# AIM Interim Report
# (1999 - 2000)

**March, 2000**

**China Project Team of AIM/IMPACT Model**

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# Interim Report for Fiscal Year 1999

by

CISNAR Team

March 18, 2000

# 1. Improvement of Multi-annual average-based hydrological Model

# 2. Analysis on the Countermeasures to Climatic Disasters in China

# 3. Data Collection

(1) Digitized China county boundary map (1995) with scale of 1:4 million

(2) Digitized Vegetation Regionalization map of China

(3) Database of the Codes for the administrative divisions of the People's Republic of China of 1995

(4) Codes for the administrative divisions of the People's Republic of China of 1999

(5) Chinese environment regarding data at national, province, city and industry sectors level in 1998,

(6) Chinese environment status report in 1998

(7) Coefficient Notebook of Production and Discharge of pollutants from industry

(8) Chinese water resources status report in 1998

(9) Chinese water supply and demand in 21 Century

(10) Main crop water requirement and irrigation of China

(11) Input-Output Table of China in 1997

(12) Forestry data

# 4. Investigation and Suggestion on the Input-Output Table data regarding Water Impact Model in China

**- Input/output table**

**- Water consumption data**

. no water consumption data exactly matching with each sector in I/O table

. water consumption data

.. agriculture
.. industry
.. residential
.. water consumption
.. per capita
.. per GDP
.. per mu
.. per person
.. per unit industry output.

**- Suggestion**

To construct water input/output table based on the national or provincial I/O table of 1997.

(1)Water consumption data processing

Only agricultural water consumption, industries water consumption, and residential water constipation is available, they do not match with sectors in input/output table. Therefore, data need to be processed based on the judgement of the experts from each sector to meet the requirement in I/O table (at least 6 sectors).

(2)Combination of some sectors

For to satisfy the data requirement, some sectors need to be combined.

(3)Study area selection

First select a city (or province), which is shortage in water, for example, Beijing or Gansu, as case study area, then to whole China.

# 5. Data Set Regarding Global Change Study in Center for earth Science Data and Information Network (CESDIN)

**- Geographical data**

(1) China administration map at the scale of 1:1M in provincial level, district level and county level,

(2) Map of China and its laboring countries at scale of 1:1M. Information of river system, road system, railway system, location of administration headquarter of counties and contour line were included (China Digital Map, version 1)
(3) The fourth population census and rural economic statistical data at the scale of 1:1M in county level, 1990
(4) Provincial level economy statistical data at the scale of 1:1M in county level (1990, 1991).

**- Attribute Data**

Totally, there are about 300 tables with over 4000 items in China natural resources database.

(1) Water resources data,

(2) land resources data

(3) forestry resources data

(4) Other information related to Natural Resources

(5) Climate data

. Monthly mean value from 1951 – 1980

. Monthly value from 1951-1995, year by year

(6) Population and labor.

. Data from 4 times population census

. Data from statistic for each province, each county, year by year

. Estimated Data from population research

(7) Social economic statistical data at national, provincial level, from 1949-1998, year by year

(8) Agricultural statistical data, over 100 items from 1980, 1984-1997,year by year

(9) Environmental data at provincial and city level, 1981-1998,year by year

**- Remotely sensed data**

(1) NDVI (every 5 days) of 1999

(2) Monthly NDVI of 1999

(3) NDVI of Chinese NongLi (every 15 days) of 1999

(4) NOAA-AVHRR data (every 5 days) of 1999

(5) NOAA-AVHRR data (monthly) of 1999

(6) NOAA-AVHRR data (every 15 days, according to Chinese NongLi) of 1999

**- Environmental Regulation and Law Data**

All national and provincial environmental regulations, laws, and international treaties, which China signed since 1949, were collected.

(1) Regulation and Law of China Resources and Environment (version 1), including 30 international treaties, 1949-1999

(2) Regulation and Law of China Resources and Environment (version 1), including 30 national regulations and laws, 1949-1999

(3) Regulation and Law of China Resources and Environment (version 1), including 29 local regulations and laws, 1949-1999

# Hydrological Impacts of Climate Change in China

1. Introduction
2. Hydrological Model Scheme

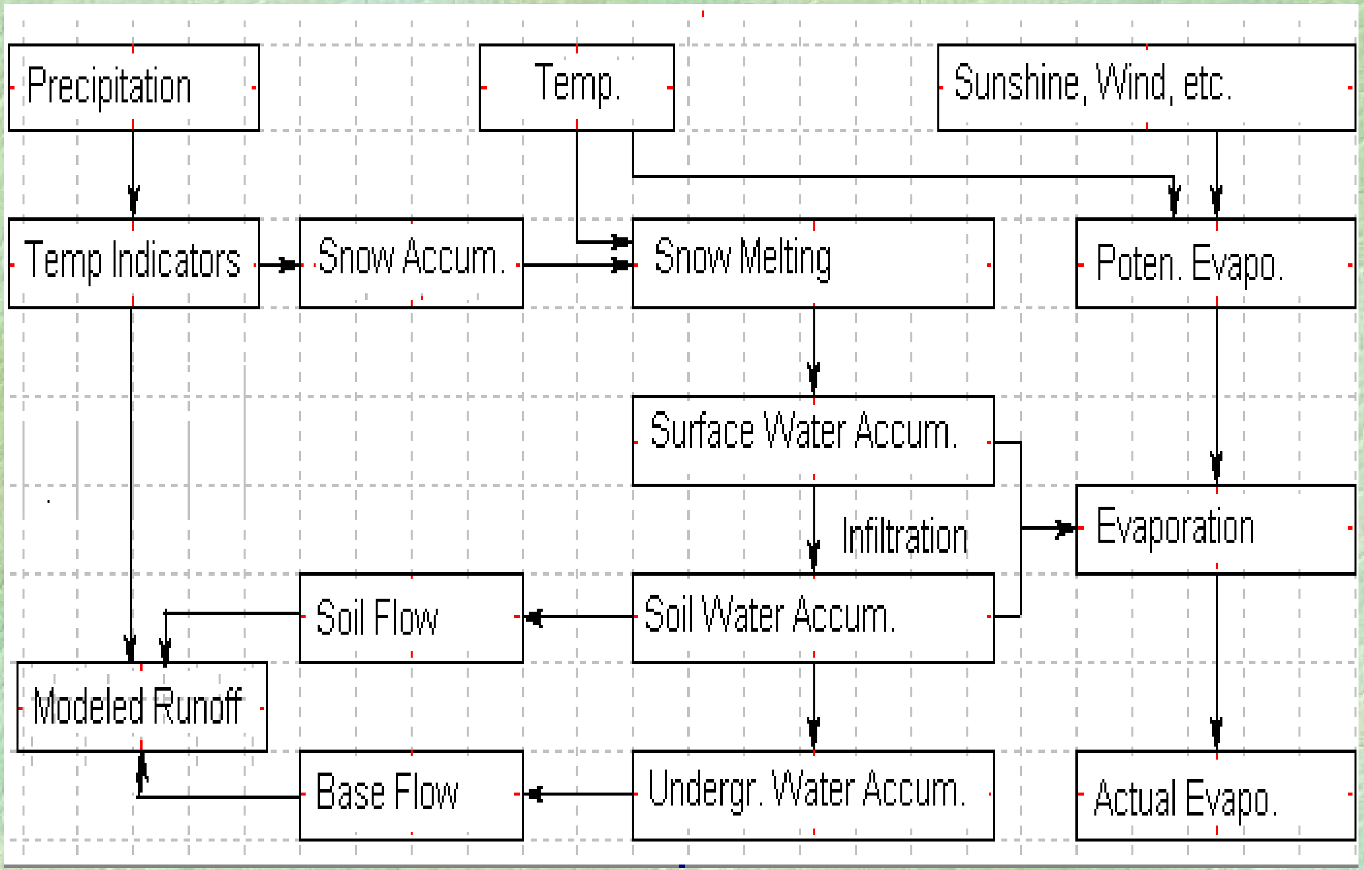



**Figure 1 Hydrological Model Scheme**

# 3. Developed sub-models

(1) Evaporation model: quantitatively describing the potential evapotranspiration and actual evaporation process in each unit basin;
(2) Soil water model: representing the dynamics of soil water;
(3) Runoff model: representing surface, ground and snowmelt runoff processes.

