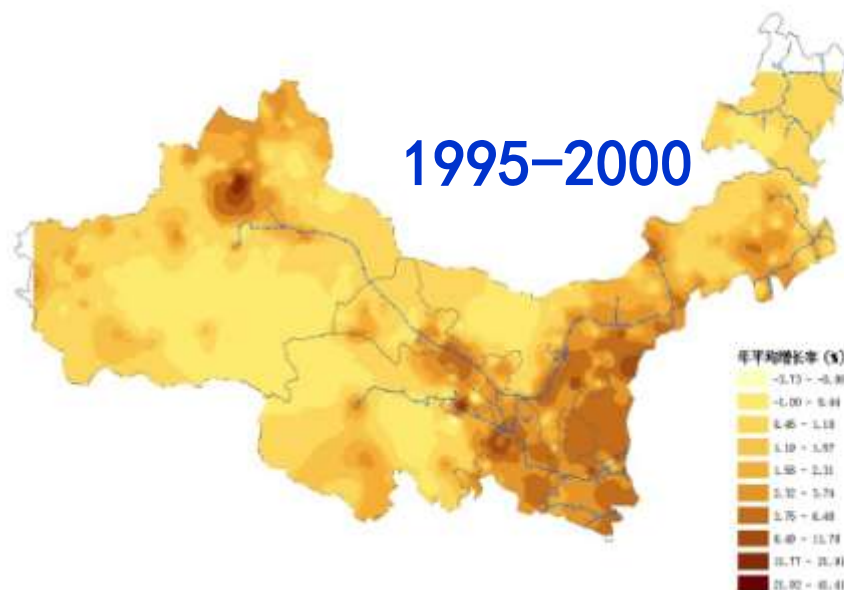


# Spatial differentiation of urbanization in northwest China

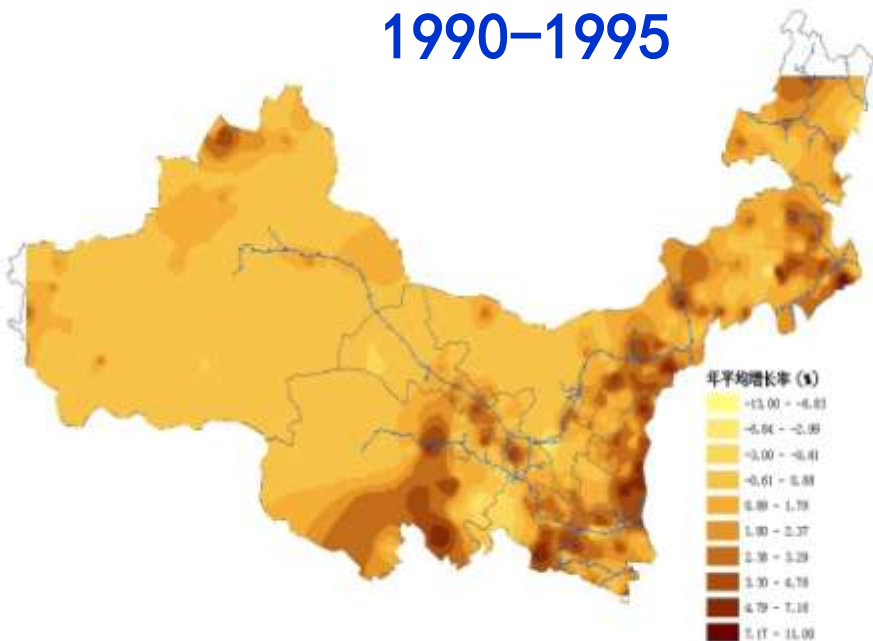
2003



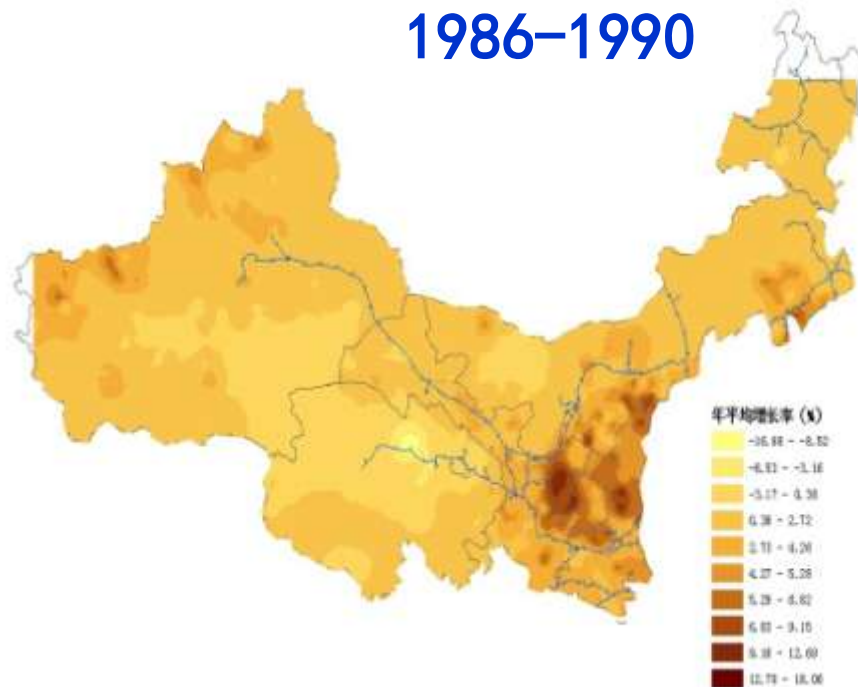
1995-2000



1990-1995

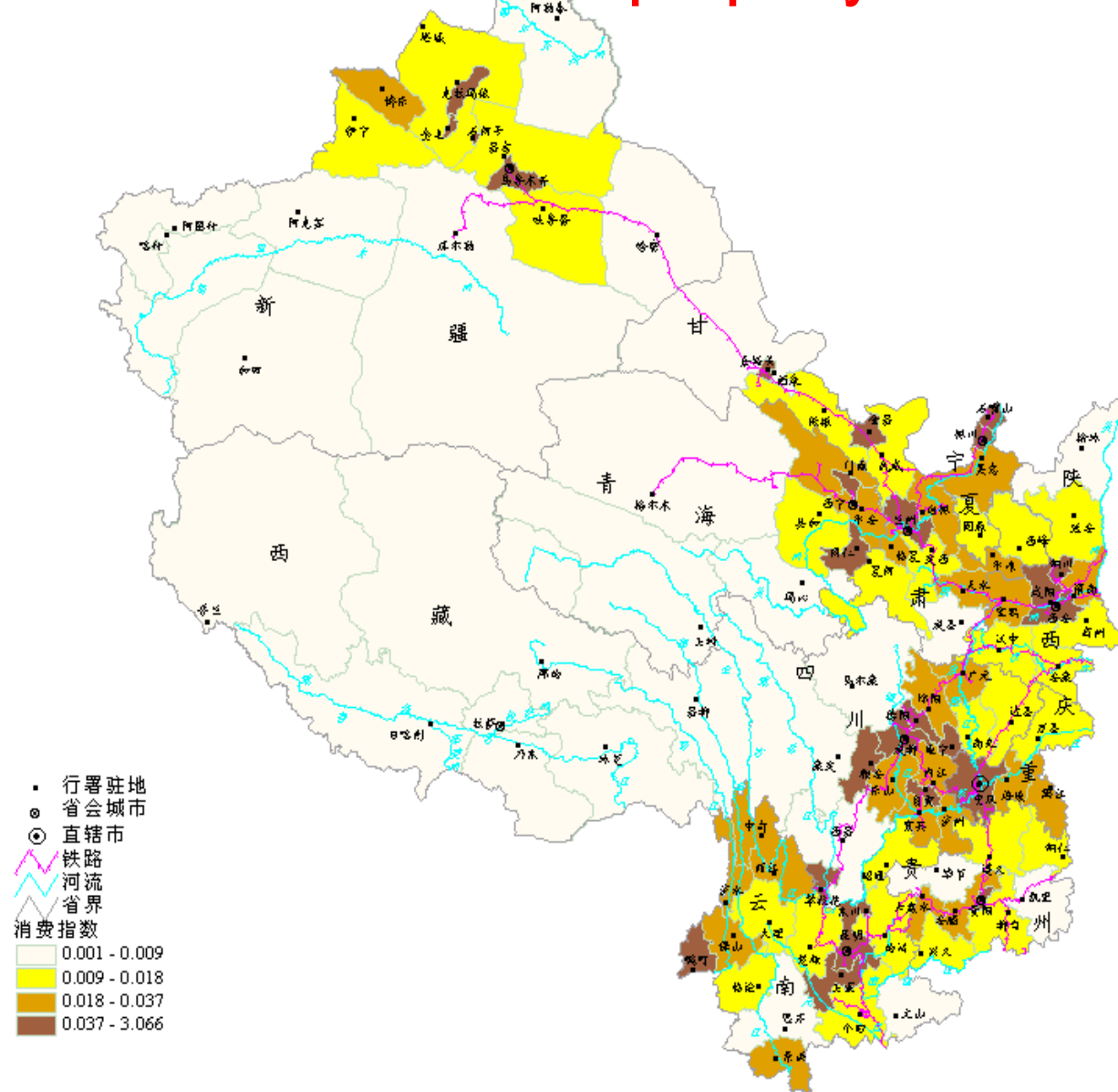


1986-1990

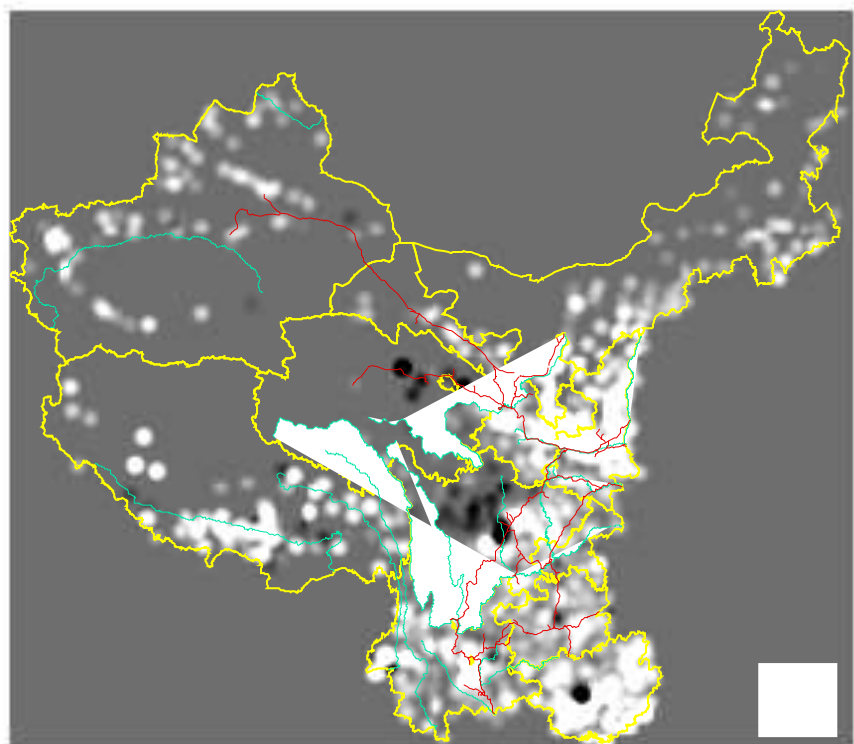




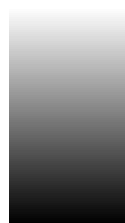
# Point-axis-zone and center-periphery structures



# Distribution of the county towns in northwest China



1980'



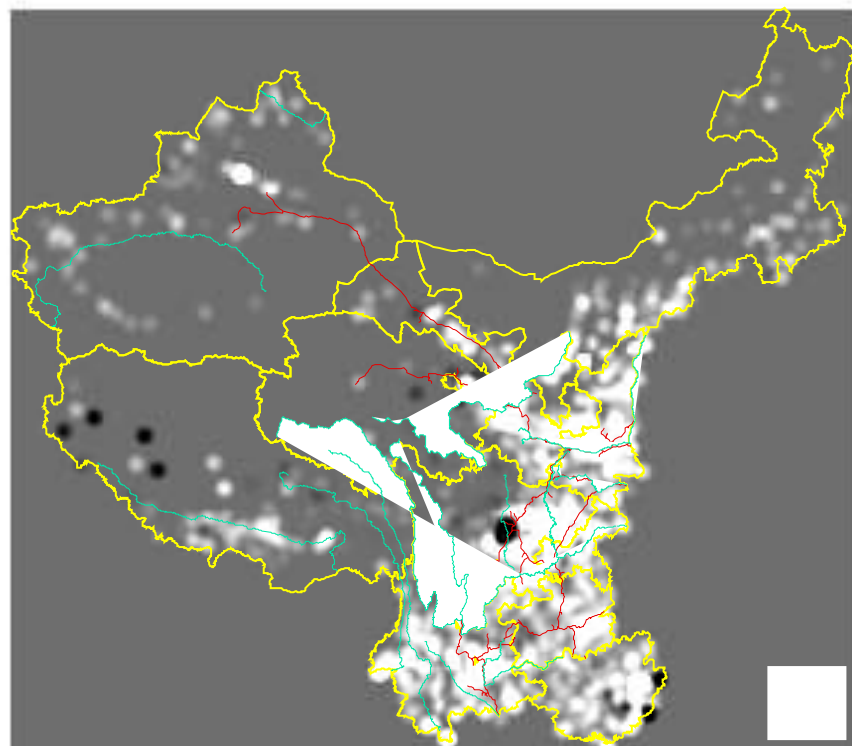
高: 101.180283

低: -16.563803

Legend

— railway

— river



2000'



