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Environment and Health Management for Climate Change in China

Volume Ⅱ – Health Impact , Adaptation Strategies and Research Priorities






Ministry of Health,P.R.China

Institute for Environmental Health and Related Product Safety, China CDC

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Executive summery

Climate is not only important natural resources but also a component of the ecological environment and human society. Since the 20th century, along with the development of economic and the improvement of people's living standard, the greenhouse gas emission by human activities shows a sharp increase. The global climate is warming.

Climate change will affect human health and well-being through a variety of mechanisms. Altered weather patterns (temperature, precipitation, sea-level rise and more frequent climate extreme events) can impact human beings directly and influence on the morbidity and mortality of the related diseases. On the other hand, human beings are exposed to climate change indirectly through changes in water, air and food quality and changes in ecosystems, agriculture， settlements and the economy.

In China，researches on health impacts of climate change just begin in the recent years. So, related scientific information is very poor. Based on the fully data collection of international experience and national works, we focused on national data review and gap analysis, further to make commendations on works which should be done in the future on climate change adaptation, especially for health agency.

This report can be divided into three parts.

- Observed change of the climate and the trend of the climate change in the future[Chapter 1]
- Researches on the health impacts of climate change in China[Chapter2 to Chapter 6]
- Adaptation strategy on health impacts of climate change and research priority[Chapter7 to Chapter 8]

On this report, health impacts of climate change are mainly referred to two aspects:

one is the observed results of the health effects, and the other is the projected health impacts due to global warming in the future.

Evidence of climate change effects on human health shows that health impacts of climate change including:

- increased heat wave-related deaths [chapter2]；

- altered the distribution and productivity of some vectors important to the transmission and extent of the vector-borne diseases. [chapter3];

- water shortage and drinking water pollution [chapter4]；

- increasing the concentration of O_3 and other air pollutants and the transmission mode[chapter 5]；

- changing of food security and crop yields [chapter6].

Projected trends in climate change-related exposures of importance to human health will:

- increase malnutrition and consequent disorders, including those relating to child growth and development [chapter 6];

- increase the number of people suffering from death, disease and injury from extreme weather events such as heat waves, floods, storms, fires and droughts [chapter2，4，5，6];

- continue to change the transmission scope of some infectious disease, produce some new infectious disease due to climate change [chapter3， 4].

Climate change has become an indisputable fact; mitigation and adaptation are important strategies of response to the climate change and could reduce the adverse impacts. Adaptation is a necessary measure to reduce the greenhouse gas but not a replacement. To reduce greenhouse gas emissions can lower the speed of climate change , increase the possibility of adaptation and decrease the related cost. China has already developed a series of measures to response climate change effectively; however, it is a big and new challenge for all over the countries to face the changing nature, the rapid warming speed, the vulnerability of ecosystems and human health as well as the limits of human capacity to adaptation. Therefore, climate change adaptation in China has its particularity, which needs fully understand of the vulnerability and multi-sector and systems to collaborate in order to have effective adaptation strategies [chapter7].

Based on the clearly awareness that climate change is a indisputable fact，fully analysis the existing research field and development trend of health effects of climate change and taking into account of the uncertainties working out a practical development plan combining with China’s specific conditions and pointing out the research priorities will give a clearly guideline on the development of studies on the health impacts of climate change in China[chapter8].

Preface

Climate change has become the most important global environmental problems. According to the signs and recent research results, the climate change and the human activities have a close linkage in the last 100 years. The Intergovernmental Panel on Climate Change (IPCC) which was established by the World Meteorological Organization and United Nations Environment Program, specially pay attention to the research results on climate change in the past century. Following the year of 1990, 1995 and 2001, IPCC issued the Fourth Assessment Report on Climate Change in 2007. According to the Fourth Assessment Report, Global surface air temperature has increased by 0.74℃ over the last 100years (1906–2005). The warming rate over the last 50 years is almost double to that over the last 100 years (0.13℃± 0.03℃ vs. 0.07℃ ± 0.02℃ per decade)；while the global surface air temperature will rise 0.2℃ per decade in the next 20 years.

China is one of the countries which affected by climate change seriously. "National Assessment Report on Climate Change" points out that in the background of global warming，the climate in China has also undergone a significant change in the past 100 years which was in the same trend of global climate change. In the recent 50-100 years, the annual average surface air temperature was increased by1.1℃ and 0.5℃～0.8℃ respectively, which was higher than the global temperature increase. In terms of geographical distribution, the significant warming areas in China are in the northwest, north and northeast; in terms of season distribution, winter is warming significantly. According to the newly results of China Meteorology Bureau, since 1986 to 2007, China has experienced 21 warming winters. The winter in 2007 is the warmest one since 1951.

Global climate change impacts the ecology, society, economy and so on. The climate change also threatens the human health in many aspects. The international researches on climate change mainly refer to the following areas:

- ✓ Direct effects of heat
- ✓ Health effects related to extreme weather events,
- ✓ Air pollution-related health effects,
- ✓ allergic diseases
- ✓ water- and food-borne infectious diseases
- ✓ vector-borne and zoonotic disease
- ✓ food and water scarcity
- ✓ mental health problems, and
- ✓ long term impacts on chronic disease and other health impacts

In recent years, China extreme weather events have become the trend of much more and stronger. Floods, heat waves, freezing rain, snow weather and so on which were rarely happened in history, caused great harm to health and society. The most direct impact on the health of climate change is heat, which can change the incidence and mortality of heat or cold related disease. Researches in China, Africa and America showed that, in big cities, thousands of deaths due to heat wave attack each year, especially the vulnerable areas and populations (Bojkov RD et al.,2005). Abnormally high temperatures in Europe in the summer of 2003 were associated with over 44 000 more deaths than the equivalent period in previous years (WHO, Report by the Secretariat，2008). Other extreme weather events (such as storms, floods and drought, etc.) are also seriously affected the human living environment and sustainable development of society, which can cause death, injury, psychological imbalance and public health facilities damages.

Climate change may affect the existing and mutation of the infectious disease pathogens and the epidemiological characteristics and breeding of vector insects by affecting the ecological balance, especially the micro-ecological balance. These infectious diseases forward north from the tropical and subtropical regions. The population threatened by the infectious diseases will be increased and the disease prevalence time will be much longer. Climate change can influence the existing and the range of infectious disease (such as malaria, dengue fever and schistosomiasis).

The local ecosystems change caused by water and food contamination will also lead to diarrhea and other infectious diseases. Climate change can influence the weather and pests which may affect the food production and lead to malnutrition, hunger and children hypogenesis. The sea-level rising caused by global warming may bring on migration and infrastructure damage and other social problems. Global warming can increase forest fires frequency which leads to the concentration of pollutants in the air increased (including allergic to pollen and inhalation particulate matter, etc.).The air pollutants can also bring on biological effects, such as asthma, allergies, acute and chronic respiratory disease and death. Stratospheric ozone reduction will cause skin cancer, cataracts, and may also lead to immunity decreased.

Climate change affects the agro-ecosystems, marine fisheries and the infectious diseases spread slowly, as a result, the health impacts presents slowly too. However, this kind of impact is constantly accumulated, once it happened, the consequences will be very severely.

In China, research on the health impacts on climate change is still in the first stage, which mainly focuses on the temperature (extreme heat) related disease, vector borne disease and infectious diseases. At the same time, climate change is an environmental problem in a large space scales and period (more than 10 years, global). China is a large scale country, which has various ecological and economical positions. The ecology and human health impacts on climate change are various in different areas in China. The vulnerability is indeterminacy in the national level which makes a big challenge to the health impacts research on climate change. As a result, the most important and urgent missions in China are to strengthen the awareness and support of health impacts on climate change on the national level, to develop the health impact assessments of climate change, to do the gap analysis and identify the research priority areas.

This report forwards the integrate evaluation on climate change and health impacts in China, indicates the gap and limitation of the related researches, identifies the research priority areas. In the aspect of response to climate change, China's public health emergency response system is introduced on focus and the development of emergency response system has been advised.

At the same time, facing the current trend of global climate change, China has summed up the adaptation and mitigation strategies and measures. We hope this report can be a reference to the researches on climate change in China as well as in the regional range.

Chapter 1 Profile of Climate change in China

According to the Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC), climate change is really true and the key reason leading to global warming is the mankind's activity. The effects include:

- The global average surface temperature has increased by approximately 0.65°C over the last 50 years.
- Eleven of the last twelve years (1995-2006) rank among the 12 warmest years since records began in the 1850s.
- The rates of warming, and of sea level rise, have accelerated in recent decades.
- Many areas, particularly mid- to high-latitude countries, have experienced increases in precipitation, and there has been a general increase in the frequency of extreme rainfall.
- In some regions, such as parts of Asia and Africa, the frequency and intensity of droughts have increased in recent decades.
- The frequency of the most intense tropical cyclones has increased in some areas, such as the North Atlantic, since the 1970s.

Global emissions of carbon dioxide are still increasing. Estimates of future population growth and energy use are used as inputs to global climate models, in order to project future climate change. Reviewing outputs from a range of such models, the IPCC has made the following projections for the next century:

- Global mean surface temperature will rise by 1.1℃-6.4℃, depending partly on future trends in energy use. Warming will be greatest over land areas, and at high latitudes.
- Heat waves, heavy precipitation events, and other extreme events will become more frequent and intense.
- Sea level rise is expected to continue at an accelerating rate.

In the context of global warming, climate in China has experienced noticeable changes over the past 100 years as well. According to “China’s National Climate Change Programme”， promulgated by National Development and Reform Commission in June 2007，the major observed evidence of climate change in China includes the following data.

Section 1　Climate change in China in the last 100 years

1 Annual average air temperature

Annual average air temperature has increased by 0.5~0.8°C during the past 100 years, which was slightly larger than the average global temperature rise（0.6±0.2℃）; Most of the temperature rise was observed over the last 50 years. Annual mean surface air temperature as a whole rose by about 1.1℃ for the last 50 years, with a warming rate of about 0.22℃ per 10 years. The warming rate of China in the latter half of the 20th century was more rapid than that of the world and the Northern Hemisphere. Northeast China, North China and Northwest China experienced more significant warming in terms of annual mean temperature, while there are no significant warming trends in the south area of the Yangtze River; The seasonal distribution of the temperature changes shows that the most significant temperature increase occurred in winter and next is in spring, which is agree with that of the world and Northern Hemisphere. Meanwhile, the warming rate of China from 1920s to 1940s was more significant, and this is not coinciding with that of the world (fig.1-2). From 1986 to 2007, 21 consecutive warm winters were observed in China according the data from China Meteorological Bureau.

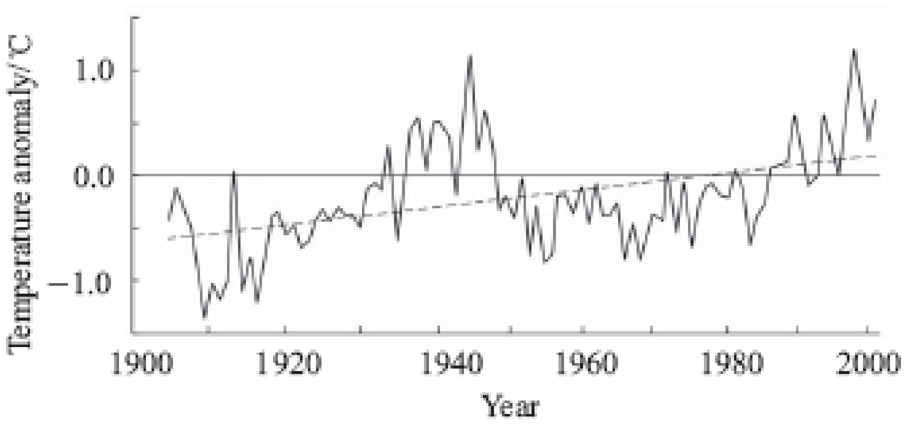


Fig.1-2 Change of annual mean surface air temperature over China in 1905-2001

2 Precipitation

In the past 100 and 50 years, there was no significant change in annual mean precipitation in China, but there exists considerable variation among different regions. The annual mean precipitation was higher in the earlier periods of 20^{th} and from 1930s to 1950s. And it decreased gradually since 1950s with an average decreasing rate of 2.9 mm/10a, although it increased slightly during the last 20a. The regional distribution of precipitation shows that the decrease in annual precipitation was significant in most of northern China, eastern part of the northwest, and northeastern China, averaging 20~40 mm/10a, with decrease in northern China being the most severity; while precipitation significantly increased in southern China and southwestern China, averaging 20~60 mm/10a;

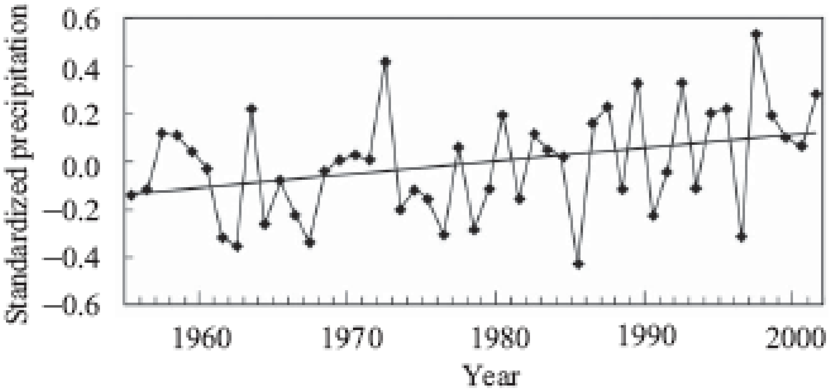


Fig.1-3 Standardized anomalies of annual precipitation over China in 1956-2002

3 Extreme climate/weather events

In the background of the global climate change, the frequency and intensity of extreme climate/weather events throughout China have experienced obvious changes during the last 50 years.

3.1 High Temperature Days and Heat waves

According to the Climate subarea and the distribution characteristics of hot day numbers in China, the whole country can be divided into five areas: Xinjiang, North China, the middle and lower reaches of Yangtze River, South China and West China. During the last 50 years, the high temperature days have an evolutional trend of increasing-decreasing-increasing and there are significant increasing trend in the last 20 years. But the time of changing from decreasing to increasing is not synchronous for the whole country, (Gao et al.，2008). The trend of variation in high temperature is deferent from that of the global mean temperature. The global average temperature in the last 50 years shows no very high variation before 1980s and it begin to sharp increasing after the 1980s. (Ren et al.,2005)

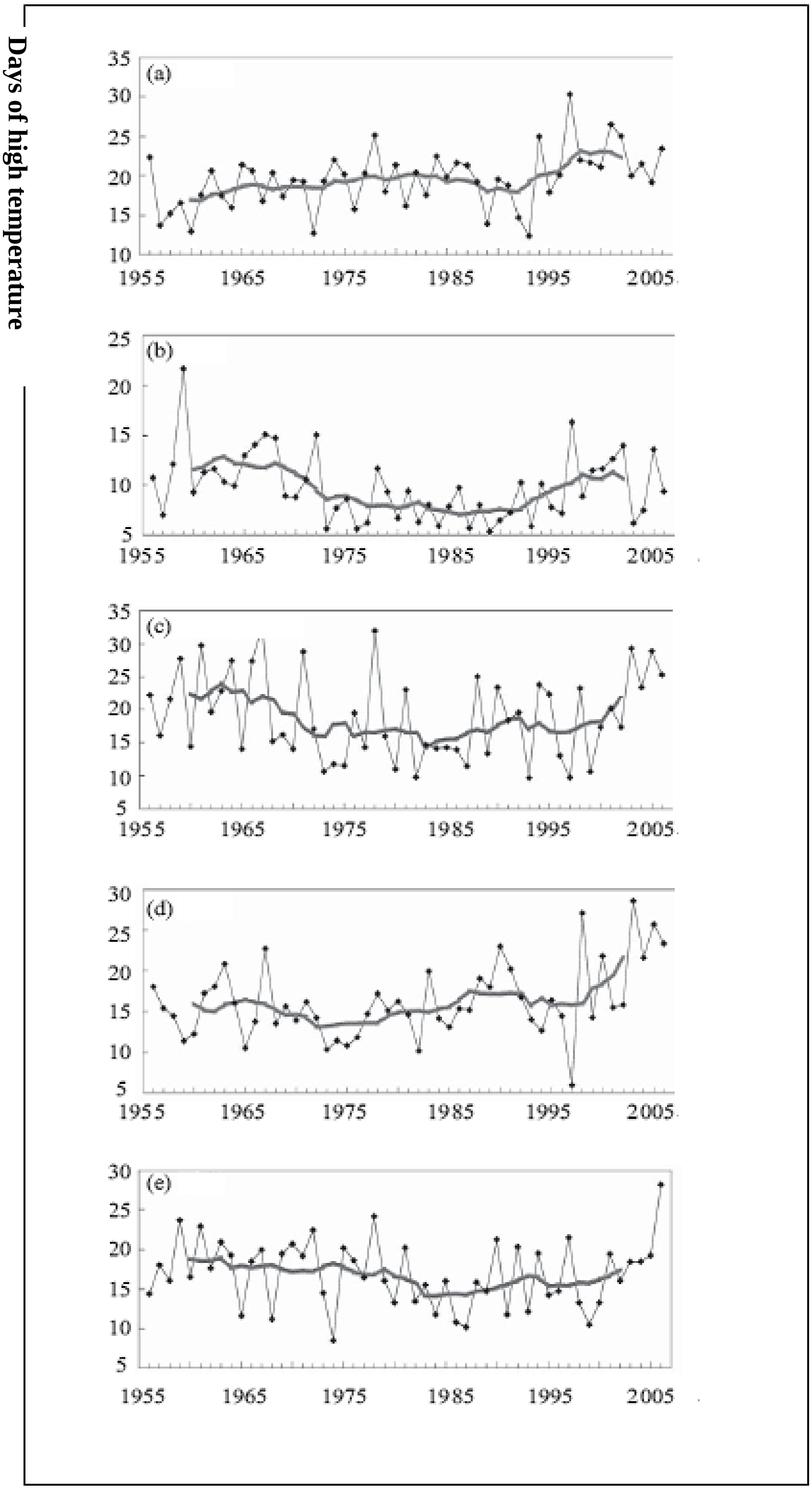


Fig.1-4 The inter-annual variations of the yearly day number of daily maximum temperature ≥35℃from 1956 to 2006 in Xinjiang (a), North China (b), middle-lower reaches of the Yangtze River (c), South China (d), and Southwest China (e) (The thick solid lines are 9-year running mean curves)

In recent years, serious heat wave appeared frequently in China. North China, the eastern part of Northwest China and most of the regions south of the Yangtze River were very sensitive to heat wave, while the frequency of heat wave became higher and higher. Three heat wave peaks in the last 100 years are 1940s, 1960s and after 1999 to yet. From 1999 to yet, extreme heat events happened in North China, Yangtze River and the area to the south, the eastern part of northwest almost every year, it lasted more than ten days, and the intensity and scope was very great(The days with the temperature was higher than 35℃). In the summer of 2003, days of continually high temperature, with the day highest temperature higher than 35℃ in the south areas of China, especially in the south of Yangtze River and South China District, had lasted more than one month. It was rare for the distributing area was so large, lasting time was so long and the temperature was so high.

Heat wave induces and aggravates the local extreme droughts. Meanwhile, the acceleration of urbanization, the increasing of energy consumption adds more heat to the urban areas. Urban planning and construction change the use of land; heat island effect due to urbanization such as vegetation reduced and so on also aggravates the degree of extreme heat.

Extreme heat wave seriously endangers human health, especially to the vulnerable groups. Besides, it also threatens the electric power, agriculture and so on.

3.2 Flood

In recent years, the trend of extreme precipitation events in Chinese region was basically the same as that of the global; the average annual precipitation didn’t change significantly, while the precipitation in some region changed notability. The main character was that regional and local became obviously （Yan et al., 2000）, and it would lead to the increasing of drought and flood. For example, since 1986, floods in drainage area of the Yangtze River have occurred frequently. It mainly due to the increasing of frequency and intensity of extreme rainfall in South-eastern and south-west of Yangtze River（Su et al., 2006）, it also had a close relationship with the spatial and temporal distribution of extreme rainfall.

In 21 century, high temperature will lead to water cycle speed up, the distribution of rainfall become more asymmetry, the frequency of extreme rainfall event increase, and then the probability of droughts and floods will augment. The results of extreme rainfall events cause serious socio-economic problems and casualties. For example, In 2003, 1.3 billion people were affected because of Yangtze River flood events（Xie et al.,2005）

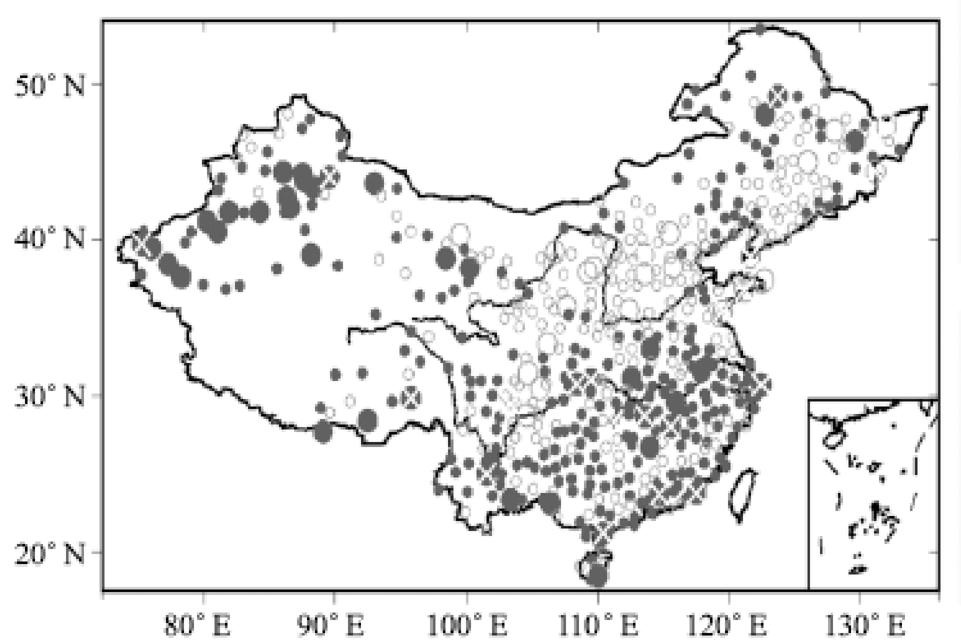


Fig.1-5 Change of days with extreme strong rainfall over China in the last 50 years >7.5%/10a, (7.5%—2.5%)/10a, <2.5%/10a, <-7.5%/10a, (-7.5%—-2.5%)/10a, >-2.5%/10a, areas marked with pork if the changes are significant.(From Ding et al.,2006)

3.3 Drought

As one of the most serious natural disasters, droughts get attention in the early 1930s.

In recent years, people have recognized the impacts of global warming on droughts, and the fact that droughts which was caused by warming in the global and regional scale became more and more serious has been revealed（Fu C et al.,1994; Dai AG et al.,2000).

In the late 20th century, the droughts in China especially in northern China were strengthened gradually both in area and times. In 1997 and 1999~2002, Some regions have continually suffered drought for five or six year, then have caused shortage of water resources, deterioration of the environment and great loss of agricultural production. The droughts cause health damage including death, malnutrition, infectious diseases and respiratory diseases and so on (Menne and Bertollini,2000).

3.4 Frost days

From 1950s, the average frost days in whole country decreased by about 10days, which is agree with the fact that the increasing trend of daily lowest temperature is more obviously higher than that of the daily highest temperature. The change variability of frost days in North China, eastern areas of Northwest and the south-western of Northeast China were great, especially in the middle north of North China District and east of Northwest District. In general, the change variability in the east China was greater than that in the west China.

3.5 Cold wave

The temperature significantly heightened and the days of low temperature showed decreasing trend in China, especially in the north China, with the global warming. The frequency of low temperature in Northeast District rapidly decreased since the late of 1970s. The severe lower temperature in large scale hadn’t almost emerged especially after 1980s.

3.6 The frequency of snow disaster increased.

Tibetan Plateau was the area where the frequency of snow disaster was highest. The winter rainfall in Tibetan Plateau was significantly increasing since the late of 1980s and the frequency of snow disaster increased in winter and spring.

In January 2008, China has witnessed a Severe Weather event with Cold Air, Freezing Rain and Snow over South China. For its lasting so long, the intensity was so large and the influenced areas were so broad, it made severe social problems and the direct losing in economic were reached 151.65 billion.

3.7 Strong typhoon increases and the impact exacerbates

Global warming causes the ocean sea temperature and the surface temperature increase, and it is the factor of typhoon formation and disappearance, it will easily lead to the increase of the intensity of typhoon. Since the last 50 years, the intensity of typhoon that landing in China strengthened; in 2006, there have been the strongest typhoon landed in China named “Saomai” nearly the last 50 years. The energy is very grate and the destructive power is strong, it will make serious effect on the life, economic development and social stability. According to incomplete statistics, from 1982 to 2006, the highest death toll caused by typhoon was in 1990, and the annual average was up to 497.6. In 2006, the death toll could get 1552 and it was the second place for the past 24 years because of super typhoon and mobile complicated path of the typhoon. Zhejiang, Fujian, Guangdong and some other provinces are the most serious regions in the past 20 years, the death toll were more than 2000 people.

3.8 The effects of environment disaster such as haze and mist become complicated

Haze and mist affect China seriously because of climate warming and the development of economy.

The number of haze which the air is turbid is increasing and the increasing trend become obviously in the 21 century. From 2003 to 2006, the frequency was the highest since 1961 when the observation record begins. In haze, the air mobility is very weak, the suspended particles in the atmosphere can be easier to carry a variety of bacteria, viruses into the human body, and that will lead to respiratory infection, so that asthma, chronic bronchitis and so on can be turned into acute respiratory diseases.

Haze causes surface layer ultraviolet weakened, decreases the ability of ultraviolet, so that enhances the activity of infectious bacteria, indirectly leads to the diffusion of some other diseases and form the public health incidents.

The mist in our country has notable features of the temporal and special distribution. From 1954 to 2004, the average number of days in fog was decreased. The days in fog of 2004 were just a half of that in the middle of 1950. The days in fog of Huang-Huai, Western Jianghuai, Liaodong peninsula and the eastern part of Sichuan Basin increase while those of Northeast, middle region of Shanxi, southwest and some parts of South China decrease. The tread of this was negatively correlated to the average temperature but was positively correlated to the relative humidity.

Traffic accidents caused by fog are 2.5 times higher than that caused by other severe weather. The number of injury and death accounts for 29.5% and 16% of the total number of death.

4 Sea level

The rate of sea level rise along China’s coasts during the past 50 years was 2.5 mm/a, slightly higher than the global average.

5 Glaciers

Since the 1980s, with the global warming, glacier retreat at an accelerated rate and about 80% glacier are in the state of thaw. According to preliminary estimates, by 2030, glacier in the west of China will thaw obviously, water that glacier melts will increase, and it will reach peak in 2050. Since the mid of 20th century, the change of frozen soil has showed that ground temperature increased, the size reduced, lower bound raised, the thickness of active layer increased. Snow area of the north was in the state of increasing or stabilization.

In the background of climate warming, frequency, intensity and affected area will increase. The change of cryosphere will make profound and long-term effects on the climate, water resources, ecology and environment. Glacial melt water is necessary to the stable development of arid area in northwest; but glacier thaws, human activities exacerbates, the natural balance is destroyed, so that inland river shrinking and ecological deterioration. The degeneration of frozen soil has great effect on hydrological cycle, wetlands, carbon cycle, biodiversity and major construction projects. The change of cryosphere affects the energy of plateau and heat balance, lead to temperature changes, and then affects monsoon climate of the east; it is the main factor that augment the capability of short-term climate forecast of our country. Besides, snowstorm, snow slide, glacial lake outburst, ice also can affect traffic, communication, agriculture and animal husbandry, travelling and people’s lives and property safety.

Section 2 The trend of climate warming in China

The trend of climate warming in China will further intensify in the future. The projections by Chinese scientists indicate that:

— The nationwide annual mean air temperature would increase by 1.3~2.1°C in

2020 and 2.3~3.3°C in 2050 as compared with that in 2000. The warming magnitude would increase from south to north in China, particularly in northwestern and northeastern China where significant temperature rise is projected. It is estimated that by 2030, the annual temperature would likely increase by 1.9~2.3°C in northwestern China, 1.6~2.0°C in southwestern China;

— The possibility of more frequent occurrence of extreme weather/climate events would increase in China, which will have immense impacts on the socio-economic development and people's living;

— The arid area in China would probably become larger and the risk of desertification might increase;

— The sea level along China's coasts would continue to rise;

— The glaciers in the Qinghai-Tibetan Plateau and the Tianshan Mountains would retreat at an accelerated rate, and some smaller glaciers would disappear.

Chapter 2 Impacts of Thermal Stress on human health

According to “Climate Change 2007: Synthesis Report”(IPCC,2007), Eleven of the last twenty years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The global surface air temperature increased by 0.74°C (0.56 to 0.92) from 1906 to 2005, which is higher than the level of 0.6°C(0.4 to 0.8) from1901 to 2000, according to the Third Assessment Report (Fig.2-1). The linear warming trend over the 50 years from 1956 to 2005 is nearly twice than that of the 100 years from 1906 to 2005.