# 4. Used Data Sets for each basin

(1) Hydrological data: basin area, elevation, geographic location, river gradient, precipitation, runoff, evaporation etc.

(2) Meteorological data: temperature, humidity, wind speed, sunshine hours, pressure etc.

(3) Soil data: soil type, field water holding capacity etc.

(4) Vegetation data: vegetation type etc.

# 5. Climate change scenarios

The average of climate change scenarios for temperature and precipitation from 11 different GCMs is used to assess the hydrological impacts of climate change over the unit basins in China. The GCM outputs are interpolated into $0.5^{o} \times 0.5^{o}$ grid data.

# 6. Results

According to the GCM climate change outputs, under doubled $CO_2$, the annual average temperature is expected to increase by 30 percent while the precipitation might decrease by 5.8 percent over China. Regionally, northeast, Huaihe and the coastal southeast areas are likely to experience the decrease in precipitation, while North China, Yangtze River and some of the inland rivers are likely to have more precipitation. The results for the 77 Level II basins suggest:

- Evaporation: Evaporation will increase in most areas in China (Fig. 2) especially in March to November in South China and Qin-Tibet Plateau (Fig. 3, Fig. 4.), where the evaporation will increase 40mm for each 3 months.

Fig 2 Differences of Annual Ea between Present and Future Climate (mm)