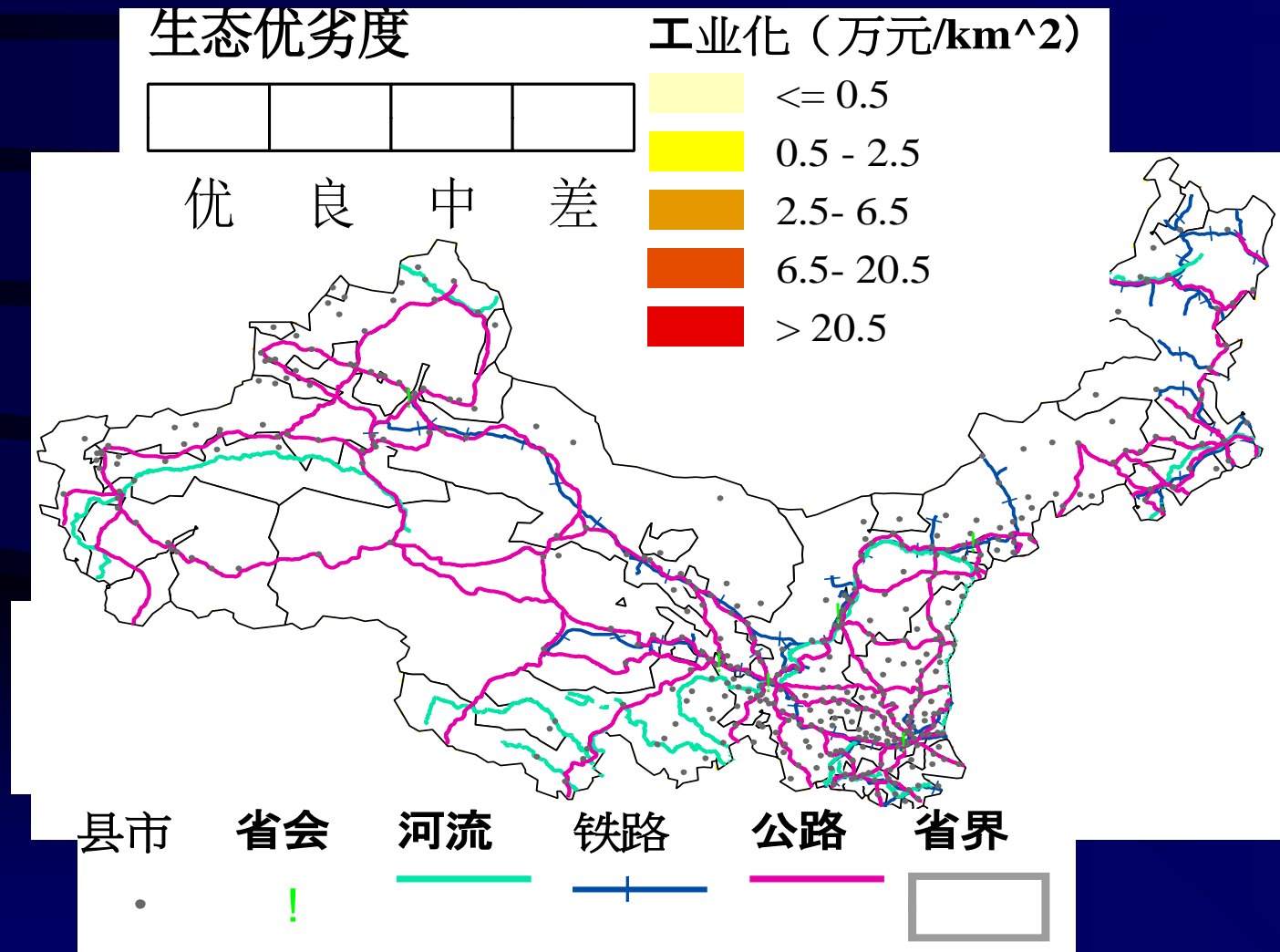
高: 92.769051

低: -12.496306

3. Urbanization and environment are highly coupled, along the national railway , highway and large river, and decreased away from the axes in northwest China.

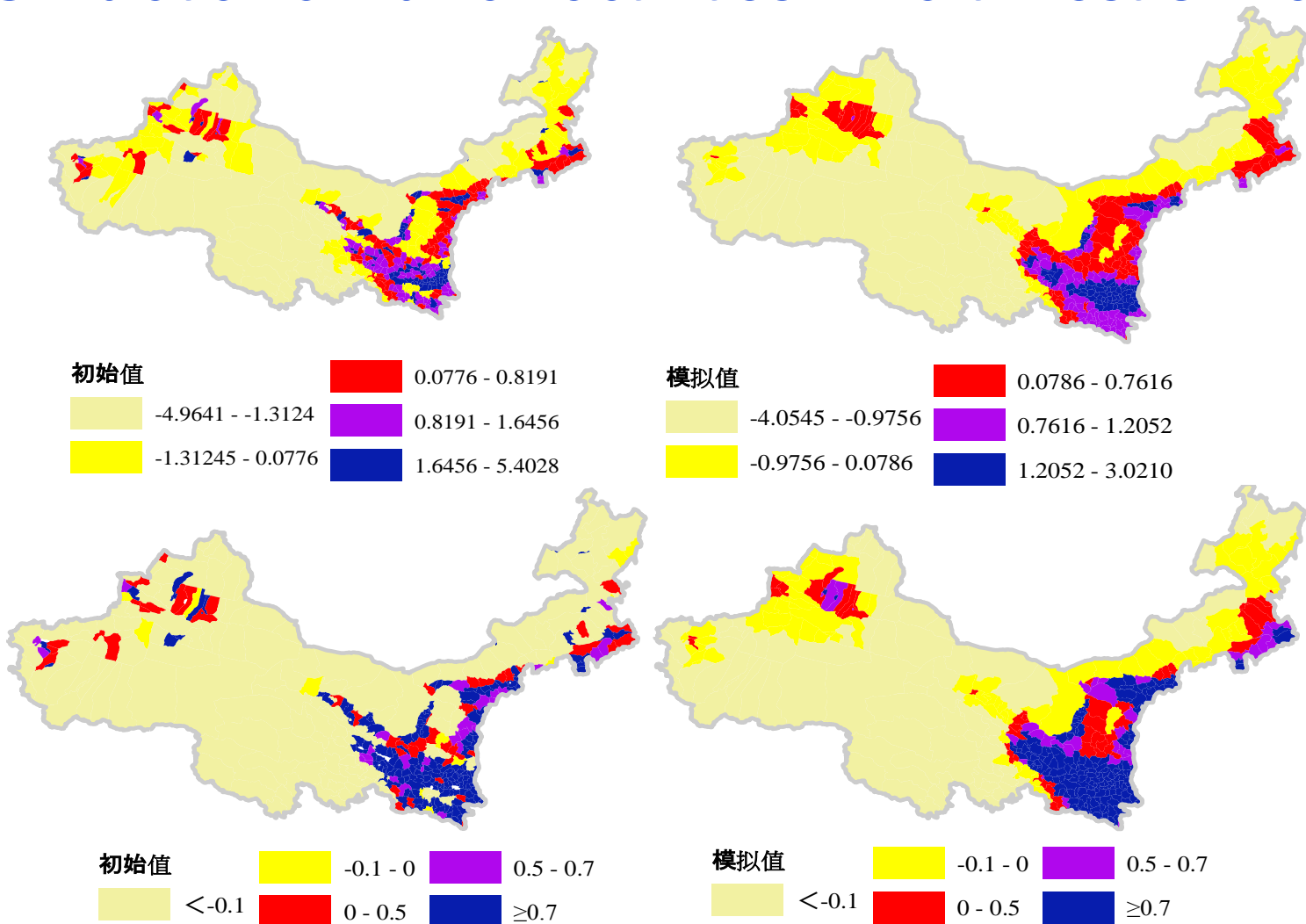
- The most polluted areas of northwest China are heavy industry and mineral exploitation oriented cities, industrial pollution concentrated mainly in loess Plateau, Guanzhong plain in Shaanxi province, cities along the Yellow river, Hexi corridor and Xin Jiang Autonomous Region, and so on.

# The industrialization and ecological fragility





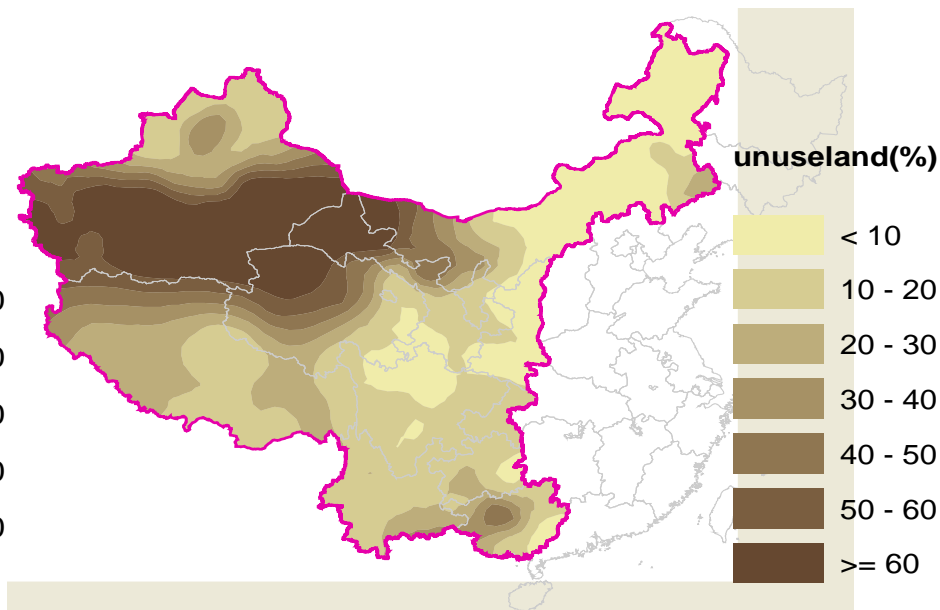
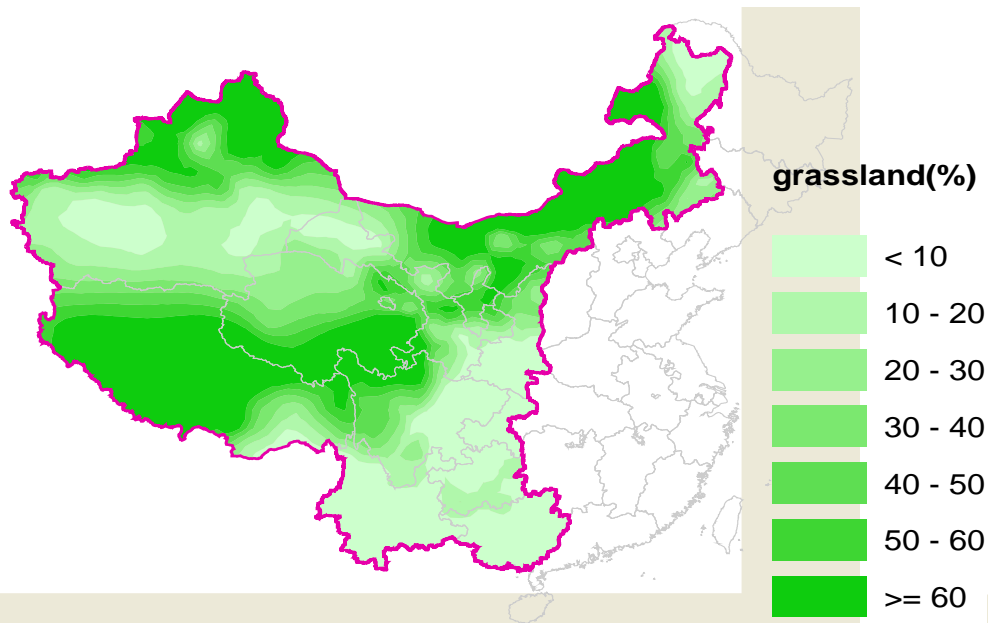
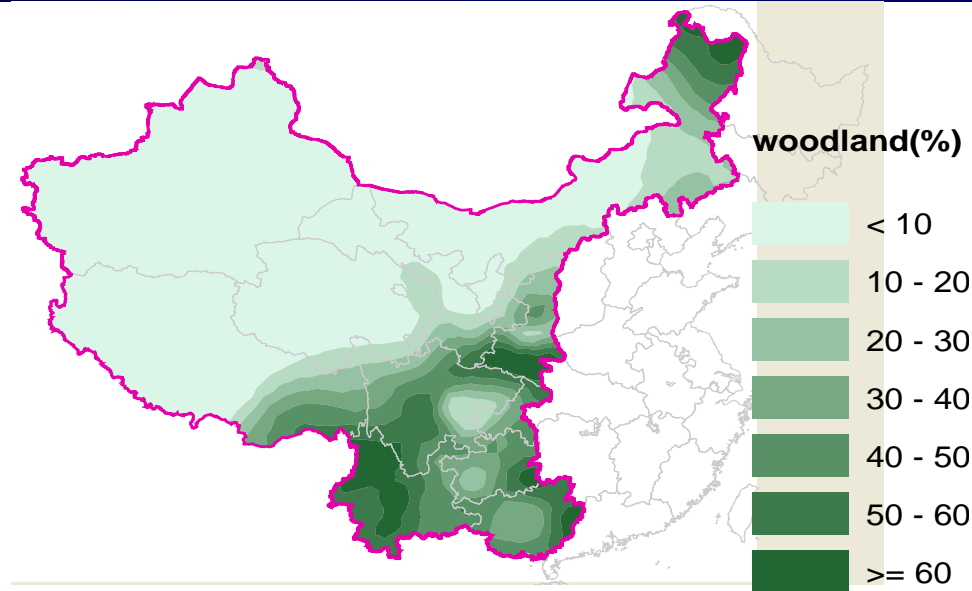
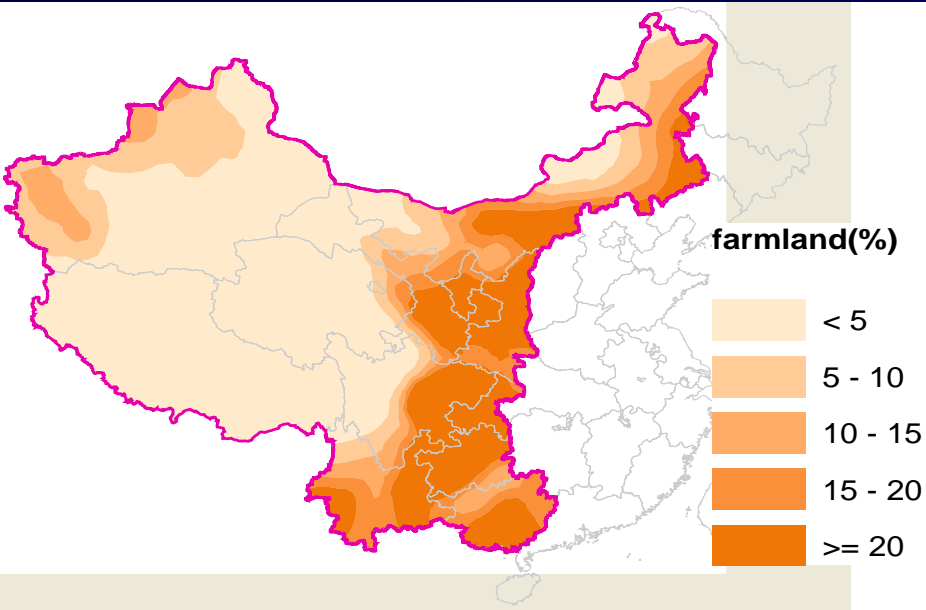
# Simulation of human activities in northwest China