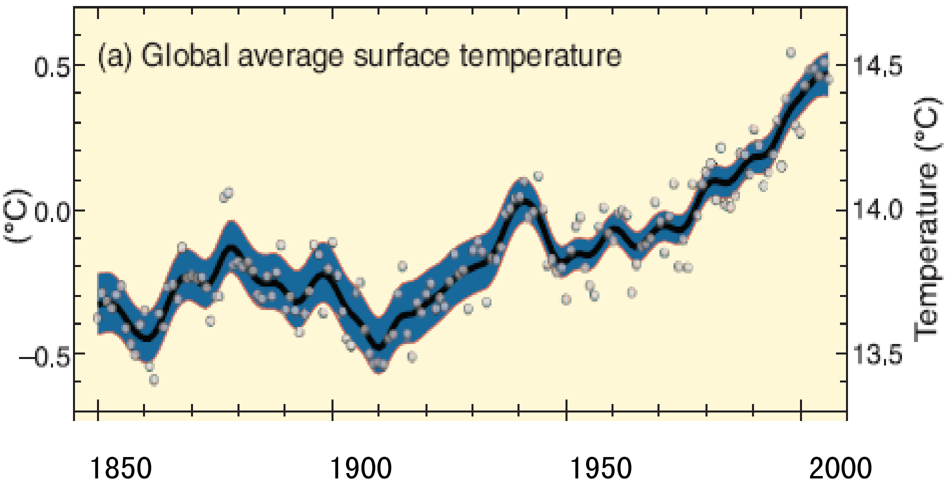


Fig. 2-1 Observed changes in (a) global average surface temperature

Note：All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties

Territory of China covers large latitude and longitude extension over East Asia. The highest plateau, Tibetan Plateau, stands towering in the west, and the Pacific Ocean bordered on the east. Therefore, characteristics of climate vary from region to region in China. However, climate change in regions shows similar trend and the trend is statistically significant only in temperature, the warming trend in China is in great accordance to that over the Northern Hemisphere or the globe (Fig.2-2). Instrumental observations of temperature during the 20th century showed a significant warming trend. The warming rate during the period of 1905～2001 is 0.81℃/100a according to maximum and minimum temperature records on the stations in China. and it is 0.58℃/100a for the period of 1880～2002 based on blending the observational data with proxy data in Western China. The latter is almost the same as the global warming rate. Two warm periods, which occurred in 1937-1948 and 1987-2001, respectively, are evident, with 1946 and 1998 as the warmest ones within the record period. It is forecasted that the warming trend in China will continue in the 21st century. Compared with the average during 1961 to 1990, the temperature will possibly increase1.3~2.1℃, 1.5~2.8℃, 2.3~3.3℃, 3.9~6.0℃ in 2020, 2030, 2050, 2100 respectively.

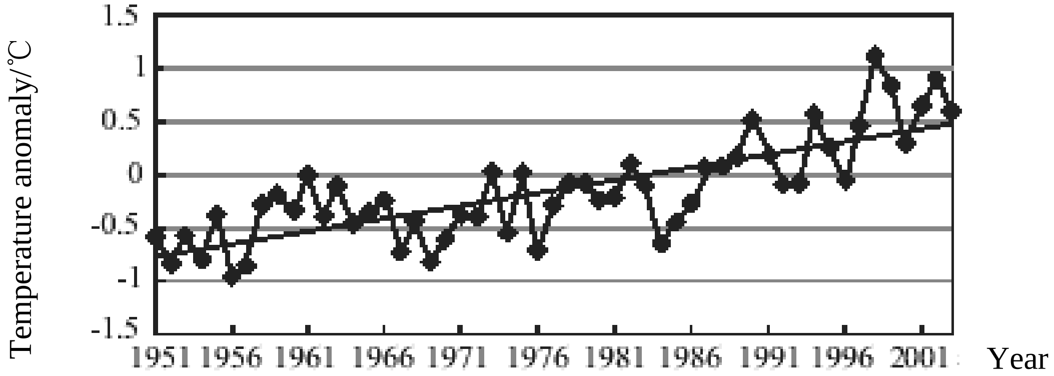


Fig.2-2 the average temperature of the earth's surface in China from 1951 to 2001

（Compared with the average temperature from1 1971 to 2000）

Section 1　Review of the impacts of climate change on human health

It is the core of climate change that climate is warming now. High temperature result from climate warming could cause the disorder of body's function. Many researches show that there are significant relationships between meteorological factors (especially temperature) and diseases. For example, high temperature results in the increasing mortality of the heat-related diseases, and there are more severe impacts on patients with cardio-cerebrovascular diseases or respiratory diseases with the increase of heat wave in intensity and duration.

At present, we have done some studies on the relationship between temperature and diseases, such as cardio-cerebrovascular diseases, respiratory diseases and mental diseases. However, it still needs to be further researched.

1 Impacts of temperature on total mortality

The effect of elevated temperature on mortality is a public health threat of considerable magnitude. Every year, a large number of hospitalizations and deaths occur in association with exposure to elevated ambient temperatures (Mackenbach JP et al.,1997; Faunt JD et al.,1995). Generally speaking, the graph of the relation of air temperature to total mortality shows shape of “U”, V” or “J”. There are seen the increase mortality following higher and lower temperature.

From 1998 to 2003, the Institution for Environmental Health and Related Product Safety, China CDC，carried out environmental surveillances in Nanjing, Guangzhou, and Harbin. Results show that there are great difference in daily maximum temperature and diurnal temperature range (Fig 2-3).

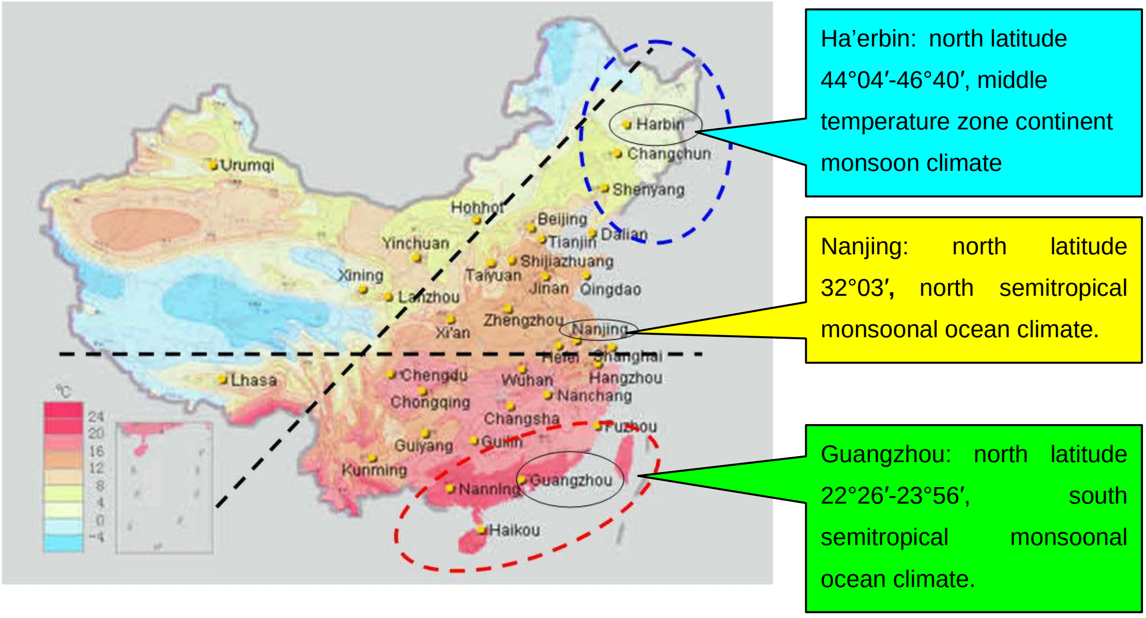


Fig. 2-3 Distribution of daily average temperature in China

The result indicates that the mean daily mortality show the U shape distribution (Fig.2-4). That is, in winter when daily average temperature decreased to some degree, mean daily mortality gradually increased with the decreasing of daily mean temperature. On the contrary, in summer when the daily average temperature rises to a certain extent, mean daily mortality obviously increased with the increasing of the daily mean temperature. But the critical temperature value of 3 cities at which mortality significantly increased was slightly different. The critical temperature value of Guangzhou was the highest among the three cities, and it was higher in Shanghai than that in Nanjing. Compared of U-map on both sides of the slope, we can see that mortality of Guangzhou was sensitive to lower temperature in winter, but mortality of Nanjing and Harbin was sensitive to higher temperature in summer, this might be the results of the residents' adaptation to local climate.

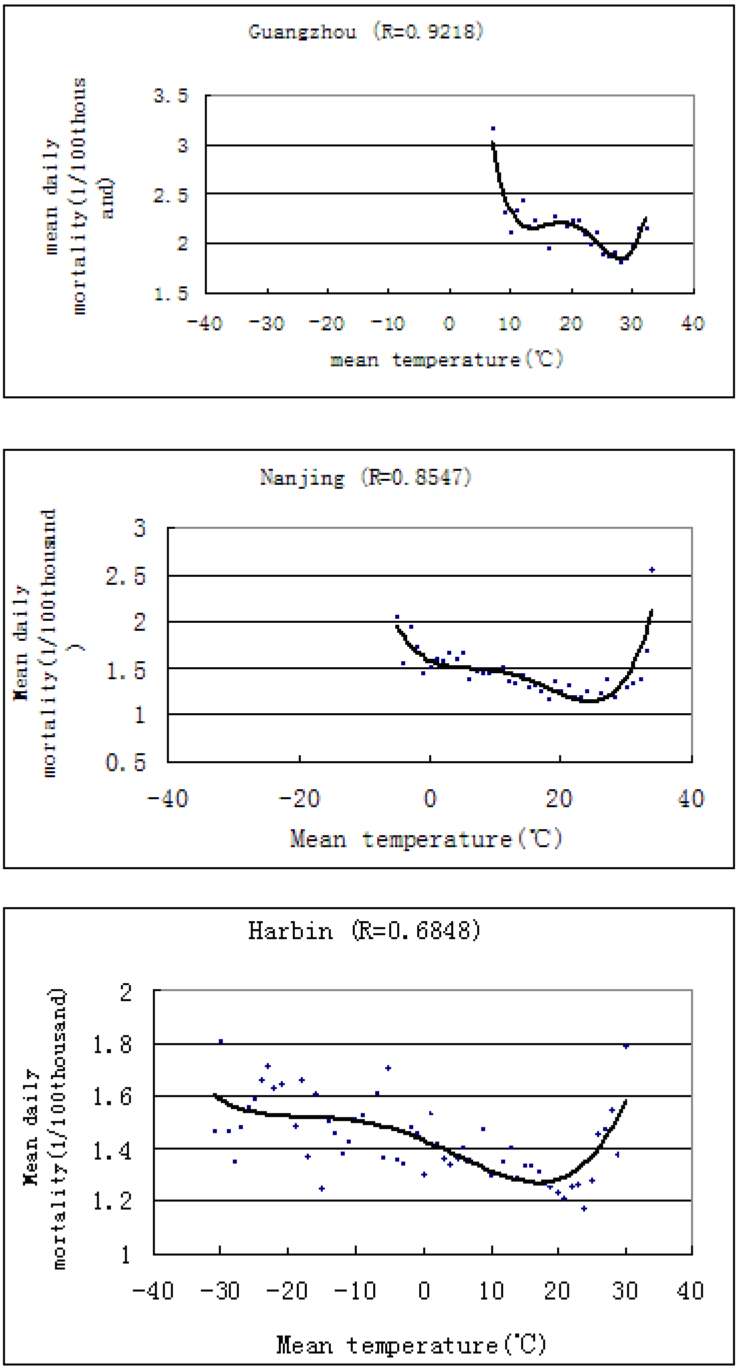


Fig.2-4 Relationship between daily average temperature and mean daily mortality in 3 cities from 1998 to 2003

Meanwhile we analyze the impacts of high temperature on total morality in summer (Fig.2-5), the result shows that the mean daily mortality significantly increases with the increase of the daily maximum temperature when the daily maximum temperature increased to a certain degree in summer. The critical temperature value at which mean daily mortality obviously increased was 31℃、35℃、30℃ in Guangzhou, Nanjing and Harbin respectively.

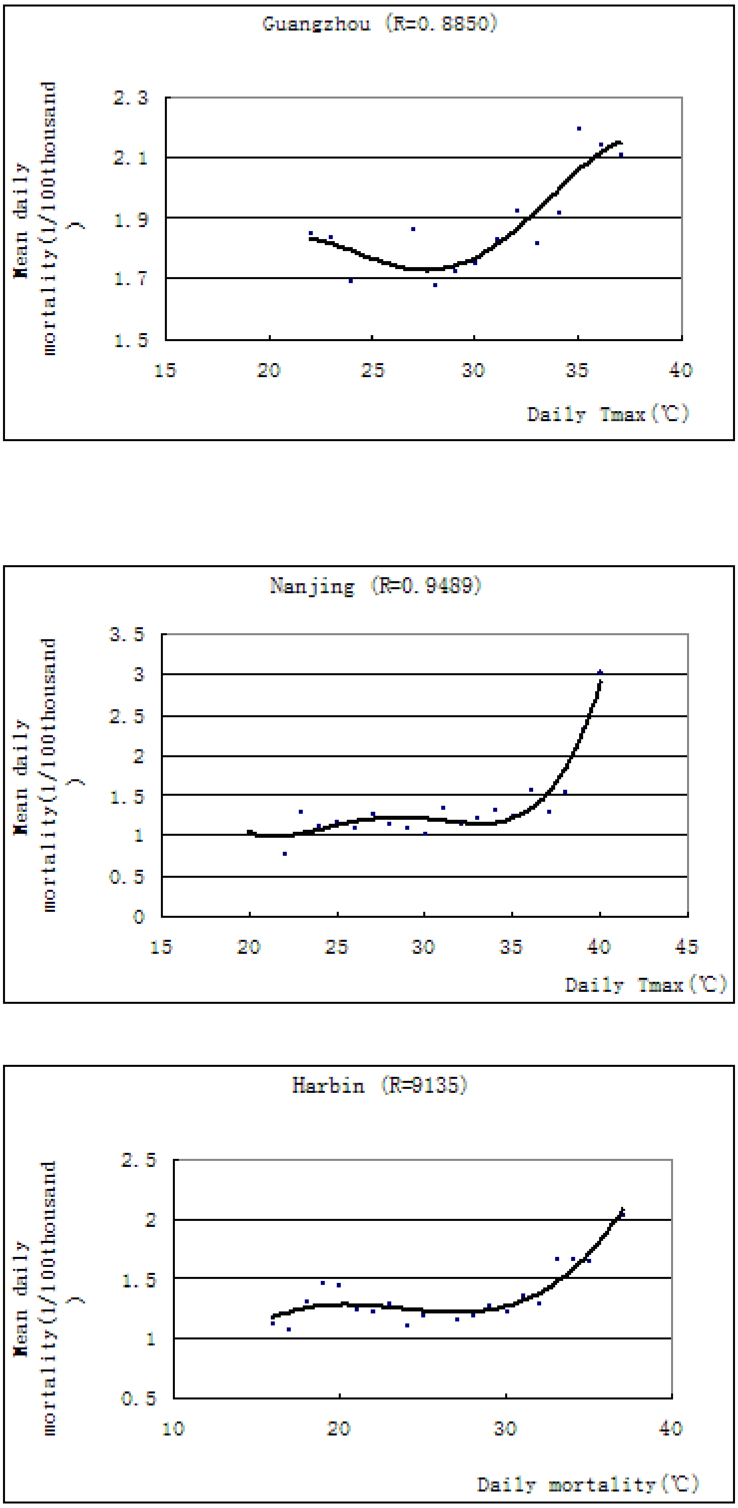


Fig.2-5 Relationship between daily maximum temperature and mean daily mortality in 3 cities in summer from 1998 to 2003

From 1980 to 1989, the study was done on the relationship between daily maximum temperature and total mortality in summer of Guangzhou, Shanghai (Wang et al.,1997), and the results showed that the mortality (number of death) significantly increased with the increase of the daily maximum temperature when temperature reached a certain degree (Fig.2-6). The critical temperature at which the mortality increased significantly was both 34℃in Guangzhou and Shanghai. And these values are close to the critical temperature of New York, Chicago and Detroit, about 32－33℃(Tan et al., 1994). This value will not have great change in various areas; therefore it has biological meanings to a certain extent.

To sum up, the relationship between temperature level and mortality outcomes has been well established. Typically, a U-shaped relationship between mortality risk and temperature level is observed with mortality risk decreasing from the lowest temperature to an inflection point and then increasing with higher temperature. Very hot and cold days appear to exert a cumulative effect upon mortality. The relationship may be different for areas with different weather patterns, latitudes, air pollution levels and prevalence of air-conditioning systems.

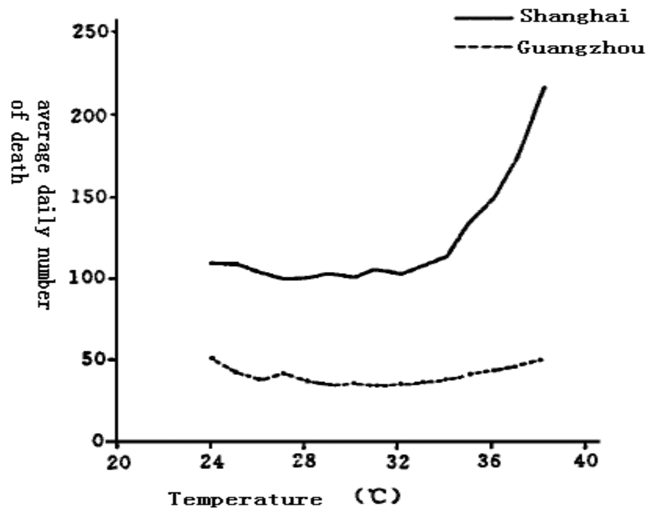


Fig.2-6 Relationship between average daily total mortality and daily maximum temperature in summer (1980－1989)in Guangzhou and Shanghai

Besides, some scientists in China have begun to explore other meteorological indicator associated with global climate change which may be related to a variety of health outcomes. For example, diurnal temperature range (DTR) which suggests within-day variation in temperature, defined as the difference between maximal and minimal temperatures within 1 day, may be a novel risk factor for death(Chen et al.,2007; Kan et al.,2007)

2 Impacts of temperature on cardio-cerebrovascular diseases

Cardio-cerebrovascular disease, which includes cardiovascular diseases (such as hypertension and coronary heart disease, etc.) and cerebrovascular diseases (such as storke, subarachnoid hemorrhage,etc.), is a kind of common disease jeopardizing the life and health. The total death caused by cardio-cerebrovascular diseases is ordered in the first position of the death in the cities of China. As we know, meteorological condition may trigger cardio-cerebrovascular disease onset and death. Many researchers found that: the graph of the relation of temperature to the incidence and mortality of cardi-cerebrovascular shows shape of “U”, V” or “J”. There are seen the increase incidence and mortality following higher and lower temperature. Take some main studies for example (Table 2-1).

Our study in Nanjing, Guangzhou, and Harbin found that when daily maximum temperature increased to a certain degree in summer, with increasing daily maximum temperature, average daily mortality of cardio-cerebrovascular diseases significantly increased. The critical temperature value at which daily mortality of cardio-cerebra vascular diseases significantly increased was 31 ℃ 、 33 ℃ 、 30 ℃ in Guangzhou ,Nanjing and Harbin respectively (Fig.2-7). Similarly, in the days of extreme low temperature in winter, the mortality of cardiovascular diseases was higher than that of ordinary times (Zhang et al., 1999). However, the impacts of temperature on different diseases are different. Taking stroke and acute coronary events for examples, their relationships with temperature are as follows.

Table 2-1 the typical research on temperature and cardio-cerebrovascular

Country(city)	Research Method (analysis technique ）	Result	Reference
Brzail （St. Paul）	descriptive epidemiology (principal component analysis）	The CVD curve was a U-shaped, showing higher mortality for cold or heat stress	Goncalves FLT et al., 2007
France	Longitudinal research (Poisson regression model）	With the temperature decreased, the incidence of acute coronary heart disease rate was gradually increased. A 10°C decrease was associated with a 13% increase of the incidence of acute coronary heart disease（P<0. 0001）	Danet S et al.,1999
Russia （Siberia）	Longitudinal research (Poisson regression model）	Compared to high temperature (≥7.3℃), low ambient temperature（≤-2℃）(RR=1.32 CI 1.05-1.66) was an important predictors of ischemic stroke occurrence, while mild ambient temperature(RR=1.52 CI 1.04-1.66) was an important predictors of intracecerbral hemorrhage.	Feigin V L et al.,2000
China （Taiwan）	descriptive epidemiology （Logistic regression model）	A U-shaped relation was observed between temperature and mortality from coronary artery disease and cerebral infarction. The range corresponding to least deaths from coronary artery disease (26-29℃) and cerebral infarction (27-29℃) was higher than that in countries with colder climates. In the elderly, the risk of cerebral infarction at 32℃ was 66% higher than that at 27-29℃; the risk increased by 3% per 1℃ reduction from 27-29℃. The risk of coronary artery disease at 32℃ was 22% higher than that at 26-29℃; below 26-29℃, the risk increased by 2.8% per 1℃ reduction. Mortality from cerebral hemorrhage decreased with increasing temperature at a rate of 3.3% per 1℃.	Pan et al.,1995
United States （107cities）	Case crossover design （conditional Logistic regression model）	In summer 1987， the average increase in cardiovascular deaths due to a 10°F increase in temperature was 4.7%. By summer 2000, the risk with higher temperature had disappeared (-0.4%). In contrast, an increase in temperature in fall, winter and spring was associated with a decrease in deaths, and this decrease remained constant over time. Heat-related cardiovascular deaths in the elderly have declined over time, probably due to increased use of air conditioning, while increased risks with cold-related temperature persist.	Barnett A G et al.,2007

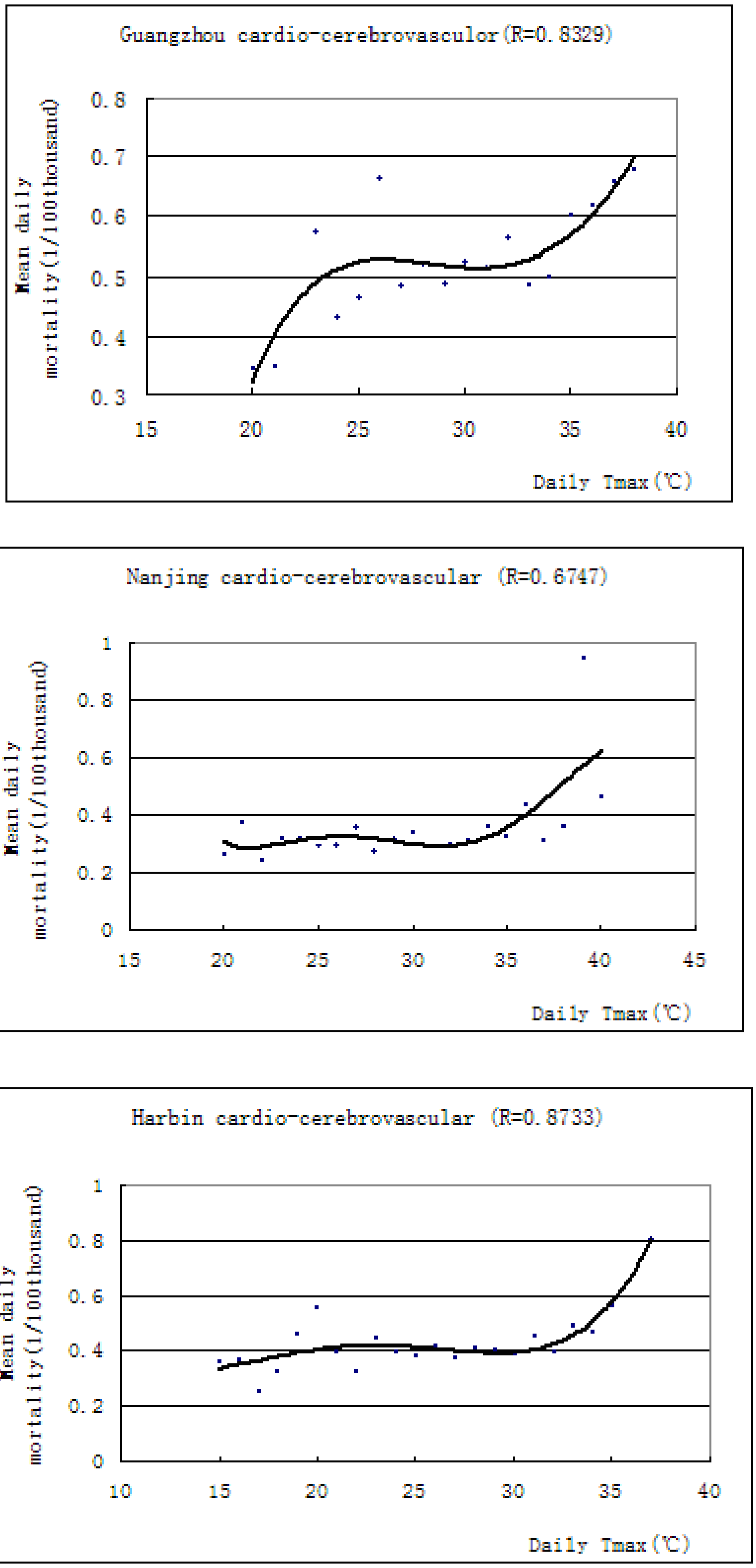


Fig.2-7 Relationship between daily maximum temperature and average daily mortality of cardio-cerebrovascular diseases in 3 cities in summer

2.1 Impacts of temperature on stroke

Research in Beijing indicates that the interaction between weekly mean temperature and stroke was related to the type of stroke. Age, gender and history of stroke in the past had different effects on the relationship between weekly mean temperature and stroke incidence. Cold is the risk factor to stroke incidence. The incidence of stroke is higher than the baseline when weekly mean temperature is lower than 8.5℃ and the incidence increased with the temperature decreasing(Fig 2-8);Cold is more likely to effects the female with first-episode stroke, as well as the people older than 65-year-old. However, the female who suffered the stroke before and those less than 65-year-old are more likely sensitive to heat. Cold is dangers to both hemorrhagic and ischemic stroke while heat only affect ischemic stroke (Liu et al., 2004) (Fig. 2-9).

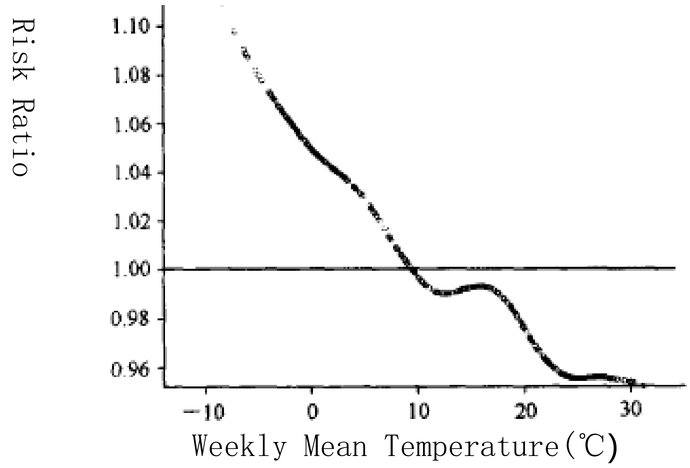


Fig.2-8 Weekly Mean Temperature and the incidence of stroke

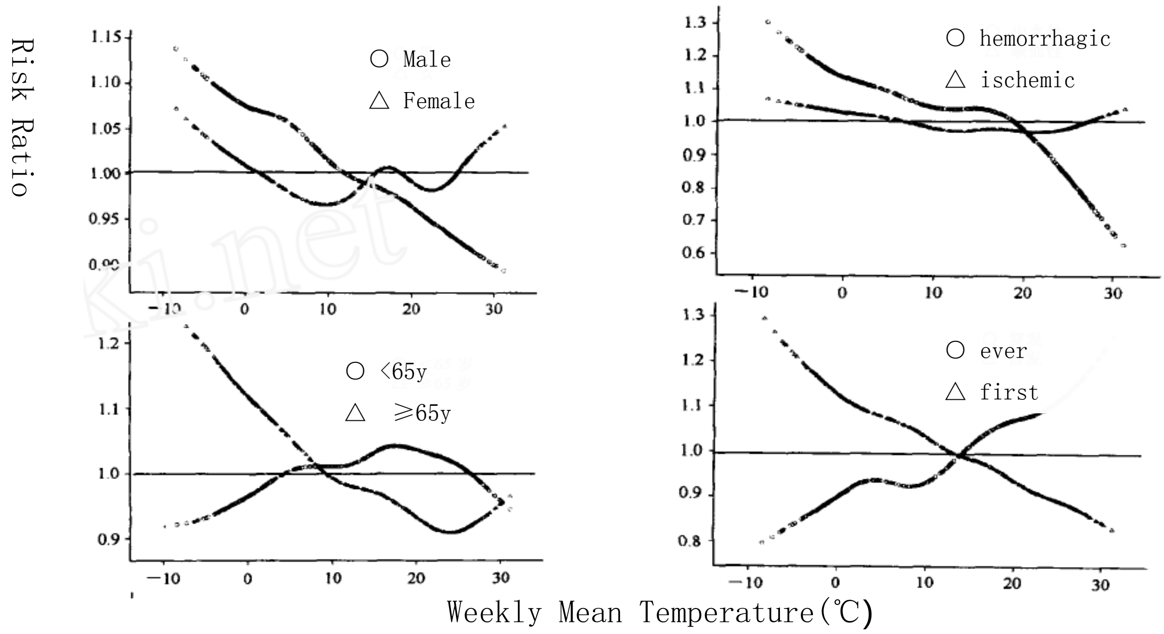
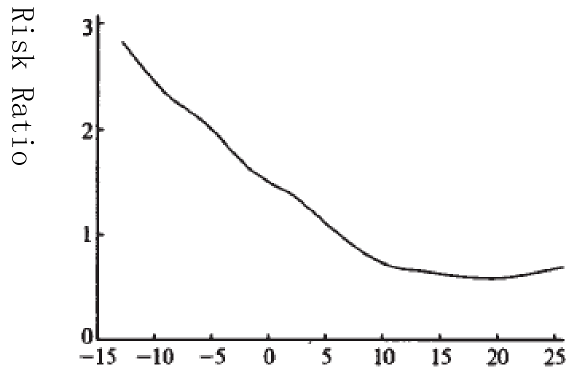


Fig.2-9 Weekly Mean Temperature and the incidence of stroke by gender, age, type of stroke, first-episode and recurrence.