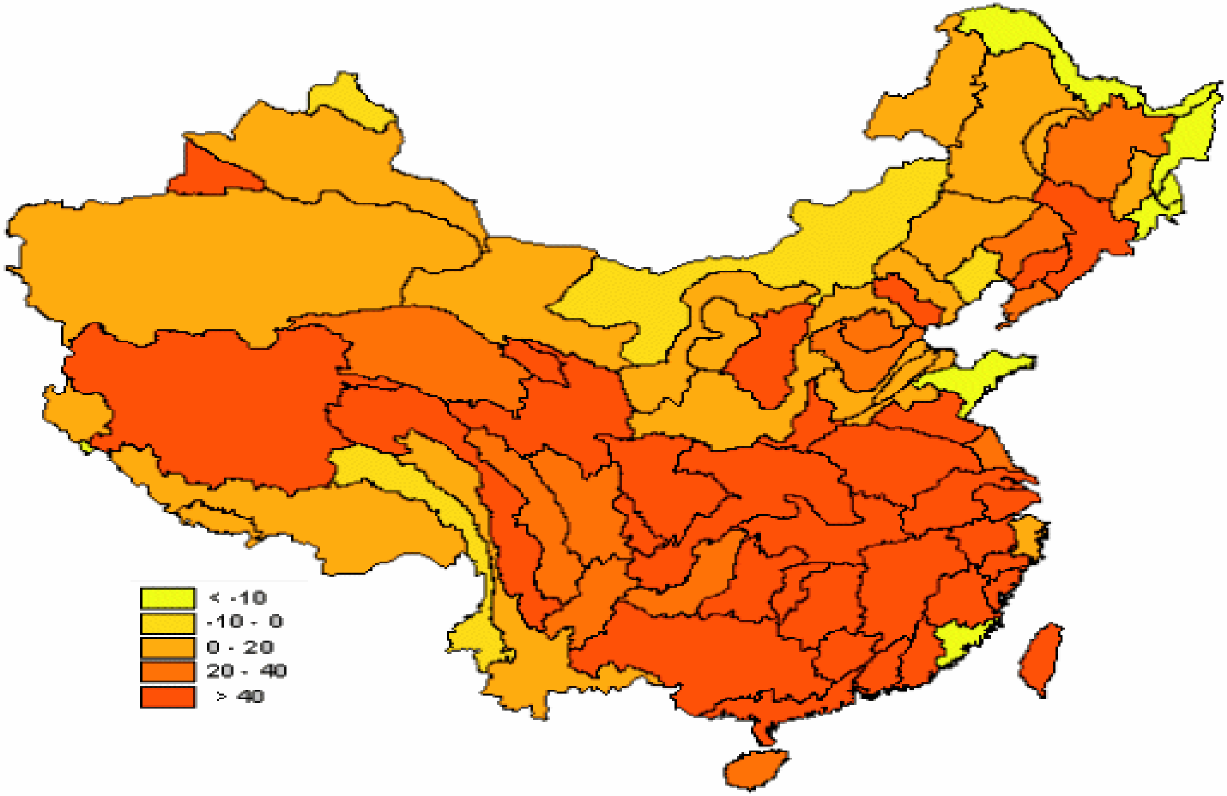


**Fig 3** Differences of Seasonal Ea between Present and Future Climate (mm)

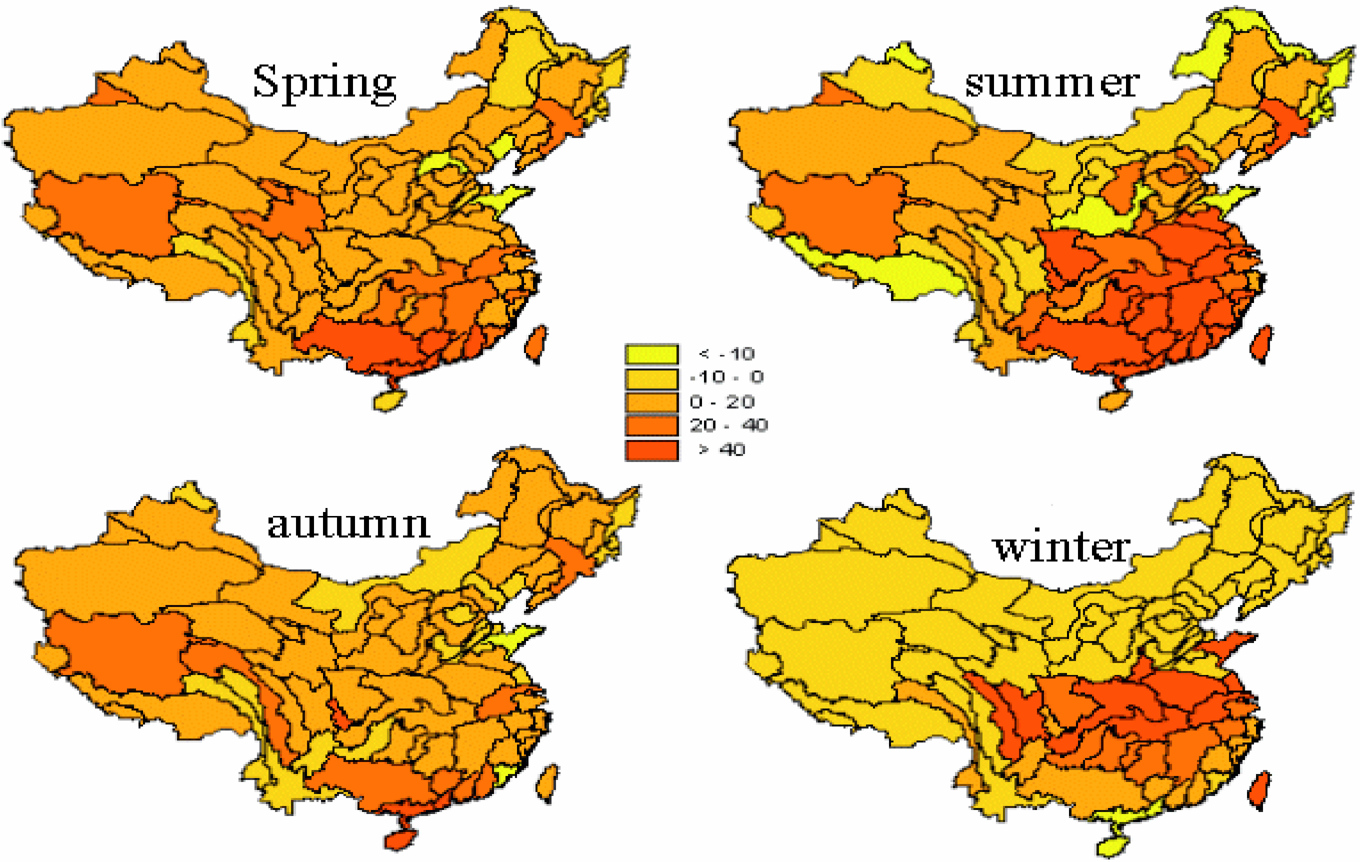
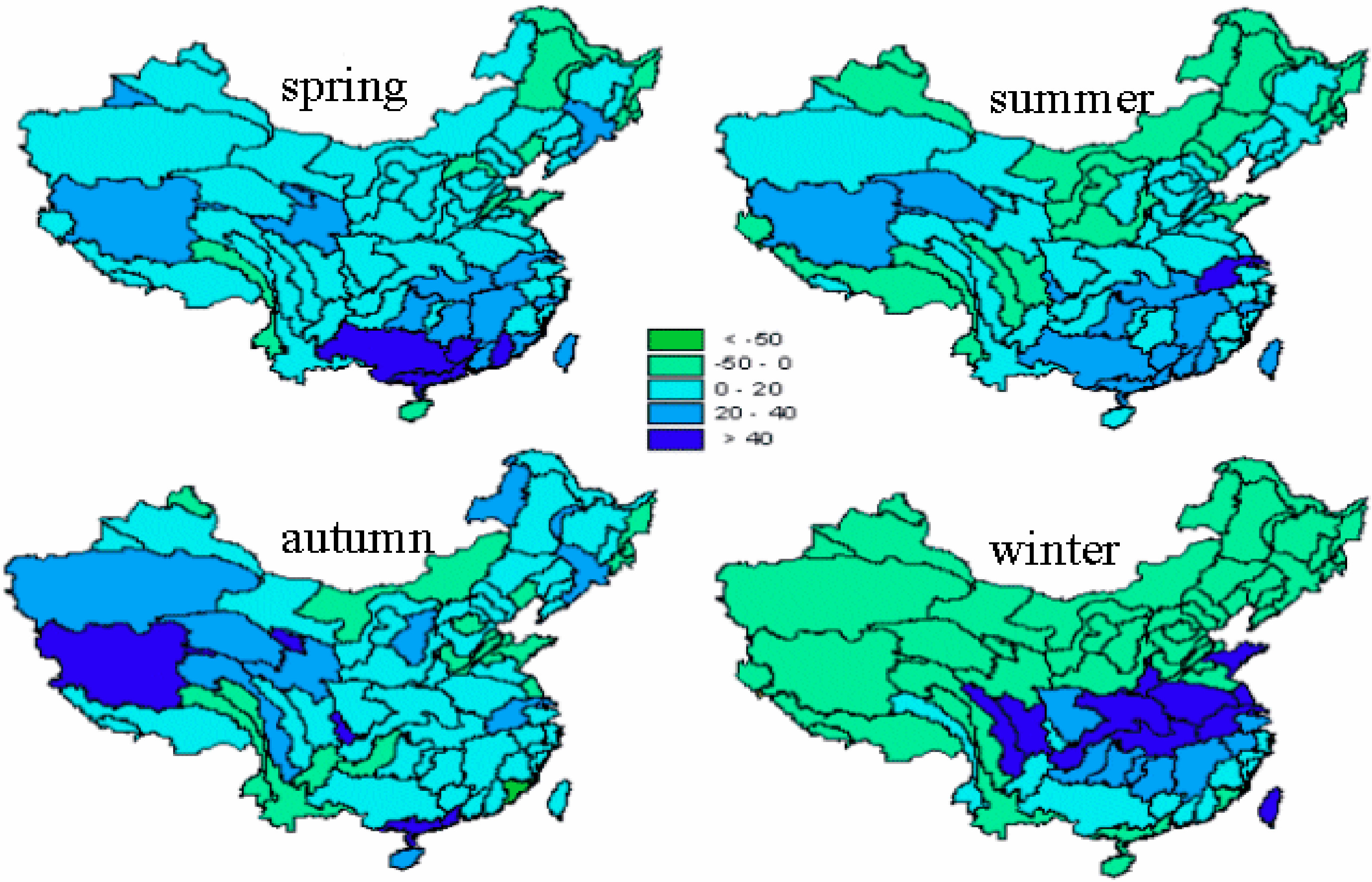
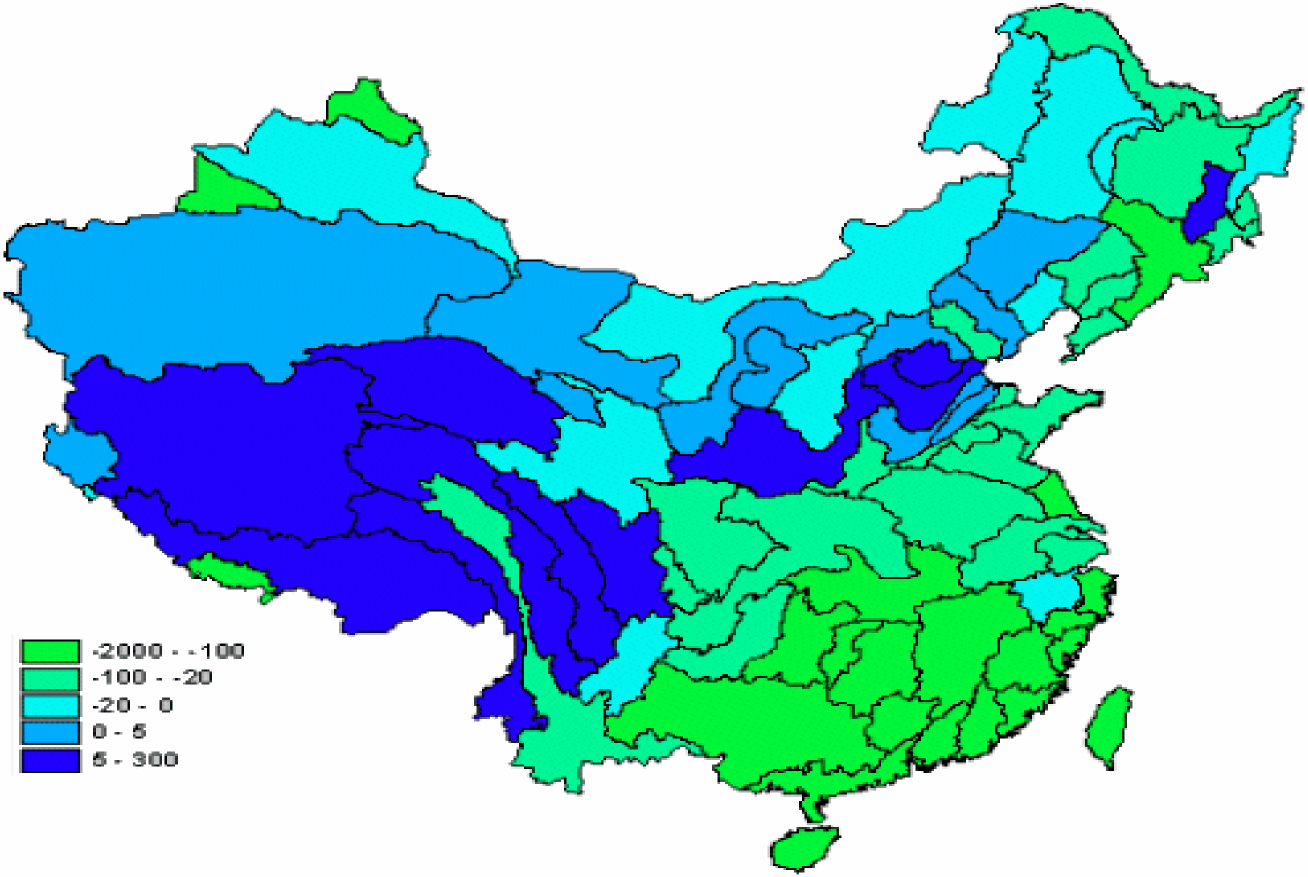