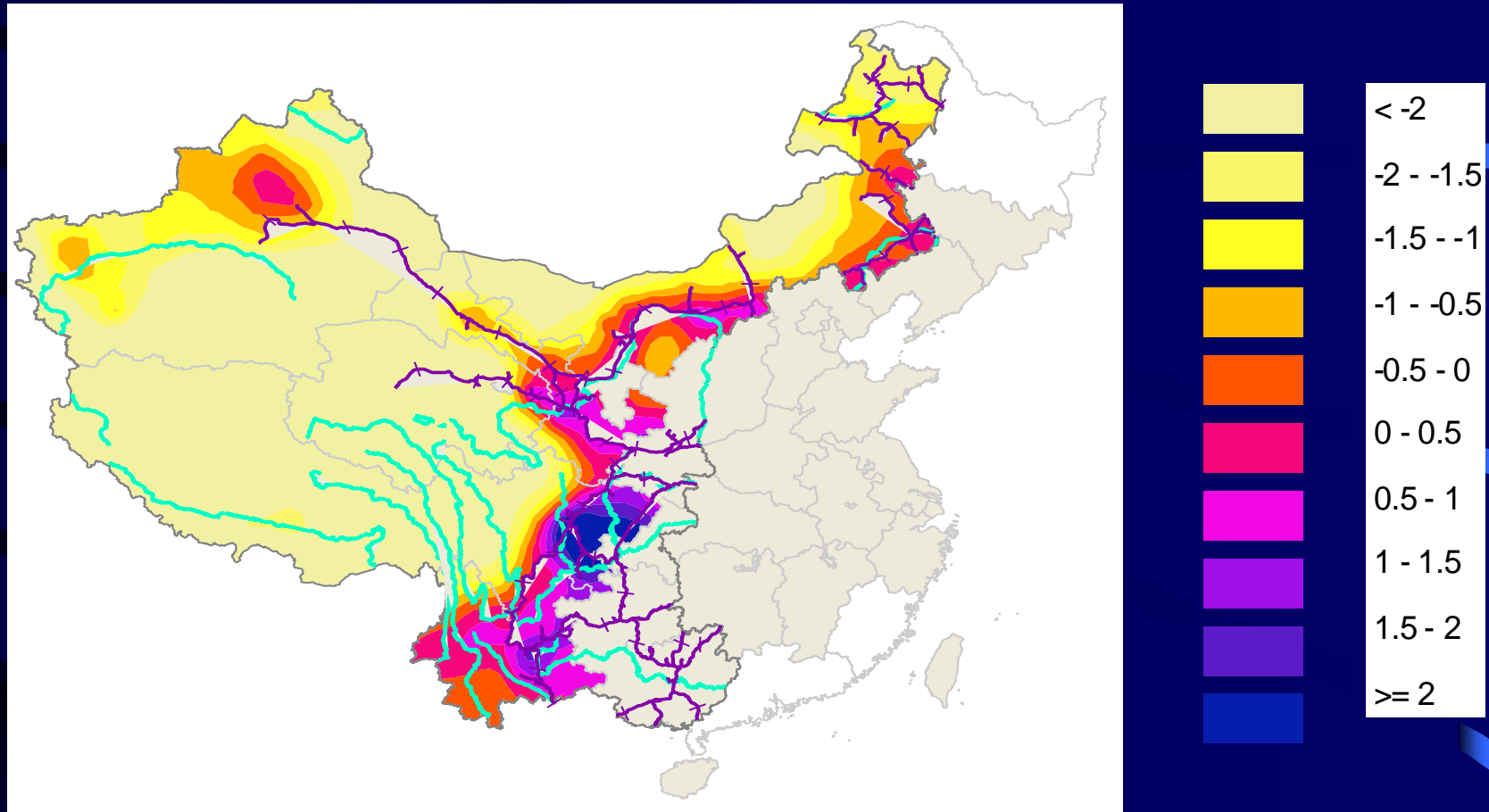
$P = \ln(\sum \lambda p_j / m)$ ,  $P$ 为研究区域空间单元*i*的人类综合活动强度指数,  $p$ 为*i*单元要素*j*的强度,  $\lambda$ 为系数,  $m$ 为评价要素数;

$p_j = d_{ij} / \sum d_{ij}$  ( $i=1, 2, \dots, n$ ),  $d$ 为*i*单元*j*要素的空间密度,  $n$ 为研究区域空间单元数。

# LUCC



# Index of Human Activity



强度人类活动地域， $P > 0.5$ ；中度人类活动地域， $-0.5 < P \leq 0.5$ ；低度人类活动地域： $P \leq -0.5$ 。

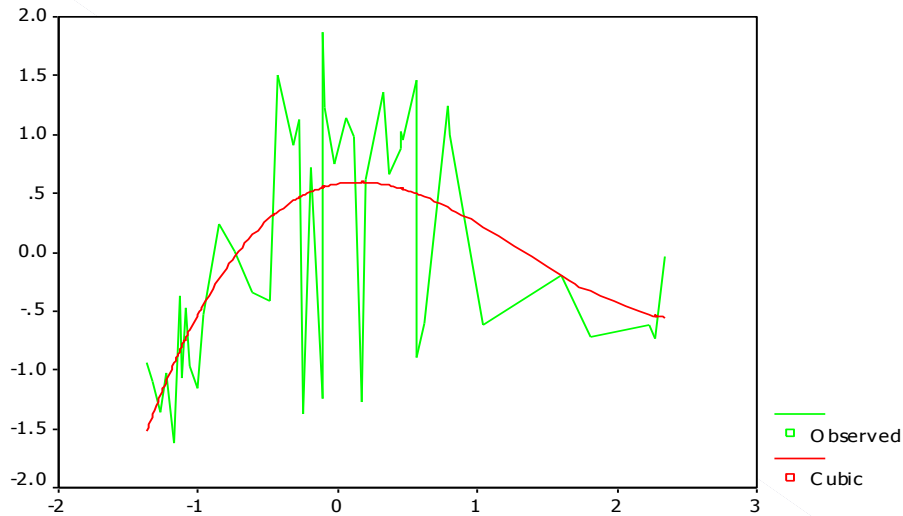
## 4. The urbanization has effects of hot island, drought island, rain island and dark island.

### Simulation of city climate change by urbanization

Index		Optimal regression modeling	F-Test	R <sup>2</sup>
	Index Y			
	Temperature	$Y=0.5820+0.1998X-0.7217X^2+1834X^3$	9.55	0.417
	Humidity	$Y=0.2317-0.8280X-0.2406X^2+0.1504X^3$	10.90	0.450
	Rainfall	$Y=0.6715+0.1096X-0.8745X^2+0.2723X^3$	15.62	0.539
	Sunlight time	$Y=-0.6967+0.2588X+1.0702X^2-0.5192X^3$	32.96	0.712



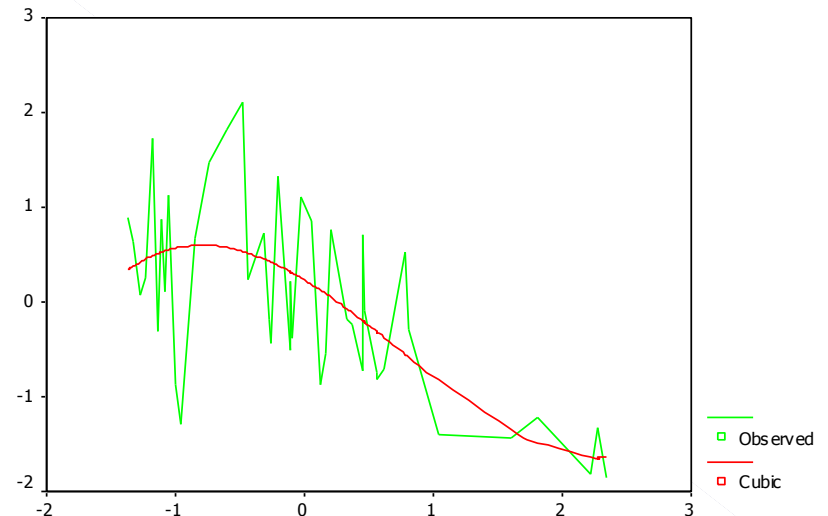
Zscore(VAR00008)



REGR factor score 1 for analysis 1

Annual average temperature simulation

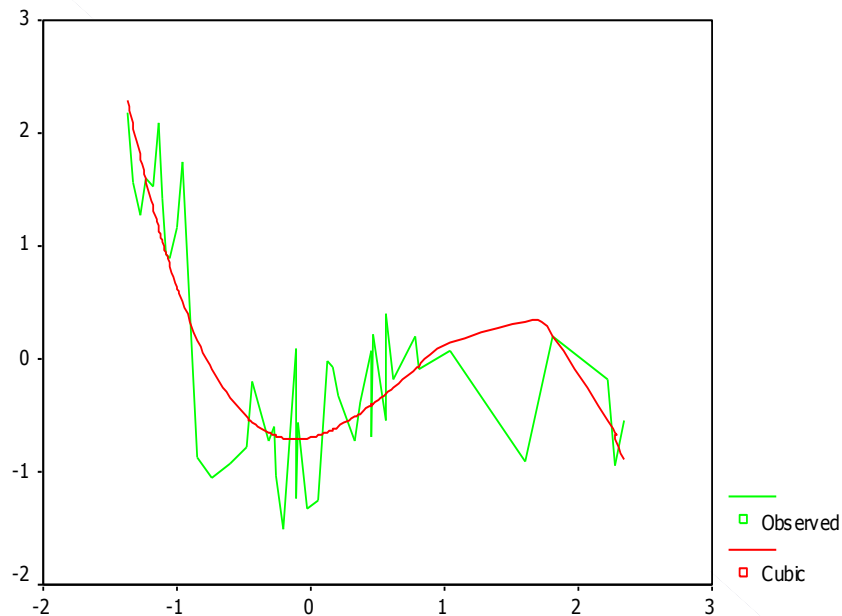
Zscore(VAR00006)



REGR factor score 1 for analysis 1

Annual average humidity simulation

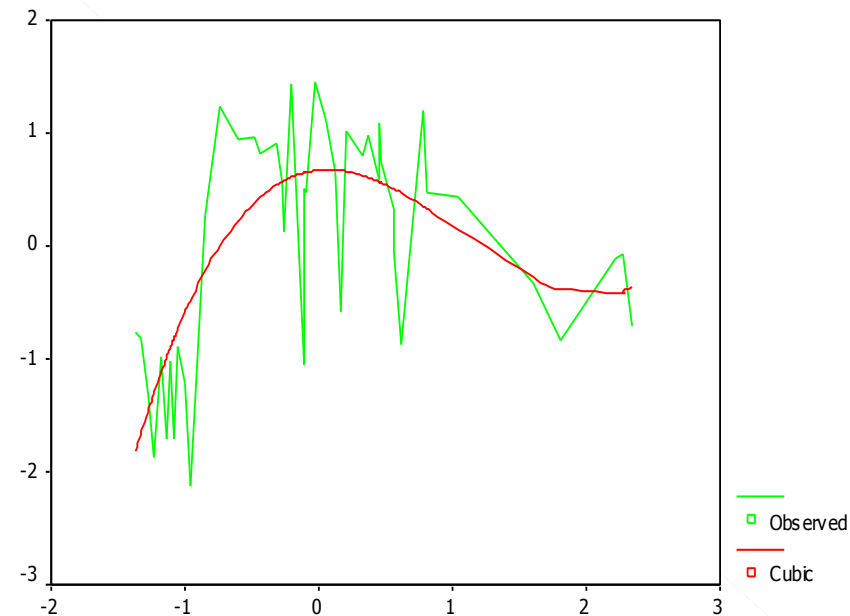
Zscore(VAR00009)



REGR factor score 1 for analysis 1

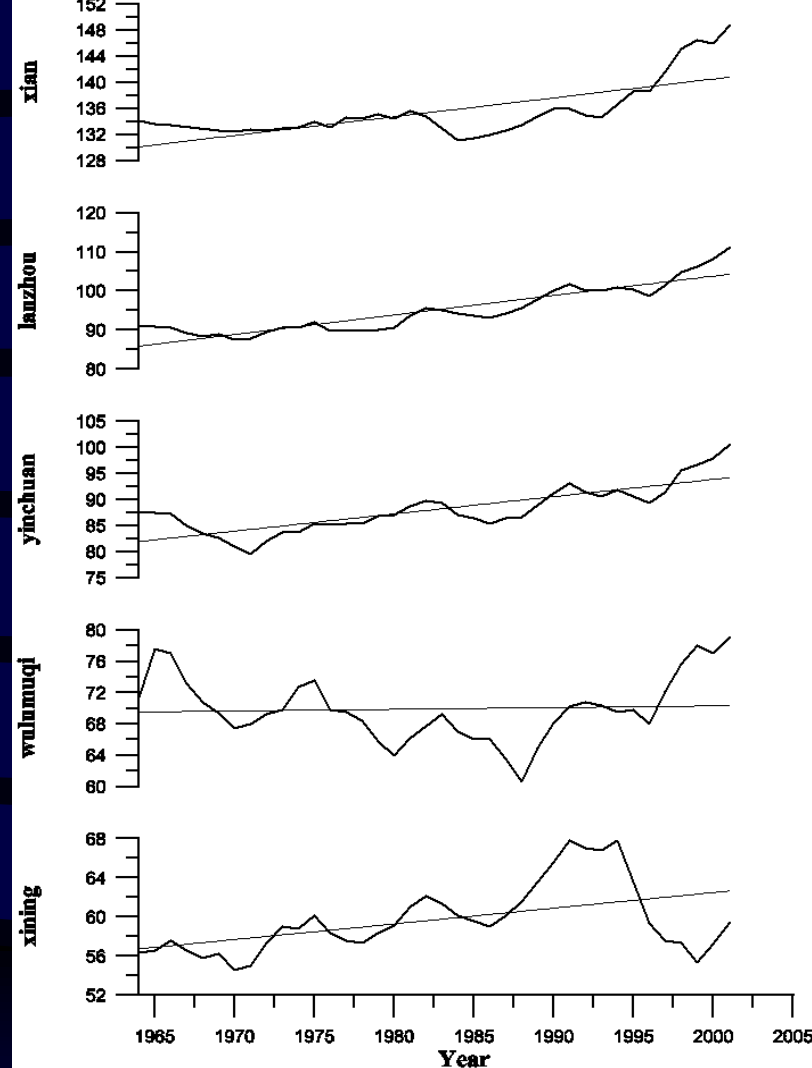
Annual rainfall simulation

Zscore(VAR00007)