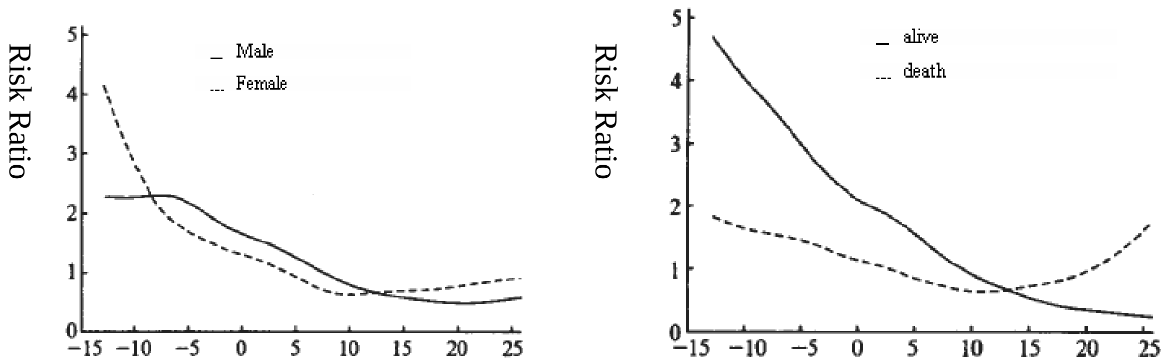
2.2 Impacts of temperature on acute coronary events

Study by Liu Fang et al showed that low temperature easily induced the acute coronary events in those populations who are male, above 65 years old or have incidence history of acute coronary events. The incidence rate of acute coronary events is higher than the baseline when weekly mean of lowest temperature is lower than 6℃, and the incidence was increased with the decreasing of weekly mean of lowest temperature(Fig. 2-10) (Liu et al.,2005). The relationship of weekly mean of lowest temperature and the incidence of acute coronary events are similar for different sub-population, but relative risk and dangerous temperature range are different (Fig.2-11).



Weekly Mean of Lowest

Fig.2-10 Weekly Mean of Lowest Temperature and the incidence of acute coronary



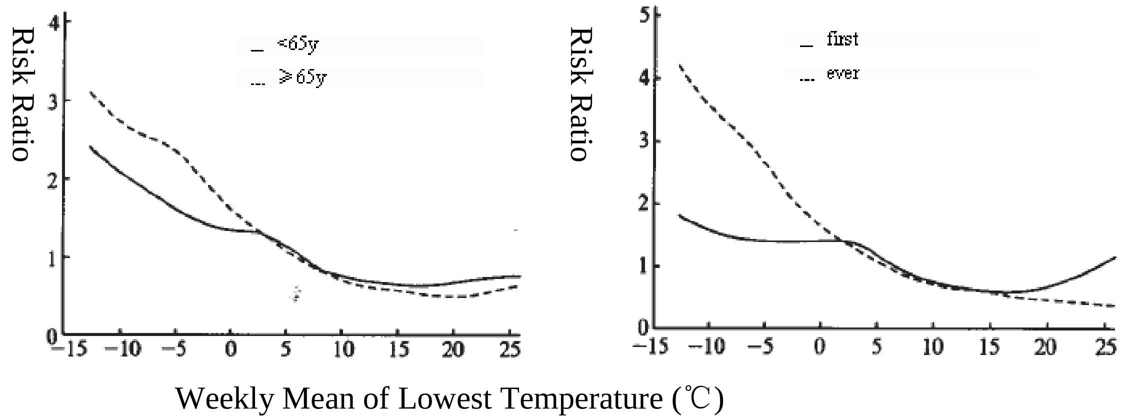


Fig.2-11 Weekly Mean of Lowest Temperature and the incidence of acute coronary events by gender, age, outcome, first-episode and recurrence

In addition, Shan Yichang et al found that there was significant correlation between daily temperature changes and the incidence of cardio-cerebrovascular diseases. The correlation coefficients with heart disease, cerebrovascular diseases and hypertension were 0.7566, 0.7901 and 0.6903($P<0.05$), respectively (Shan et al., 2002); Chen et al declared that DTR is a new risk factor for acute stroke death independent of the corresponding temperature level and he suggested that the association between DTR and stroke mortality was reasonably robust and probably not due to methodological bias or confounders (Chen et al., 2007). Kan Haidong et al used a semi-parametric generalized additive model (GAM) to assess the acute effect of DTR on mortality after controlling for covariates including time trend, day of the week (DOW), temperature, humidity, and outdoor air pollution; they found a strong association between DTR and daily mortality after adjustment for those potential confounders. A 1℃ increment of the 3-day moving average of DTR corresponded to a 1.86% (95% CI 1.40－2.32%) increase in cardiovascular mortality and mortality. The effects of DTR on cardiovascular mortality were significant on both ‘cold’ (below 23℃) and ‘warm’ (at least 23℃) days, an increase of 1℃ DTR corresponded to 1.76% (95% CI 1.23－2.28%) and 1.91% (95% CI 0.83－2.98%) increases in cardiovascular mortality(Kan et al.,2007).

3 Impacts of temperature on respiratory diseases

A study showed that mean air temperature had more significantly positive correlative with the morbidity of upper respiratory tract infection (Lu et al., 2003). Analysis was done on the relationship between the maximum temperatures and the total mortality of respiratory diseases in summer of Guangzhou, Shanghai and Nanjing. The results showed that mortality of diseases significantly increased with the increase of daily maximum temperature, when daily maximum temperature increased to a certain extent. In Guangzhou, Shanghai (Wang et al., 1997) and Nanjing, the critical temperature at which the mortality increased significantly was respectively 36℃、35℃、33℃ (shown in fig.2-12, 2-13, 2-14). It is consistent with our study in Nanjing, Guangzhou, and Harbin.

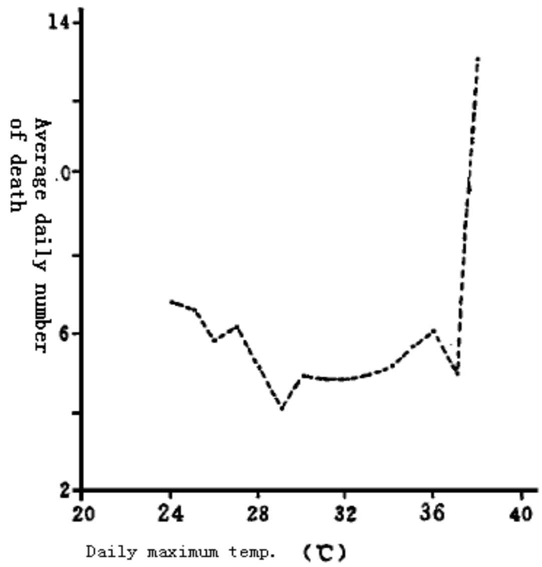


Fig.2-12 Relationship of average daily mortality of respiratory diseases and daily maximum temperature in summer in Guangzhou

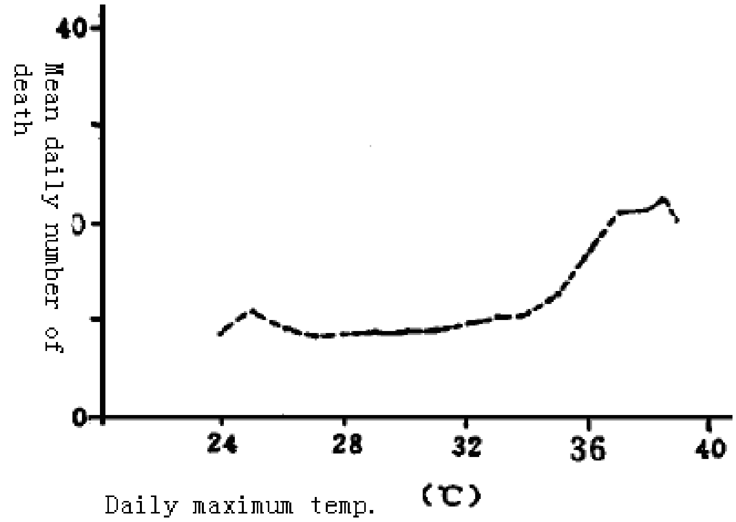


Fig.2-13 Relationship of average daily mortality of respiratory diseases and daily maximum temperature in summer in Shanghai

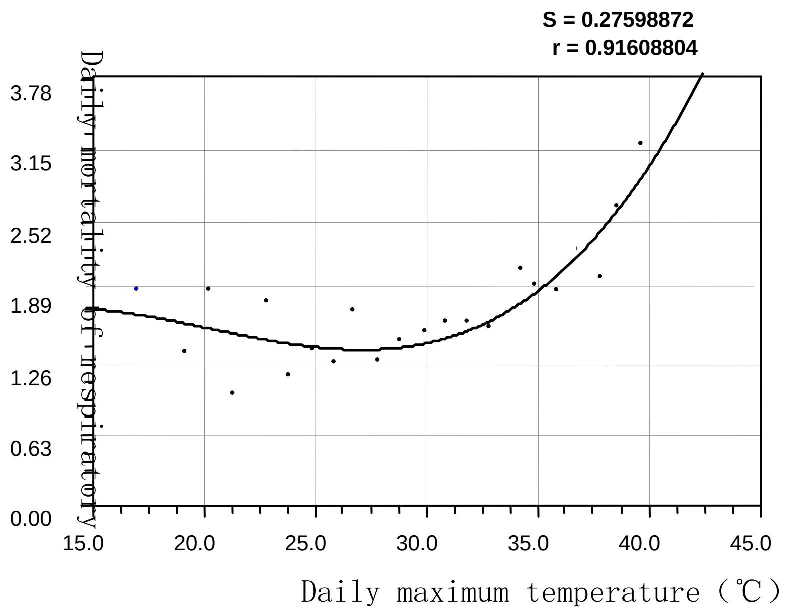


Fig.2-14 Relationship of mortality of respiratory diseases and daily maximum temperature in summer (1994—2003) in Nanjing

Research by Li Zhibin et al established the regression equation which suggested the relationship between meteorological factors and various respiratory diseases (table 2-2), and found that there are close relationships between upper respiratory tract infection and average temperature, chronic bronchitis and lowest temperature, pulmonary heart disease and lowest temperature, bronchial asthma and average humidity/average temperature ratio, and spontaneous pneumothorax and average humidity/average temperature ratio(Li et al.,1994). In addition, one study carried by Zheng Yang showed that there was a negative relationship between the rising of air temperature and the incidence of a disease of pediatric respiratory tract in Beijing, (r_s= - 0.530, $p < 0.01$) (Zheng et al.,1999). Shan Yichang et al analyzed the cases data for ten years in Weifang and found that there are good correlation between daily temperature range and respiration diseases（r=0.8633）, the number of inpatients with respiration diseases increased with daily temperature range increasing(Shan et al.,2002).

Table 2-2 the relationship between meteorological factors and various respiratory diseases

disease	regression equation	multiple correlation coefficient	partial correlation coefficient	residual error	variance ratio	regression variance significance test
upper respiratory tract infection	$y=0.7710373-0.102455x_1+3.2435\times10\text{-}3x_1^2$	0.33598	0.18092	0.5391	22.4594	F=13.320 P<0.01
chronic bronchitis	$y=1.3897-0.1667813x_3+5.050534\times10\text{-}3x_3^2$	0.24156	0.21336	0.8216	10.937	F=8.986 P<0.01
corpulmonale	$y=2.353261-0.2509448x_3+6.69801\times10\text{-}3x_3^2$	0.23185	0.22637	1.2561	10.027	F=12.595 P<0.01
episode of bronchial asthma	$y=-0.3528557+0.1760956\ x_2/x_1$	0.1954	0.1951	1.9972	14.053	F=28.066 P<0.01
spontaneous pneumothorax	$y=-0.533275+0.2260038\ x_2/x_1$	0.1811	0.1811	3.8528	11.999	F=46.230 P<0.01

x_1： average temperature, x_2: average humidity, x_3: lowest temperature

4 Impacts of temperature on other diseases

4.1 The impacts of temperature on mental diseases

Climate change has not only an impact on physiological function but also on one's mood, then change the mental status. Because climate change can indirectly affects the function of the thermoregulation centrum of hypothalamus, mood and gonad regulating centrum, this can result in schizophrenia.

The studies indicated that the occurrence of schizophrenia was linked with seasons, air temperature, air pressure, relative humidity and mean hours of sunshine (Gao et al.,2003). Annual temperature change was consistent with mental disease morbidity. Every year from the end of summer to winter, morbidity of diseases decreased with reducing temperature, it was proved by the studies in Wuhan, Chongqing and Guangxi.

The single factor statistical results of the impacts of meteorology factors on mental diseases showed that great daily temperature range can cause the increase of incidence of mental diseases. Multi-factors results (Chen et al.,1999) showed that daily temperature range and average sunshine time had closely correlation with schizophrenia. Regression equation was as below: $Y = 14.0236\ X_1 - 6.9984\ X_2 - 6.8390$ (X_1-temperature daily range, X_2-average sunshine hours, Y-incidence). It will be further research.

4.2 The impacts of temperature on mortality of injury and toxicosis

Study in Guangzhou, Nanjing and Harbin found that when the daily maximum temperature increased at a certain degree in summer, average daily mortality of injury and toxicosis significantly increased with increasing daily maximum temperature. The critical temperature at which daily mortality of injury and toxicosis significantly increased was respectively 34℃、35℃、30℃ in Guangzhou, Nanjing and Harbin(Fig. 2-15).

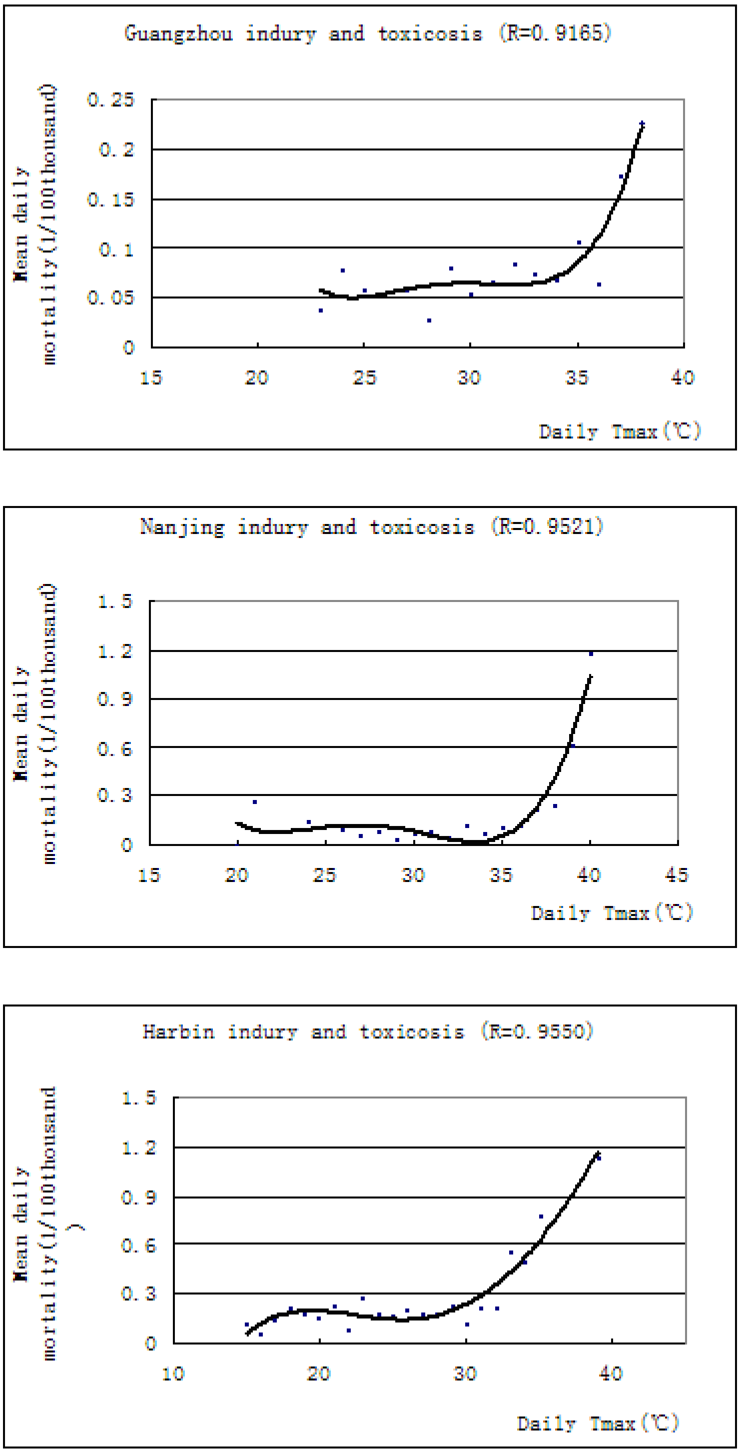


Fig.2-15 Relationship between daily maximum temperature and average daily mortality of injury and toxicosis in summer in 3 cities

4.3 The impacts of temperature on mortality of tumor

Study in Guangzhou, Nanjing and Harbin suggested that the impacts of air temperature on the mortality of tumor were different in 3 cities (Fig.2-16). With increasing daily maximum temperature, mortality of tumor first increased then decreased in Guangzhou, while it shows no significant change in Nanjing. But in Harbin mortality of tumor shows a decreasing trend with the increasing of daily maximum temperature. These need to be further researched.

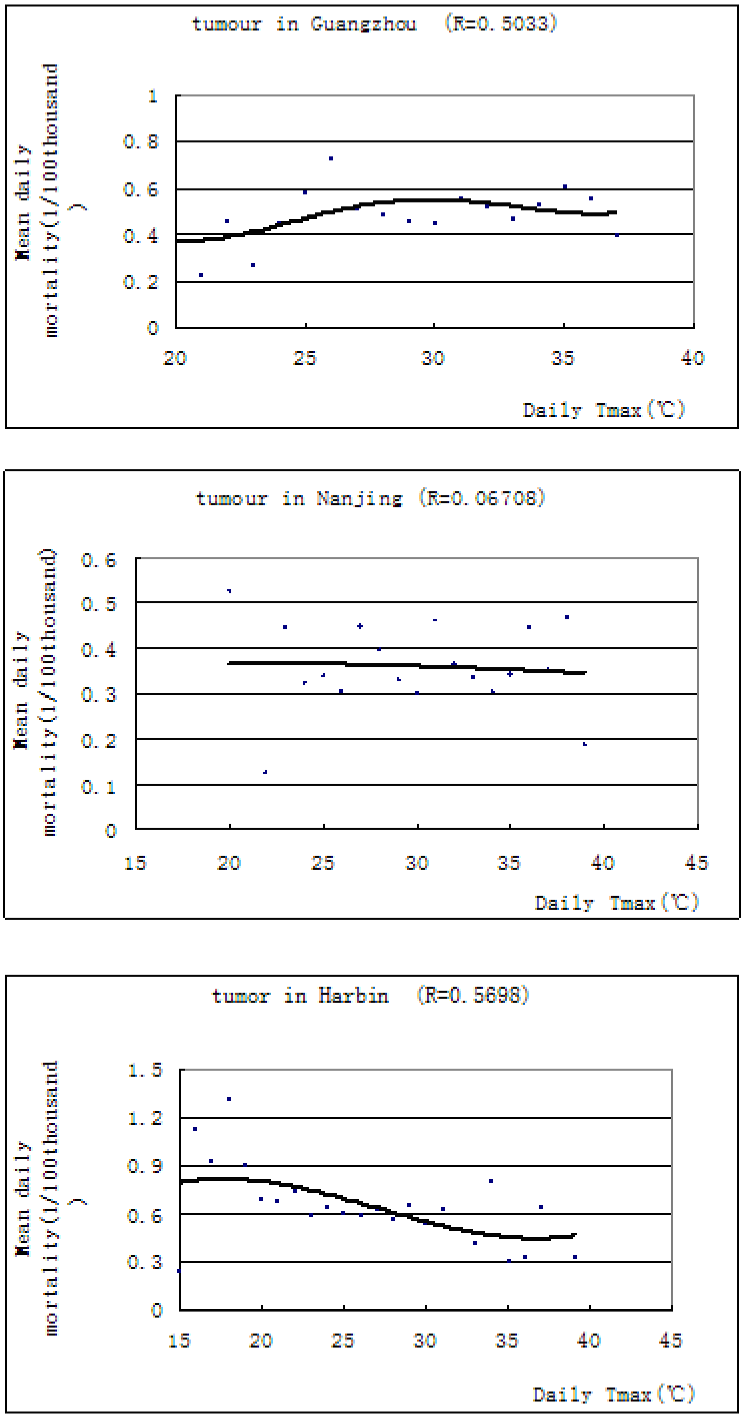


Fig.2-16 Relationship between daily maximum temperature and average daily mortality of tumor in 3 cities in summer

4.4 Status of human population health

Climate warming causes the extreme hot weather, high temperature and high humidity causes the disorder of body's function. So，heatstroke more and more severe threatens the human health. In 2003, 900 subjects were random sample selected in Guangzhou, Nanjing and Ha'erbin, 300 subjects in each city. The questionnaire survey was carried out, in order to learn the status of residents' health in the summer. The result showed that the occurrence of stroke was mostly consecutive high temperature days in July and August. the occurrence rate of stroke in Nanjing was highest (4.7%). High temperature in summer can result in the occurrence of subclinical symptoms besides stroke, for instants, fatigue, aggravated diseases, and disturbed sleep and so on.

5 Heatwaves and health

Many studies on heatwaves have been carried out in the world, but so far there is no standard international definition of heatwaves. China Meteorological Bureau suggests heat warning should be promulgated when the daily maximum temperature is above 35℃(Tan et al.,2004).

Global climate warming is likely to be accompanied by an increase in the frequency and intensity of heatwaves, as well as hot days in summer. The impact of extreme heat in summer on human health may be exacerbated by increases in humidity. The direct impacts of heatwaves on human health are the increasing of morbidity and mortality. Besides, high temperature can make germina, bacteria, parasites and allergen more active as well as damage people's spirit, immunity and resistance. There are more than 100 thousand people died due to heatwaves all over the world every year. In the recent several decades, China have suffered consecutively from hot summers in 1988, 1990,1994,1998,1999,2002 and 2004. Some reports indicated that heat waves could bring thousands of excessive deaths every year. For example, in

1988, 1488 deaths were ascribed to heat waves in Nanjing and Wuhan (Mao et al.,1989). In 1998 Shanghai suffered from the most severe heatwaves in the recent several decades, and the death toll during heatwave were 2 to 3 times of those during not heatwaves, especially, the mortality of the elderly aged 65 or more increased even higher. Heatwaves do great harm to infants, too. Besides the direct effects such as heat stroke and death, heatwaves can result in cardiovascular, cerebrovascular and respiratory diseases. It is reported that the mortality and incidence of heart diseases and hypertension will increase with the climate warming.

Take Nanjing for example (Located in the lower reaches of Yangtze River; Nanjing is one of the three furnaces cities in China with sweltering and wet weathers in summer. It belongs to the typical inland upland climate and often suffers from heat waves). Study by Jin Yinlong et al in Nanjing found that in the year with more hot days, standardized mortality was relatively higher and the correlation coefficient was 0.832 (Fig.2-17).

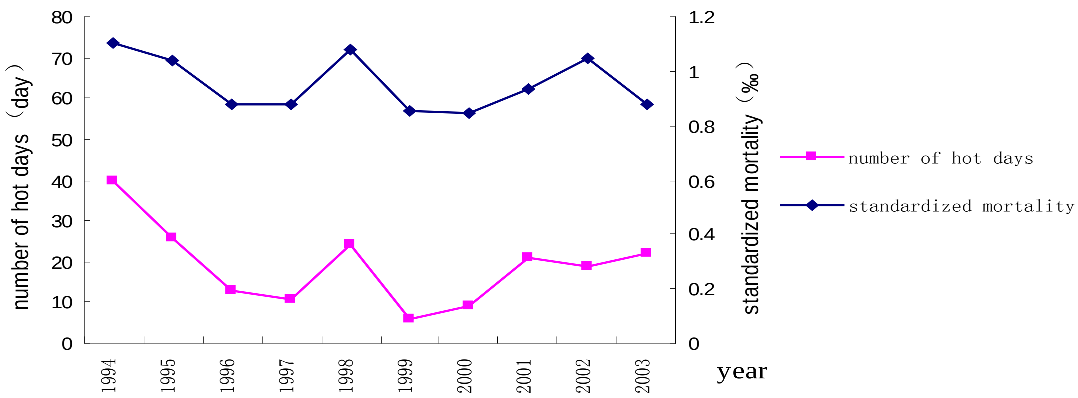


Fig. 2-17 Relationship between numbers of hot day and the standardized mortality in every summer form 1998 to 2003

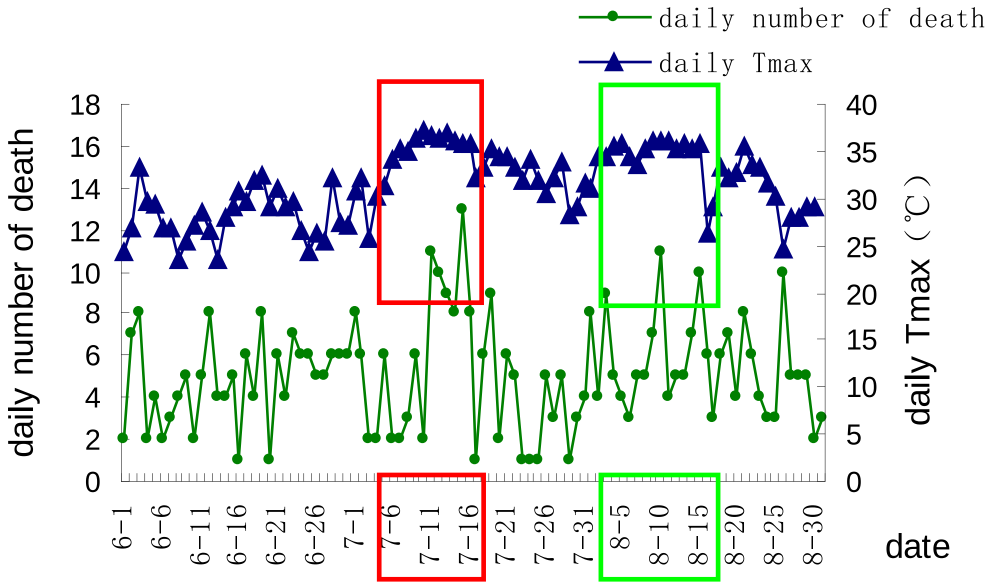


Fig. 2-18 Relationship between daily maximum temperature and daily number of death in 1998

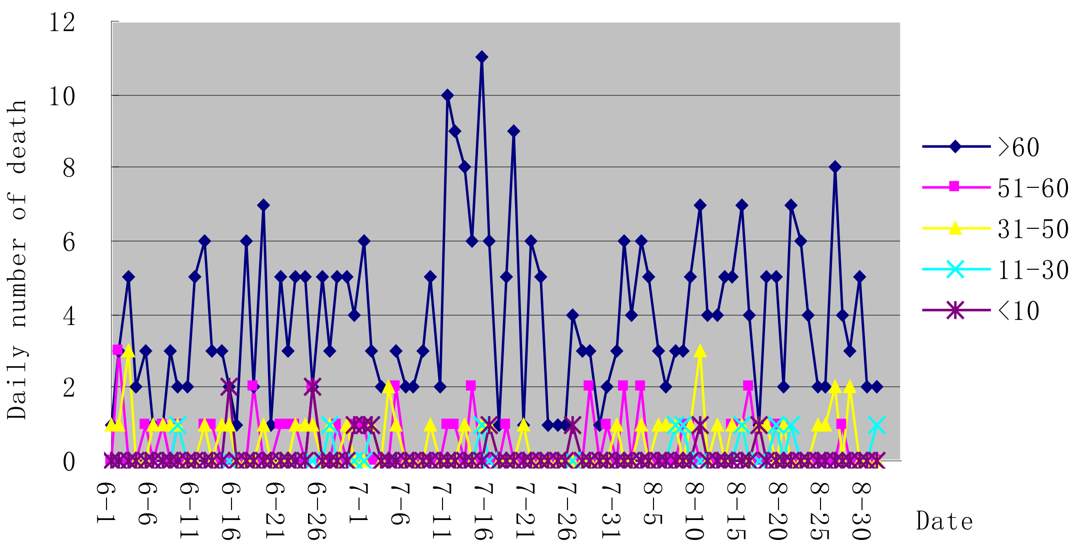


Fig. 2-19 Relationship between daily maximum temperature and daily number of death by age in 1998

In the 10 years from 1994 to 2003, the ratio of average daily excess deaths in hot days to those in not hot days was 1.17, and the excess deaths in summer accounted for 2.5% of all the summer deaths of 10 years. In 1998, the excess deaths accounted for

11.3% of total number of deaths in the whole summer. There are two death peaks from July 6 to 16 and from August 4 to 15, with the first death peak greatly higher than the second. And in correspondence with this, Nanjing was also suffering from heat waves. From July 6 to 16 and from August 4 to 15, the average daily maximum temperature respectively was 35.5℃ and 35.2℃ with the highest temperature respectively being up to 37.2℃ and 36℃(Fig. 2-18), and the mortality for people aged 60 or more was much higher than that of others. For people aged 60 or more, the mortality variation was similar to those above, and two peaks of mortality（$p<0.05$） were observed, but those of other ages were not(Fig. 2-19). It may indicate that the elderly aged 60 or more were more sensitive to heat waves.