Fig 4 Ration of Seasonal Ea under double $CO_2$ to that under Present Climate (%)



- Runoff: The patterns of runoff changes vary from region to region while the national annual runoff will decline (Fig. 5). The typical region of runoff decrease is South China. Where the annual runoff decrease is more than 100mm. While in Qin-Tibet Plateau, runoff will increase over 5mm and a slight runoff increase will take place in northwest region.

Fig 5 Differences of Annual Runoff between Present and Future Climate (mm)



- The runoff distribute in different seasons in a year were showed in Fig. 6 and Fig. 7.

Fig 6 Differences of Seasonal Runoff between Present and Future Climate (mm)

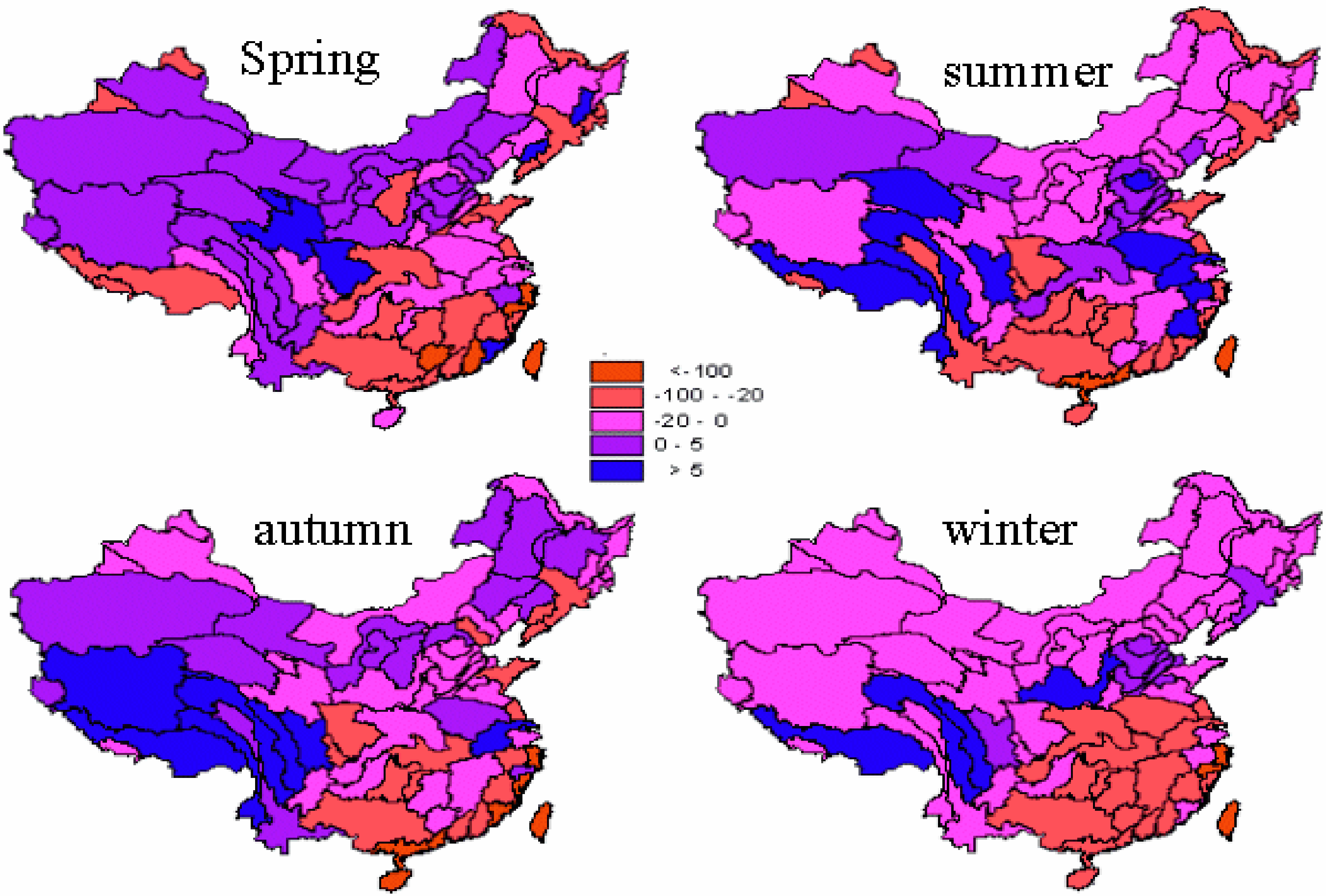
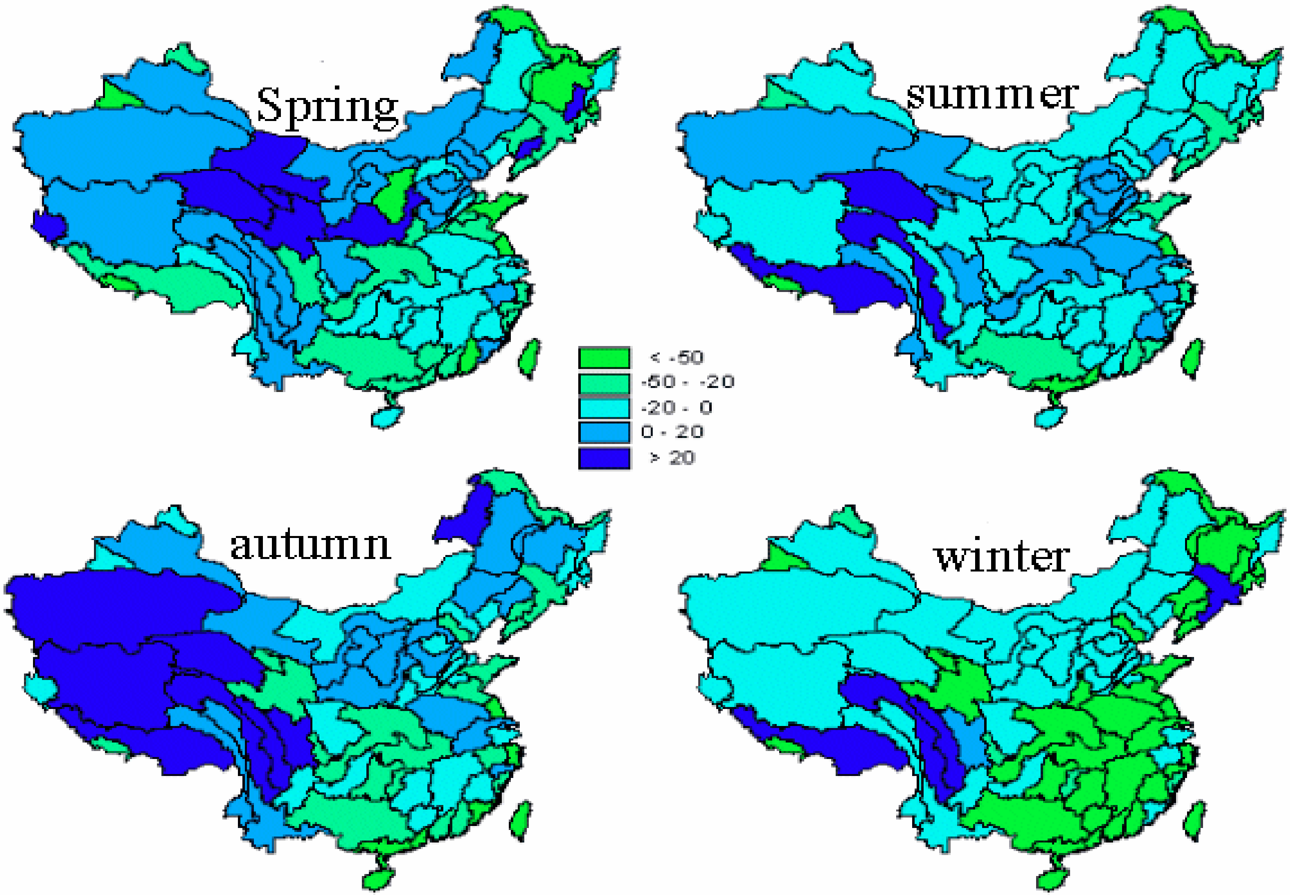
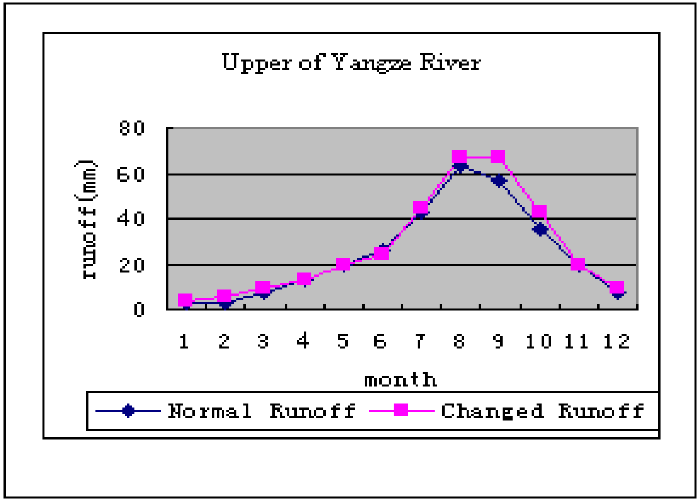