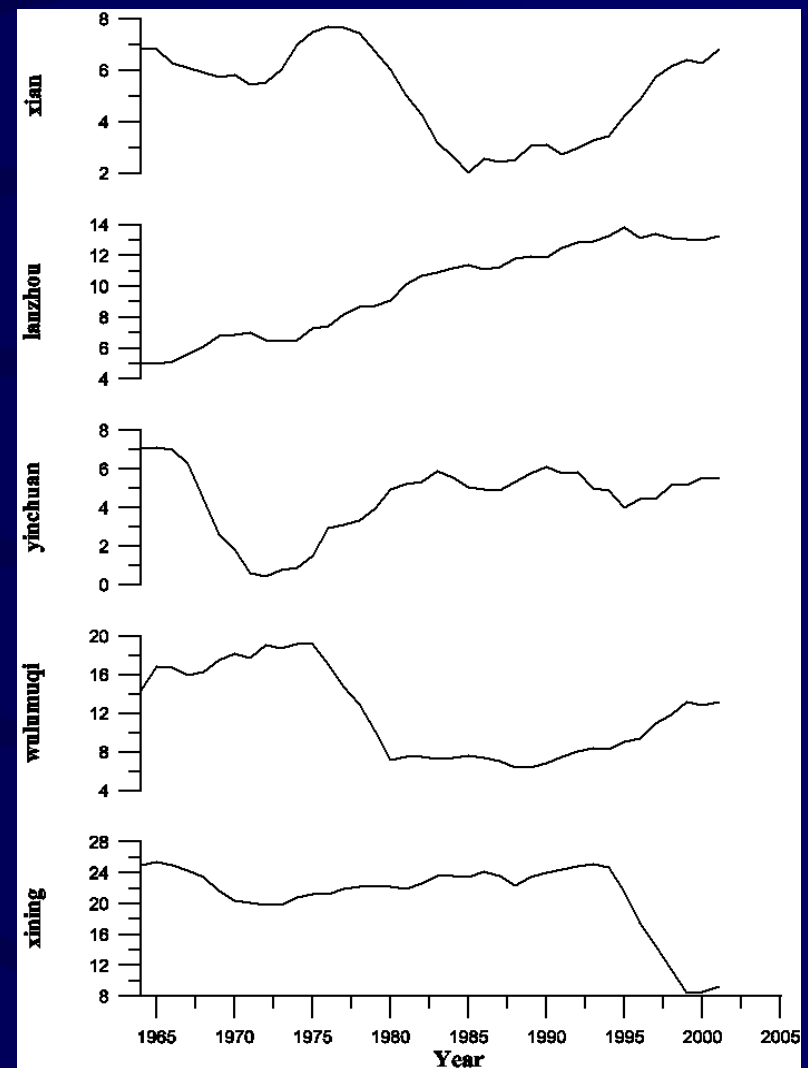


REGR factor score 1 for analysis 1

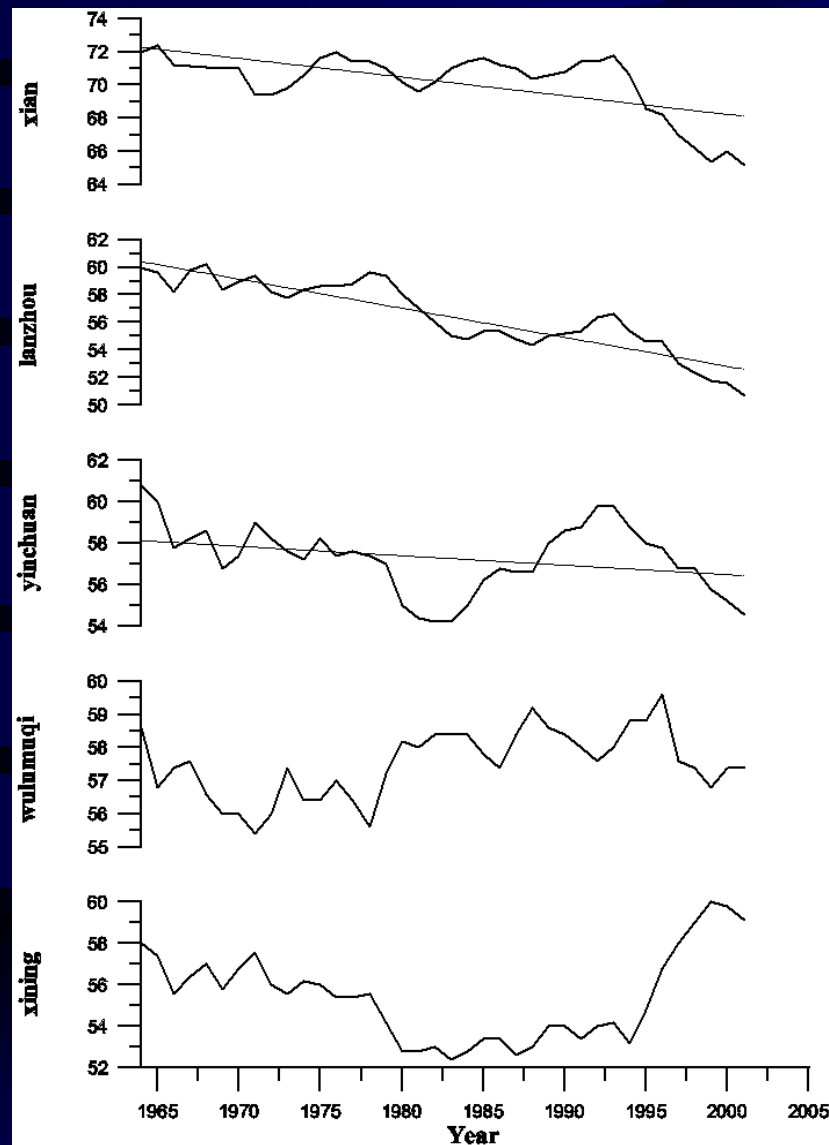
Sunlight simulation



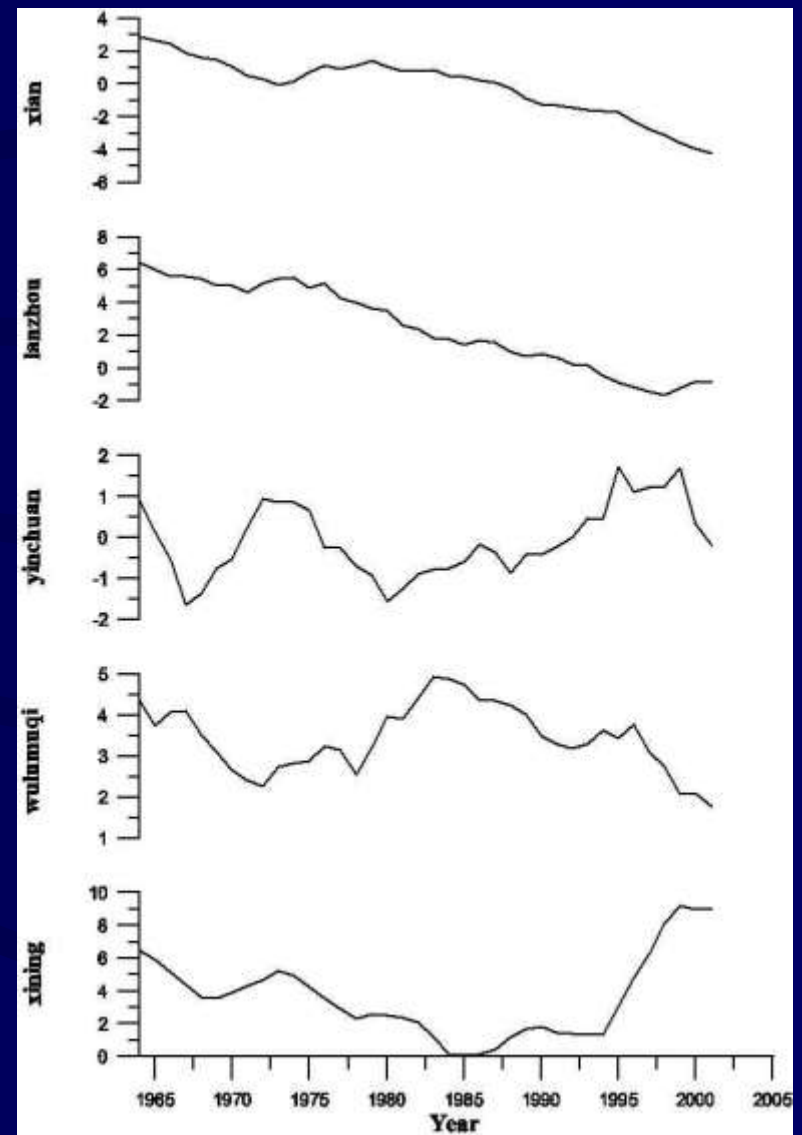
**Average urban temperature yearly  
change by urbanization in northwest  
China  
( 1960-2001 )**



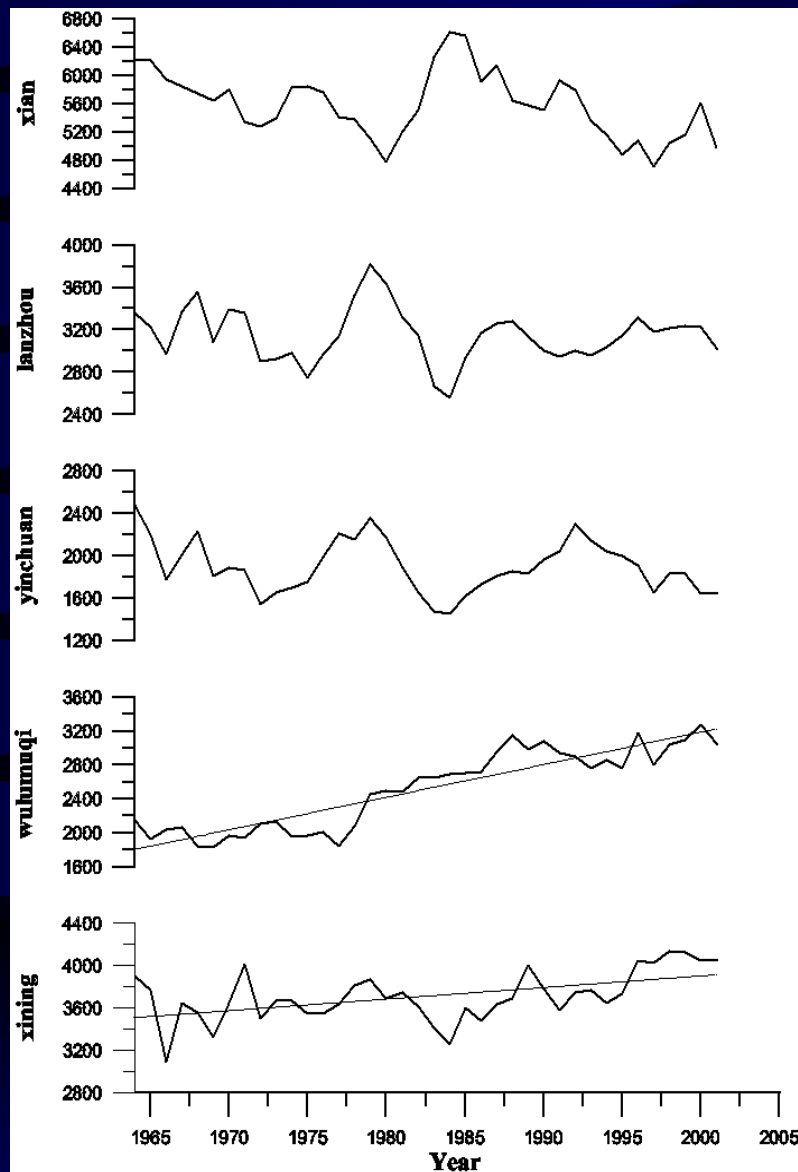
**Temperature change of  
provincial capital city by  
urbanization in northwest China  
( 1960-2001 )**



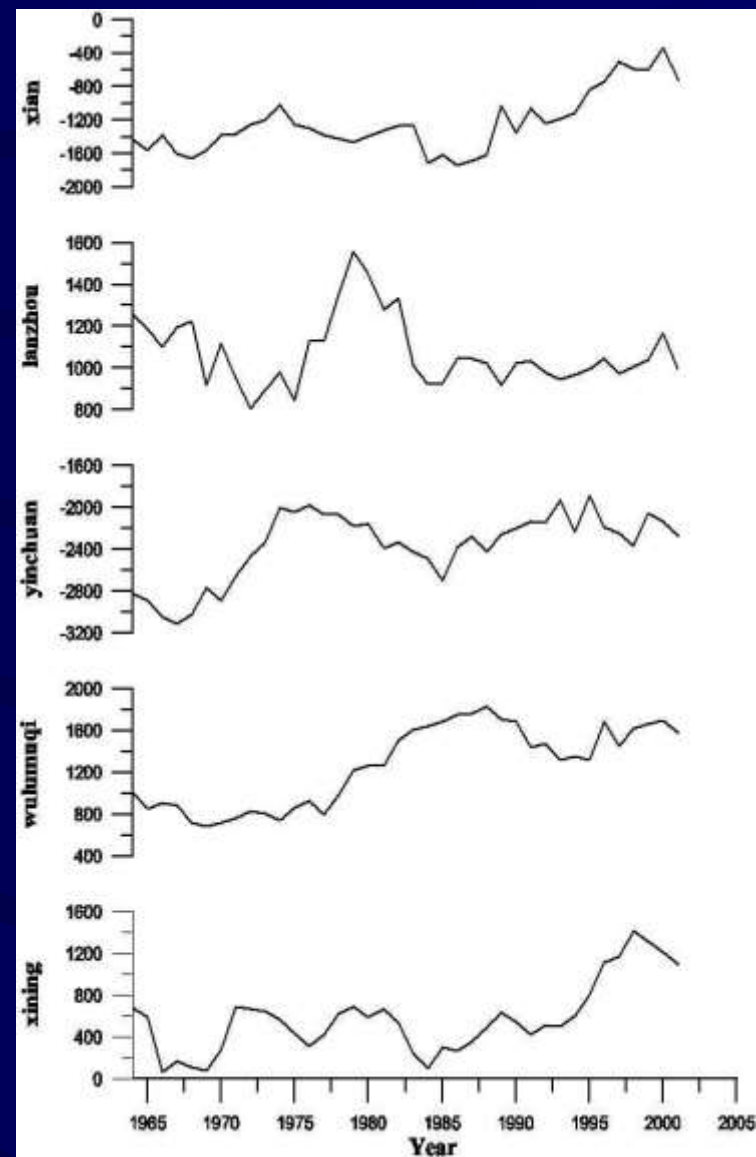
**Relative humidity change of provincial capital city in northwest China**