6 Cold waves and health

According to the regulation of Central Meteorological Station, due to the invasion of cold air, one cold wave is that the average temperature decrease by 10℃within 24 hours(or 12℃within 48 hours),and the daily lowest temperature decrease below 5℃ in one place.

Over the last decade, the temperature of China showed the obvious increase trend especially in winter (Ding et al.,2004). Under this background, many researches found that the frequency and intensity of cold waves in China also show the obvious change. The statistical analysis indicated that the frequency of various cold waves showed decrease trend and their intensity weaken in some extent(Liu et al.,1990; Bai et al.,1993; Lin et al.,1998; Yao et al.,2000;Wang et al.,2000; Ding et al.,2001). Wang Zunya et al, based on the 740 stations daily surface temperature data in China from 1951 to 2004, found that there are totally 371 regional and countrywide cold waves(that is 7 times per year on the average), and 104 countryside cold waves(that is about 2 times per year on the average) in recent 53 years. From figure 2-20, we can see that the annual variation characteristic, and the standard deviation of the total times of cold waves, the countryside clod waves were 2.46 and 1.36 respectively. Further, the decadal change was also significant. As to the total cold waves, there are relatively more cold waves in the1950s and 1960s, after 1970s interim, the cold waves become less in the 1980s and 1990s. In the 1950s it reaches the peak and in the 1980's it touches the bottom; however, the times of countryside cold waves reduce gradually from the 1950s to 1990s. Since the 1990s, the decreased trend becomes mild. On the long-term changes, both the total cold waves and the countryside cold waves showed obvious decrease trend in recent 53 years (Wang et al.,2006).

When the cold waves come and temperature decreases sharply in winter, body has not established the protective mechanism adapting to the cold stress and apt to be infected by bacteria, virus and other pathogenic microorganism. The incidence of respiratory diseases such as influenza, pertussis, measles, epidemic meningitis and scarlet fever will go up rapidly. Moreover, cold waves are also extremely harmful to some chronic diseases like cardiovascular diseases, nephrosis, canker, asthma, tracheitis and emphysema. It could cause the recurrence of disease, the aggravation of symptom and even jeopardize the life of patients. Unfortunately, the epidemiological researches about the impact of cold waves on health in China have not been found.

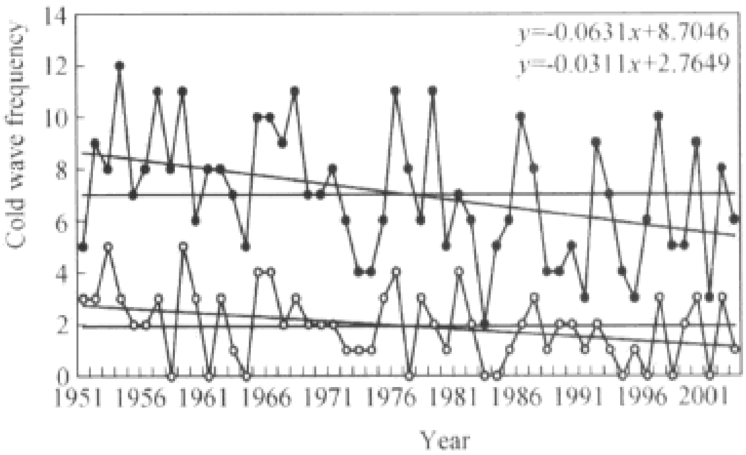


Fig.2-20 Time series of the frequency of the regional and countrywide cold waves (top) and the frequency of the countrywide cold waves(bottom) and their linear trends from 1951 to 2003

Section 2 Current gaps in knowledge and research needs for China

In China, the research status for temperature related health impacts is briefly summarized as follow (Fig. 2-21).we explore the current gaps in knowledge and research needs through analyzing it.

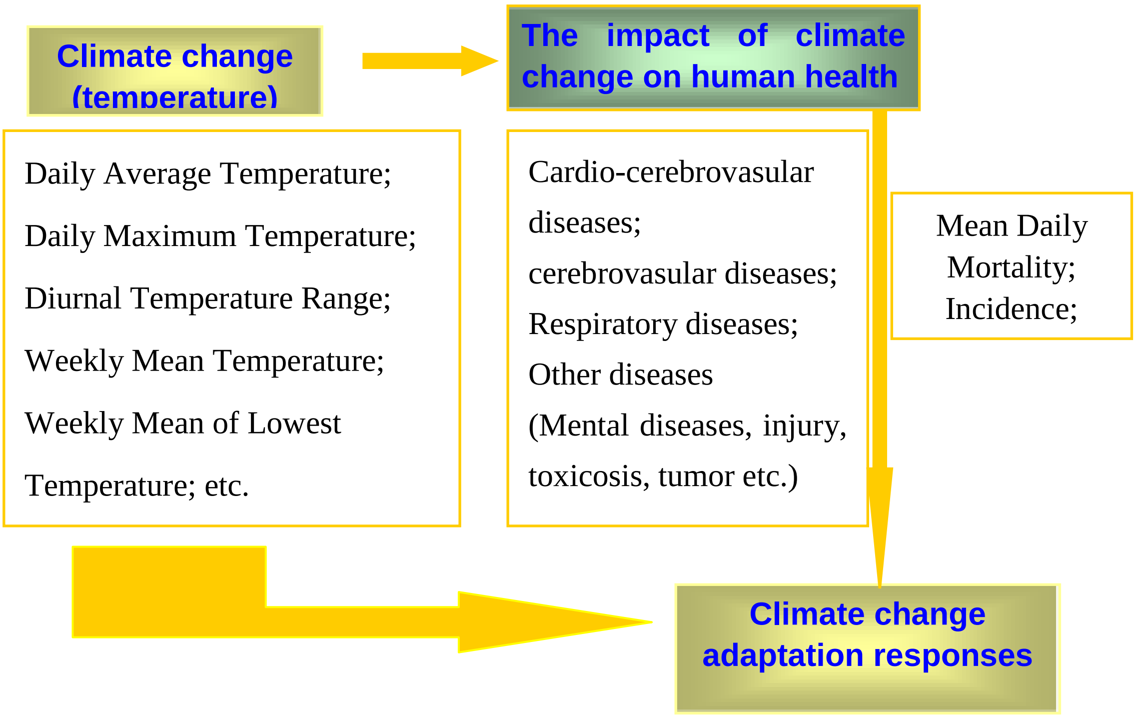


Fig. 2-20 Research status for temperature related health impacts in China

1 The current gaps in the research of temperature and health

1.1 On research contents:

(1) Most literatures focus on investigating the relationship between temperature and diseases. There are few literatures discussed on how to adapt to climate change and protect human health.

(2) Single indexes for health outcome (many studies used the mortality, and few studies used incidence) to describe the relationship between temperature and diseases.

(3) Most studies focus on impacts of single meteorological factor on health. The comprehensive impacts of various meteorological factors on health are rarely

considered.

1.2 On research method:

(1). Simply using linear correlation and regression to observe the relationship between temperature and diseases.

(2). Most researches are descriptive study, and then weakened the capacity of etiological inferences.

2 The current gaps in the research of high temperature and heat waves (Liu et al.,2008)

(1) The influence mechanisms of high temperature and heat waves on human health are very complex. Now there exist many uncertainties in the mechanism researches.

(2) Although there are some researches in the influence of high temperature and heat waves on the hysteretic nature of excess deaths, it is limited to qualitative researches and don't identify quantitatively the corresponding relation between death and lagging days.

(3) Among the methods considering the various influencing factors, some scholars made some researches about the components of atmosphere. However, when studying the health impacts, they only took the average concentrations of atmosphere components into account, and the change of atmosphere components and concentrations due to temperature change didn't been considered. Especially, there are no researches about the health impacts of the new components produced by interaction of the components in atmosphere due to increased temperatures.

(4) Because of the body adaptation, the influences of heat waves happened in the different periods on health are not equivalent. Generally, the heat waves happened in the early summer have more severe impacts than the heat waves happened in the late

summer. However, now the empirical relationships between excess mortality and high temperature are mostly reflected by the average status, which always caused the forecasting results went to the opposite.

(5) At present, the established early warning systems of high temperature and heat waves generally forecast the potential mortality when the high temperature happens. Nevertheless, high temperature could also cause occurrence of diseases, the forecasting system didn't take it into account. as well as the different levels of high temperature and the influence on the different diseases.

3 Current gaps in the research about the impact of cold waves on health

At present, the researches about the impact of cold waves on health are still at the beginning period, it is obviously insufficient and most researches are qualitative, so there is lack of systemically epidemiologic studies.

Section 3 Adaptive strategies and suggestions

People address climate-related extremes by using a series of physical and social adaptation measures. Seasonal changes in our clothing and lifestyles, the design of our buildings and other structures, and the behavioral, social and economic adaptations have allowed us to remain generally healthy and comfortable except under the most extreme weather and climate conditions. Nevertheless, future climate changes will force people to deal with conditions beyond the range of historical experience. The adaptation strategies and measures related to the temperature change are very limited, and the main measures are as follows:

1 Establishment of early warning and forecast system

1.1 Heat and cold early warning system

In China, according to the change of temperature, the government release three-level early warning signals include yellow signal, orange signal and red signal. Their implications are as follows：

	Early warning signal	Implication
Heat warning	Yellow signal	The maximum temperatures will approach or reach 35℃ or have reached above 35℃ within 24 hours.
	Orange signal	The maximum temperatures will increase above 37℃within 24 hours.
	Red signal	The maximum temperatures will increase above 39℃within 24 hours.
Cold warning	Yellow signal	The local temperature decrease rapidly by 10℃within 24 hours, or the daily average temperature maintain below 12℃.
	Orange signal	The local lowest temperature will decrease below 5℃.
	Red signal	The local lowest temperature will decrease below 0℃.

The system forewarns the different weather only from the perspective of air temperature and didn't take other meteorological factors and their influences on human health into account. The guiding significances for protecting human health to adapt to climate change is very limited.

1.2 The early-warning and forecasting system of heat wave

Many cities all over the world release the high temperature or heat wave alarm. Supported by WMO/ WHO, Shanghai meteorological bureau and Health department cooperated with Delaware University of America developed a health monitoring and early-warning systems of heat wave in Shanghai. The application of the system showed a relatively satisfied result.

Once the early warning of heat waves was released, people could effectively reduce the potential impacts of heat waves by adopting various adaptive measures. The public could receive timely alarm by media such as broadcasting stations, television stations and newspapers and other media; the public health department and media should enhance the publicity and education of the knowledge related to the heat waves especially for the risk population who are apt to affect by heat waves on how to defend against heat waves and protect people’s health; the hospital and community service sections should make sufficient preparations; the departments of power supply and water supply should ensure the supply of electricity and water during the alarm period of heat waves; the residents should prevent sunstroke by turning on the air-conditionings, staying under the cool environments, arrange their activities in the coolest time of one day. Slow down the pace of work, reducing or canceling violent activities, and so on.

2 Developing the related policy

2.1< The United Nations Framework Convention on Climate Change> and <Kyoto Protocol>

the Government of China has actively participate in the process of addressing climate change of International Community and fulfilled the obligations of the < United Nations Framework Convention on Climate Change> and the <Kyoto Protocol>, so play an active role in international cooperation.

2.2 <China National Climate Change Programme>and <China's Policies and Actions on Climate Change>

On May 30, 2007, the Premier of State Council, Wen Jiabao presided over executive meetings, the meetings considered and decided on the promulgation of the <China National Climate Change Programme>. On October 29, 2008, the Chinese Government promulgated the <White Paper: China's Policies and Actions on Climate Change>, which comprehensively introduce the policies and efforts of China response to climate change, as well as the progresses and results of implementation of the<China National Climate Change Programme>. It will have important guiding significance on response to climate change.

2.3 <China National Environment and Health Action Plan>（2007-2015）

Recent years, to adapt to climate change and promote the national work about environment and health, Ministry of Health together with other 17 Ministries have signed < China National Environment and Health Action Plan> and put the priority to the impact of climate change on health. In the < China National Environment and Health Action Plan> ,it pointed out: To study the human health effects of climate changes in urban and rural areas in our country, especially the effects on various provincial and regional incidence of diseases which are sensitive to climate changes, to exploit and establish pre-warming systems of climate changes and health, emergency responding plans and related methods and techniques, to assess the effectiveness of the pre-warning systems and other intervention measures.

2.4 Other related policy

To further implement the Scientific Outlook On Development and further carry out "The State Council’s decision on strengthening the energy saving tasks" (The State Council issued [2006] No.28), and to promote the use of air-conditioning scientifically, so that the use of energy resources could be economically, the emissions of greenhouse gas could be reduced and eventually the environment could be protect effectively. The General Office of the State Council issued a notice about some related problems on the strict implementation of the temperature controlling standards of public buildings’ air-conditioning, the notice inform that, all units in public buildings, including the state organs, social organizations, enterprises, and individual industrial and commercial households (some special units, such as hospitals, and some approved users thanks to the specific requirements on temperature in the production process, are excepted), the indoor air-conditioning’s temperature settings is not lower than 26 Centigrade in summer and not higher than 20 Centigrade in winter.

3 Develop health education and improve the public awareness

Recent years, Chinese government have been strengthening education and propagation of the impacts of climate change on ecosystems and human health, adding the contents about climate change in the teaching, and through various media, strengthening the publicity, education and training on the globe climate change, encouraging public participation to enhance the public awareness of protecting the global environment and climate, guiding people to establish a life style and consumption mode which is helpful for reducing greenhouse gases emissions and to learn about the direct and indirect effects of climate change on human health, to promote social and economic development.

4 Suggestions on future possible climate change adaptations in China

4.1 Using scientific research methods and developing researches on the impact of climate change on thermal stress

Using gradually more reasonable design and (or) statistical model. e.g. the time series using general additive models(GAMs) and the time-stratified case-crossover design; to explore the relationship between temperature and human health more accurately, other confounders(like relative humidity, air pollution, etc.) should be considered.

4.1.1 Time series analysis In recent years, people are interested in using time series analysis when considering the relationship between temperature and mortality. Diggle and other researchers pointed out that time series analysis is an effective method to study the relationship between temperature and mortality in one period of time for one or several regions' samples (Diggle PJ et al., 1994). Take mortality or the number of dead as the outcome variables; take temperature measurements collected at the same time interval (every hour, every day) as the forecast variables of interest, the information that need to be collected is the sum information about exposure and outcome rather than personal data; and this can be easily got from National Public database (Basu R et al.,2002). Time series analysis also can be used to study the relationship between temperature and acute diseases with temperature sensitivity. People can adopt Poisson generalized additive model of time series, after controlling the secular trend, seasonal variation and other confounding factors, to study the relationship between average temperature and the mortality or morbidity of cardiovascular disease (such as Coronary Heart Disease)(Zhao, et al.,1994;Dong et al.,2008).

4.1.2 Case-crossover design In the past few years, several international studies has begin to use case-crossover design to study the relationship between the temperature and mortality. in 1991, Maclure firstly put forward case-crossover design to see the impact of temporary exposure (such as air pollution, environment temperature) on the rare acute events (Maclure et al.,1991).The basic idea is to compare the exposure before the occurrence of the acute events(index time/at-risk period/case time) and the exposure during the period of no incidents（referent time/control time）.If the occurrence of the rare events are related to exposure, the frequency of exposure before the events should higher than that during the earlier time. In China, no such studies have been reported yet.

The general findings suggested that the curve of temperature and temperature-sensitive diseases or death showed “U”,”V” or “J” type. But the result in China and abroad is not exactly the same, and this may due to the difference of region, climate and population characteristics or the unreasonable / inadequate study methods and so on. As an exposure factor, climatic change is different from other risk factors, so we should expand the study scope, carry out joint research in several cities or regions and focus on the integrated impacts of multi-meteorological factors on cardiovascular and cerebrovascular diseases, and keep on developing new metrical method and tools.

4.2 Strengthening the mechanism research and establishing gradually the monitoring system of impact of thermal stress on health to establish the scientific and reasonable forecast system and provide the basis for taking effective intervention measures.

Ecological methods were always used in the published researches, the capability of causal inference are limited. So mechanism researches and experimental epidemiology studies should be strengthened, especially identifying how the meteorological factors cause diseases. We should try to search early index of health effect reflecting the impact of temperature change on human health, which could provide the basis for taking intervention measures. And the disease monitoring systems have been improving, and the monitoring on environment and health have gradually developed. At present, in China there are some monitoring systems such as drinking water safety and health monitoring network, air pollution and health monitoring network and so on. But there are no monitoring systems about thermal stress and health. In the following years we could try to add the content about the impact of meteorological factors like temperature on health and establish the early warning and forecasting model to aim directly at various diseases, finally, the research results can provide services for the public.

4.3 Strengthening multi-section, interdisciplinary cooperations and

communications.

The issues about the impact of thermal stress on health involve in many fields like natural science and social science, which need the accurate meteorological data provided by meteorological sections, diseases data collected by health departments, environmental data supported by environmental sections, etc. The knowledge and data from only one section is much too limited. Therefore, a comprehensive cooperative mechanism involves in the related sections and countries should be established to facilitate the resource share, make good use of advanced technique and method, then, the related thermal stress issues could be promoted rapidly.

Chapter 3 Climate Change and Infectious Diseases

In recent years, the distribution of infectious diseases was spreading more and more globally, with the acknowledged reasons of more frequent migration due to the increasingly developed traffic, excessive use of antibiotics and poor public health infrastructures in the developing countries. But, people had neglected an important factor that was global warming.

Climate change may affect the ecological balance to accelerate the transmission of some communicable diseases, especially the vector- and water-borne diseases. The current three prevalence trends of vector-borne diseases were: new diseases being continuously discovered, the epidemic areas increasingly expanding and the prevalence frequency continuously increased. Lots of data showed that the vector-borne disease had an increasing trend in the whole world in recent years, so far more than 100 entomophilies and viruses were discovered with the ability of make human and animals ill. It’s reported by WHO that the deaths of vector and water-borne diseases accounted for 5.67% of the total death (WHO,2004).

Table 3-1 the global vector and water-borne diseases death number

Disease	Total Deaths
Diarrhoeal diseases	1,797,972
Malaria	1,272,393
Trypanosomiasis	47,774
Chagas disease	14,470
Schistosomiasis	15,371
Leishmaniasis	51,134
Dengue	18,561

Japanese encephalitis	13,957
Total	3,232,051
% of all deaths	5.67%

(Estimates for 2002, from WHO World Health Report, 2004)

Climate change can directly affect the disease transmission by changing the geographic distribution of entomophilies, accelerating the reproducing and shortening the incubation period of pathogens. The borderline of tropic may reach to the subtropics and parts of the temperate zone may become subtropical zone as the climate warming. It’s generally known that the Africa with tropical climate was the high prevalence area of communicable diseases and parasitic diseases and the candle of vector and water-borne diseases. The warming of the temperate areas will expand the distribution of insects and rodents with pathogens prolong the harmful period and make the related diseases prevalence possible. Take an example of the intestinal infectious diseases, increasing of temperature would benefit pathogens survival and reproduction in the outside environment, and enlarge their living areas. The survival water temperature for comma bacillus was 16℃, and the most proper temperature was 20－30℃. The water temperature was generally 20－30℃ in the prevalence season. With the global warming, the area with the appropriate water temperature would enlarge consequentially. Once the water was polluted by comma bacillus, the prevalence or outbreak would happen accordingly. A study of Peru showed that the incidence rate of diarrhea was closely related to the temperature showed in Fig. 3-1(Checkley et al., 2000).

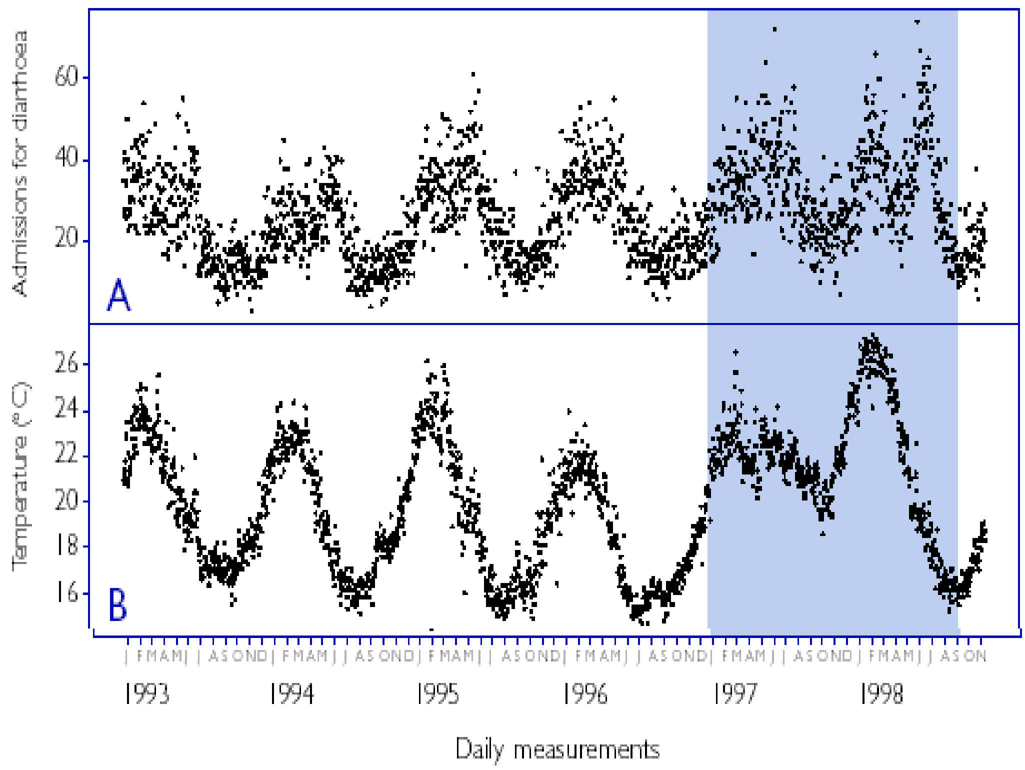


Fig. 3-1　Relationship of incidence of diarrhea and temperature

（Checkley et al., Lancet, 2000）

The precipitation has also obviously changed as the same time of global warming. Flood disaster has frequently happened in recent years. Climate warming would induce extreme weather events such as cyclone and flood which might trigger the outbreak of some vector-borne diseases. For example, the flood happened in Mozambique in February 2000 not only caused direct loss of lives and property but also the same huge loss caused by the following outbreak of water-borne diseases. The surface water for drinking was polluted when flood happened, which brought the threat of cholera, typhoid, hepatitis A and so on. Actually, the sufferers might migrate to areas without public health infrastructures and became more sensitive to diseases. Climate warming and precipitation model changing may bring more outbreaks of vector and water-borne diseases.

The increasing of sea water temperature and the sea surface level induced by climate change may increase the incidence rate of water-borne diseases such as cholera and seashell poisoning. The malnutrition caused by the impacts of awful climate on agriculture malnutrition and the potential change of human immunity system caused by ultraviolet radiation may make human body more susceptive to communicable diseases.

Vector-borne disease was also a severe issue of public health in China. The incidence number of vector-borne diseases accounted for 5%-10% of the total incidence number of communicable diseases and the death number accounted for 30%-40%. But, in China, it's not so clear about the host animals and mediums of most vector-borne diseases. Some vector-borne diseases were sensitive to climate change in China, such as Malaria, schistosomiasis, dengue fever and viral encephalitis, etc.

Climate is one of the important factors which affected the transmission of infectious diseases. China is also facing the climate warming. The relation of climate change and infectious diseases must be studied and preventing strategies and public health policies must be established to reduce the possible effects of climate change on the infectious diseases.

Section 1 Effects of Climate Change on Vector-borne Diseases

The climate change will affect the transmission of vector-borne diseases. It will change the regional distribution of entomoplily, increase the reproductive rate of entomophilies and shorten the outer delitescence of pathogen. The vector-borne diseases which are affected by climate change significantly in China are malaria, Schistosomiasis and dengue fever.

1 Malaria

Malaria is the most serious vector-borne diseases in the world. 1/20 of the world population were suffered from malaria and there were 350 million new cases and 2 million people died from malaria (Zhou, 1991).The transmission of malaria is the result of interaction among host (human), pathogen (plasmodium) and medium (anopheles). The distribution and transmission of malaria is related with temperature, rainfall and humidity. The temperature and rainfall affect the reproducing of anopheles and the growth of anopheles in plasmodium .The rainfall and humidity affect the propagating and zone distributing. United States Institute of Medicine found that since 1973, there is a clear resurgence for malaria. The general spreading of malaria is usually to the region where the winter isotherms is 16 ℃, due to the reason that below this temperature, the parasite cannot growth Temperature and humidity is the most important factor for the spreading of disease. From 20 ℃ to 27 ℃, the vitro incubation period of the malaria parasite shortened significantly. Climate factors can increase the inoculation rate and also speed up the breeding of mosquitoes, which are the most important reasons for the outbreak of malaria in non-endemic areas. In China, the epidemic region of malaria is mainly in the south of north latitude 45 degrees. Tibetan Plateau occupying 1/4 of land in China is in high altitudes and cold with no malaria. The changes of temperature and rainfall due to the global warming will affect the original distribution of malaria. As prediction by the General circulation model (GCM), the global mean temperature increase by several degrees in the year 2100 will increase the epidemic potential of the mosquito population by twofold in tropical regions and more than 100-fold in temperate regions. The malaria cases will be increasing by 50-80 million each year, and approximately 45-60% of the world's population will lived in malarias areas in the last half of 21 Century (Martens W et al., 1995). The incidence rate of Malaria in China has showed the increasing trends since 2000, it reached to 3.55 per 100,000 in 2007, which was the 1.83 times of that in 2000.

1.1 Direct impacts of climate warming on malaria transmission

1.1.1 Impacts of temperature on anopheles distribution

Anopheles is the transmission medium of malaria. The impact on the anopheles ecology of the climate is mainly reflected on the number of mosquito groups by temperature and rainfall, especially the effects on the anopheles density by temperature. Environmental temperature influences the transmission of malaria in many ways (Xi et al., 2000). Temperature determines the activity of mosquito vector, and then influences the geographic distribution of malaria. The reproduction speed depended on temperature. The optimal developmental temperature of mosquito vector was between 20℃ and 30℃, the generation development time will decrease when temperature interpolating the rage. So the density of vector mosquito and malaria transmission speed will increase when weather get warmer. Temperature influenced the lifespan of mosquito and biting behavior. The ideal temperature of vector mosquito activity was between 20℃ and 35℃, a little temperature change will bring the significantly difference of biting frequency, the interval of two biting will shorten with temperature increasing. Then the epidemic regions of malaria will enlarge and the human with no immunity to malaria will be in danger (Tian, 2001).

1.1.2 Impacts on the plasmodium's growth by temperature

Climate temperature not only affects the anopheles larva's growth but also impact on the plasmodium's growth. The higher the temperature is, the quicker the plasmodium's growth is when the temperature is between16-30℃. The plasmodium's growth is slower when the temperature is below 16℃ or above 30℃.

The reproduction of plasmodium spore was rapid and its density was high when the relative humidity was 80% and temperature was 25-28℃(Zheng et al., 1997). It slowed down significantly when temperature was below 25℃, slightly slowed in 31℃ and ceased over 33 ℃. The lowest temperature of plasmodium vivax growth in mosquito was 14.5℃ and for falciparum malaria was 16℃(Tian et al., 2001). The area where the temperature was below the lowest value needed by plasmodium spore to existing in environment was called non-affected zone. There is also no malaria in some places where the altitude exceeded 3000 meter and the mean temperature was low (Yang et al., 2002).The non-malaria zone where monthly average temperature is below 16℃ will become to the epidemic area because of global warming.

1.1.3 Temperature impacts on the prevalence season of malaria

The length of malaria prevalence season is determined by monthly average temperature in prevalence zone. The malaria prevalence season is from May to September in Beijing, from May to October in Nanjing, from March to December in Guangzhou and whole year in Hainan Province (Martens W et al., 1995).The difference in temperature of each year is large in northern of China. The incidence of malaria will increase when the prevalence season increases. Malaria broke out in Heze, Shangdong Province in 1961 because the time fitted for the malaria transmission was 80 days and 9.3 days longer than 70.7 days in usual year, the accumulating temperature was 201.8℃ higher than that in usual year. Based on the meteorological and malaria data of 40 townships in Yunnan Province, Tianfang (1998) analyzed the relation between malaria and climate change, and collected ecology parameters of Anopheles minimus to predict the prevalence of malaria by temperature increasing 1-2℃ using mathematic model in different latitude and elevation. The results showed the tendency was warming from 1984 to 1993, and ENSO and warming year affected malaria clearly, and the model showed the potential transmission power of P.vivax and P. falciparum will increase 0.39-0.91 and 0.64-1.41 times with temperature increasing by 1-2℃, respectively. The transmission season will be prolonged 1 month with temperature increasing by 1℃, and 2 months with temperature increasing by 2℃. This displays climate warming will influence the malaria in China, and the potential transmission power will be increase and the infection rate will be increase and transmission season will be prolonged.