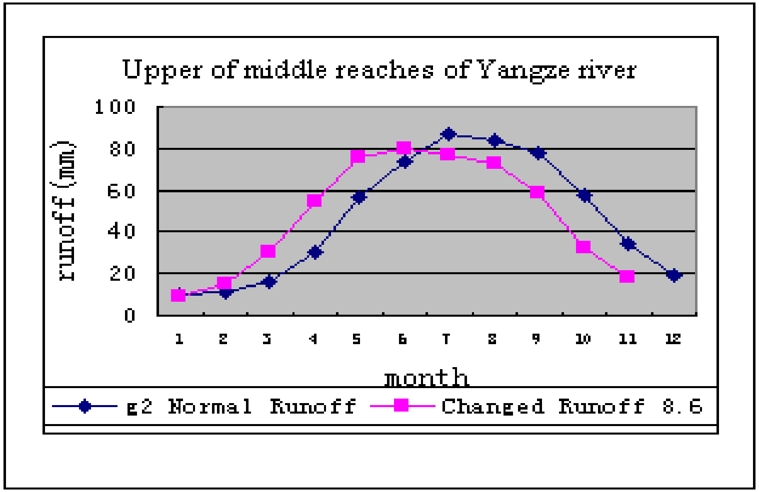
Fig 7 Ration of Seasonal Runoff under double $CO_2$ to that under Present Climate (%)

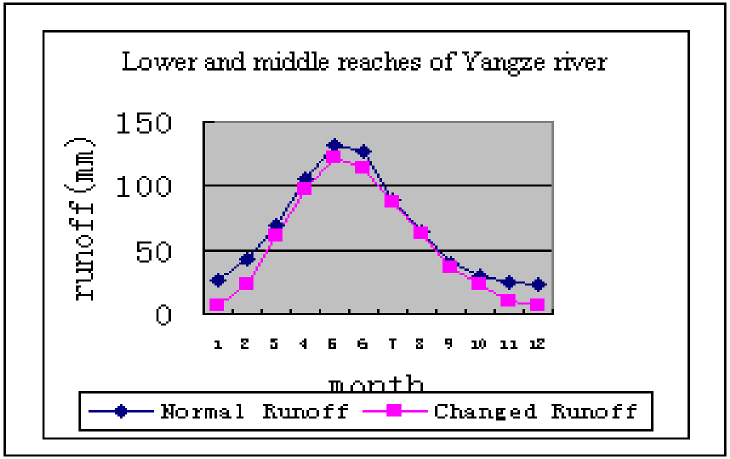


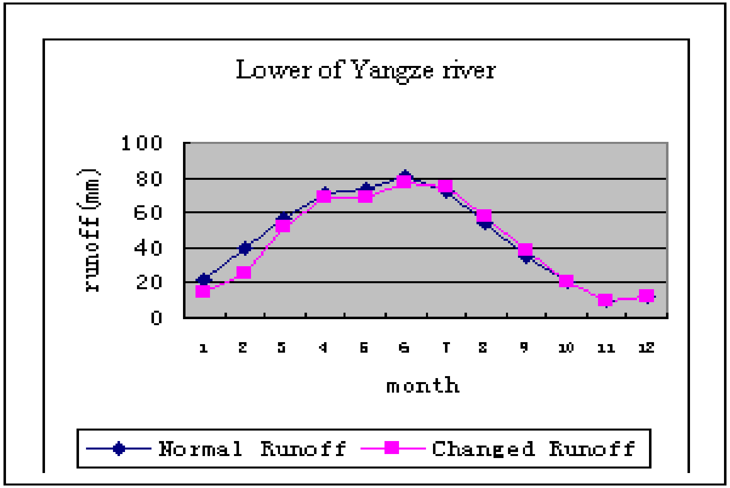
# 7. Monthly Runoff in Some typical Basin under Doubled $CO_2$

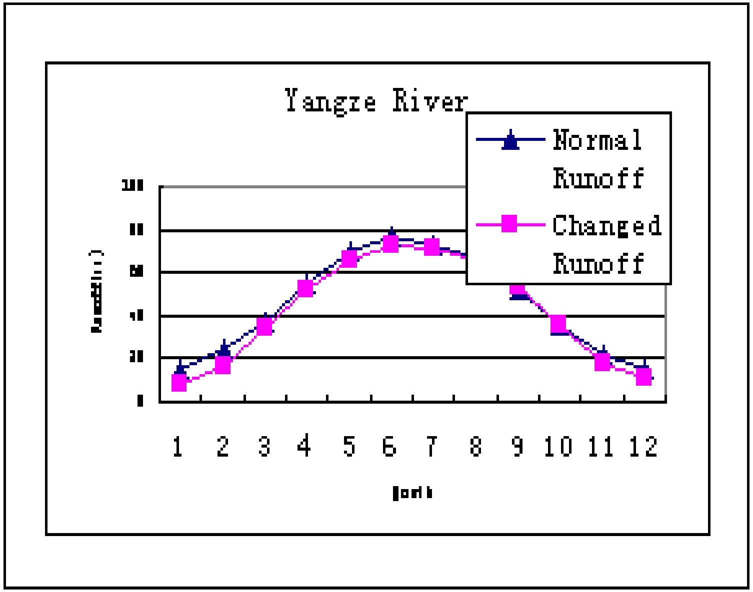
Fig 9 shows Monthly Runoff in Some typical Basin under Doubled $CO_2$.