**Relative humidity change of provincial capital city by urbanization in northwest China**



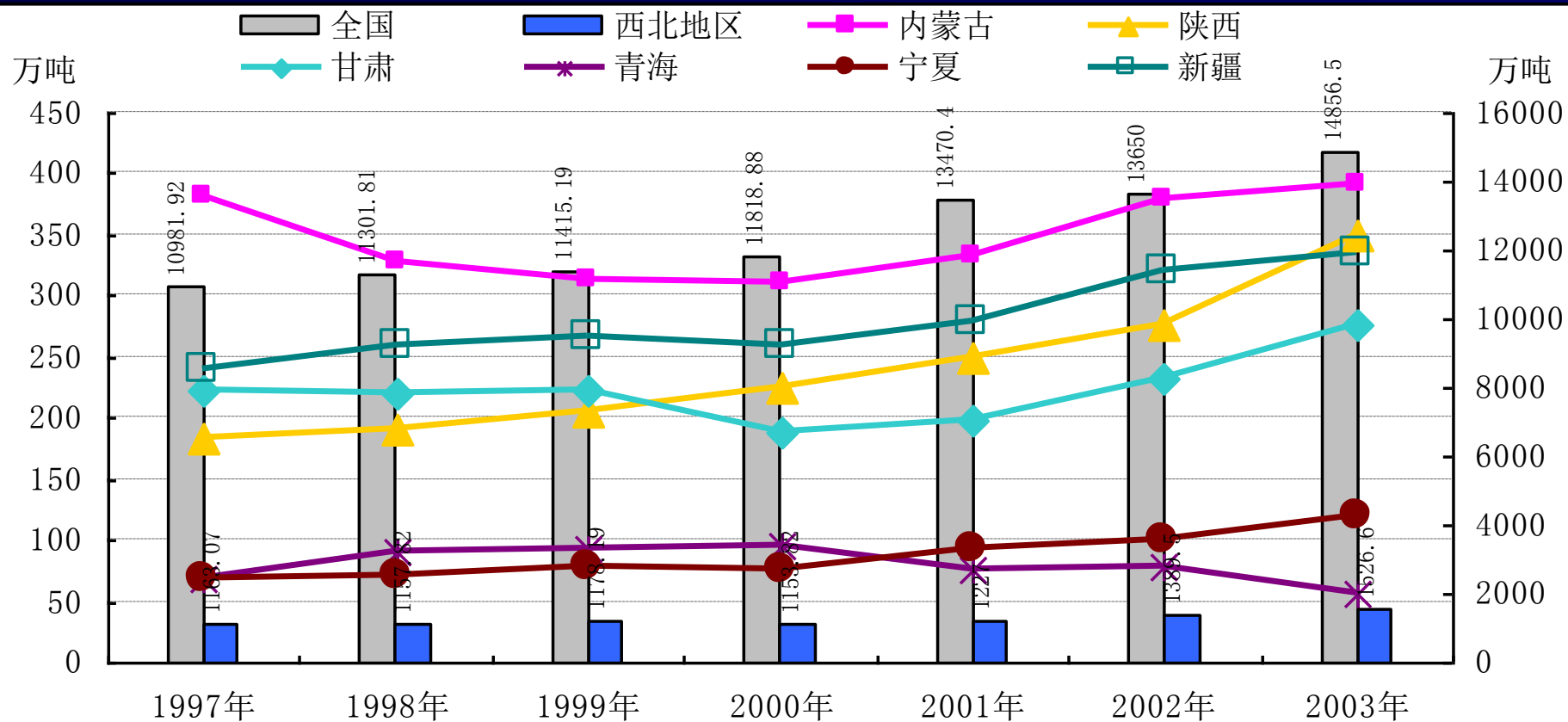
**Rainfall change of provincial capital city in northwest China**



**Rainfall change of provincial capital city by urbanization in northwest China**



## Increase of domestic waste is the common trend



**5. City along river valley has the potential risks of environmental pollution not only to itself but also to the lower reach of the watershed, because of its special characteristics of location and natural environment structure.**

- Industrial allocation contravened the regional climate and caused severe environmental pollution.
- Urban construction disobeyed the natural laws, interrupting the recycling of urban ecosystem.
- Over consumption in daily life brought about environmental issues, such as the increasing of domestic waste.

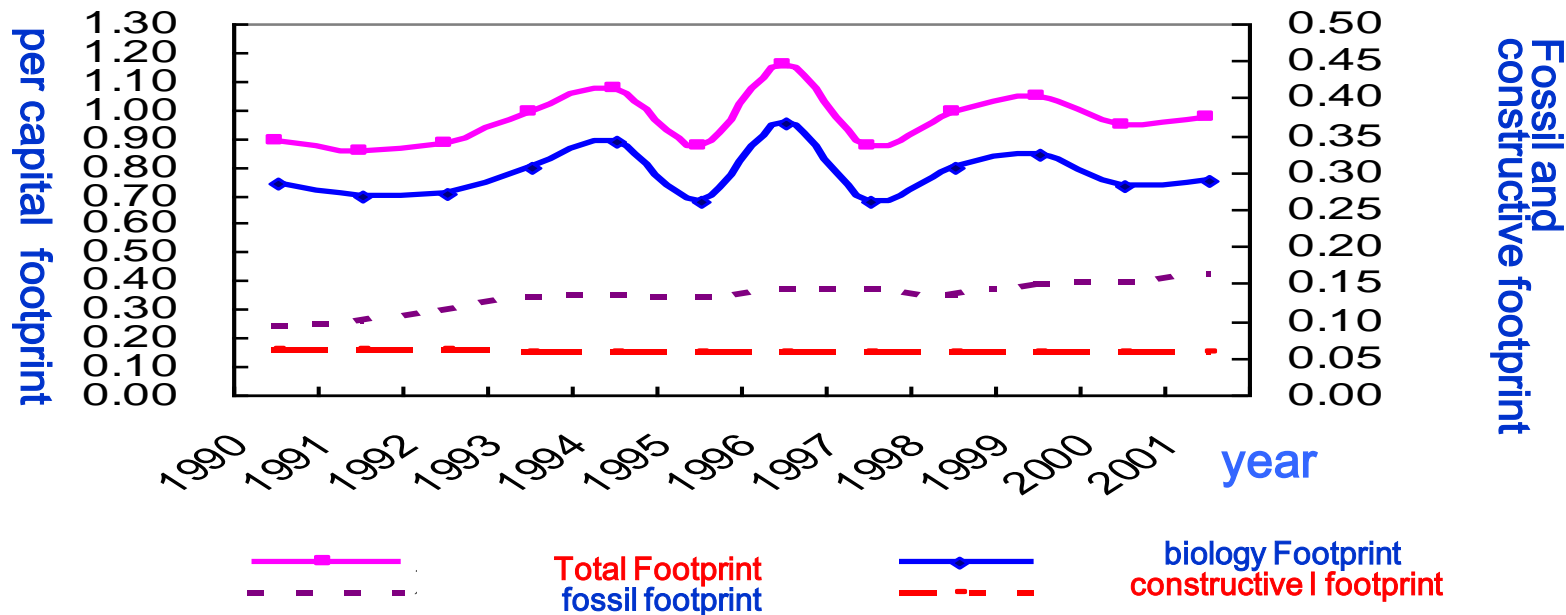
# City of Lanzhou, Capital of Gansu Province



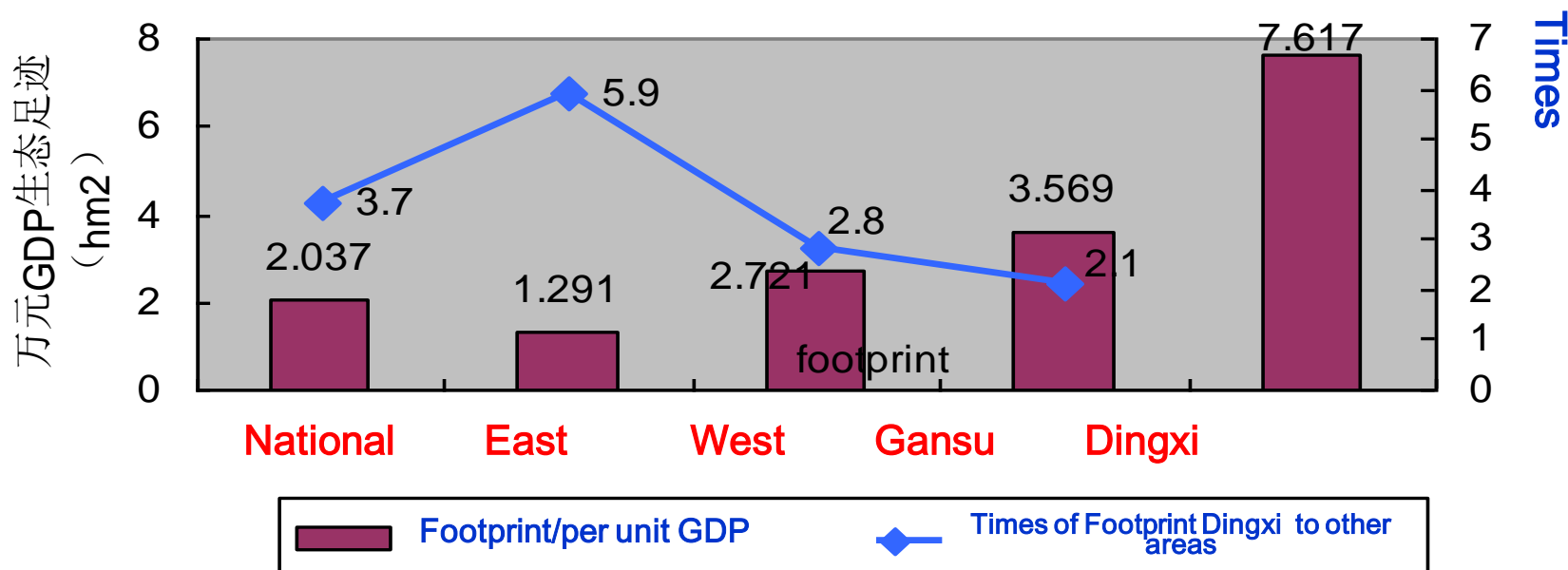
Yellow River



**6. The footprint analysis showed one of the main barriers in less-developed areas, such as in the environmentally fragile loess plateau with poverty, is over growth of rural population and traditional agriculture caused huge natural resource and ecological deficits. It is a fundamental way to accelerate urbanization and transfer the surplus farmers from rural areas to towns and cities and reduce the pressures on the rural environment by rural population and traditional agriculture and lifestyle.**



Per capita Footprint of Dingxi City in Loess Plateau, 1990-2001



Footprint of per unit GDP of Dingxi City in Loess Plateau



## 7. The oasis city Wuwei in arid land of Hexi corridor areas along the ancient 'Silk Road', is being in a great danger of vanishing.

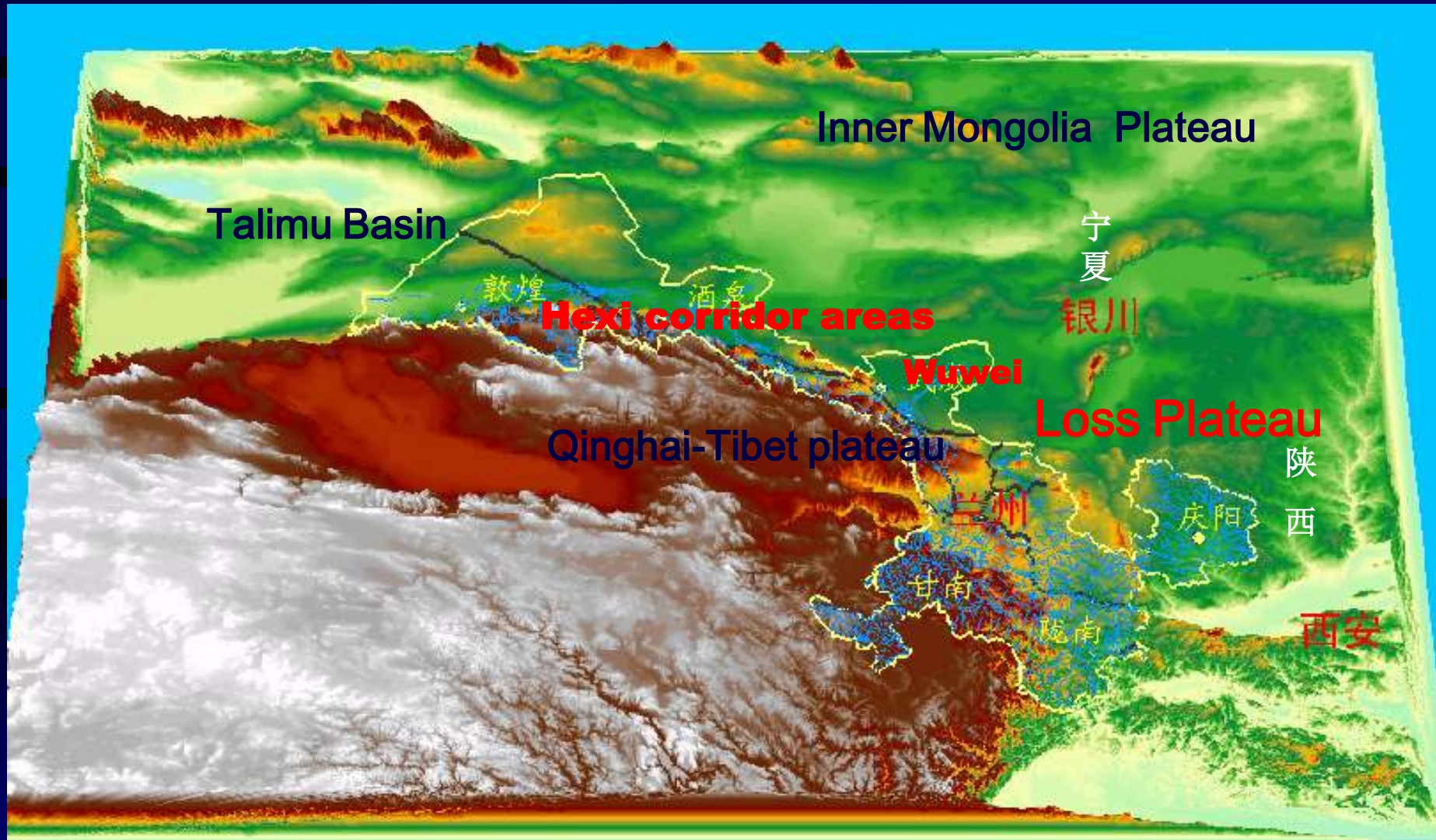
The traditional developing model will threaten the sustainability of eco-environment and economic development. So intensive urbanization policy should be adopted, and circular economy should be developed by the end of 2020. Under the background of globalization, human activity's intension in the arid northeast China's oasis eco-economic system will be aggregated, and the **per capital ecological foot print** will surpass the carrying capacity of eco-environment. **So the ecological deficit will grow up. If the traditional developing model would be adopted, the oasis ecological footprint would have been three times of the eco-carrying capacity, and the natural oasis would last only 15-18 years. So it is urgent to protect the oasis ecosystem,** and the regional developing strategy must be adjusted, at the same time, the structure and distribution of industries should also be optimized. The ecological water saving industry and structure system of high appending value should be encouraged. The big city development in oasis area must be constrained, and the intensive urbanization policy and eco-city model should be implemented. In this way of eco-economic development model, Wuwei's eco-city construction will successfully solve the contradiction between human and .the nature.