1.1.4 Impacts of rainfall on malaria

The effects of rainfall to malaria prevalence were complicated and showed significant difference resulted from the different distribution and different reproducing characteristic of mosquito. The seasonal distribution of rainfall also affects the seasonal variation of malaria prevalence around the year. The prevalence peak of malaria is often after the rainy season in the areas where is low-lying and easy to flood in temperate regions, while the peak approaches when the rainy season come in torrid rain forest areas (Yang et al., 2006).

1.1.5 Effects of humidity on anopheles

The relative humidity affects activity and life-span of anopheles. Warm and moist climate is fit for the growth and reproduction, as well as sucking blood and the more chance of malaria transmission. The low relative humidity can shorten the life-span of anopheles. If it was lower than 60%, malaria transmission will stop. Different combinations of temperature and humidity have different effects on the hatch rate of anopheles, livability of anopheles larva, pupa eclosion and the number of laying eggs. Some scholars think that saturation deficit is more appropriate to be used for evaluate the effects on the anopheles than relative humidity; low saturation deficit can prolong the life-span of anopheles (Practical Malaria, 1978). Foreign researchers carried out the early-warning system to surveillance the outbreak of malaria in Uganda plateau areas. They found out that in Africa, the warm semi-arid lowlands, the most simple, practical means of early warning is to monitor the excessive rainfall. While in high-lying areas, the situation is relatively complex and temperature and rainfall should be taking into account together. This is different from the prevalence situation of malaria in China (Hay SI et al., 2003).

1.2 Indirect effects of climate warming on malaria transmission

1.2.1 Flood

The chance of flood will increase in the areas near sea and river with climate’s warming and rainfall’s increasing. After flooding, the propagating zone of anopheles will enlarge, the humidity will heighten, the anopheles density will increase rapidly and the life-span of anopheles will prolong. Furthermore, the crowded victims and the poor conditions for living and preventing make the environment even worse. So the incidence of malaria will increase rapidly. In China, the outbreaks of malaria in the past were mostly resulted from the large-scale flooding. In the south of latitude 33 degrees northern of Henan and Yangtze River and Hanjiang River's drainage area of Hubei, the malaria had broke out in 1954 due to flooding and the incidences of malaria were 3.2 times and 1.5 times higher than that in 1953 respectively (Martens W et al., 1995). Furthermore, flooding lead to migration that the malaria cases went to the low prevalence zone and non-prevalence zone, the population with no or low immunity to malaria went to the high prevalence zone. Thus it increased the malaria prevalence (Yu et al., 2001)

1.2.2 Factors related to human activity

An important factor of malaria transmission is the human–anopheles exposure. Bivouacking in summer was affected by geography, society, economic, culture and lifestyle and so on. The bivouacking human in summer have increased because of global warming and the prolonging of summer and high temperature days. Then the incidence of malaria will increase for the increased bivouacking in summer and the more chance to contact with anopheles.

2 Schistosomiasis

The epidemic areas of schistosomiasis in China are distributed in 413 cities/counties of 12 provinces (cities, autonomous regions) in or to the south of the Yangtze River drainage basin. These provinces are including Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Zhejiang, Yunnan, Sichuan, Fujian, Guangdong, Guangxi and Shanghai. There are more than a hundred million people who are threatened by schistosomiasis in these areas. Studies have shown that the north terminal line of schistosomiasis epidemic area is northern latitude 33° 15' (Baoying county of Jiangsu province). The water-snails can't live in north because the temperature there is too cold for them in winter, so they can't reproduce (Liang et al., 1996). The distribution of schistosomiasis is closely correlated with temperature, light, rainfall, humidity etc. Temperature and light affect the propagation of intermediate host of the schistosomes-water-snails, the hatch of myracidium and the development of schistosomes in body of water-snails. Rainfall and humidity determine the distribution of the breeding place of water-snails.

2.1 Impacts of climate change on water-nail distribution

According to the studies on the ecology of water-snails, the distribution scope of water-snails is mainly determined by nature factors. For example, in the mainland of China, where water-snails exist in are the areas that the average temperature in January is all over 0℃. Moreover, it is associated with soil and plants. The change of rainfall and temperature caused by global climate warming are doomed to affect the distribution style of schistosomiasis. The studies of the impacts of climate change on the distribution scope and extent of the spreading of schistosomiasis are very poor. Liang Yousheng etc (1996) inferred that climate change may affect the distribution of water-snails. Zhou Xiaonong etc (1999) proposed the necessity of study on the impacts of global warming on the epidemic trend of schistosomiasis and the distribution of water-snails. Zhou et al (1999), by using space analysis model, found that the north borderline of schistosomiasis endemic area in China is consistent with the isoline of mean lowest temperature of -4℃, which suggested that the lowest temperature of an area might determine the snail distribution range of O. hupensis. Yang Kun et al (2003) studied the impact of temperature change on enzymes in O. hupensis and related gene expression, which suggested that temperature increase in winter and spring would facilitate the enzymatic activity and related gene expression so as to enhance the activity and reproduce ability of the snail. Series studies (Zhou et al., 2001) have shown that the climate change brought by global climate warm--for example the rising of lowest temperature in winter, the increase of rainfall---spell the possibility of water-snail moving to north. Climate warming in winter is benefit for water-snail to survive in winter, reduce the mortality and shorten the dormant period, so as to enhance the density of snails. Snail density in some areas have rebounded in recent years may be closely related to winter warming. Basic temperature is different, and then the effects of warming may be different. When the temperature is belonging to the sensitive area, the extent of the impact may be heavier. (Yu et al., 2004). According to the national temperature data for the years 1951-2000, Zhou et al.(2004) projected that water-snail are mostly found along the Yangtze River and south of the region, and in recent years it has showed an expanding trend. In the next 50 years, the potential distribution areas can be shifted northward to the Shandong, Hebei, Shanxi and other regions, significantly larger than the scope of the current distribution of snail, which is agree with the rising trend of the country's annually mean temperature, and can lead to the increasing of the distribution area of the water-snail in the whole country.

2.2 Impacts of temperature on Miracidium

Miracidium can invade snail and its activity is related to temperature. To some extent, temperature can directly influence the development of S. japonicum larva in O. hupensis. Many researchers have reported the impact of temperature on cercarial shedding. No cercaria sheds when water temperature is about 1-3℃, a few shed at 5℃, and it is found that 20-25℃ is the most suitable temperature after continuously observing at different temperature(Sun et al., 2000). Generally, it is suggested that global warming may increase the infection rate and prolong the infectious season of snail in original endemic area when taking into consideration the impact of temperature on snails and mammals.

2.3 Impacts of Humidity to schistosomiasis transmission

The impact of humidity change on schistosomiasis transmission is also obvious. Humidity changes the vegetation of snail living point, thus changes snail distribution and density. Miracidium inclines to move in upper, clearer and lighter water, so such factors of water can impact directly the ability of miracidium's infectivity (Yang et al., 2006). Humidity can also affect greatly cercarial shedding. Field investigation suggested that cercarial shedding is the highest in autumn, then in spring, with obvious seasonal change. Seasonal change is impacted by environmental factors greatly, for only when infectious snail connects with water can cercaria shed. Therefore, more cercaria shed when water line increase obviously. As a result, when weather is warmer, rainfall is more, water area is more or ground seeper increases, the opportunities of snail to be infected, cercaria to shed and mammals to contact water also increase, which make the original endemic range wider and density higher.

2.4 Impacts of water south-to-north on schistosomiasis transmission

Meanwhile, the starting points of the project that transfer the water in south to north locate in Jiangdu city of Jiangsu province where the water-snails exist. The water transferred to north will go through three counties including Jiangdu, Gaoyou and Baoying. Water-snails exist in these counties too. Because the area where water-snails exist and the density of water-snails in the north of Jiangsu province are increasing in recent years, the possibility that water-snails move to north following the transition of water exist. But whether they can propagate in north or not need further studies.

In recent years, endemic situation of Yangtze River Valley tends to diffuse and new endemic areas are found constantly. Yu et al selected the past years' mean and mean lowest temperature in Jan. of 126 weather stations from all 733 ones nationwide to analyze the impact of climate warming on endemic range (Yu et al., 2004). As a result, temperature in winter tended to be increasing nationwide, and mean and mean lowest temperature in Jan. were 1.3℃, 0.9℃ higher respectively than 1986. And isoline of January mean lowest temperature of -4℃ and mean temperature of zero moved north by 1-2 latitude. All suggested that weather warming in winter was good to snail's living through the winter and that weather warming and South-to-North Water Transfer Project might increase the possibility of the distribution of O. hupensis extending to north, so that snail surveillance should be enhanced. In recent years, Zhou et al applied GIS to predict the endemic tendency of schistosomiasis based on the study of degree-day models of O. hupensis and S. japonicum (Zhou et al., 2004). The author founded GIS weather database by using the weather data of 193 weather stations nationwide, established schistosomiasis climate-transmission models and calculated the yearly effective accumulated temperature of O. hupensis and S. japonicum in different regions. Based on results of degree-day model founded and GIS weather database, the author analyzed their space-time distribution. According as the mean temperature of China will rise by 1.7℃ and 2.2℃ respectively in 2030 and in 2050, the diffusing tendency of endemic areas and high-risk regions were predicted. Based on the prediction of the potential endemic regions in 2030 and 2050, the endemic regions will move north obviously, and the latent endemic sensitive regions in 2050 will rise greatly compared with that in 2030. All showed that the latent endemic regions will move north with weather warming, which will increase the population threatened from schistosomiasis. Therefore, the sensitive regions of the north are the emphasis of surveillance of endemic north borderline in future.

3 Dengue fever and other arthropod-borne infectious diseases

At present, dengue fever is mainly distributed in some tropical zone. But with the global becoming warmer and warmer, the distribution scope of dengue fever may expand (the mosquitoes that can transmit dengue fever will be killed by frost and constant low temperature). Epidemiological studies show that temperature is an important factor of impacting on the transmission of dengue fever. The temperature goes up and then the latent time of virus in mosquitoes become shorter, the frequency of mosquitoes biting people increased. Otherwise, the distribution scope of mosquitoes that transit dengue fever may expand (Duan et al., 1994).

Chen Weijiang et al. discovered that the whole winter (3 months) in the north Hainan is not fit for the disease's transmission (Chen et al., 2002), though that may be suitable in southern regions where environmental temperature is only a little higher than the critical temperature for transmission. Yu Shanxian et al. have analyzed the tendency and range of the climate warming based on the data of average January temperature in past years (Yu et al., 2005), which were collected from 8 weather stations in Hainan. The results showed that Qionghai which located in the north of Hainan, also possessed the climate condition under which the disease could prevail all the time. It hinted that more than half of the areas in Hainan would have such condition till the year of 2050 due to the climate warming in winter. Zeng Siqing also has pointed out that the occurrence of Dengue fever is sensitive to the climate change. Hainan province is not the epidemic area of dengue fever now. But if the temperature increased by 1~2℃ with the global climate warming, it is estimated that Hainan province will be suitable for the spreading of dengue fever all the year. So Hainan may become epidemic area of dengue fever. Although the global warming is a gradual process, the geography and climate of Hainan are the juncture of epidemic area and non-epidemic area of dengue fever, temperature is also the borderline, and near the Southeast Asia where are epidemic areas of dengue fever. So we should on guard against epidemic and the prolongation of the epidemic time limit of dengue fever. The whole year epidemic may form, too. The geographical epidemic areas of dengue fever have been expanded north to Guangdong and Guangxi.

4 Epidemic encephalitis B

In China, Culex papiens is the chief intermediate host of Epidemic Encephalitis B virus. When the Epidemic encephalitis B virus develops in the body of C. papiens it will lose infectivity at the temperature below 20℃. When ranging from 26℃ to 31℃, the titer in vivo raises and the virulence increases, the infectivity is also strengthened. Although this disease was reported rarely in China, the area suitable for prevalence is wide, which contains most areas of China including Beijing. As the disease constantly spreads to the north, several cases are also found in Mongolia and the Northeast of China. Epidemic encephalitis B occurred in some cities in the summer and autumn of 1990, and the number of patients amounted to the highest level in the vaccine immunity period. The incidence was 2.5 times as high as that in 1989, but the most serious area is Hebei province which is located at the north bank of the Yellow River (Kang et al., 2001). The analysis on epidemic situation in Gansu province between 1983 and 1997 suggested the same thing (Yu et al., 1999). Through carrying out the planning-immunity and vaccination project and improving people's health level, the incidence has obviously declined compared with that before liberation. However, along with the global warming, the incidence may rise and epidemic area may expand.

5 Angiostrongyliasis

Angiostrongylus cantonensis is considered as the most common pathogen of eosinophilic meningitis. There is no proven treatment for this disease. Heavy infections can lead to chronic, disabling diseases and even death. In recent years, with the awareness of A. cantonensis and its danger, some places have launch researches, occurrence of the parasite and new angiostrongyliasis cantonensis cases are reported, especially, the outbreak cases in Wenzhou, Zhejiang province in 1997, in Changle, Fujian province in 2002, and in Fuzhou, Fujian province in 2002. A. cantonensis has been found in more than ten provinces. The new situation indicates that the parasite is threatening public health. The Ministry of Health, P. R, had paid more attention to the public problem caused by the parasite, and listed angiostrongyliasis as an emerging infectious disease in 2004.

The occurrence and developmental tendency of angiostrongyliasis are directly related to the distribution of A. cantonensis and regional worm burden, and the later is closely linked to environmental temperature. A. cantonensis and its intermediate hosts belong to poikilothermic animals, and environmental temperature affects their growth and development. So, environmental temperature is an important factor which determines the parasite distribution and regional worm burden. Environmental temperature does not directly but indirectly act on the parasitized A. cantonensis through its intermediate hosts. Under the same temperature condition, the same parasite may not share the same growth and development due to different intermediate hosts. Effective accumulated temperature for development and developmental threshold temperature are the indices which reflect the difference among the intermediate hosts, and the indices also indicate transmission ability of intermediate hosts. Hitherto, there is no correlative report in the aspect.

In addition, the distribution of the parasite and regional worm burden are not independent but intermediate host-dependent: firstly, the distribution of intermediate hosts circumscribes the distribution region of the parasite (Zhou et al., 2003). Furthermore, the susceptibility and transmission ability of intermediate hosts also affect the parasite distribution and regional worm burden. Intermediate hosts of A. cantonensis are diverse; they may have different distribution, susceptibility and transmission ability. Therefore, it is necessary to select some important intermediate hosts to predict the parasite distribution and regional worm burden. At present, the majority of angiostrongyliasis cantonensis are imputed to Pomacea canaliculata and Achatina fulica, but related study is few.

Although present distributions of some intermediate hosts of A. cantonensis have been known, global climate change might bring about the changes of the distribution. It will be constructive for prevention and control of disease to predict the changes by degree-day model. Fortunately, some researchers in China mainland have use the model to study the distributions of intermediate hosts such as P. canaliculata and A. fulica, and even primarily construct climate-angiostrongyliasis model to predict the danger of the parasite. However, we still will confront many problems, such as multifactor model.

6 Other vector-borne diseases

Tsutsugamushi disease, which has established in some parts in the south of Yangtze River valley, began to spread to north China since 1980s. The prevalence in Shandong province in 1986 was documented. And Tsutsugamushi disease was reported for the first time in the countryside of Tianjin in 1989. Recently, the epidemic focus is also found in the three provinces in Northeast of China and Yuncheng in Shanxi province. With the climate warming, some regional drought will lead to change in ecosystem. Due to the rapid increase of murine, the prevalence of the disease related to Han tan virus will become serious (Xue et al., 2005). Other vector-borne diseases such as Lymph Filariasis and River Blindness may be affected by climate change.

Section 2 Impacts on water-borne infectious diseases of climate change

With the global climate warming, the frequency of flood and drought is increasing. Drinking water is contaminated, so the threat of cholera, typhoid and hepatitis rise. The difficulty of preventing enteric infectious diseases will be enhanced because of the crowding of several pathogens in extensive water body. Thus the correlation of water and climate is most predominant in the tough problems of water resource. Flood and drought make the assurance of drinking water safety becoming more and more difficult. We will introduce the impacts on water-borne infectious diseases of climate change with the example of cholera and paracholera.

Since 1817 to now, the worldwide epidemic of cholera added up to 8 times. The origin site of the previous 6 times is India. The pathogen is classical cholera vibrio. The epidemic areas are mainly limited in Asia. The 7th cholera epidemic derives from Sulawesi island of Indonesia. The EL To r type cholera (i.e. paracholera) in the island expanded gradually to most of Asia countries and some countries of Mideast, Africa and Europe. The 8th big epidemic derives from Africa. Then it expanded to South

America. Now a new type of cholera O139 type which has more power virulence is expanding gradually from South Asia to East Europe. Climate change (such as increased temperature and rainfall, more frequent flood, windstorm and rising of sea level) and environmental deterioration can lead to outbreak epidemic of cholera. The ecological opinion of cholera epidemic received more and more concerns by the scientists. That is to say that the disequilibrium of nature ecological system is correlated with the big epidemic of cholera. We have known that phytoplankton in the ocean provide inhabitant place for cholera. When the water's temperature increase or becomes eutrophication (e.g. cities along the coast discard too much waste water), phytoplankton multiply magnificently (e.g. red tide). This will be helpful to the outbreak of cholera and other diseases (e.g. shellfish ocean products poisoning). The cholera epidemic in our country expanded 2 provinces northward in 1994 and 1995, respectively. It is still epidemic in these areas nowadays.

Section 3 Climate changes probably bring about new infectious disease

It's not neglectable that the new species must appear as the same time as part of the old extinct induced by climate change. The change of species may break the existent situation of viruses, bacteria and parasites and make new variation. Global warming accelerates pathogen reproduction and spreading speed and scope. Global warming accelerates pathogen reproduction and spreading speed and scope. It may bring about some aberrance of viruses and produce some viruses which we do not know how to prevent. In addition, warming season wind brings seawater of Torrid Zone and temperate zone, along with countless plankton and body of various animals, to ice layer of polar region. With the concentration of CO_2 increasing continually, greenhouse effect pricks up and the melted speed of glaciers quickens. The melted glaciers will release many frozen viruses such as smallpox virus, various peculiar flu viruses and some unknown viruses.

American scientists announced recently that they have collected four samples in the deep ice layer of Greenland, the age of the four samples vary from 500a to14×104a. After gene determination it indicates that there are more than 15 strain of pathogen TWV tomato spot strain included. Under the protection of extreme cold climate and the protein which can make the viruses alive in execrable environment, these viruses possibly remain alive over thousands years. Once they are in appropriate condition and temperature, these viruses may be active again to reproduce, spread and even have mutation and then cause new infectious diseases. In recent years, the break-out of zoonosis happened so frequently in China, which had greatly threatened the agricultural sustainable development, ecologic safety and human health. The human plague happened in Gansu and Qinghai provinces from September to October of 2004 had made great loss of health and properties in the local areas.

In conclusion, many factors affect the pattern and spreading process of infectious diseases. Different infectious diseases have different sensitivity to climate changes. In order to prevent and control infectious diseases it is important to forecast precisely the spreading trend of infectious diseases. At present, there are little research work on the relationship between climate changes and infectious diseases in china. Research methods are limited and especially there are little studies to convince the relationship between infectious diseases and long-term climate changes. So it is urgent to establish an advanced analysis method with multi-subject cooperation and enhance epidemic survey to investigate the impact trend of global climate changes on infectious diseases spreading. Thus more scientific data may be collected to formulate the effective public health policies to deal with the problems related to climate warming.

Section 4 Adaptive Measures

1. Establishing related strategies

Chinese government has taken great attention on the control and prevention of infectious diseases and had established a series of regulations and strategies especially about the vector-borne diseases, which mainly includes:

（1）Law of Infectious Diseases Control and Prevention-2004

（2）Regulation of schistosomiasis control-2006

（3）Technical plan for snails monitoring and elimination and disease diagnosis of schistosomiasis control---2005

（4）Technical plan of schistosomiasis control

（5）Technical plan of Malaria control

（6）Criteria for diagnosis and treatment of schistosomiasis-1995

（7）Criteria for control and elimination of Schistosomiasis in China-1995

2. Developing infectious diseases surveillance

Disease surveillance means continuously and systematically collecting the data of diseases and its risk factors for a long time, then feedbacking the information in time after analysis, so as to take intervention measures and assess the effects. Diseases surveillance is one of the very important contents of disease control and prevention and provides evidence for establishing strategies and measurements of disease control and prevention.

China CDC had launched the key infectious diseases surveillance system since 2004. Surveillance of vector of Malaria and schistosomiasis in the whole China had also started. But in general, the epidemic situation surveillance system for the majority of parasitic disease is not yet perfect so far, and it just developed some surveillance work to different degree in different stage of control and prevention. For example, there are

62 surveillance points for malaria and the content of surveillance includes case, mosquito's density, mosquito resistance and malaria parasites surveillance and so on. There are 80 schistosomiasis surveillance points which including different prevalence types.

3. Developing vector medium surveillance

Vector surveillance means continuously and systematically collecting vectors such as rats, mosquitoes, flies and cockroach with scientific method for a long time, then feedbacking the information in time after analyzing the kind, quantity, distribution and seasonal changing, so as to give evidence for health service departments and center for diseases control and prevention to establish, implement, assess and adjust strategies and measurements of vectors control in order to control and prevent vector-borne diseases in time.

The vectors surveillance has been developed in the whole country of China. The surveillance system composed of Ministry of Health, the local service departments and center for diseases control and prevention.

4. Developing scientific research

Health impacts of climate change have attracted great attention. In order to mitigate and response to the possible effects of climate change on infectious diseases especially vector-borne diseases, we have strengthened developing research on the impacts of climate change on infectious diseases, as well as developing research on diseases control.

Researches on infectious diseases control mainly focused on the serious illness prevention, infection rate and intensity control. For example, in China, breakthrough had been made on Antischistosomals (Praziquantel,et al) and oral preventive drugs (Artemether et al.) in the schistosomiasis control researches and varying degrees of progress had been made in the control of snails, schistosomiasis diagnosis, treatment drugs, schistosomiasis vaccines, etc.

The research on climate change impacts on infectious diseases mainly include ecological investigation, experimental investigation, spatial statistics and time-series models, which is the basis of forecasting the effects of climate change on infectious diseases prevalence.

The ecological study is the base of forecast for vector-borne diseases. It provides references to the control of vector-borne diseases through investigation on the vector populations' ecological behavior, life cycle, habits, etc, such as threshold temperature, effective accumulated temperature for development, vector transmission dynamics. There are many methods for the study of the relationship between environment temperature and the organism development, among which the degree-day model is simple, flexible and reliable, widely used in agriculture and forestry. The model illuminates the relationship between temperature and organism development.

Experimental investigation is mainly to simulate the outside climate change with instruments in the laboratory and observe the impact of climate change on vector(s) and pathogen(s), and then establish the mathematic models between the climate change and the stages of life cycle of vector(s) or pathogen(s) so to induce the relationship between the climate change and vector-borne diseases.

Spatial statistics is that the analytical techniques on spatial information are employed to develop spatial models based on the observation, experiment and simulation of raw data so that we can obtain new experience and knowledge and make decisions. Suitable models are more and more needed to reflect the distribution patterns and the influence factors of diseases when the spatial relationship between diseases and environment is researched. Zhou et al (1999) employed weather-hydrology balance model to calculate the transmission indices of schistosomiasis in different areas and drew the distribution map of transmission indices of schistosomiasis, which was basically consistent with the epidemic of schistosomiasis in southern areas of China. Yu et al (2004) explored the possibility of moving to north of O. hupensis because of the warming in winter by the study of the hibernation temperature for O. hupensis. In 2001, Tian et al (2001) established a multivariable regression model on climate factors and used it to predict the incidence rate of malaria in a certain place and the possibility of the impact of global warming on malaria transmission. By using GIS and RS techniques, the data on vector, Anopheles, RS biological data, the information about diseases can be integrated to develop combined models to predict the epidemic situation of malaria effectively, just as Wen et al conducted in Hainan Province (Wen et al., 2003). GIS and RS techniques also can be used to forecast rainfall, temperature and El Nino phenomenon so to predict the potential transmission tendency of malaria.

5. Making measures for control and prevention

At present, we had comprehensive control measures for vector-borne diseases, including control of disease, prevention of transmission and eradication of infection resource. Different measures were taken according to the characteristics of disease spread; meanwhile, some measures would not come to truth because of the fund limitation and some environmental problems. For example, disease control was still the major measure for schistosomiasis control.

Section 5 Gaps and suggestions

1. Gaps

With the global warming, the geographical environment, biome, species density and distribution of vectors will vary, and then the occurrence, development and prevalence of vector-borne diseases will also change. So there are still some limitations on research to climate change and other related changes using the traditional perspective and research methods. Therefore, under the situation of global climate change, predicting the developmental tendency of vector-borne diseases by dependable mathematical models is not only the important task for diseases control and prevention, but also the key research field of climate change impact on epidemic. At present, Chinese scholars gradually undertake researches on the impacts which global warming brings about on vector-borne diseases, but we will still confront with many problems currently.

First, because vector-borne diseases are diverse in China, the biological and ecological characteristics of many pathogens as well as their vectors are not fully understood. On account of different transmission regulations of vector-borne diseases, the factors involved may be various. It is necessary to research biological and the ecological characteristics to make sure how to establish and make use of mathematical models to predict the various regulations of disease transmission.

Second, there are a lot of uncertain factors involved into pathogens, vectors and environments. To set up the model between the climate and vector-borne diseases, many problems need to be resolved. So, sometimes, to establish prediction models, we have to ignore some factors that should be considered originally, such as the migration of vectors, the influence of prevention measures, the change of land utilization and the development of social economy. Therefore, the models involving single factor or a few factors would result in bigger deviation from the fact. The prediction models of multifactor need to be established.

Third, assumptions some models based on also need further verification and the scientificity of data need to solve. Because many factors cannot be quantified by appropriate quantitative methods, most of current researches belong to qualitative or half-qualitative researches which conflict with some assumptions of mathematical models. There is no suitable model to accurately predict the prevalent tendency of vector-borne diseases in current research. The meteorological permeates are relatively absent for prevention and control of vector-borne diseases. Furthermore, the data of GIS and RS being used to establish prediction models are not complete, and the relation is uncertain between the traditional meteorological indicators and the surrogate indicators of RS biology.

In addition, combination among different subjects and development of interdiscipline need promotion. The impacts on human health of climate change are beyond our acquired knowledge. Further studies imply that the impacts not merely involve meteorology but also are related to epidemiology, environmentology, geography and so on. The knowledge of other science will undoubtedly facilitate us to explore and study the impacts and make the related theories more substantial and perfect. For instance, current researches by the techniques of RS and GIS still stay in a relatively independent and dispersive stage and there is no comparability among the materials and results of researches.

2 Suggestions:

The focus of future researches should be concentrated in the following aspects: First, further understanding the relation among the pathogens of vector-borne diseases, the biological and ecological characteristic of vectors and the climate change variety; Second, introducing the more advanced mathematical models to improve predicting level, such as the comprehensive researches of the environmental dynamic model, the time dynamic model, the space dynamic model and the time-space dynamic model supported by remote sensing technique of vector-borne diseases transmission; Third,, reinforcing the interdiscipline researches of different subjects such as GIS, RS, biology, ecology, epidemiology and meteorology, etc; the fourth, improving the theories and the scientificity and reliability of data prediction models based on; additionally, effectively carrying on the prevention of vector-borne diseases transmission.

To sum up, in face of the situation of the global warming and the atmosphere deterioration, people should make great efforts to prevent against the global temperature increase and environment deterioration, at same time, should enhance the researches of climate and diseases, prediction and forecast , endeavoring for health and safety of human being.

Chapter 4 Water Quality and Human Health

The impact of global warming on water is direct and significant since the process of atmospheric circulation and the hydrological cycle speed up. Water resources and its spatial distribution changes caused by global climate change could lead to further deterioration of water shortage and the water ecological environment. By the impact of climate change, precipitation in the region, as well as the time between the annual distributions is more uneven. At the same time, as the water temperature increased, the quality of fresh water may also decline. The impact of Climate change on water shortages, water quality, as well as floods and drought frequency and intensity bring greater challenges to the management of water resources and flood. It is more vulnerable when climate change has a negative impact with a poor management of water systems.

Globally, in the period 1900-2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s. There is high confidence, based on substantial new evidence, that observed changes in marine and freshwater biological systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation. These include: shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans; increases in algal and zooplankton abundance in high-latitude and high-altitude lakes; and range changes and earlier fish migrations in rivers. Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease.

In China distribution of water resources are very uneven which may be worse effected by climate change. A decreasing trend in runoff was observed during the past 40 years in the six main rivers, namely Haihe River, Huaihe River, Yellow River, Songhuajiang River, Yangtze River, and Pearl River. Meanwhile, there is evidence for an increase in frequency of hydrological extreme events, such as drought in North and flood in South. The Haihe-Luanhe River basin is the most vulnerable region to climate change, followed by Huaihe River basin and Yellow River basin. The arid continental river basins are particularly vulnerable to climate change.

In the future, climate change will have a significant impact on water resources over China. With the warming climate, floods and drought frequency and intensity increased, while water shortages and the deterioration of water quality problems become more prominent, a serious threat to human health, such as bringing cholera, typhoid and intestinal diseases such as hepatitis threat, algal blooms caused by the deterioration of water quality, flood and drought to safe drinking water makes it more difficult to protect the health and other threats.