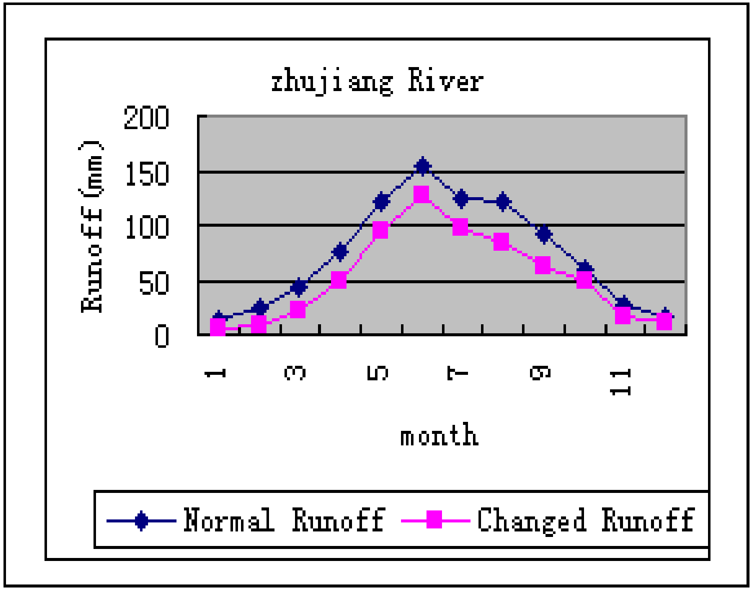

Upper of Yangze River
runoff(mm)
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12
month
Normal Runoff
Changed Runoff

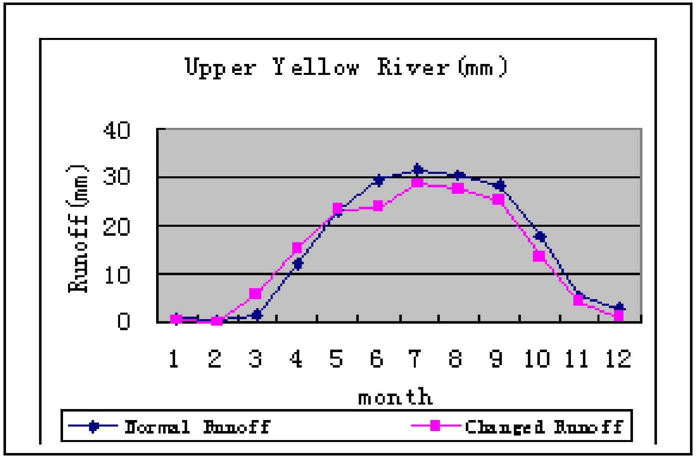

Upper of middle reaches of Yangze river
runoff(mm)
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12
month
g2 Normal Runoff
Changed Runoff 8.6

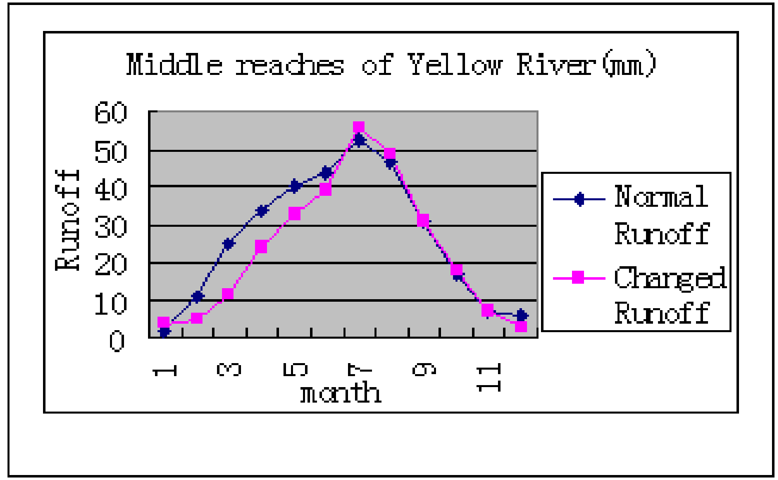

Lower and middle reaches of Yangze river
runoff(mm)
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12
month
Normal Runoff
Changed Runoff

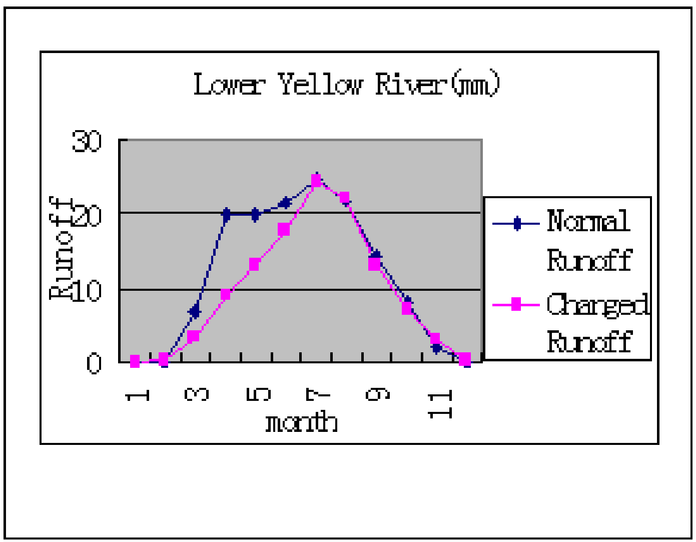

Lower of Yangze river
runoff(mm)
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12
month
Normal Runoff
Changed Runoff