# Location of Wuwei City in arid areas of Northwest China



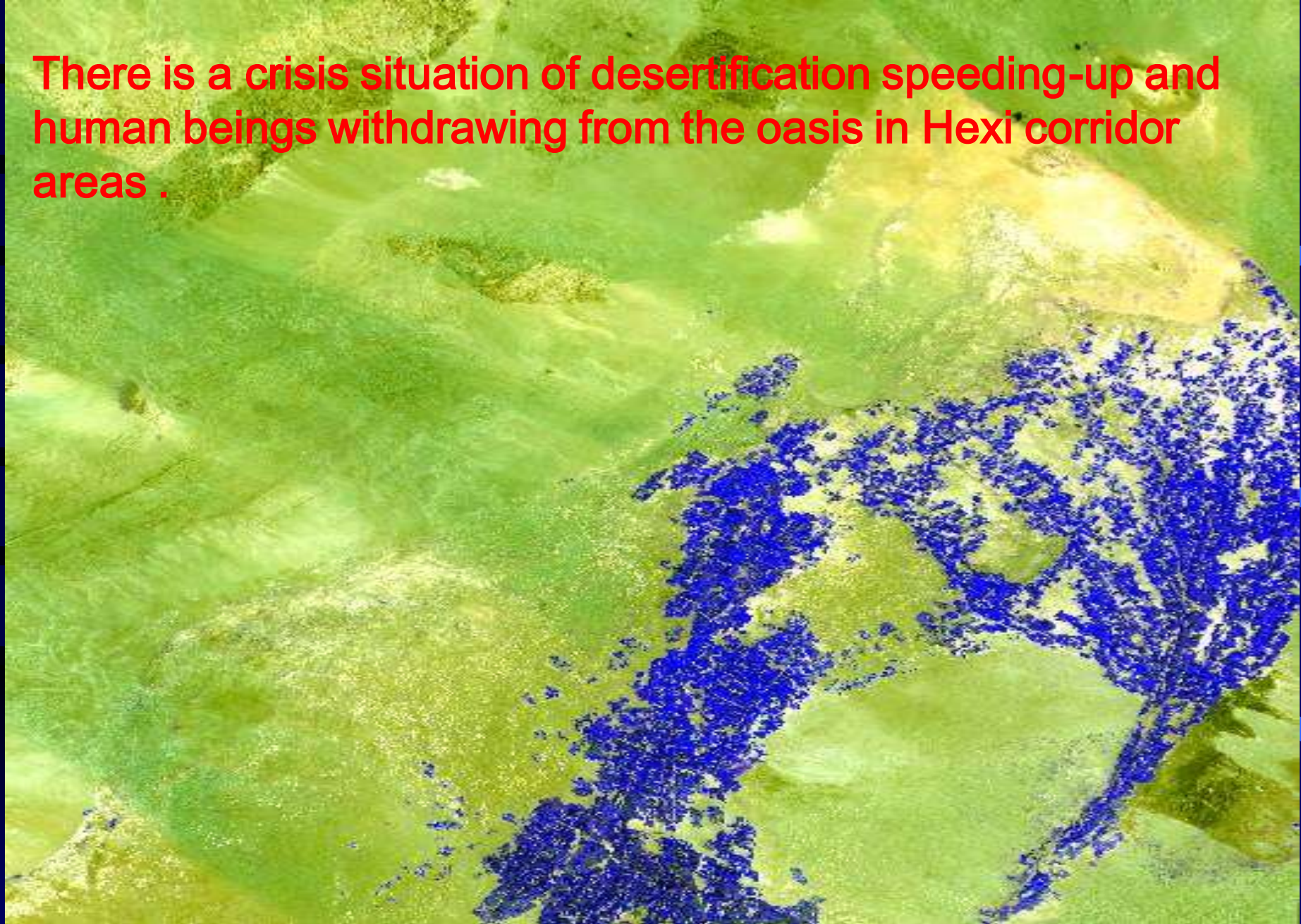


## Location of oasis city Wuwei in arid land of Hexi corridor areas





**There is a crisis situation of desertification speeding-up and human beings withdrawing from the oasis in Hexi corridor areas .**



**(aster satellite image, May, 2001)**

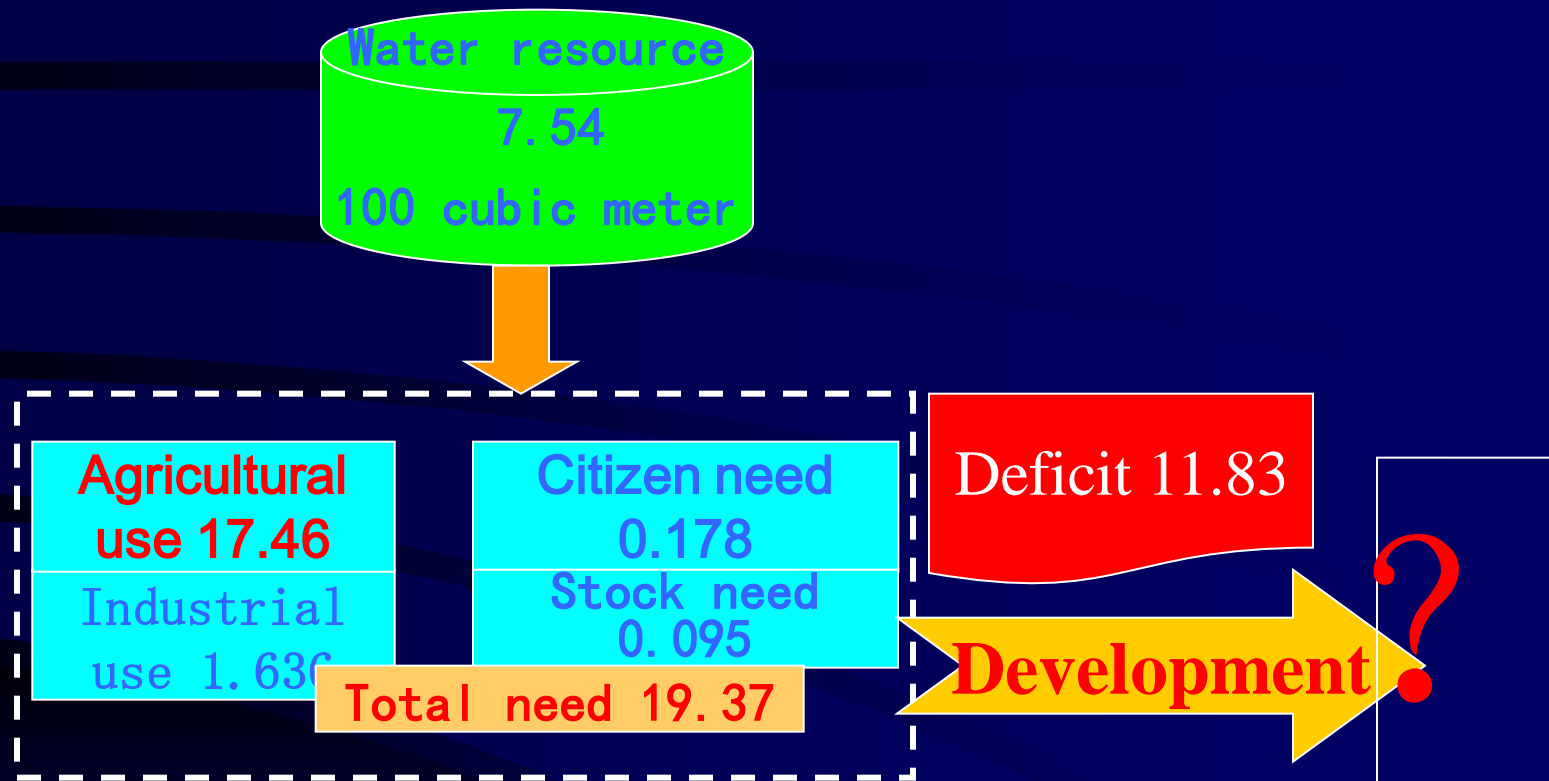


❖ Over cultivated land and draw underground water, made environment degraded.

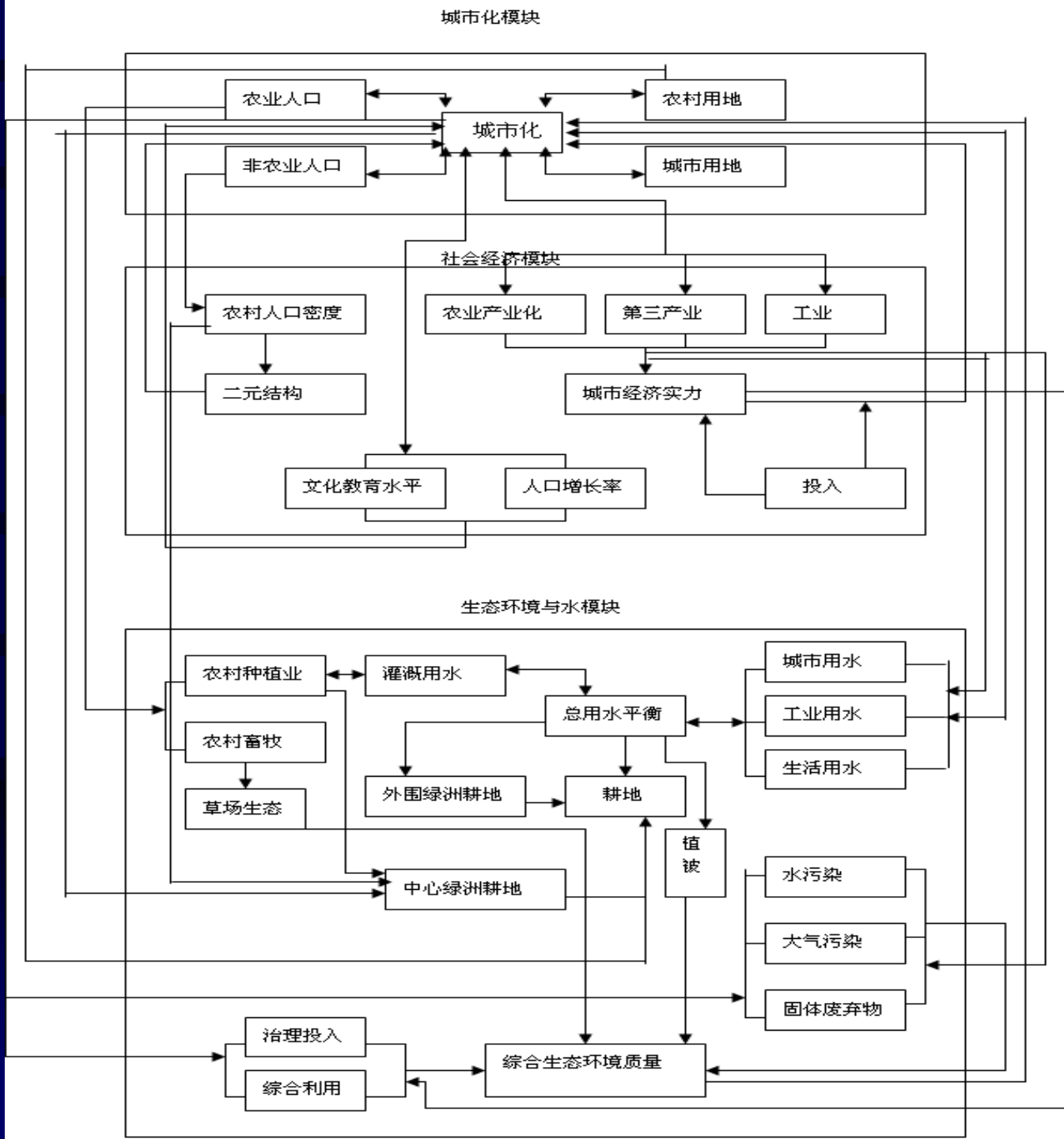




# Needs of traditional development model



# Systematic Dynamics



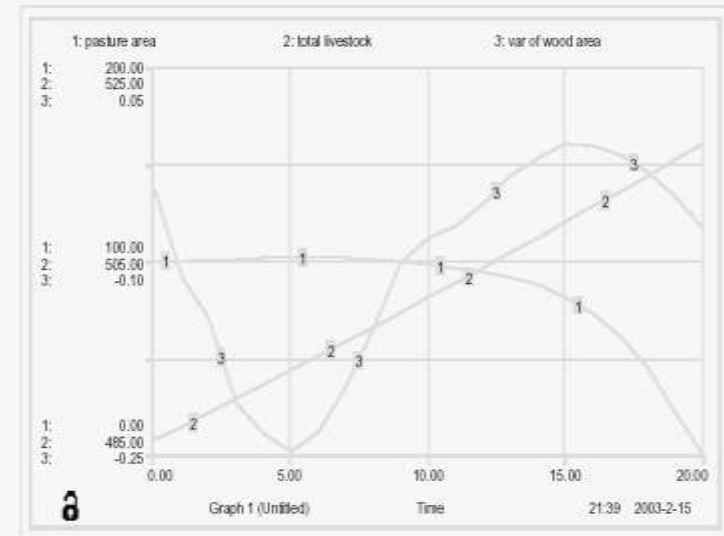
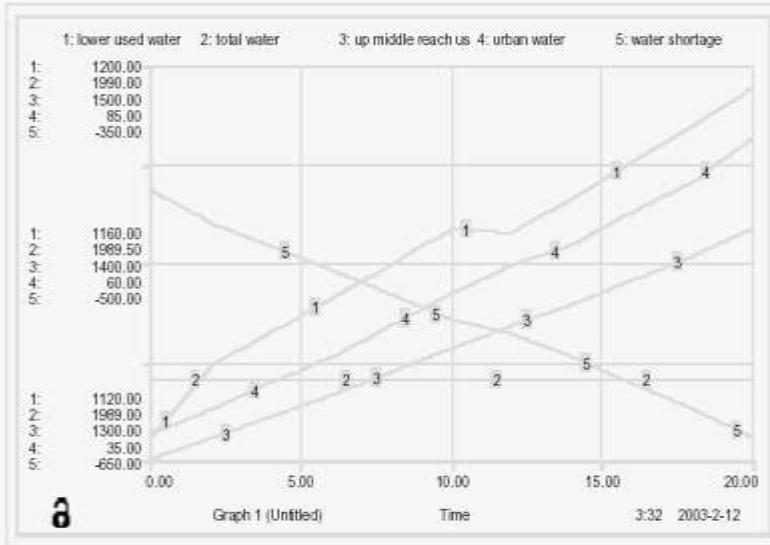
# •Scenario 1

## Traditional model

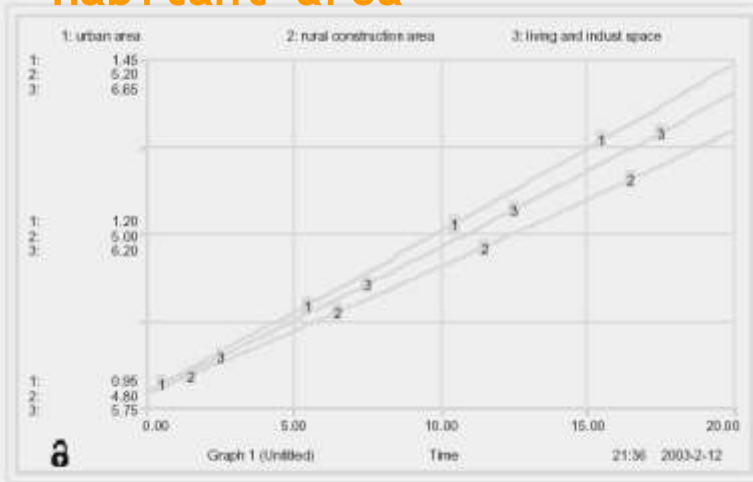
year	Urban population	Rural population
2000	36.90	154.2
2001	38.06	154.49
2002	39.23	154.79
2003	40.41	155.09
2004	41.59	155.39
2005	42.78	155.69
2006	43.97	156.00
2007	45.18	156.31
2008	46.39	156.62
2009	47.61	156.93
2010	48.83	157.24
2011	50.07	157.56
2012	51.31	157.88
2013	52.55	158.21
2014	53.81	158.53
2015	55.07	158.86
2016	56.34	159.19
2017	57.62	159.52
2018	58.91	159.86
2019	60.20	160.20
2020	61.50	160.54