Section1 Review

The impact of global warming on water is direct and significant since the process of atmospheric circulation and the hydrological cycle speed up. Water resources and its spatial distribution changes caused by global climate change could lead to further deterioration of water shortage and the water ecological environment. Even the drought and flood disasters occurred increasing frequently, and it will bring threat on human health that drinking water polluted by pathogens such as cholera, typhoid and hepatitis. And it is more difficult to prevent intestinal disease with a variety of pathogens gathered in a wide range of water. Thus the assurance of drinking water safety is becoming more and more difficult with Drought and floods.

1 Impact of climate change on water resources

The issue of the impact of climate change on water environmental has caused people's attention widely in the world. As early as 1979, in the "World Climate Plan" which was organized by the World Meteorological Organization, United Nations Environment Programme, the International Association of Hydrological Sciences, and other international organizations, there was a "water plan" established specifically which involves the studies referred to the sensitivity issue of water environment on climate change rate, and the assessment of the impact of climate change on hydrology and water resources, including the impact of climate change on groundwater and water quality. Globally, observed decreases in snow and ice extent are consistent with warming in. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% (2.1% -3.3%) per decade, with larger decreases in summer of 7.4% (5.0% - 9.8%) per decade. Mountain glaciers and snow cover on average have declined in both hemispheres. The maximum areal extent of seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with decreases in spring of up to 15%. Trends from 1900 to 2005 have been observed in precipitation amount in many large regions. Over this period, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.。Globally, the area affected by drought has likely2 increased since the 1970s.Some extreme weather events have changed in frequency and/or intensity over the last 50 years:

It is very likely that cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent.

It is likely that heat waves have become more frequent over most land areas.

It is likely that the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas.

It is likely that the incidence of extreme high sea level3 has increased at a broad range of sites worldwide since 1975.

Based on growing evidence, there is high confidence that the following effects on hydrological systems are occurring: increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and warming of lakes and rivers in many regions, with effects on thermal structure and water quality. There is high confidence, based on substantial new evidence, that observed changes in marine and freshwater biological systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation. These include: shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans; increases in algal and zooplankton abundance in high-latitude and high-altitude lakes; and range changes and earlier fish migrations in rivers. Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease. The resulting increased flood risk poses challenges to society, physical infrastructure and water quality. It is likely that up to 20% of the world population will live in areas where river flood potential could increase by the 2080s. Increases in the frequency and severity of floods and droughts are projected to adversely affect sustainable development. Increased temperatures will further affect the physical, chemical and biological properties of freshwater lakes and rivers, with predominantly adverse impacts on many individual freshwater species, community composition and water quality. In coastal areas, sea level rise will exacerbate water resource constraints due to increased salinization of groundwater supplies (**IPCC**, 2007)

Changes in temperature, sea level and Northern Hemisphere snow cover

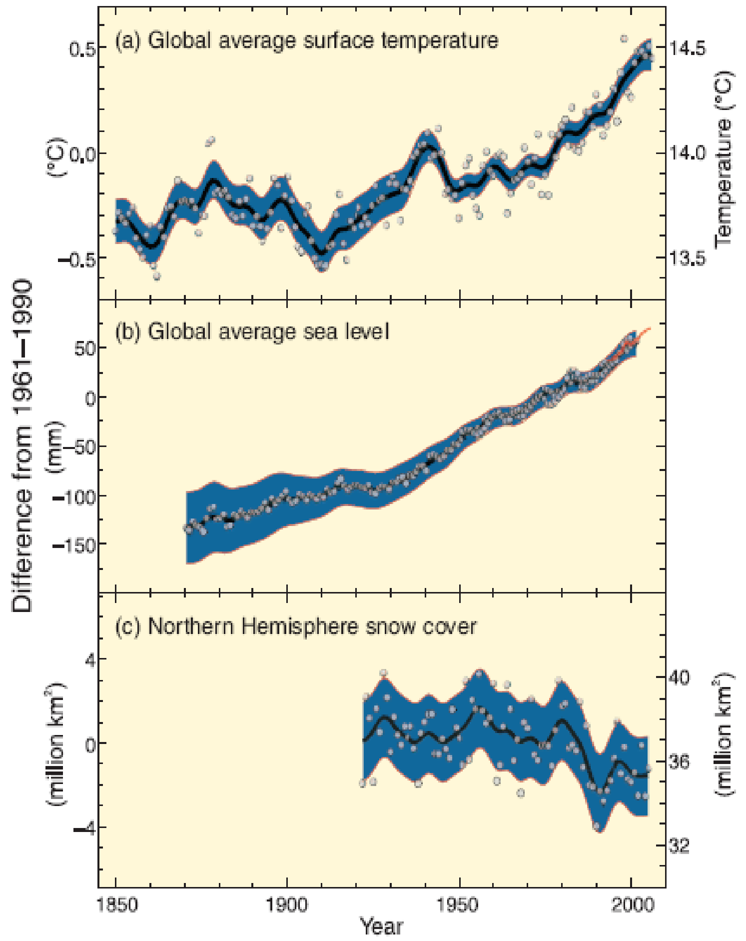


Figure 1.1. Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {WGI FAQ 3.1 Figure 1, Figure 4.2, Figure 5.13, Figure SPM.3}

Fig.4-1 Global temperature, average sea level and Northern Hemisphere snow cover

(IPCC, 2007)

Meanwhile, climate change has already caused the changes of water resources distribution over China. A decreasing trend in runoff was observed during the past 40 years in the six main rivers, namely Haihe River, Huaihe River, Yellow River, Songhuajiang River, Yangtze River, and Pearl River. Meanwhile, there is evidence for an increase in frequency of hydrological extreme events, such as drought in North and flood in South. The Haihe-Luanhe River basin is the most vulnerable region to climate change, followed by Huaihe River basin and Yellow River basin (Zhou et al., 2001). The arid continental river basins are particularly vulnerable to climate change.

In the future, climate change will have a significant impact on water resources over China: in the next 50-100 years, the mean annual runoff is likely to decrease evidently in some northern arid provinces, such as Ningxia Autonomous Region and Gansu Province, while it seems to increase remarkably in a few already water-abundant southern provinces, such as Hubei and Hunan provinces, indicating an increase of flood and drought events due to climate change; the situation of water scarcity tends to continue in the northern China, especially in Ningxia Autonomous Region and Gansu Province, where water resource per capita are likely to further decrease in future 50-100 years; providing that water resources are exploited and utilized in a sustainable manner, for most provinces, water supply and demand would be basically in balance in future 50-100 years. However, gap between water resource supply and demand might be expanded in Inner Mongolia Autonomous Region, Xinjiang Autonomous Region, Gansu, and Ningxia Autonomous Region.

In the past 50 years, the terrestrial climate in China had experienced a relatively significant change, in northern area in China, especially the precipitation of north China significantly trends to reduce. Even more with the impact of human activities, the water shortage in vast areas of in northern area in China was extraordinary serious. Meanwhile, in southern China, especially in the area near the middle and lower reaches of the Yangtze River, the increased precipitation intensity and variability are projected to increase the risks of flooding and drought in China. With the increasing frequency of flooding, flood control situation is becoming more and more serious. It is particularly obvious that drought in the North and floods in the South in China since the 1990s.

1.1 Impact on water distribution

The studies referred to the impact of climate on water in China began in the late 1980s.From the 1980’s, the natural runoff change of the major rivers have been investigated widely and researched deeply. In the last decade especially in the last five years, there were several researches which conducted a preliminary study on the climate change caused by human activities in the future and its impact on water resources, and settle the foundation for going deeper into the study.

1.1.1 The impact on Precipitation

According to 2007"the national climate change assessment report", it has pointed out that with the global warming , the frequency of warmer weather and climate events will increase and that of colder weather and climate events will reduce due to the increased mean of temperature. Thus, as global warming lead to higher rates of evaporation and rainfall, high temperatures, storms and other extreme events will become more frequent, more precipitation will occur in a short period of time, hence the intensity of rainfall will increase. From the national average, the change of China's total precipitation was not obvious, but there was a significant reduction in the number of rainy day. The unchanged or increased total precipitation and the reduced frequency of rainfall means that the trend of the rainfall process may be strengthened and the tendency of drought and floods may be increased (Zhai et al., 1999). Recently, some studies have pointed out that in China the extreme precipitation is becoming longer and stronger. The average intensity and the extreme precipitation values have been increased. And there are more extreme precipitation events, especially in the 1990s, the proportion of extreme rainfall tends to increase (**CNCCP**, 2007). There are frequent floods in some areas, particularly since 1990, the Yangtze River, Pearl River, Songhua River, the Huaihe River, Taihu Lake, both for the Yellow River floods occurred repeatedly. Because of storm surges, floods, heavy rainfall and so on, drinking water may be polluted by all kinds of intestinal pathogens or other pollutants, and the incidence of water-borne diseases will increased greatly (CNARCC, 2007).

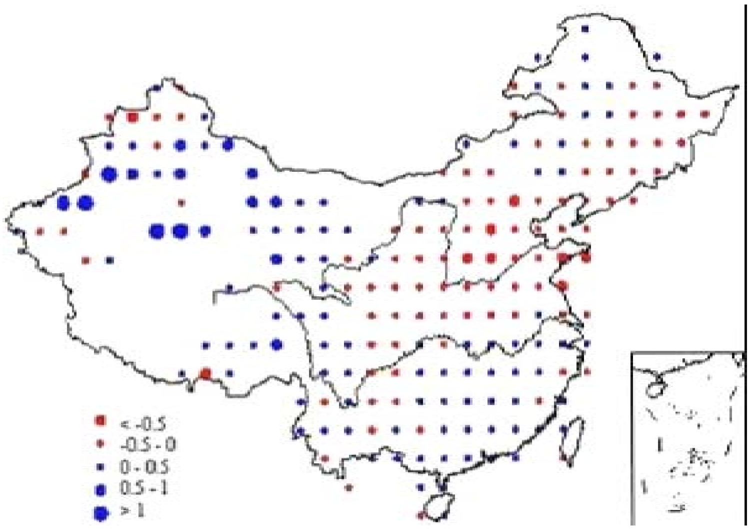


Fig.4-2 Precipitation variation from 1951to 2002 in China

(From "Climate change assessment report, 2007")

1.1.2. The impact on river runoff and river discharge

In the past several decades climate change has caused change of the hydrological cycle in China. Some major rivers were dry up frequently. So, the conflict between supply and demand of water resources was extraordinary intensified. The main control station of six major rivers in China measured the surface runoff change. The tendency of those changes and significant analysis of the results showed that since the 1950s, particularly from 1980, the runoff of six major rivers measured were in downward trend. In those, the runoff of Haihe River valley reduced obviously. Compared to the runoff before 1980, since 1980 it decreased of 40-70%. The runoff of Yellow River, Liaohe River, and Songhua River measured also dropped significantly. In addition, the upper reaches of the Yellow River and Yangtze River upstream where human activities' effect is little, the runoff also trended to reduce. All those implies that the climate change on these regions have had a certain impact on the runoff (Zhang et al., 2007). Some research shows a very good relationship between the flow fluctuations and the average precipitation throughout the lower reaches of the Yangtze River since the 1950s. It's indicated that the impact of climate change and climate variability on Yangtze River runoff is very clear (Ren et al., 2003; Jiang et al., 2005). Moreover, it is reported in a study that since 1980 the run-off reduction in the riverhead region of the Yellow River is mainly because of climate change, in particular due to the reduction in summer rainfall. The higher surface temperature may also enhance the ability of evaporation, resulting in further runoff reduction in main stream of the upper reaches of the Yellow River (Ren et al., 2007). In the last 50 years the situation of drought in northern China has been becoming worse gradually, with the average area of drought gradually increasing, while the area of drought in the extreme drought year significantly expanding. Many studies support the conclusion that the runoff change of major rivers may attributed to climate change and climate variability. But whether the run-off changes in the past was the response to global warming or global climate change is still unclear. And the fact is that runoff reducing, drought in the North lasting. All of those will make the situation of the lack of water resources even more serious, will make further deterioration of water quality, and will make the safety of drinking water and protection work more difficult.

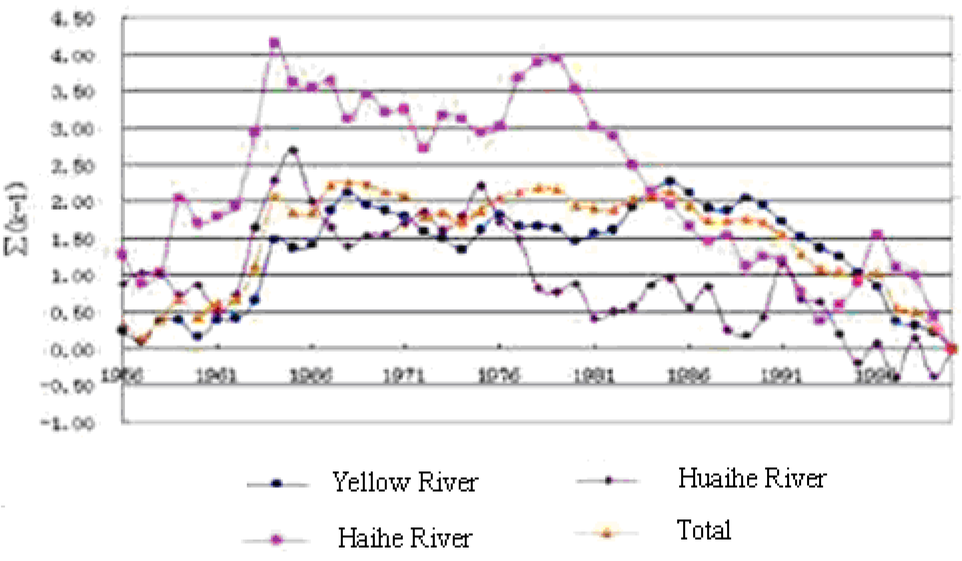


Fig.4-3 The accumulate curves of the annual runoff (Yellow River, Huaihe River and Haihe River) (Zhang et al.,2008)

1.1.3. Snow, land ice and sea-level

Currently, the rising of sea-level in global was at a speed of about 1.7 mm / a. It will result in groundwater salted in larger area, the reduction of freshwater and acceleration of the erosion of the coastal zone, and the increase of flood risk. Since the 1950s, coastal sea level in China rose by an annual 1.4 mm ~ 3.2mm. The climate change and the rising of sea-level has have effect on coastal zone in China. Storm, floods, heavy rainfall, drought and other extreme weather events caused more obvious disaster in the coastal areas. In addition, the study indicated that, it will be evaporation increasing, mountain glacier being melted, snow line shifting and due to climate change. It also indicated that the Northwestern region will be drier and hotter, the ice grades in Bohai Sea and the northern of Yellow Sea will drop, the glaciers area in northwest has reduced by 21%, Tibet's permafrost thinned in 4 m ~ 5m at the most, surface of some inland lake in plateau higher, and southwest in China, Qinghai and the Sanjiang Plain wetlands area reduced with functional declining (**CNARCC**, 2007).

1.1.4. Future trends

According to “China’s National Climate Change Programme” published in 2007 June, the trend of climate warming in China will further intensify in the future. The projections by Chinese scientists indicate that:

1. Precipitation in China would possibly increase during the next 50 years, with a projected nationwide increase of 2~3% by 2020 and 5~7% by 2050. The most significant increase might be experienced in southeastern coastal regions;

2. The possibility of more frequent occurrence of extreme weather/climate events would increase in China, which will have immense impacts on the socio-economic development and people’s living;

3. The arid area in China would probably become larger and the risk of desertification

might increase;

4. The sea level along China's coasts would continue to rise and the glaciers in the Qinghai-Tibetan Plateau and the Tianshan Mountains would retreat at an accelerated rate, and some smaller glaciers would disappear.
Chinese scientists analysis and simulate the extreme weather events by using history data and high-resolution regional climate model. It showed that the greenhouse effect will enable the maximum and minimum temperatures increasing significantly, and the difference reducing in China region.

According to this model, it is almost in southern China where the average of maximum daily temperature in a year increases significantly. And it is in the north of the Yellow River and south of the Yangtze River where the average of minimum daily temperature increase significantly. The greenhouse effect may result in frequency increasing of heavy precipitation events. In Southern China, there will be more and more rainy days, particularly in the western region of Fujian and Jiangxi, and southwest of Guizhou, Sichuan and some areas in Yunnan. There will be heavy rain and the climate trends to worse. On the other hand, the forecast also shows that the future will increase the intensity of the typhoon; China will likely be affected by stronger typhoon. Otherwise, the arid region may also be expanded and intensified (CNARCC, 2007).

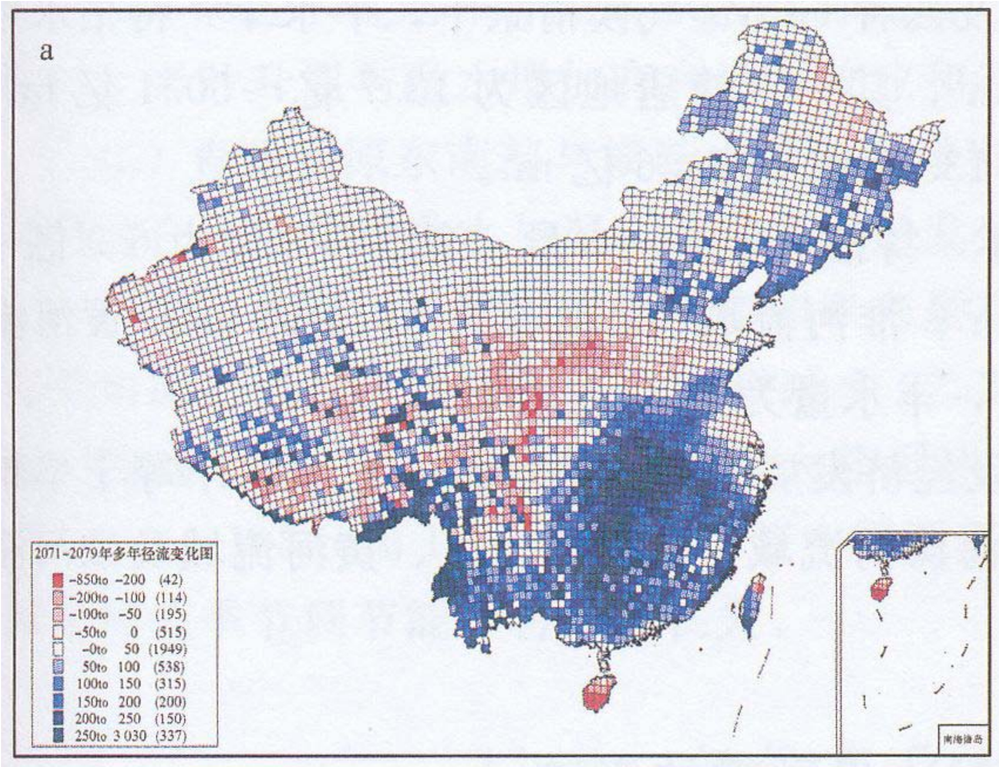


Fig.4-4 The projected annual runoff of climate change in future

Climate change has already caused the changes of water resources distribution over China. The arid region in North may be expanded; heavier flood will happen in South, drought and high temperature in local may increase. All of those may lead to the lack of freshwater resources. The safety of drinking water received threats to health and water quality may be deteriorating further.

1.2 Impact on water quality

1.2.1. Various pollutants such as various Pathogens, arsenic, fluorine and heavy metals

The projected increase in precipitation intensity is expected to lead to a deterioration of water quality, as it results in the enhanced transport of pathogens and other dissolved pollutants (e.g., pesticides) to surface waters and groundwater; and in increased erosion, which in turn leads to the mobilization of adsorbed pollutants such as phosphorus and heavy metals. In addition, more frequent heavy rainfall events will overload the capacity of sewer systems and water and wastewater treatment plants more often. An increased occurrence of low flows will lead to decreased contaminant dilution capacity, and thus higher pollutant concentrations, including pathogens. Floods affect water quality and water infrastructure integrity, and increase fluvial erosion, which introduce different kinds of pollutants to water resources, while Droughts affect water availability and water quality.

In areas with overall decreased runoff (e.g., in many semi-arid areas), water quality deterioration will be even worse. It is said that with global warming, the evaporation is increasing in some regions, and the river flow tends to reduce. So that pollutants are concentrated in the river, exacerbating the pollution of rivers, especially in the dry season (Arnell et al., 2004). At the same time, since the water temperature rise, the solubility of heavy metals in precipitation will also increase. The sediment re-dissolves in the river releasing of pollutants with further deterioration of water quality (Zhou et al.,1999).

On the other hand, the scope of time and space suitable for the breeding of water-born pathogen expand, so that the growth and breeding season of bacteria, viruses and parasites prolong. And the gastro-intestinal infections, the temperature is conducive to pathogens in the environment for the survival and reproduction. Take Vibrio cholera for example, the suitable temperature for the survival outside is 16 ℃ , and the most suitable is 20-30。 Also the temperature of water area in popular season is 20-30℃. And the water area with the temperature will enlarge with global warming. Once it is infected, the local outbreak will spread followed the water resource. It is the most dangerous way of the epidemic of various water-borne intestinal infectious diseases.

1.2.2. Higher water temperatures promote nutrients

Higher water temperature has brought certain impacts on freshwater lakes and rivers in physical, chemical and biological characteristics, which result in adverse effect on many freshwater species, communities and constituents. Focusing on the relationship between climate change and eutrophication of lakes and red tide, some research has shown that the later is caused by the increasing of nitrogen, phosphorus and other nutrients in water. In particular, phosphorus pollution is limiting factors of the eutrophication. No doubt, climate change has impact on biogeochemical cycles of nitrogen, phosphorus and other nutrients, especially through influencing the precipitation changes ,so the situation of non-point source pollution become worse. With Climate warming, microbe in soil will be more active, resulting in declining soil fertility, leading to the excessive use of fertilizer such as nitrogen, phosphorus; On the other hand, they also led to the accelerating nitrogen, phosphorus and other chemical fertilizers in the water body. Therefore, the climate change will lead to further exacerbation of eutrophication of lakes and red tide of oceans finally (Paerl et al.,2003).

In 2007 there was a outbreak of cyanobacteria in Taihu Lake in China. It was said that global warming was the main reason. In April 2007, the average water temperature in Taihu Lake is 19.56 ℃, which is the highest for the past 25 years. Besides, much less rainfall has provided appropriate conditions for the algae outbreak (Wang et al., 2008). In addition, Chinese scientists analyzed the relationship between outbreaks of cyanobacteria in a large area of water and the peak time of total concentration of phosphorus and nitrogen. The results show that nitrogen and phosphorus are no longer a restrictive factor for outbreak of cyanobacterial bloom since the middle term of 1980s, which suggests that external nutrients (such as nitrogen and phosphorus)are weak affects under a saturated eutrophication lake. However, the present analysis for relations of climate changes and outbreak of cyanobacterial bloom reveal that they have a significant correlation. The analyses suggests that meteorological conditions would play a dominant role in the outbreak of cyanobacterial bloom of Taihu Lake, which has a important scientific significance for understanding changes in lake waters in the future(Lai et al.,2007).

Climate change results in lack of water resources in a more serious situation, and is also expected to lead to a deterioration of water quality. Therefore, the opportunity of diseases and their spread will increase which endanger human’s health. Especially after floods, incidence chance of infectious diarrhea such as cholera, dysentery, typhoid is greatly increasing.

1.2.3 Overview of Water Quality Variation in China

China has built automatic water quality monitoring stations on Songhua River, Liaohe River, Haihe River, Yellow River, Huaihe River, Yangtze River and Pearl River and so on,which can Carry on the real-time continuous monitoring and the long-distance monitoring to the water quality. According to the monitoring results on 183 rivers and 376 cross section belong to seven big river system, it indicated that the water quality of Pearl River, Yangtze River is better, that of Yellow River and Songhua River is poor, pollution in Haihe River, Liaohe River and Huaihe River is worse. The main contamination index is the BOD, the permanganate index, the ammonia nitrogen and the petroleum class. In recent years, with the improve of system on monitoring water quality, The implementation of water conservation measures are effective, the overall quality of China's seven major river systems have been improved accordingly.

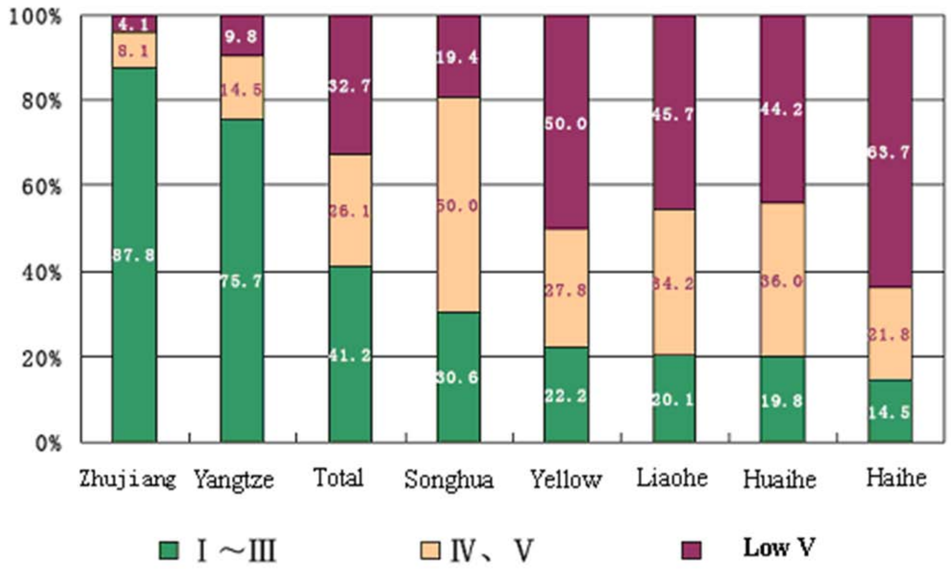


Fig 4-5 Water quality in Seven major River in China, 2002

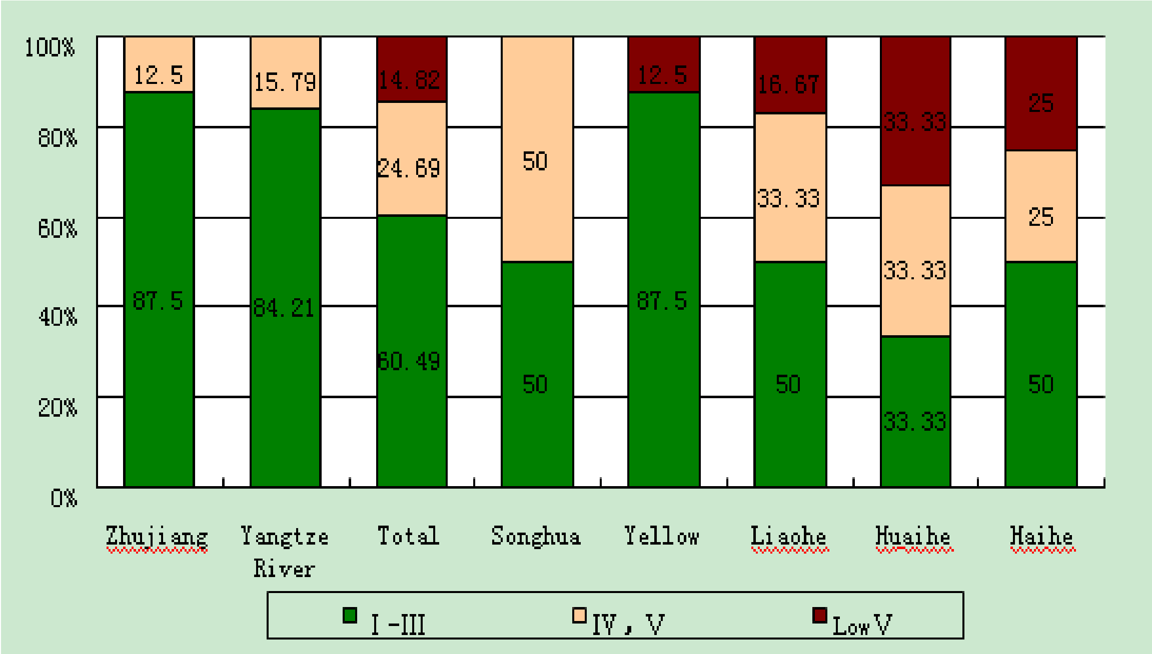


Fig 4-6   Water quality in Seven major River in China, 2009

2 The health effects

Global warming and its impact on water environment are indisputable facts. Climate-change-induced effects on water pose a threat to human health through changes in water quality and availability. The impacts of climate warming on the distribution and quality of surface water, may lead to flooding, water shortage, destruction of underground drainage systems and bad personal hygiene. Those will cause epidemic of diarrhea (including cholera and dysentery), especially in China, for poor health facilities. Many bacteria, viruses can cause diarrhea, which can survive in water for several months, particularly in warm weather conditions. The pathogens spread easily under more and heavier rainfall, so the diarrhea cases will increase, in particular of poor health facilities countries.

2.1 water-borne infectious diseases

2.1.1 Cholera

Higher ocean temperature would lead to excessive growth of ocean plankton and algae directly. It is especially suitable for the growth of Microorganisms such as cholera in the marine environment. In exceptional circumstances, the number of cholera bacteria will expand the scope of marine species. All of those could lead to a cholera outbreak such as in Peru in 1991. Climate change, such as warming, increased rainfall, frequent floods, storms and rising sea levels, may cause cholera outbreak. There is some data showing that cholera epidemic in India and the Bay of Bengal has obvious seasonal characteristics. And in China Cholera is still popular. In 1994 and 1995, the epidemic areas of cholera, was expanded to two provinces northward, respectively. In order to understand the impact of the water on cholera, the institution of infectious disease of China CDC has monitored the Pearl River estuary waters for one year. Vibrio cholera O1 and O139 group is separated. And the relationship between isolation rate and climatic factor is analyzed. The results show that there is no significant relationship between the detection rate and temperature, water temperature. The Vibrio cholera can be detected all the year in a limited range. And the detection rate was in the month of the maximum temperature and the highest temperature. Lower temperature and water temperature in winter and spring, so was the separation rate. The study was just the preliminary experiment, and will continue to monitor for a long time to clarify the relationship between proliferation of Vibrio cholera and the environment.