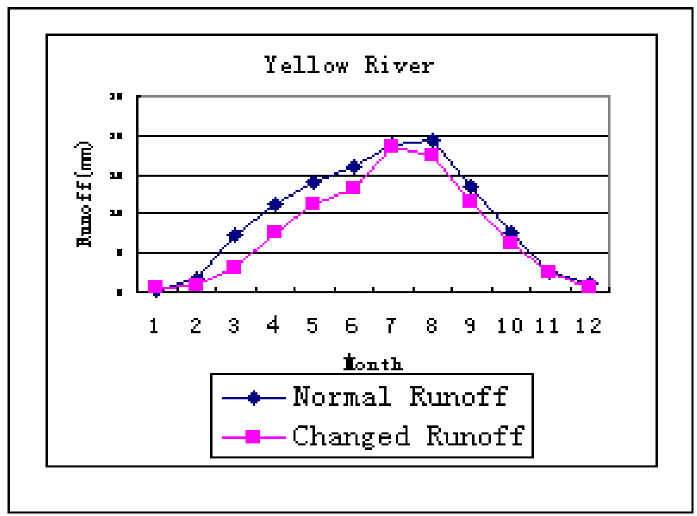

Yangze River
Normal Runoff
Changed Runoff
1 2 3 4 5 6 7 8 9 10 11 12

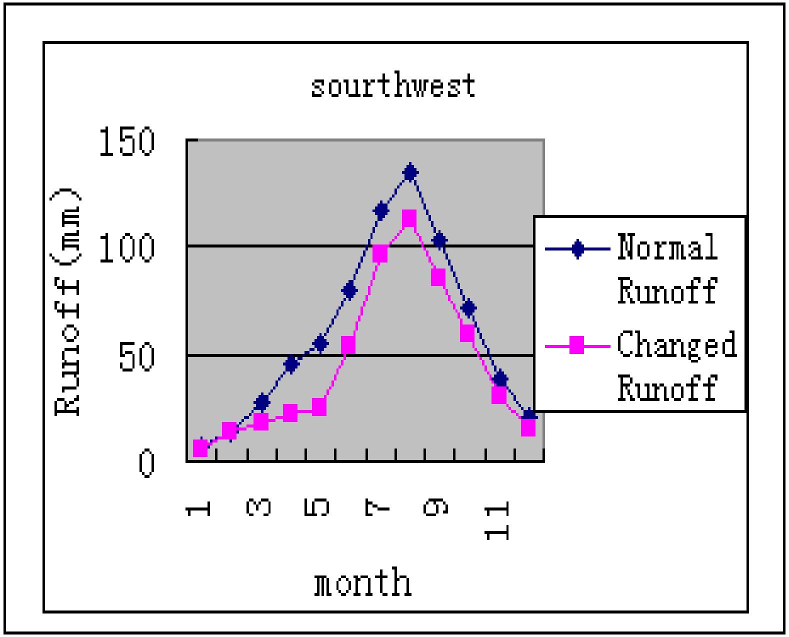

zhujiang River
Runoff (mm)
200
150
100
50
0
1 3 5 7 9 11
month
Normal Runoff
Changed Runoff

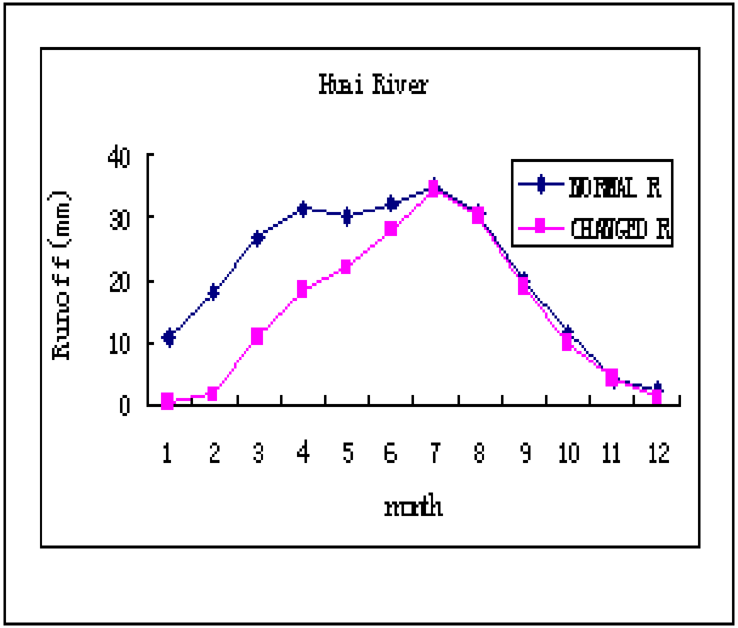

Upper Yellow River (mm)
Runoff (mm)
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
month
Normal Runoff
Changed Runoff


Middle reaches of Yellow River(mm)
Runoff
60
50
40
30
20
10
0
1 3 5 7 9 11
month
Normal Runoff
Changed Runoff


Lower Yellow River(mm)
Runoff
30
20
10
0
1 3 5 7 9 11
month
Normal Runoff
Changed Runoff


Yellow River
Runoff(mm)
1 2 3 4 5 6 7 8 9 10 11 12
Normal Runoff
Changed Runoff


sourthwest
Runoff (mm)
150
100
50
0
1
3
5
7
9
11
month
Normal Runoff
Changed Runoff


Huai River
Runoff (mm)
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
month
NORMAL R
CHANGED R

**Huaihe Basin**

Climate change will impose more profound impacts in this basin. Precipitation will

decline by 2.9 percent while evaporation increases by 12.1 percent. The annual runoff is expected to reduce over 20 percent .

# 8. Impacts of Changes in Hydrological Cycle

The balance of the various impacts suggests that climate change will mainly impose negative effects on the national economy in China. As for Huaihe Basin, the runoff decrease in spring and summer implies that this area will experience more severe droughts.

The predicted runoff increases the upper and middle reaches of the Yangtze River and most of the western basins might benefit the regional development. Runoff decrease during the flood season in some basins (e.g. Heilongjiang, Liaohe, Huanghe, Changjiang) may also benefit the annual flood control practices. Nevertheless, runoff reduction will worsen the already acute water scarcity problem in China.

# Analysis on the Countermeasures to Climatic Disasters in China

# Background

Studies on the impacts of global warming on hydrology and water resources reveal that, over the past 20 years, due to the increase in global mean surface temperature, the global water cycle has been intensified and the global mean precipitation has been increasing, which has led to more frequent floods.

Based on the existing studies, this paper summarizes the major causes of the 1998 Yangtze River Flood, and analyses the countermeasures to address climatic disasters in China.


新疆
西藏
青海
甘肃
内蒙古
黑龙江
吉林
辽宁
北京
天津
河北
山西
宁夏
陕西
山东
河南
江苏
上海
安徽
湖北
四川
重庆
浙江
湖南
江西
福建
贵州
云南
广西
广东
台湾
香港
澳门
海南

# 1. Major Causes of the 1998 Yangtze River Extraordinary Flood

The relevant researches concluded that the causes of the 1998 Yangtze River Flood lie in the following two aspects:

## 1.1 Abnormal Climate

In 1998, China experienced an abnormal climate. Due to the intensified El Nino, during the main flood season, Yangtze River had frequent and intense rainfall of wide coverage and long duration; Rain season came earlier with heavy precipitation in Songhuajiang. Historical data show, every next year of the El Nino, in the summer, there are two bands of strong rainfall in China. One of them is located in the Yangtze River and the areas to the south. The other one is in the northern part. With global warming, sea temperature in the eastern Atlantic Ocean is relatively high, which leads to more frequent El Nino events. The strongest El Nino of the $20^{th}$ century occurred in the May of 1997, peaked at the end of the same year, and ended in the June of 1998. This extraordinarily strong El Nino is one of the major causes leading to the excess rainfall in the Yangtze River in the summer of 1998.

- The increasing accumulation of snow in the Plateau Area where the Yangtze River originates is a key contribution to the extraordinarily strong summer rainfall in the Yangtze River and the south area.

According to the climate theory, while there is excess snow accumulation in the Europe-Asia and Qinghai-Tibet Plateau in the winter and spring, East Asia Monsoon generally delays with a weaker summer monsoon, the main rain band moves southwards and there is excess rainfall in the Yangtze River.

- Abnormal Asian middle latitudal circulation and active blocking high-pressure ridges provided the cold airs for the long lasting strong rainfall in the Yangtze River.

- Abnormal west Atlantic sub-tropical high-pressure is an important contributor to the location and intensity of rain belts in China .

During the June-August of 1998, due to the west Atlantic sub-tropical high-pressure, storm weather frequently occurred in middle reaches. It lead to the water level in the middle and lower reaches of the River kept rising.

# 1.2 Human activities

The degradation of natural environment induced from human activities reduced the resilience of the environment to sudden extreme events like floods. This is another important factor leading to the 1998 extraordinary flood. Human activities include deforestation, conversion of lake into cropland and construction of water projects.