## Water resources

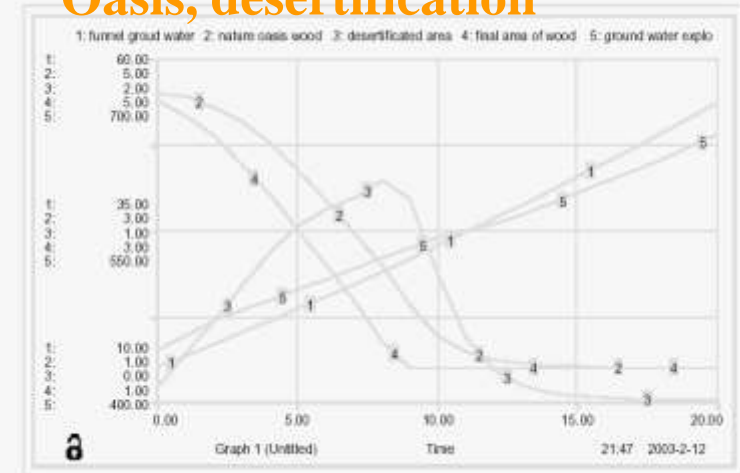
## Grass land



## Habitant area



## Oasis, desertification



The scenarios on urbanization and environment of Wuwei in next 20 years under the BAU model

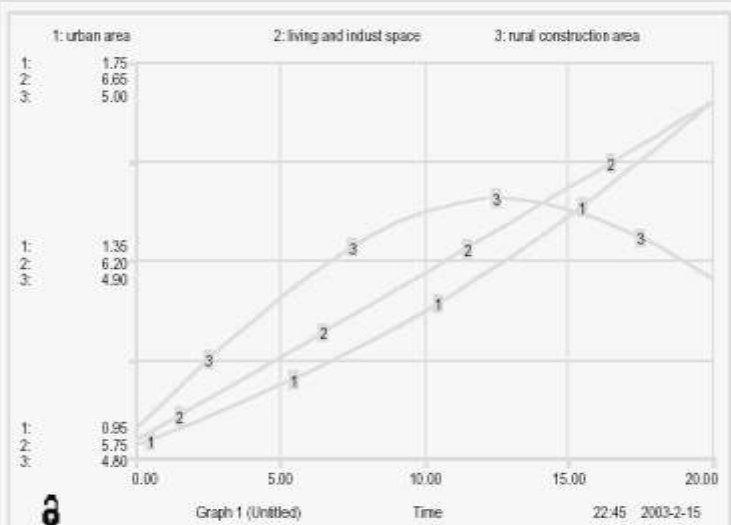
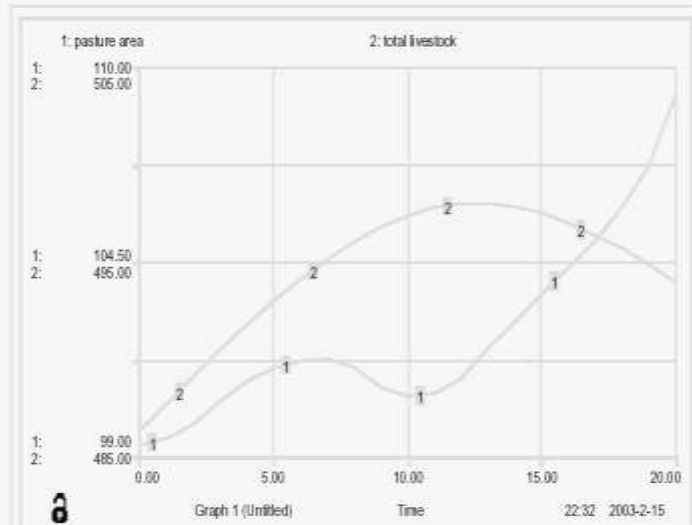
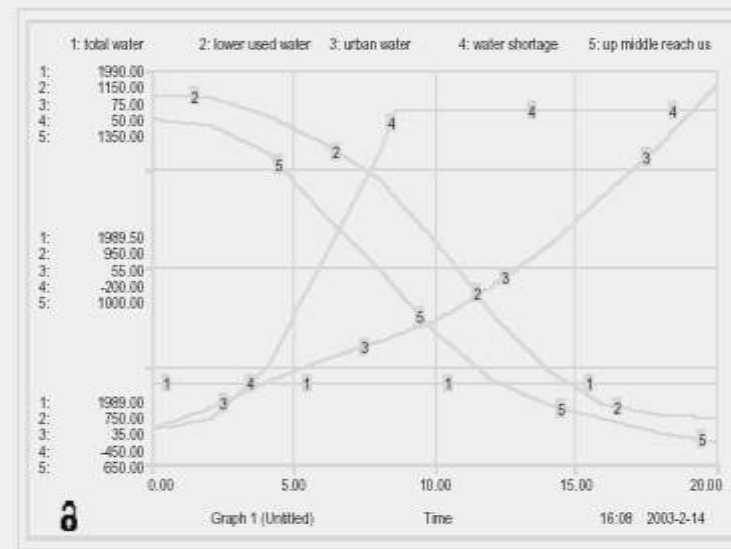
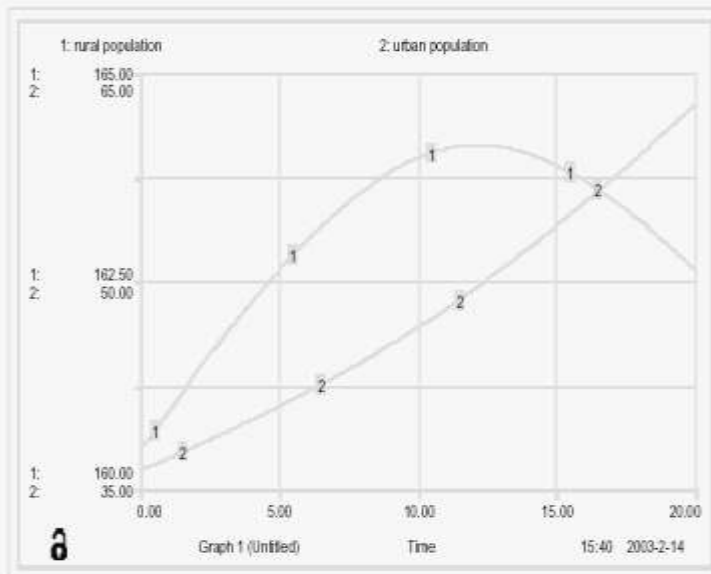
## **Sustainable Urbanization**

**Intensive Urbanization** can improve the structure and efficiency of energy utilization. And a relative integrated technical equipment system taking certain environmental protection measures can cut down the waste discharge largely. In the model of **Intensive Urbanization** the driving forces will continually increase, however, the intensity of resources consumption and the waste discharge will be decreased, at last, the aim of environment protection will be fulfilled. The output of end-using analysis indicates that by the 2015, the difference of total emission volume of CO<sub>2</sub> between two kinds of scenarios will be 300 thousand tons; by the year 2030 the difference will be 500 thousand tons (Table 2) .

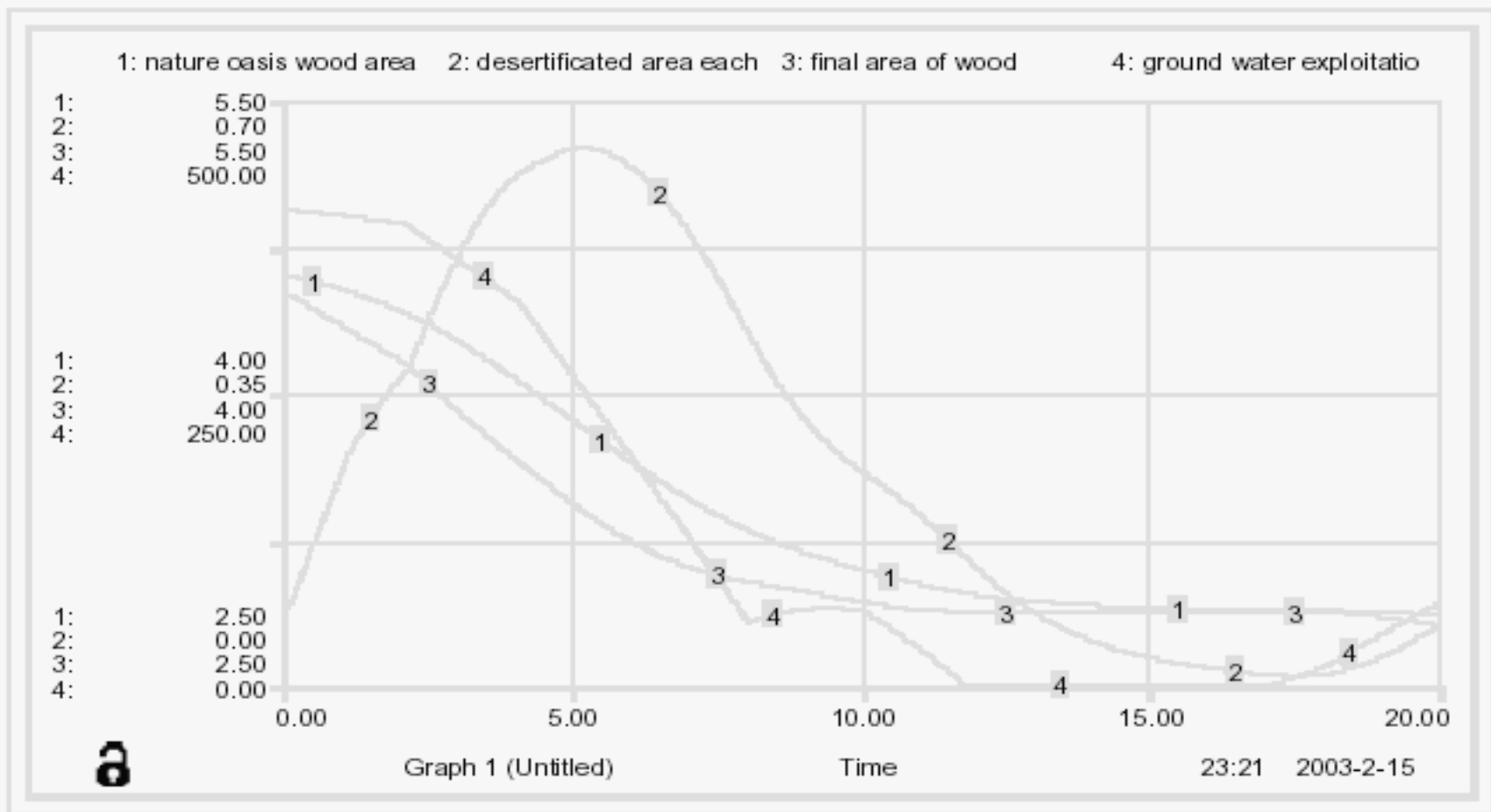


# The Total Waste Discharge in Two Kinds of Scenarios

Total Waste (t)	2015(BAU)	2030 (BAU)	2015 (IU)	2030 (IU)
CO2	2314580.0	4529159.2	2005969.5	4003327.6
CH4	2408.36	4616.71	2087.24	4053.37
Nox	8299.71	15505.42	7152.35	13204.33
Sox	13317.42	26634.85	11541.77	21307.88
COD	30846.53	63561.61	28600.8	56468.9
BOD (living)	18831.5	20840.2	17930.2	17859.8
SS (industry)	21339.6	61775.4	18936.6	56322.2
Nox Waste (t)	113274.2	138972.3	113274.2	126770.3
P Waste (t)	38970.44	43556.98	369874.4	428975.6



The scenarios on urbanization and environment of Wuwei in next 20 years under the IU model

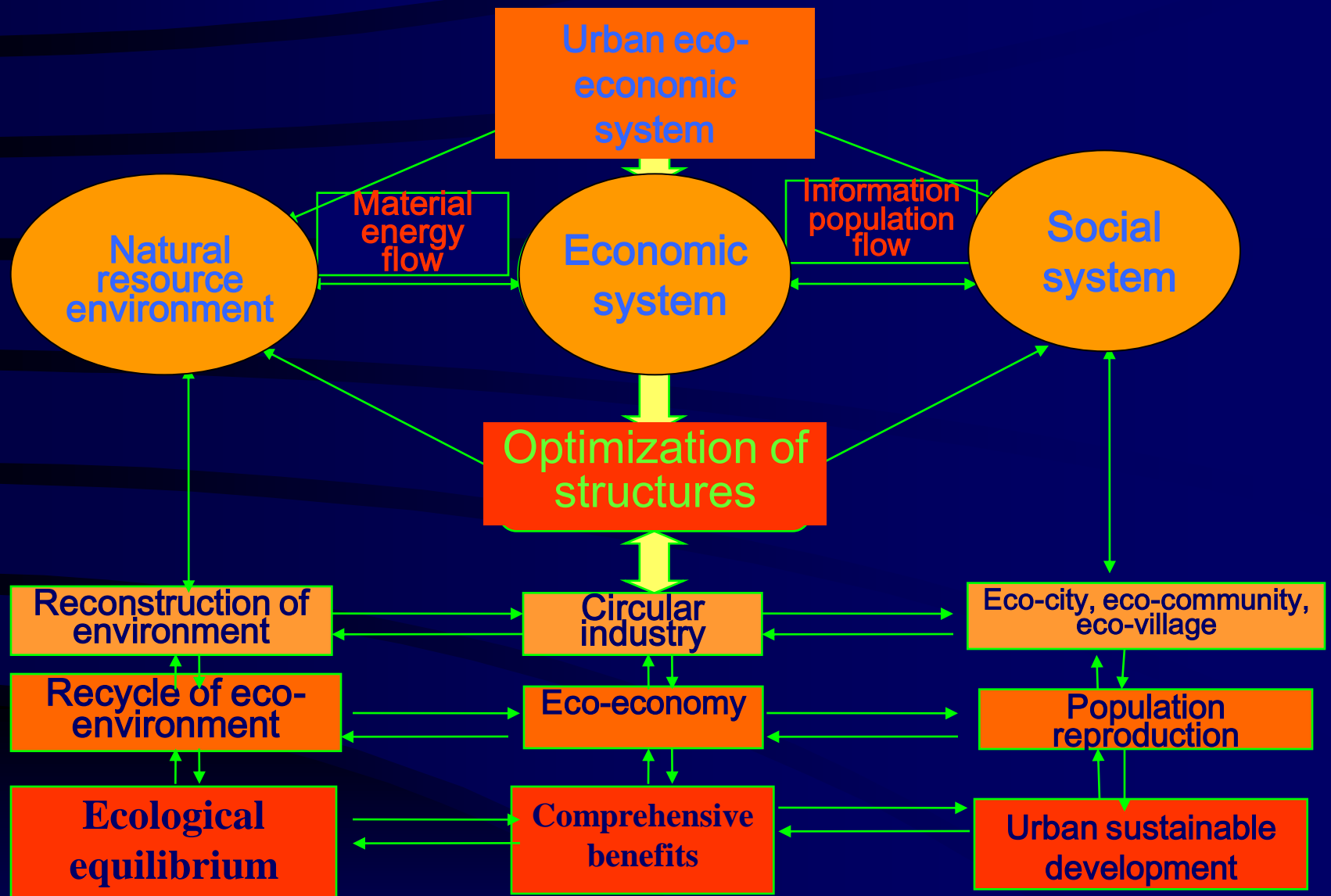


**The Scenarios of Wuwei's ecosystem under the Intensive Urbanization model in next 20 years**

# **IV Exploring Sustainable Urbanization Strategies**

## **4.1 Sustainable development of ecological economy strategies**

- **Firstly, Based on systematic theory, the principle of equilibrium and harmonization of ecosystem, consider northwest China as a giant complexity of ecological-economical system, and set up the objectives of development as pursuing optimal comprehensive benefits including ecological benefits, social benefits and economic benefits. Combine the ecological construction with the economic development.**