2.1.2 Schistosomiasis

In China, it is believed that the north boundary of Schistosomiasis epidemic area is latitude 33 ° 15 '. Warming, increased rainfall in some area, frequent floods will have complex impacts on epidemic of Schistosomiasis with snails moving northward. At the same time, some large-scale water conservancy projects such as diverting water South to North may also make the snails in the water moved northward. So schistosomiasis may be spread northward with expanding regions popular of schistosomiasis and increasing prevalence in original epidemic area.

Since 2001, Zhou Xiaonong et al., carried out a series of research about impact of global warming on the spread of schistosomiasis (Zhou et al., 2002).

It includes the direct potential impact of temperature and humidity. First of all, temperature influences the distribution of snails. Hong Qingbiao et al focus on snail developmental threshold temperature and the effective temperature. The study provided parameters for the theoretical prediction model of warming impact of the spread of schistosomiasis. It is observed that warming, such as the lowest temperature generally increased in Northern China, makes the possibility of the spread of snail to the North significantly increased. Second, the impact of humidity on the spread of schistosomiasis is obviously (Sun et al.,2003), which can influence the distribution and density of snails by altering the vegetation of snails breeding. When the climate is warming, rainfall and seeper are increasing. The opportunities of snails infected by schistosomias are increasing, so was the number of cercaria escaped. While more mammals will contact with infected water， the scope will expand ,the prevalence will increase in the original epidemic region accordingly.

2.1.3 Leptospirosis

Leptospirosis is an acute infectious disease caused by the pathogenic Leptospira. People are infected through contacting with the infected water. The animal host is infected rats and livestock. Change of natural factors leads to the host animal migration, more opportunities of contact with infected water. So Leptospirosis is likely to spread. Jiangxi is the most serious provinces of Leptospirosis epidemic with higher incidence rate over the years. Mei Jiamo et al research on Leptospirosis epidemic characteristics in onset conditions, natural factors and animal hosts in the Jiangxi Province. The results showed a certain relation between the incidence of leptospirosis and the average temperature in 1973-1998. In addition, 25-28 ℃ is the most appropriate growth temperature for leptospirosis. The peak incidence of that is in July and August when the average temperature is 26.9 ℃ -29.8 ℃ which is more appropriate for the growth and development of leptospirosis. All of those suggest that with the Climate warming, the survival of leptospirosis will be possible in some regions which were unsuitable. And the scope of leptospirosis will be expanded. Furthermore the researchers analyzed the incidence and rainfall. The results showed that when the average annual rainfall> 1700 mm, it was positively correlated between the average annual rainfall and leptospirosis incidence rate. So rainfall caused by global warming is a major indirect factor to the epidemic of leptospirosis. At present, epidemic of leptospirosis declines steadily in China without huge floods. But since the natural disease may cycle in a period, once precipitation exceeds the normal level with climate change, or leptospirosis bacteria change has not been grasp in time, outbreak of leptospirosis is possible (Mei et al.,2005).

2.1.4 Others such as hepatitis, typhoid

With climate warming, the rainfall in most area will increase, air humidity will increase, and temperature and pressure will fall. The epidemic spread of certain diseases will exacerbate. According to some reports, the hepatitis incidence rate is consistent with precipitation of early spring and summer. Rainfall and humidity is conducive to the hepatitis virus survive and multiply outside, improve its ability to communicate and infection rate. Those fully show that the warming will increase the incidence of hepatitis and infection rates.

In addition, since 1951 China has a typhoid epidemic report, the highest peak of epidemic was recorded in 1959, and the incidence rate is 31152/100 000. Then there are subsequent two small peaks, the incidence rate is of 25199/100 000 and 13146/100 000 in 1970 and 1992 respectively. In 2002, the incidence of typhoid fever dropped to the lowest level recorded (3181/100 000). Typhoid epidemic outbreaks mainly are caused by drinking water and food contamination. It is likely to rebound after the floods such as dysentery. It indicated that climate warming lead to increased rainfall, drinking water pollution, and indirectly results in the outbreak and spread of typhoid epidemic (Chen et al., 2005).

2.2 The safety of drinking water

It is essential to be aware of the health and environmental risks caused by reusing low-quality water. In China, both in the north water-scarce areas and the south flooded area, the assurance of drinking water safety is difficult. Vulnerabilities are related to a lack of relevant information, institutional weakness in responding to a changing environment, and the need to mobilize resources.

2.2.1 Lack of water resources, poor management, and drinking water security is threatened

Climate change brought huge demand for water, coupled with poor management of water resources caused a global decline in the quality of water resources. According to statistics there are more than 1.7 billion people without adequate access to safe drinking water supply, more than 30 million people without adequate sanitation, in the third world 2.15 million people were killed daily by water-borne diseases on average. According to the World Health Organization (WHO) reports, it estimates that about 4 million annually dysentery cases, of which about 94 percent of all caused by unhealthy water environment and water-related health conditions. Around the world, 1.5 million children die of diarrhea each year. Most of them are less than 5 years old in developing countries. In China, the lack of freshwater resources and water pollution make people to use some backup or poor quality water resources, leading to water-borne diseases spread increasingly. There was the risk of pollution in unsafe water sources, which is also possible to be water-borne disease vector. Safe drinking water and health conditions of sanitation are essential to make sure water-borne diseases reducing.

2.2.2 Drought, heavy rainfall caused water pollution

With climate change, the extreme weather events and natural disasters will happen frequently, including typhoons, floods, drought or tsunami. The normal clean water may be undermined, with sewage and storm water polluting the uncovered wells and surface water. The prevalent of water-borne diseases may increase without effective protection of the drinking water. The increase in precipitation intensity is expected to lead to a deterioration of water quality, as it results in the enhanced transport of pathogens and other dissolved pollutants (eg., pesticides) to surface waters and groundwater. It is more concerned that the health impact of the natural disasters in community which use surface water. Floods have a considerable impact on health both in terms of number of deaths and disease burden, and also in terms of damage to the health infrastructure.

In areas where amounts of surface water and groundwater recharge are projected to decrease, water quality will also decrease due to lower dilution. Unfortunately, in some regions the use of such water may be necessary, even if water quality problems already exist. For example, in regions where water with arsenic or fluorine is consumed, due to a lack of alternatives, it may still be necessary to consume the water even if the quality worsens. It will produce adverse effects on human health seriously. A study about Kaschin-Beck disease in Tibet indicated that soil erosion is likely to affect the distribution of Kaschin-Beck disease as an important factor. Kaschin-Beck disease is more likely to appear in regions with serious soil erosion rather than flat regions.

Global climate change may cause increased drought in some areas. The river flow tends to reduce in some areas because of increased evaporation. So that the pollutants in the water have been concentrated, which make the pollution of the rivers worse, especially in the dry season. At the same time, the water temperature increases, so does the solubility of heavy metals. The precipitation in the river may re-dissolve releasing of pollutants which cause further deterioration of water quality. The increased concentration of various pollutants in water, such as various organic pollutants and heavy metals, may have an impact on aquatic products. China CDC The institution of nutrition carried out a long-term monitoring of aquatic products in the network of China's national food contaminants detection to get a view of its trend.

2.2.3. Higher water temperatures promote algal blooms such as Cyanophytes

Climate change leads to the rising of air and water temperatures, the excessive growth of algae and plankton. In recent years, the cyanobacteria occurring frequently in China, there are many lakes and river systems are facing the problem of microcystin(MC) which is proved to be a carcinogenic promoting agent. Therefore, the drinking water and aquatic products polluted by microcystin (MC) are huge threat for human health. Water is the main environmental media by which MC hazards the crowd, including drinking water daily and entertainment water in lakes, rivers. It may cause gastroenteritis, such as a gastroenteritis outbreak in a small town in Ohio of the United States in 1931. It was said that the outbreak may relate to algal blooms of cyanobacteria. And in Zimbabwe in Harare children gastroenteritis were epidemic each year when Microcystis aeruginosa dissipated in the reservoir water (Hilzfeld et al., 2000). Microcystin (microcystin, MC) exposure may cause liver damage. Studies have shown that the abnormal liver enzyme indicators of crowd serum, is not only due to infection by the hepatitis B virus, but also to the pollution of MC in drinking water (Lian et al.,2000).A survey focusing on the relationship between drinking water polluted by MC for long-term and primary liver cancer (PLC) increased morbidity show that the PLC incidence rates were 100.13/105 and 4.28/105 respectively for people drinking ditch water and well water. And water sample analysis shows that MC in ditch ponds was significantly higher than that of well water (Chen et al., 2002).

2.3 Others implications

Floods, storm and other extreme weather events may easily led to deterioration of normal clean water. The confluence of drinking water and sewage may pollute the well and surface water at the same time and led to the risk of water-borne disease. Especially in the densely populated low-lying areas, the prevalence of such diseases will be a greater risk. Meanwhile some micro-organisms may be rushed into the valley and accumulated in coastal. In 1997-1998, since the average daily rainfall in Peru, Ecuador, Argentina and Uganda were as high as 75-125 mm serious floods happened in these areas. The incidence of water-borne diseases highly increased. Referred to the weather-related diseases, some studies have shown that the incidence will increase by 8% per 1 ℃ increase in the temperature of atmosphere surrounding. In South Pacific region, there is positive correlation between an average temperature and the incidence of diarrhea. Another example is of Latin America and the Caribbean with different climatic zones. It is even more vulnerable in the face of natural disasters and climate change. In 1970-1999, 70 percent of the region's natural disasters were related to their special terrain and climate change. Flooding is the most serious and major disasters. In addition to the topography, population density could increase the vulnerability to climate change. In this region, about 60% of the population lives in coastal areas, 70% of the big cities locate in coastal areas. During 1970-1999, 30 natural disasters occurred including typhoons, floods, droughts and tsunami, which have increased water-borne diseases chance by various potential forms.

In addition to the above mentioned water pollution and drinking water security issues caused by drought or heavy rainfall (2.2.2), floods, drought and other extreme weather events, has also affect human health in stages adopted in many ways. It can be divided into short-term, medium-term and long-term effects. Short-term effect is the main casualties. Medium-term effect is the spread of infectious diseases and the increase of the incidence. Long-term effect includes the spirit of depression due to economic hardship and loss of life or property caused by floods, the increased malnutrition in crowd due to no harvest of grain production caused by drought, and also a variety of diseases caused by the lack of water.

In China, Flooding is a serious disaster. According to the 1950-2003 floods in statistics, as a result of the floods in annual national average level, there are 9,590,000 hectares of farmland hit by floods of which 5,390,000 hectares as disaster area and the disaster rate of 56%, 2,050,000 houses collapsed and 4962 population was killed. Along with the construction of the system of flood control projects, the number of casualties caused by floods was gradually reducing over the nearly 20 years.

Some areas of southern often subjected to severe flooding rains, while in the north the large-scale of drought often occur. According to the monthly precipitation data of 629 stations in China during 1950 -2000, some researchers analyzed the development trends and changes of floods in the southern China which is the south of Qinling Mountains and the Huaihe River. The study found a slight downward trend of the floods coverage area. And in the past 51 years, the most serious floods are in 1954. In 1983, 1998 and 1961 the situations are also serious. In November and December among the six winter months, there is strong growth trend of the floods coverage area. Particularly since the 1990s, the trend is even stronger and there is a rapid expansion of the scope of floods in January and March (Wang et al.,2005). In 1998, due to strong El Nino, the heavy rains and wide flood in China last for a long time which is the entire river basin flood. It is rare in history following the Yangtze River occurred in 1954. The situation is very serious in the areas along the river and lake, resulting in direct Economic losses amounting to more than 2000 billion Yuan.

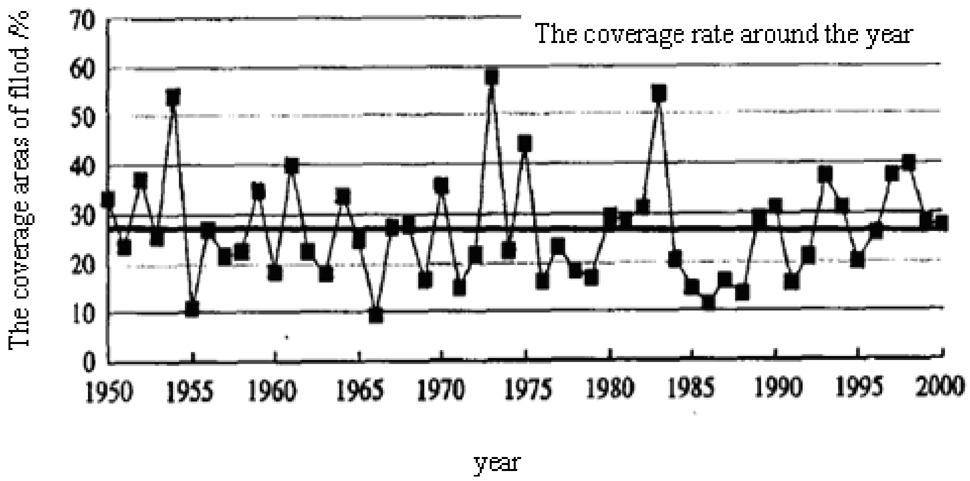


Fig.4-7 the coverage ratio of flood in interannual change from 1950 to 2000

It is reported that the strength of the typhoon is increasing and the frequency of strong typhoons is also getting higher due to climate change. 30 years ago, the frequency of strong typhoon in the world is only about 20%. And in 1990s the frequency of the strong typhoon has increased to 35%. In August 2005, the hurricane in the United States Katelila is more than the five-category hurricane, equivalent to more than 17 typhoons, which resulted in more than a thousand dead and more than 400 missing, more than 100,000,000,000 U.S. dollars of losses. In 2006 the Super Typhoon Saomai occurred in China and resulted in hundreds of deaths, which is the strongest typhoon since 1949 and the center of wind reached 17. These severe weather disasters have been great threat on people's lives and property and the development of the national economy.

In China, the drought is also a major problem. Before 1949, drought occurred once every 2 years in average. In the last 50 years, it is said that drought tends to increase gradually, especially since 1990s; the drought-hit region expands from the traditional northern and western regions to some wet areas in the south and east. In particular, the development of drought in northern China trends to worse significantly with average area of drought increasing and the expansion of the area in the extreme drought year. In 2000, there is severe drought in most regions in China, resulting in more than 4,000 million hectares of crops affected, with total destruction of 8,000,000 hectares, and led to more than 300 county-level cities and towns were forced to limit time-limited water supply. More than 2600 million people in total were affected. In some plains of eastern China, there is excessive extraction of ground water in shallow grave. Groundwater level has dropped to the current ten meters from 3-4 meters years several decades ago. It is said that there is water shortage in 60% of the cities, including 110 cities which are serious water shortage. It has to be noticed that the impact of drought on the economic and social is growing.

At the same time, the development trend of drought in northern China increases gradually nearly 50 years. The sizes of drought area both in average and in extreme drought year are expanded. In recent years, drought in north has also exacerbated. In 1997 and from 1999 to 2002, there are a number of areas for suffered drought continuously 5 to 6 years, leading to water shortages, environmental degradation ,loss of huge agricultural production and also many health problems, including death, malnutrition, infectious diseases and respiratory diseases, and many other damage. In the summer of 2007 there was serious drought in some parts of the Northeast. And in Jiangnan and Huanan, there was severe heat of late summer and the drought last from last summer to early winter. The drought was serious in large areas. In the early spring peak in May, the National drought-hit area is 14,390,000 hectares, 3,000,000 hectares more than the same period of year, result in 8,970,000 people and 7,520,000 animals have temporary difficulty in drinking water.

Section2 Gaps in knowledge

1. Strengthen the influence of water resources and related health effect caused by climate change

There is abundant evidence from observational records and climate projections that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change. However, the ability to quantify future changes in hydrological variables, and their impacts on systems and sectors, is limited by uncertainty at all stages of the assessment process. Uncertainty comes from the range of socio-economic development scenarios, the range of climate model projections for a given scenario, the downscaling of climate effects to local/regional scales, impacts assessments, and feedbacks from adaptation and mitigation activities. Limitations in observations and understanding restrict our current ability to reduce these uncertainties. Decision making needs to operate in the context of this uncertainty. Robust methods to assess risks based on these uncertainties are at an early stage of development.

Because of the uncertainties involved, probabilistic approaches are required to enable water managers to undertake analyses of risk under climate change. Techniques are being developed to construct probability distributions of specified outcomes. Further development of this research, and of techniques to communicate the results, as well as their application to the user community, are required.

Further work on detection and attribution of present-day hydrological changes is required; in particular, changes in water resources and in the occurrence of extreme events. As part of this effort, the development of indicators of climate change impacts on freshwater, and operational systems to monitor them, are required.

Climate change impacts on water quality and human health issues are poorly understood, particularly with respect to the impact of extreme events. There are several researches based on El Nino and climate-related events, try to study the relationship between the heavy rainfall/floods and infectious diseases (Thomas et al., 2006). Floods, storm and other extreme weather events may easily led to deterioration of normal clean water. The confluence of drinking water and sewage may pollute the well and surface water at the same time and led to the risk of water-borne disease. Especially in the densely populated low-lying areas, the prevalence of such diseases will be a greater risk. Meanwhile some micro-organisms may be rushed into the valley and accumulated in coastal. In 1997-1998, El Nino led to serious floods in Peru, Ecuador, Argentina and Uganda. Since the average daily rainfall in these areas was as high as 75-125 mm along with the surrounding atmosphere and ocean temperature changes, the incidence of water-borne diseases highly increased. Referred to the weather-related diseases, some studies have shown that the incidence will increase by 8% per 1 ℃ increase in the temperature of atmosphere surrounding. In South Pacific region, there is positive correlation between an average temperature and the incidence of diarrhea. Another example is the outbreak of E. coli in Walkerton, Ontario, Canada in May 2000. As the result of the infection of a municipal water system with microbiological pathogens (E.coli), 7 people died and 2,300 people get sick. The pollution was likely caused by the extra-ordinary high level rainfall occurred over a four to five days. And the identified source of the pathogen was manure spread on a nearby field in accordance with best practices and leaching through a shallow well into the water supply system. It is recognized the increasing frequency of extreme rainfall events resulting from climate changes as having long-term impacts for quality and quantity of drinking water sources. The similar research in China is still limited. Most of the researches in this field refer to climate change (temperature and humidity) and water-borne diseases (such as Schistosoma, cholera, leptospirosis and others). Further work on study of Climate change on water resources and the impact of the disease will need the interdisciplinary cooperation among medical scientists, epidemiologists, meteorologists, biologists, mathematicians, Sociology and others. At the same time, it is important to focus on study of water quality and climate-related health problems to make sure the safety and protection of human health.

2 Lack of the perfect information shared system

Further developing the research work of climate change on water resources and health effects will need multi-disciplinary and multi-sectoral cooperation and the sharing of information resources. Take the water quality monitoring in China as an example, the Ministry of Construction, Ministry of Water Resources, Environmental Protection Department and the Ministry of Health segregate the duties in accordance with its level of the water quality monitoring, such as sharing information, but the system is still not perfect, because it is lack of appropriate information exchange platform, mainly related to the lags behind legislation of sharing information resources in China, technical standards are imperfect, some departments of local information is still in a limited extent. In recent years, China's information technology construction has made significant progress, but the development and utilization of information resources is still far behind the network infrastructure and application systems. All of these have constrained the development and utilization of information resources, as well as the comprehensive benefits of information technology. For these problems and difficulties, both need to attract further attention.

Section 3 Adaptation measures and suggestions for future work

In China, it is not only a lack of water resources, but also a fragile water resources system. It is often subjected to severe floods, drought, which led to greater economic damage. Affected by climate change, the change of the water resources of system including the quality and quantity, may lead to the change of water supply, demand and management, the occurring frequency of drought, floods and other natural disasters, and the increasing vulnerability of water systems. The in-depth study of climate change on water resources and related health effects in China is necessary for the scientific management of water resources and the deployment of a reasonable, safe drinking water to protect and promote human health. It is also provide scientific and technological support for sustainable use of water resources and protection of human health. Refers to climate change on water resources, some planned adaptation is already occurring on a limited basis in the international such as expanded rainwater harvesting; water storage and conservation techniques, water reuse, desalination, water-use and irrigation efficiency, safety drinking water and improvement of sanitation**.** And the key policy framework includes National water policies and integrated water resources management; water-related hazards management.

3.1 Adaptation measures

3.1.1 Related policies to improve water resources management system

China's government has always attached importance to the protection of water bodies, in particular the control of water pollution to ensure the safety of drinking water. There is a series of laws and regulations and standards:

(1) Law of the People's Republic of China on Prevention and Control of Water Pollution (amend in February 2008)

(2) Environmental quality standards for surface water (GB3838-2002)

(3) Integrated wastewater discharge standard (GB8978-1996)

(4) Hygienic standard for drinking water (GB5749-2006)

(5) Measures concerning supervision of drinking water (in 1996)

3. 1.2 Water conservancy

To deal with the impact of climate change on freshwater, there are several water resources projects carried out such as the Three Gorges Project Corporation and South-to-North water diversion project. It is benefit for reducing the vulnerability of water resource impacted by climate change especially improving the ability to adapt to the change of water availability.

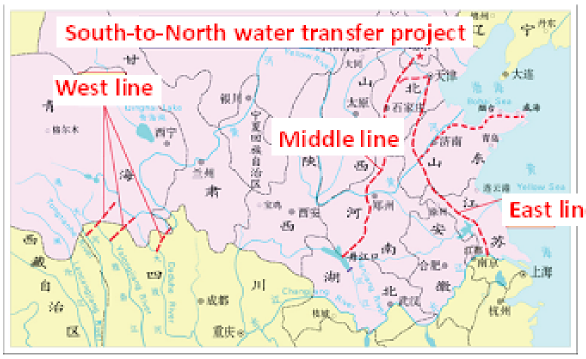


Fig 6-7 the total distribution of South-to-North Water Diversion Project

The total distribution of South-to-North Water Diversion Project is: divert water from the Yangtze River upstream, midstream and downstream in order to adapt to the development needs of the northwest, north

China, that is, the West line, the midline and the east line of South-North Water Diversion Project. South-North Water Diversion Project at the eastern, central and west three water diversion lines. After the completion, it will linked with the Yangtze, Huaihe River, Yellow River, Haihe form the overall pattern of China's water resources that is "three vertical and four horizontal, the deployment of the North and the South East and West each other relief".

3.1. 3 Surveillance and Investigation of Drinking Water

From 1983 to 1988, the National Organization of Patriotic Health and the Ministry of Health in carrying out a national drinking water quality and water-borne disease investigation, published the "Atlas of China's Drinking Water."
In 1992, China implement rural drinking water quality in the health monitoring, through the efforts of more than ten years, initially establish the monitoring network of China's rural drinking water quality.

July 2006 -2007 in November, the National Patriotic Health Campaign Committee, the Ministry of Health jointly organized a investigation of national rural drinking water and sanitation status, so carry out large-scale survey research aimed at rural areas drinking water and sanitation. Chinese Center for Disease Control and Prevention technical guidance of rural water (Water-improving Center) and the Ministry of Health Statistical Information Center take for the technical work to guide the investigation. Survey in 31 provinces, autonomous regions and municipalities and Xinjiang Production and Construction Corps, using a stratified random method, totally investigating 657 counties, 6590 villages, 65839 families. Survey content includes the basic situation of the rural drinking water, drinking water sample testing, lavatories rebuilding and excreta disposal in rural areas and the release of rural waste, sewage and so on.

In 2007, the Ministry of Health organized the monitoring experimental network of urban drinking water health, the Chinese Center for Disease Control and Prevention on Environment and health related products is responsible for the safety of technical work, selecting Beijing, Heilongjiang, Shanghai, Jiangsu, Zhejiang , Hunan and Guangdong seven provinces and cities pilot projects, establishing drinking water quality monitoring and water-borne diseases surveillance spot, including the municipal water supply treated water units, peripheral water and secondary water supply quality monitoring, self-built water supply facilities, the local Water-borne disease-related data collection and water-borne disease surveillance. In August 2008, urban drinking water health monitoring network increase including Hebei, Jilin, Fujian, Sichuan, Chongqing, Gansu, Qinghai and Ningxia Hui Autonomous Region, the expansion of the pilot regions to 15 provinces and municipalities.

In February 2008 the National Patriotic Health Office is responsible for organizing the Monitoring of National Rural Drinking Water Quality Health, Chinese Center for Disease Control and Prevention of rural water-improving technology center provides technical support. In 31 provinces, municipalities and autonomous regions and Xinjiang Production and Construction Corps of the county to select a representative monitoring points and to carry out monitoring of drinking water quality, and monitoring of infectious diseases, through the surveillance network of infectious and the surveillance network of all causes of death, so as to collect he information of water-borne diseases occurrence of epidemic-related disease in rural areas.

3.1.4 The implementation of water safety plans

A "water safety plans" pilot training aimed at strengthening the security of water supply which is organize by World Health Organization, was carried on in Tianjin, Shenzhen and Zhongwei city in Ningxia in December 2005. It is said that the "water safety plans" pilot training was jointly organized by the World Health Organization, the Chinese Ministry of Construction, Ministry of Health, and other organizations. The experts of the World Health Organization, the State Ministry of Construction, Ministry of Health, the International Association of water, gave training to the officials and staff of the three pilot cities. The pilot units reported a specific guidance developed in line with international standards of “water safety plans” in 2006. “China's urban water supply safety and security plan” is part of "water safety plans" project in developing countries which aims to ensure the safety of drinking water and to promote the ability of the urban water supply system to deal with "sudden events" and take security of water supply into safety management of the city areas.

3.2 suggestions for future work

3.2.1 Strengthen monitoring and early warning

Early-warning monitoring includes climate monitoring, water quality monitoring and monitoring of water-borne diseases. Ideally, these three areas should combine together. In practice, it may not be easy. In this case, the most important thing is to connect different aspects of data. So that decision-makers obtain enough information in a given period of time to minimize human health hazard result from climate change.

3.2.2 Strengthen water and sanitation infrastructure

In addition, natural disasters and other effects result from climate change may lead to the increasing demand of water. More efficient management of infrastructure construction should be taken to make sure water environment and water sanitation suitable for growing needs and protect water environment from pollution in extreme weather events. To improve the hardware facilities (such as wells, toilets and sewage systems), it should be noticed that infrastructure construction and maintenance of the latter part of the social needs the active participation of all parties. In addition, all people should have access to improved water environment and water sanitation, especially in rural areas. The science of climate change should be planned to promote the sustainable development of the system. In order to ensure the sustainability of development, the potential impacts of climate change requires a clear definition. In addition, it is aware of the need for emergency plans to deal with the interruption of water environmental sanitation situation to ensure the resumption after a major event.

3.2.3 Strengthen the management of freshwater resources

While uncertainties involved in the impact of global climate change on freshwater resources, probabilistic approaches are required to enable water managers to undertake analyses of risk under climate change in global. It becomes a global consensus that effective management is benefit for sustainable use of water resources, protection of economic and social sustainable development. In China, climate change could cause tension in the supply of fresh water had to face a more severe situation. Therefore, the improvement of water resources focus on more effectively manage and use of freshwater resources, further control of water pollution, a fair share of water resources and construction of large-scale water conservancy projects. The communion and cooperation with international organization could improve the management and technological of water resources in China. It is important to establish a scientific mechanism for optimizing the allocation of water resources, and an effective management for improving efficiency of water use.

Chapter 5 Climate Change and Air Quality

With the fast development of industrialization and urbanization, the species and concentrations of indoor and outdoor air pollutants have increased significantly. Atmospheric pollutants may decrease the solar radiation received by the earth's surface, increase the rainfall and atmospheric temperature, accelerate the forming of acid rain, affect the growth of plants, and further affect the climate. Since the 20th century, the emission of greenhouse gas increase rapidly, followed by worsened greenhouse effects, which may lead to continuous warming of global climate. Accordingly, the atmospheric circumfluence may be affected by the changed climate, wind speed, direction and relative humidity may change, thereby affect the diffusion of air pollutants, and threaten the human health.

Section 1 Overview of Present Situation

1 Climate change and air quality

According to the Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC), climate change is really true and the key reason leading to global warming is the mankind’s activity. Human-caused climate change has resulted primarily from changes in the amounts of greenhouse gases in the atmosphere, but also from changes in small particles (aerosols), as well as from changes in land use.

1.1 The impact of air quality on the climate change

Human activities result in emissions of four principal greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time. Significant increases in all of these gases have occurred in the Industrial Times (Fig.5-1). With economic development, global greenhouse gas (GHG) emissions due to energy consumption (Fig.5-2,5-3) have grown quickly, with an increase of 70% between 1970 and 2004.Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions have grown between 1970 and 2004 by about 80% (Fig.5-4). Fig.5-5 shows the percent of carbon dioxide emissions in different countries, 2003.The Chinese government has always concerned about the issue of greenhouse gas emissions. From 1994 to 2004, the annual average growth rate of GHG emissions in china is around 4%, and the share of CO_2 in total GHG emissions increased from 76% to 83%. China's total GHG emissions in 1994 are 4,060 million tons of CO_2 equivalent (3,650 million tons of net emissions), of which 3,070 million tons of CO_2, 730 million tons of CO_2 equivalent (tCO_2e) of CH_4 and 260 million tCO_2e of N_2O. According to tentative estimates by experts from China, China's total GHG emission in 2004 is about 6,100 tCO_2e (5,600 million tons of net emissions), of which 5,050 million tons of CO_2, 720million tCO_2e of CH_4 and 330 million tCO_2e of N_2O. Energy Information Administration (EIA) U.S. prognosticates that world marketed energy consumption and carbon dioxide emissions are projected to increase by 50 percent from 2005 to 2030.