- Degradation of ecological environment
    - Unlimited deforestation

In early 1950s, most of the upper reach of the River had good vegetation. But over the last few decades, several large scale deforestation has drastically reduced the forestry vegetation. Forestry cover rate in the upper reach has declined from 30~40 % in the early 1950s to only about 10% in 1998. Such unlimited deforestation makes the vulnerable forestry ecological resources impossible to properly regulate the river runoff.

- Expansion of soil erosion

The direct result of deforestation is the expansion of soil erosion in the mountainous areas. Survey results suggest that, due to soil erosion, the riverbed of the main stream of Yangtze River is increasing at the rate of 1 meter per 10 years. Therefore, unlimited deforestation and soil erosion will inevitably result in the silt accumulation in the water bodies, rising of riverbed and decrease in storage capacity.

- Conversion of lake into cropland

Many lakes along the middle and lower reaches of Yangtze River are connected with rivers and are important to regulate the river runoff. However, due to the natural evolution, silt accumulation and conversion into cropland, many lakes along the middle and lower reaches of the River are rapidly shrinking and even vanishing. Statistics show in the past 30 years, 12,000 square kilometers of lake area, an area even more than four times of the current Dongting Lake, has been converted into cropland in Hunan, Hubei, Jiangxi, Anhui and Jiangsu. In only Hubei Province, lake area has shrink by 6000 square kilometers.

- Illegal construction on the river shore

The rapid expansion of rural factory and population growth along the middle and lower reaches of the River, construction of tens of thousand of industrial and residential building and dykes severely restrained flood diversion.

From what discussed above, it is clear that the 1998 extraordinary flood lies in both of natural and human causes. Although the abnormal climate and intensified rainfall are out of our control, the human causes, in particular, unlimited deforestation, conversion of lake into cropland and illegal constructions aggravated the severity of the Flood.

## 2. Losses Caused by the 1998 Flood

Although the total losses from this Flood are not as bad as the other two extraordinary floods (in 1931 and 1954), due to the extremely important location of the Yangtze River in term of economic development level, this Flood caused enormous losses. … 1075 villages along the main stream of the River, Dongting Lake and Boyang Lake were burst during the Flood. Totally 321,000 hectares of land were inundated, among which 197,000 hectares were cultivated land. The Flood affected a population of 2.29 million. According to an incomplete statistics, the Flood caused a loss of 2000 lives and an economic loss of 200 billion Yuan.

# 3. Countermeasures to Address Emergent Climatic Disasters

The 1998 Yangtze River Extraordinary Flood caused enormous losses to Chinese people. However, it also trained the people and enhanced the ability to combat again and get well prepared for the climatic disasters.

## 3.1 Countermeasures in the course of floods

During the extraordinary floods, the central Chinese government targeted at ensuring the safety of the main dyke of Yangtze River, the big cities along the River, and the lives of the people, and decided to mobilize the military force so that the military and civil forces could battle jointly again the Flood.

-Well prepared and comprehensively planned

-Unified commanding and correct decision-making

In the whole course of flood relief, the central government and the Communist Party paid consistently close attention to the flooding situation and the safety of the people in the flooding areas. The government leaders went to the flooding area in person and directly involved in the battle.

-Military-civil joint efforts

During the Flood, water level on quite a few parts of the dyke exceeded the designed level. More than 9000 emergencies occurred along the main stream of the River. In those key moments, the army played an extremely important role.

-Concerted efforts and Comprehensive Flood Control

During the flood relief in 1998, all sectors took flood control as the highest priority, fully supporting the flood relief activities. Also, other countries, international organizations, foreign companies and individuals gave a great help.

-Scientific management

In the course of the flood fighting, 763 large- and medium-sized reservoirs were involved in flood blocking. 34000 million cubic meters of flood was held by these reservoirs. The hydraulic agencies at all levels paid close attention to and carefully analyzed the flooding situation. Flood control schemes were worked out in time. The weather agencies provided timely weather forecasts, scientifically supporting the flood control practices. Experts from various areas, engineers and technicians played significant roles as well. They conducted scientific analysis and judgement, successfully handled lots of emergencies and guaranteed the safety of the people祖 lives and properties.

-Flood control in accordance with the law

On the critical occasion of flood control, Jiangxi, Hunan, Jiangsu, and Anhui Provinces had declared to enter into emergent flood control state according to the flood Control Law”. The flood control commanding departments had in accordance with the Law expropriated flood control materials and tools, cleared the barriers on the flood route, and strictly penalized the people who had neglected on their duties of flood control. It had been proved that the Flood Control Law played an important role in the flood control in 1998.

- Timely supply of disaster relief and hygienic and sanitary service, reassurance of daily life of flood victims

Governments at all levels paid particular attention to the disaster relief and hygienic service. Food, clothes, accommodation and hygienic service were provided to flood victims.

## 3.2 Post-disaster reconstruction to ensure the safely handling of future emergent climate events

Although we cannot do much to control the climate anomalies, it is possible to mitigate the impacts of human activities on ecological environment, take effective actions to properly handle emergencies and minimize the losses. After the 1998 Extraordinary Flood, Chinese government paid extremely important attention to the post-disaster reconstruction. It urged to further strengthen the hydraulic constructions, insisting on the policies of overall planning and incorporation of flood control and drought prevention.

-Afforestation, soil conservation and improving the ecological environment

Special efforts should be made to improve the ecological environment in the areas where the situation is serious. Area of grassland and vegetation should be enlarged and recovered. Taking small basin as basic unit, mountain, waterway, cropland, forest and road should be systematically planned and comprehensively harnessed. Engineering measures should be incorporated with biological and water, soil conservation planting means, so as to formulate a soil and water integrated conservation system.

-Clearing the barriers to flood diversion, returning cropland back to lakes, building up new towns for flood victims and safety construction in flood storage areas

Dykes and embankments burst during the floods should be cleared up to recover the capacity of flood transferring and storage. Based on the current situation, residents in the flood storage areas should be properly settled through building up safe areas, safe stages and migrating towns.

-Enhancing and strengthening the existing dykes and embankments

Enhancing and strengthening the existing dykes and embankments should take the priority of harnessing the rivers and lakes. Trough the implementation of integrated flood control measures, dykes and embankments are expected to defend the worst floods since the foundation of PRC, while some key sections should be able to defend the floods occurring once every 100 years. New technologies, new materials and new processes are encouraged to be applied, so as to ensure the quality of flood control engineering projects.

-Speeding up the construction of river controlling projects

As for those rivers with frequent floods but no controlling projects, main and branch reservoirs should be urgently constructed, with accordance to the integrated basin plan. Reservoirs in incomplete and dangerous conditions should be strengthened.

-Strengthening the harnessing of river courses

River course and burst embankments in the lower reach of the Yangtze River should be harnessed. River sections where silt accumulation affected the smooth flow of floodwater should be cleaned up.

-Improving the technology level of flood control and enhancing the investment in science and technology

After the Flood, Chinese Government decided to gradually establish a flood control commanding system which covers the key flood control areas all across China in the coming five years, strengthen the scientific research on flood control, organize studies on flood relief technology, dyke infiltration-proof technology and potential problem detection technology, research and produce urgently needed and practical new equipment and material for flood control, and to establish a modern flood relief team.

The impacts on human society imposed by global warming are diverse. Though it requires further research on the linkage between the 1998 Extraordinary Flood in China and global climate change, the following two points should draw the attention of the scientists engaged in global climate change: first, in addition to the change scenarios of global mean climate and the adaptation to these mean changes, efforts should be also made to examine the regional and extreme climate events. Second, the impacts of human activities on ecological environment should be incorporated into the research on climate change impacts, so as to work out the countermeasures to mitigate or avoid the adverse impacts of human activities and minimize the impacts of emergent climate events.

# The End