**Eco-economic Development Pattern**

- Developing ecological urban systems

eco-city

eco-towns

eco-community

eco-village

resource saving society



- Eco-economic industrial structures with ecological industrial chains to develop circular economy

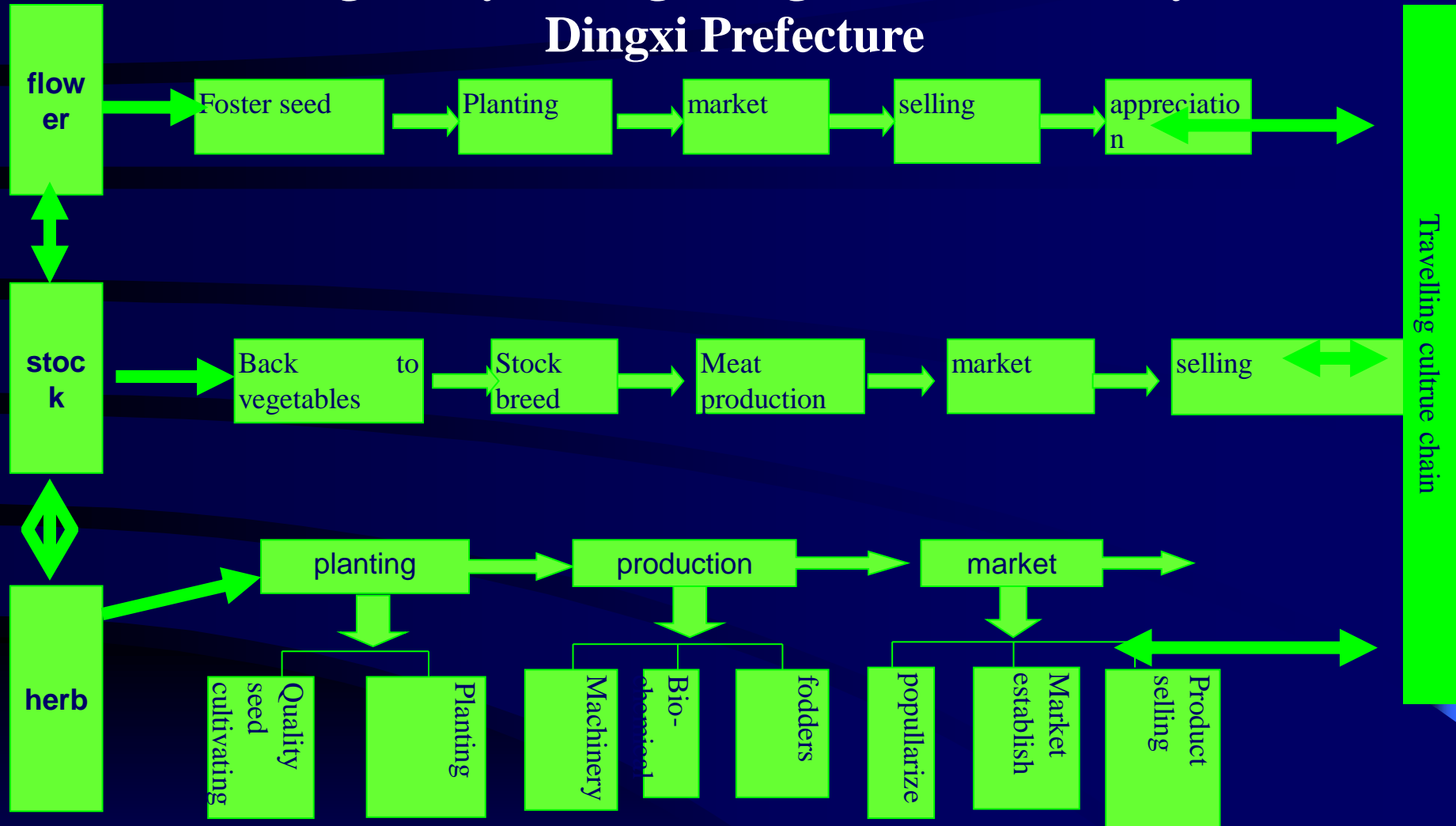
Chinese herbs and bio-industry

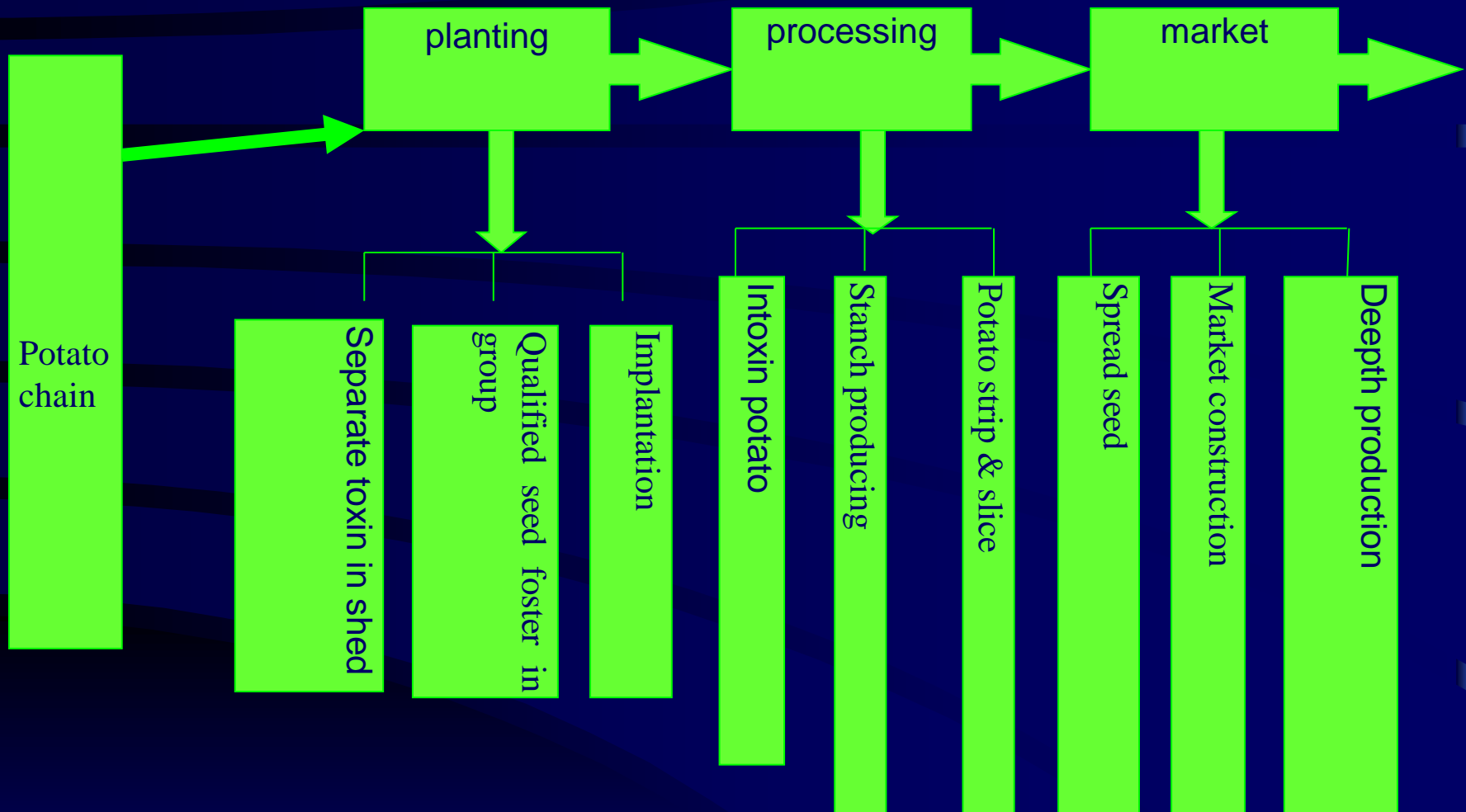
ecological agriculture

ecological industry

ecological tourism

# Case of Dingxi City: ecological agriculture industry chain in Dingxi Prefecture





**The ecological industry chain in Dingxi city of  
Gansu province in Loess Plateau**

- Eco-economic Industrial chain of flowers and plants Introducing a fine variety of improved variety of flowers to cultivate --The flowers planting -- Flowers market --Marketing of the flowers





# Chinese herbs industrial chain

angelica





# Mushroom industrial chain









# Potato industrial Chain



amylum

**Cultural tourism**  
**National writing**  
**and painting**  
**county-Tongwei**







人生不能一日而無財  
財不可無而無財  
故節儉尚焉夫  
此必留有余之財  
於水也節儉

香蘭

二月  
月  
卷  
山石  
坐  
廢  
軒  
白  
晚  
雨  
葉  
紅

黎明即起澆掃庭除要內外整潔既昏便息關鎖門戶  
搗一飯當思來處不易半絲半縷恒念物力維艱宜未雨而  
渴而掘井自奉必須儉約宴客切勿流連器具質而潔瓦缶勝金玉飲  
食約而精園蔬食珍饈勿營華屋勿謀良田三姑六婆實淫盜之媒婢  
妾妻媼非閨房之福童僕勿用俊美妻妾切忌艷粧祖宗雖遠祭祀不

古人言木必宗佳以正立方在書天據白勸片之  
入神報如太半之業字之公三言天下之燥然其可名

# Solar energy for cooking and bath





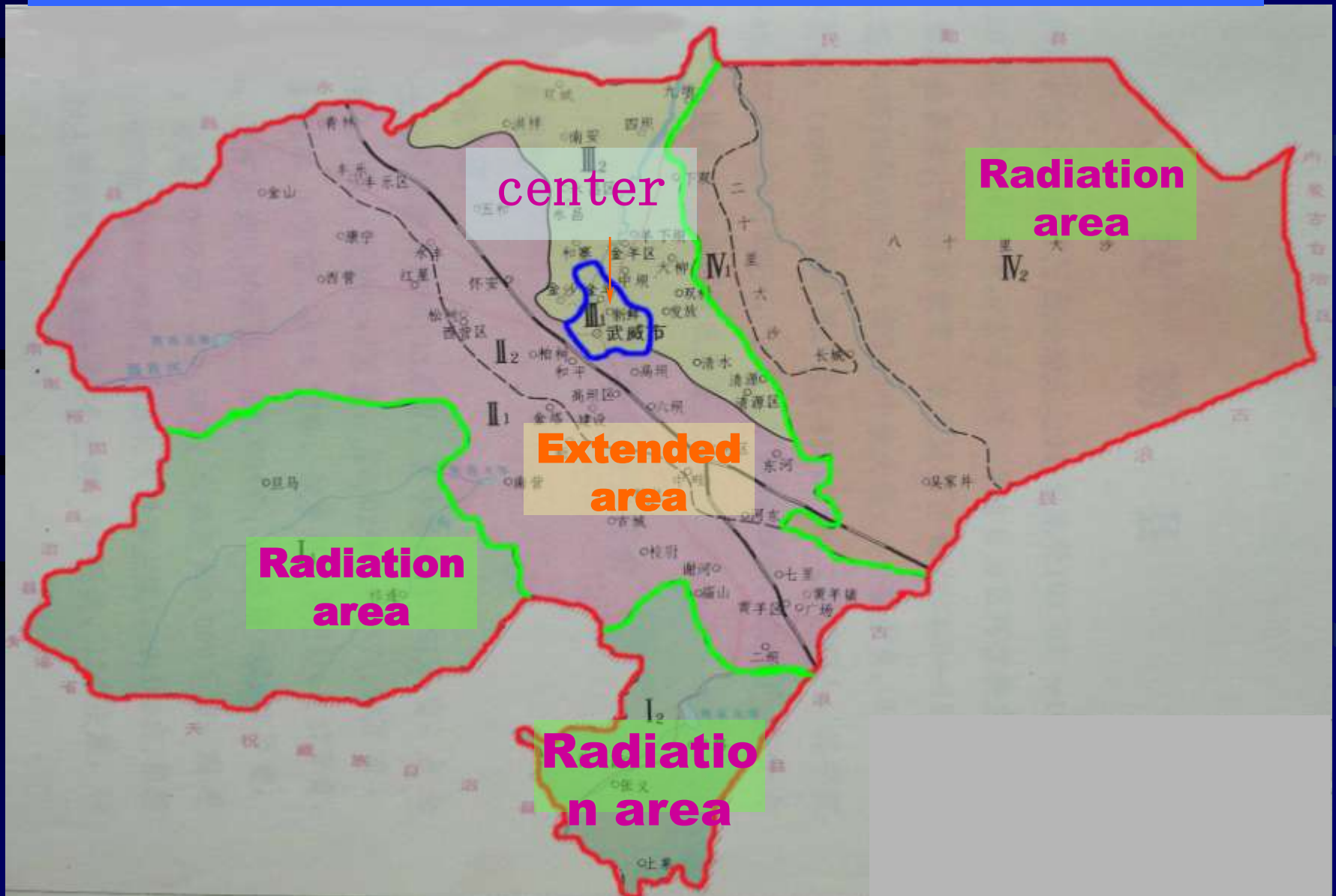
Green energy marsh gas





# Case of Wuwei, the oasis city in arid areas

## Circular economy development model



# High quality Corn and wheat industrial chains





# High quality of wine industry



# Green vegetable industrial Chain





# Tourism industry chain



Homeland of flying horse,  
China's tourism symbol





**Confucius**  
**One of the**  
**world greatest**  
**Ideologist**  
**politician**  
**educationalist**  
**Founder of**  
**Confucianism**



## 4.2 Constructing water-saving society

reasonably use water and economizing on water to guarantee the sustainable future.

- Innovate in blood irrigation and collection engineering
- Ensure the ecological used water not be over exploited
- Stabilize the sizes of oasis and agrarian areas; develop agriculture with water-saving irrigation to reduce the volume of agricultural water use in a large degree and increase water use for urban and industry
- Strengthen the uniform administration of water in one drainage area

# water cellar

The local people created a new way to collect the rare precipitation (100 mm -200mm/year) to battling with drought, which is to build a water cellar with the volume of 50 cubic meters in a field or along the road and collect rainfall from the surrounding areas, based on the gravity of rain water from the slope. In this way, an integrated synthesis defending and renovating system of multi-function and multi-objectives' water and soil saving has been established to control the loss of water or soil.





**Towards a Beautiful Future!**

**Thank you very much  
for your attention!**