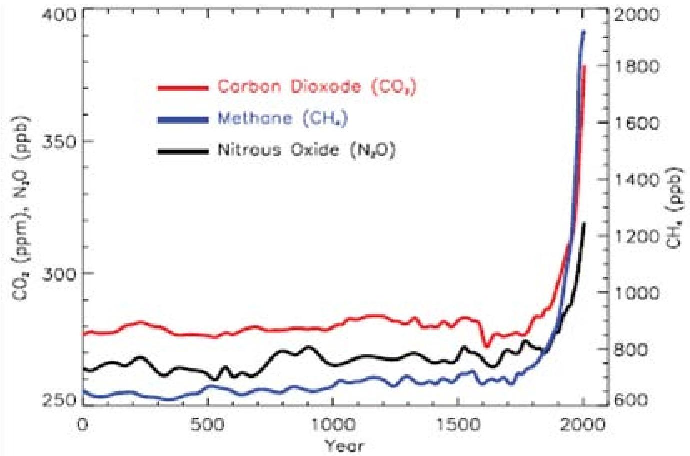


Fig.5-1. Atmospheric concentrations of important long-lived greenhouse gases over the last 2000 years

(From: Climate Change 2007: The Physical Science Basis)

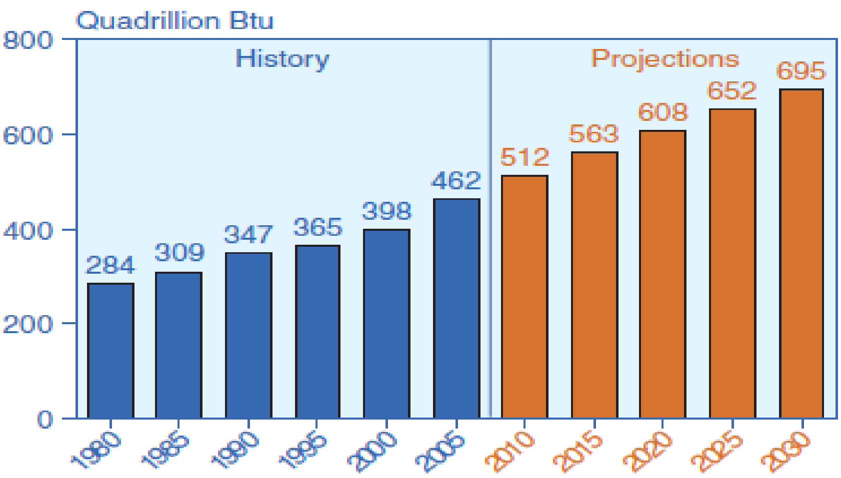


Fig.5-2. World marketed energy consumption,1980-2030

（From： International energy outlook,2008）

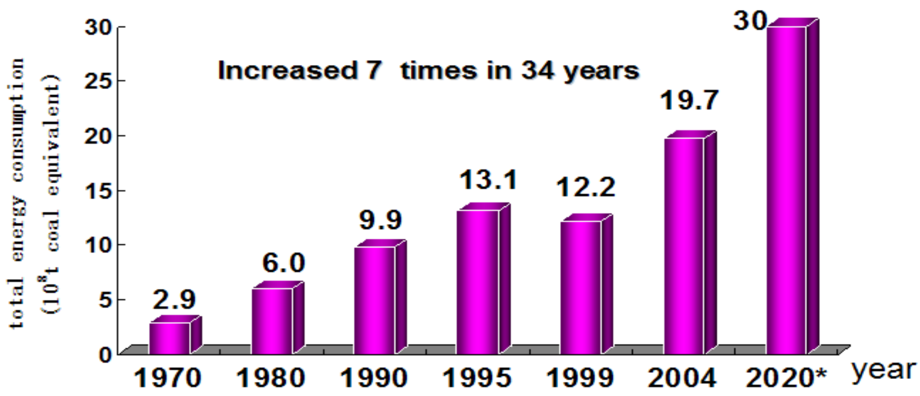


Fig.5-3 The total energy consumption in China from 1970 to 2004

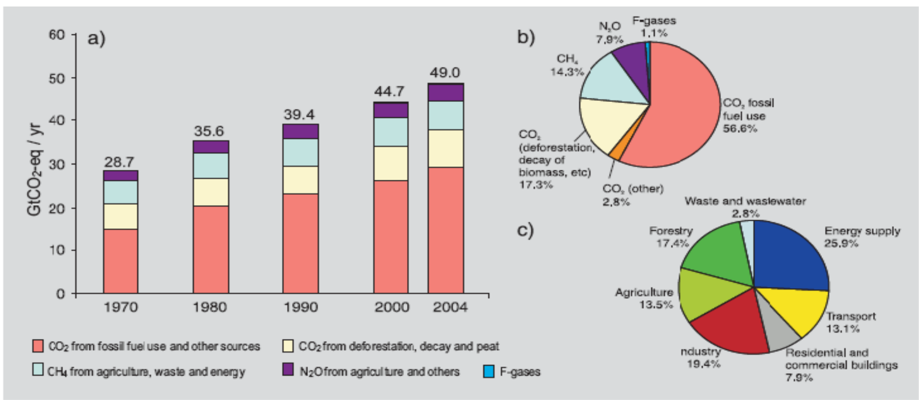


Figure 2.1. (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004.[5] (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO_2-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO_2-eq. (Forestry includes deforestation.) {WGIII Figures TS.1a, TS.1b, TS.2b}

Fig. 5-4 Global anthropogenic GHG emissions

（From: Climate Change 2007:Synthesis Report）

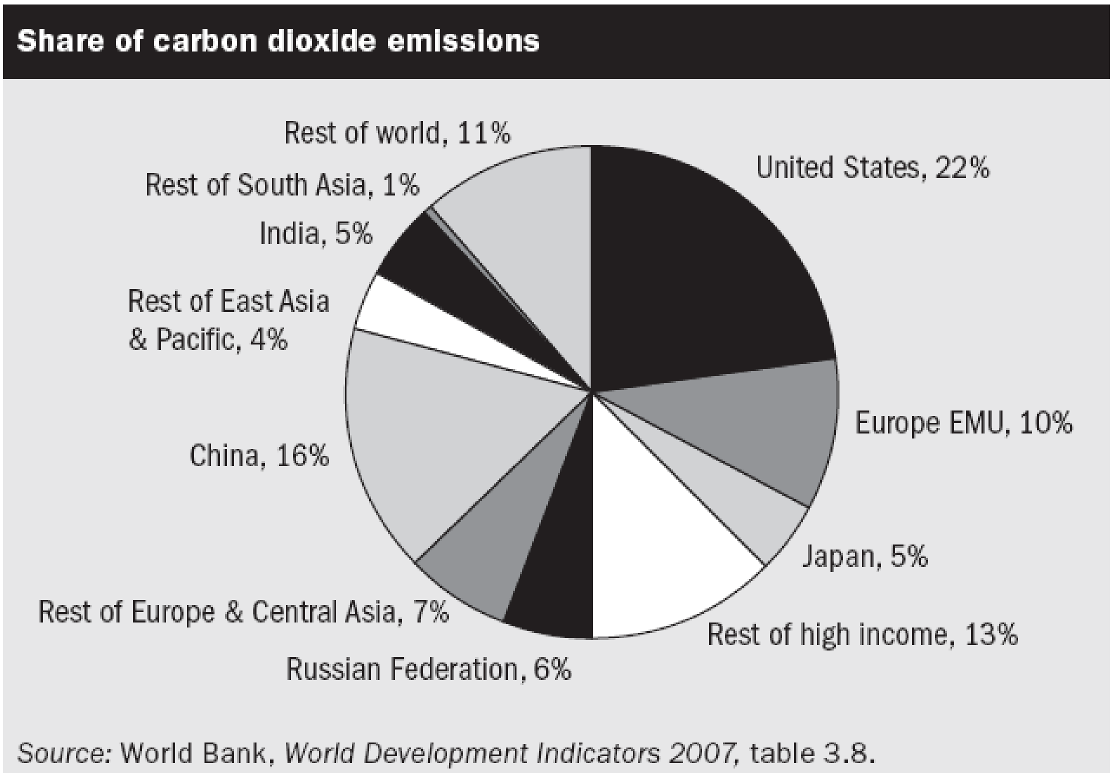


Fig.5-5 Global distribution of carbon dioxide emissions, 2003

There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades. Baseline emissions scenarios published since the IPCC Special Report on Emissions Scenarios (SRES, 2000) are comparable in range to those presented in SRES. The SRES scenarios project an increase of baseline global GHG emissions by a range of 9.7 to 36.7 $GtCO_2$-eq (25 to 90%) between 2000 and 2030(Fig. 5-6).

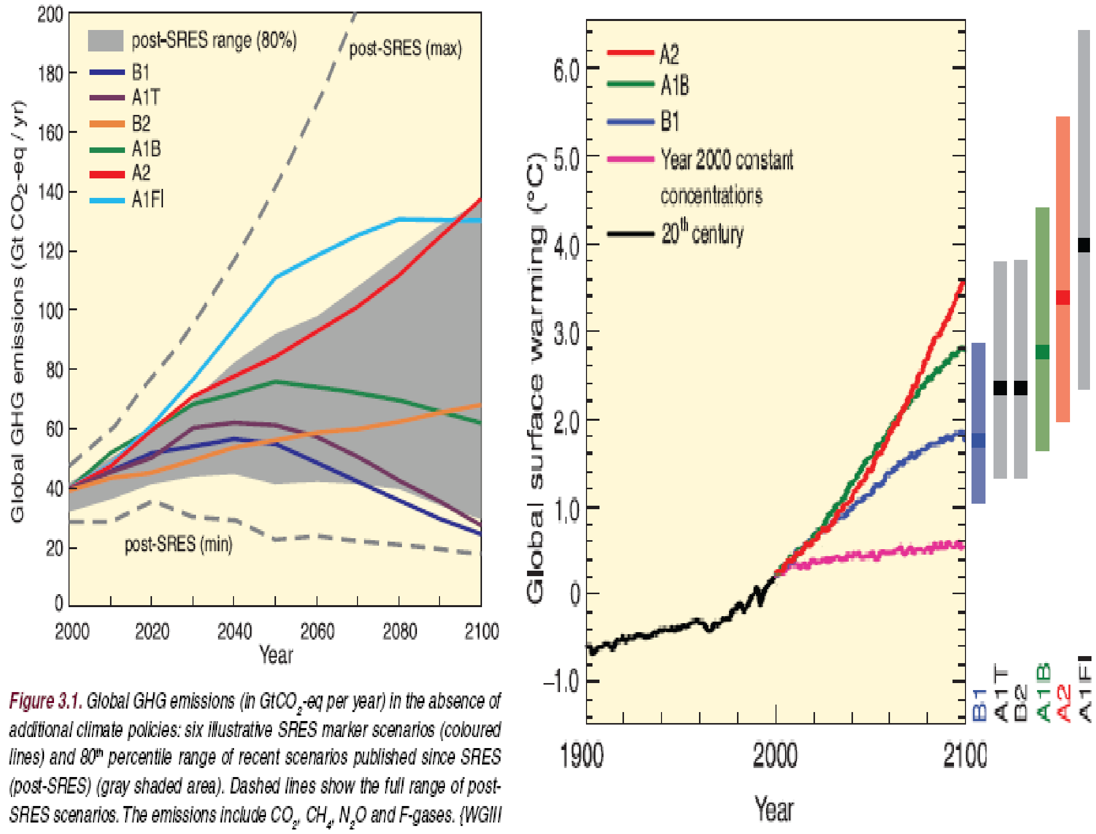


Fig. 5-6 Scenarios for GHG emissions from 2000 to 2100 in the absence of additional climate policies

（From: Climate Change 2007: Synthesis Report）

Fossil fuel and biomass burning have increased aerosols containing sulphur compounds, organic compounds and black carbon (soot). Human activities such as surface mining and industrial processes have increased dust in the atmosphere, which impact the concentration of aerosol. Aerosol particles influence radiative forcing directly through reflection and absorption of solar and infrared radiation in the atmosphere.

The Sun powers Earth’s climate, radiating energy at very short wavelengths, predominately in the visible or near-visible (e.g., ultraviolet) part of the spectrum. Roughly one-third of the solar energy that reaches the top of Earth’s atmosphere is reflected directly back to space. The remaining two-thirds is absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. It radiates primarily in the infrared part of the spectrum(Fig. 5-7). Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, including clouds, and reradiated back to Earth. This is called the greenhouse effect. And thus have an impact on climate change.

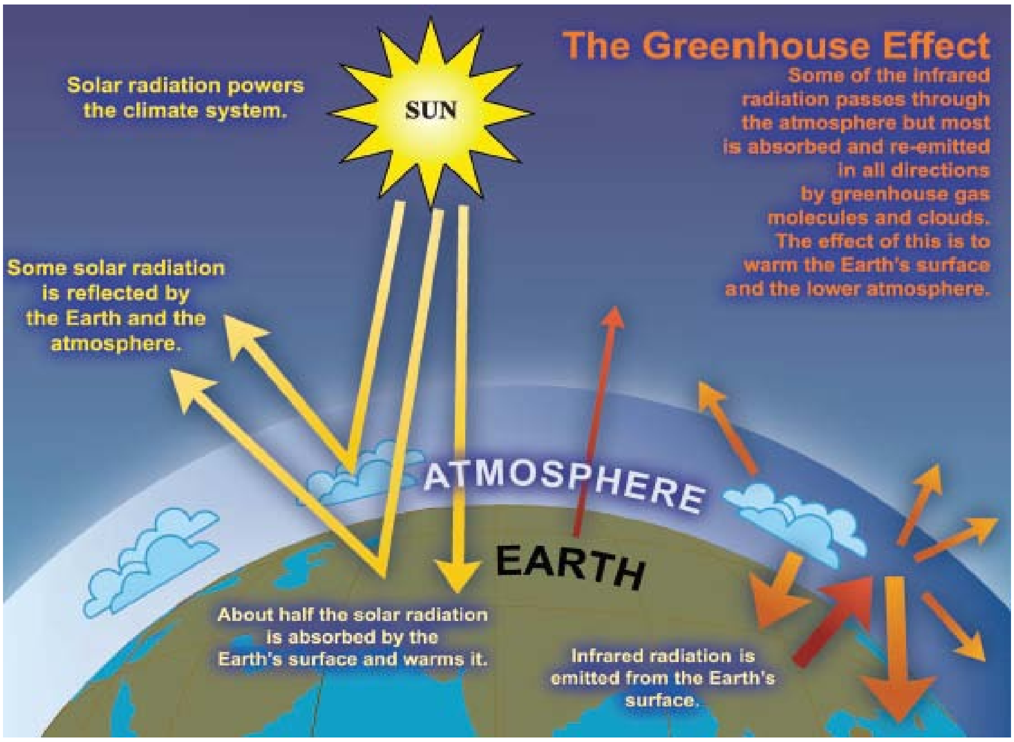


Fig.5-7. An idealized model of the natural greenhouse effect

（From：Climate Change 2007: The Physical Science Basis）

1.2 The impact of climate change on the air quality

1.2.1 Impacts on the outside atmospheric quality

Air pollution is an important factor for the global weather conditions and climate change, greenhouse gases, aerosols and cloud cover are the main reasons for climate change. However, climate change, in turn, also has a certain impact on air quality. Climate change could affect local to regional air quality through changes in chemical reaction rates, boundary layer heights that affect vertical mixing of pollutants, and changes in synoptic airflow patterns that govern pollutant transport.

Climate change could affect both average and peak air pollution levels. For example, background concentrations of ground-level ozone (a pollutant that irritates the lungs and makes breathing difficult) are expected to increase over mid-latitudes due, in part, to higher temperatures, whereas intense smog episodes are projected to become more frequent during summer months as a result of climate change. Global warming will exacerbate the surface evaporation, the ability of atmosphere to maintain the moisture will be enhanced; this will affect the concentration of air pollution through rainfall wind speed, humidity and other weather conditions. Higher summer temperatures are also likely to increase energy consumption for cooling, thereby adding to pollution emissions. Emissions from power plants increase substantially during heat waves, when air conditioning use peaks. Weekday emissions of nitrogen oxides (NO_X) from selected power plants in California more than doubled on days when daily maximum temperatures climbed from 75°F to 95°F in July, August, and September of 2004(Drechsler DM et al., 2006).

1.2.1.1 The impact on the concentration of air pollutants

Concentrations of air pollutants in general and fine particulate matter (PM) in particular, may change in response to climate change because their formation depends, in part, on temperature and humidity. Air-pollution concentrations are the result of interactions between variations in the physical and dynamic properties of the atmosphere on time-scales from hours to days, atmospheric circulation features, wind, topography and energy use (Wu et al.,2001). Some air pollutants demonstrate weather-related seasonal cycles. Weather at all time scales determines the development, transport, dispersion and deposition of air pollutants, with the passage of fronts, cyclonic and anticyclonic systems and their associated air masses being of particular importance. Air pollution episodes are often associated with stationary or slowly migrating anticyclonic or high pressure systems, which reduce pollution dispersion and diffusion（Rao et al.,2003). For example, certain weather patterns enhance the development of the urban heat island (Jonsson et al.,2004), the intensity of which may be important for secondary chemical reactions within the urban atmosphere, leading to elevated levels of some pollutants.

Use of the average concentration of pollutants with the meteorological in the ground data in 2004 at the same period of Zibo, Shandong Province, China, it showed that: the concentration of air pollutants and the surface pressure had good positive correlation, the concentration of air pollutants and the rainfall amount had good negative correlation, especially PM10 (Zhu et al.,2007). Liu guicai studied the relation of weather style, air pollution in Weifang. The result showed precipitation could reduce air pollution significantly and PM10 particulate level is very high during foggy days. As some of the air pollutant, especially SO_2 dissolves in water, and result in low measurement reading thus does not reflect the actual pollution level. The increase in wind-speed results in reduction of pollutant concentration.

1.2.1.2 The impact on the ozone

1) The impact on the stratospheric ozone

Ozonosphere (O_3) distribute in aerosphere 10-15km above the earth. Its center of gravity is about 25 km from the earth surface. The ozonosphere can gather the heat source in the stratospheric and obstruct the radiation of the sun's rays under 29A°. It is important for mankind and creature. The existence of the ozonosphere affects directly the temperature structure of the stratospheric. So the ozonosphere is very important for maintaining the climate stabilization and the existing living environment in the world. The excess emission of greenhouse gases can damage the ozonosphere which can protect the plants and animals on the earth from hurting by ultraviolet light. As shown in Figure 5-8, the amount of stratospheric ozone has decreased over the past few decades, particularly in the Antarctic. The largest decreases since 1980 have been observed over the Antarctic during the spring.

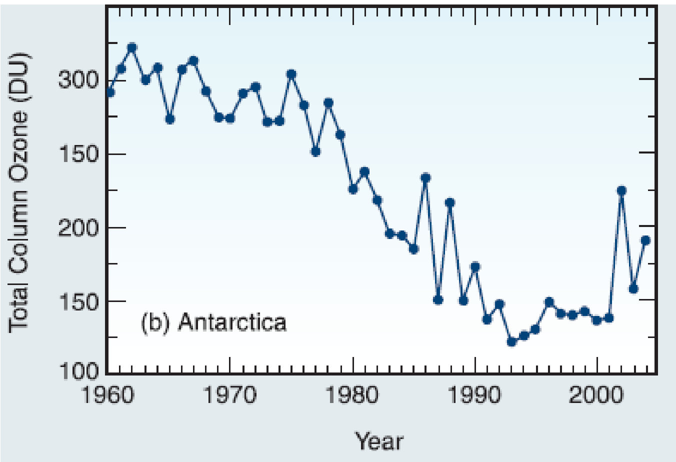


Fig.5-8 October mean total column ozone measurements from the Dobson spectrophotometer at Halley, Antarctica

The phenomenon of the ozonosphere low valley in the sky of Tibetan Plateau in summer has drawn great attention of the world. If let it be, the sky of the world ridge will appear the third ozone hole in the world following the South and North Pole.

2) The impact on the ground-level ozone

Ground-level ozone is both naturally occurring and, as the primary constituent of urban smog, is also a secondary pollutant formed through photochemical reactions involving nitrogen oxides and volatile organic compounds in the presence of bright sunshine with high temperatures. Temperature, wind, solar radiation, atmospheric moisture, venting and mixing affect both the emissions of ozone precursors and the production of ozone (Mott et al.,2005). Because of warming, the concentrations of ground-level ozone are increasing in some regions (Chen et al.,2004). There is a direct correlation between temperature and O_3 level (Bernard et al.,2001)(Fig.5-9).

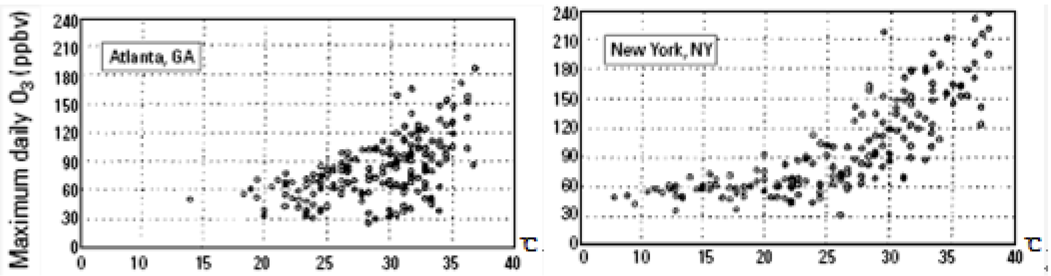


Fig.5-9 Maximum daily O_3 concentrations in Atlanta, and New York, versus maximum daily temperature, May-October, 1988-1990

1.2.1.3 Effects on microorganism pollution

Microorganisms in the atmosphere include the bacteria, epiphyte, virus and protobe. Climate warming is propitious to the prevalence of heat related diseases. The reproduction rate and spread velocity of pathogens may be both accelerated with global warming. Meteorological factors, which can influence the content of microorganisms, include temperature, relative humidity and wind speed. The content of atmospheric microorganisms increases with the increased temperature and accelerated wind speed, and decreases with the increase of relative humidity (Chen,1998). Moreover, a study in China found some association between atmospheric microorganism content and air monitoring indexes, there was significant positive correlation between the atmospheric microorganism content and PM10 concentration (Fang et al.,2002).

1.2.1.4 The impact on the sandstorms

Changes in wind patterns and increased desertification may increase the long-range transport of air pollutants. Under certain atmospheric circulation conditions, the transport of pollutants, including aerosols, carbon monoxide, ozone, desert dust, mould spores and pesticides, may occur over large distances and over time-scales typically of 4-6 days. China is one of the countries which affected by sandstorms seriously. Sandstorms usually occur in north China, especially in the northwest. Climate conditions such as drought, temperature and wind have impact on the dust storms. For almost half a century, the scope of the sandstorms impact in China decreased (Fig.5-10). For almost half a century, the scope of the sandstorms impact in China decreased, in the late 1950s and 70s dust storms occur more frequently, since 80s dust storms was tapering off, but sine 1997 the total days of storms have an upward trend, the frequency become higher and the scope spread wider(Zhou et al.,2003).

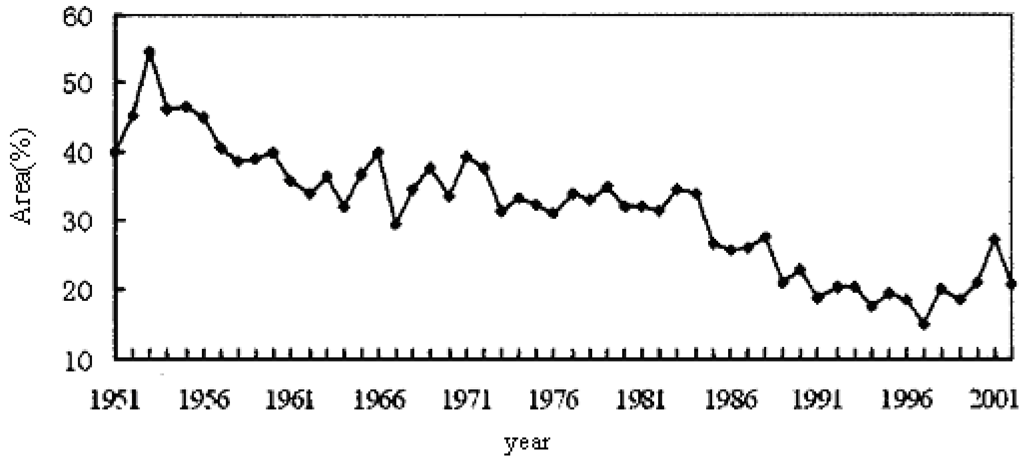


Fig.5-10 The change of sandstorms effect in 1951-2002

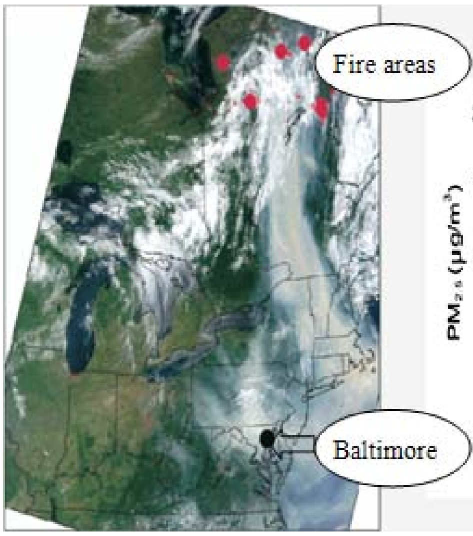
Typical strong storms in north China reduce nearly half a century, Meteorological records show that the increase or decrease of spring winds accord with the increase or decrease of dust storms in nearly 40 years(Shang et al.,1998). But storms are showing a tendency to increase in recent years, which may be related to the continuing drought sine 1997. Study in Beijing has shown a great relationship between air quality decline and sand storm. Sand storm won't have any great impact on the concentration of SO_2 and NO_2, but leads to the daily average concentration of PM_{10} rapidly rise, causing serious air pollution (Ning et al.,2005). Based on the data of daily monitoring of PM10 concentrations and daily meteorological observation in Lanzhou City, Liu Shumin et al (Liu et al.,2008) analyzed the seasonal characteristics of heavy pollution of PM10, highlighting spring and winter. Results indicated that the seasonal pollution largely depends on the meteorological conditions, e.g., the close-to ground inversion temperature stratification in winter, which restrains pollution diffusion.

1.2.1.5 Other impacts

In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of fire events. A number of researches show that the climate change will cause a longer fire season and more extreme fire weather, which make more fire activities. Especially fires in boreal forest will increase significantly

(Tian et al.,2006).Forest and bush fires cause burns, damage from smoke inhalation and other injuries. Toxic gaseous and particulate air pollutants are released into the atmosphere, which can significantly contribute to acute and chronic illnesses of the respiratory system, particularly in children, including pneumonia, upper respiratory diseases, asthma and chronic obstructive pulmonary diseases (WHO,2002). Pollutants from forest fires can affect air quality for thousands of kilometers (Sapkota et al.,2005).

Fig. 5-11 is a satellite image showing long-range transport of smoke over 1000 km (620 miles) from northern Quebec, Canada, to the city of Baltimore MD, on the east coast of the U.S. A corresponding time series of $PM_{2.5}$ concentrations in Baltimore clearly shows the impact of this event (Patrick 2008) (Fig. 5-12).



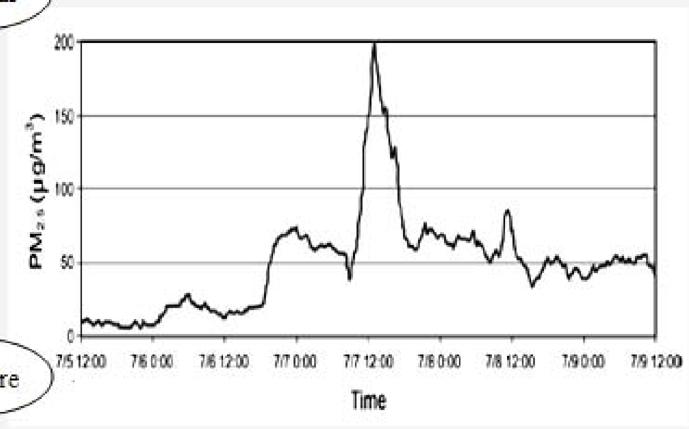


Fig.5-11 Satellite image taken July 7, 2002, 10:35

Fig.5-12 Outdoor $PM_{2.5}$ concentrations in Baltimore before, during, and after July 7, 2002

With the multiple effects of global warming, rapid development of economy and urbanization, haze and frog disasters pose more complex and rigorous impacts to China. The frequency of Haze day with turbid air shows a continuous and significant increasing trend. When it comes to the 21st century, the trend became more obvious.

From 2003 to 2006, the frequency of haze maintained the top record since 1961.Under the weather of haze, the fluidity of air is very bad, but it’s good for the invasion of pathogens attached on suspended pollutants to human body and cause respiratory apparatus infection. On the other hand, haze can weaken the ultra-violet near stratum, thus, reduce sterilization capacity, enhance the activities of infectious pathogens, cause the diffusion of many infectious diseases, and finally result in public health events.

1.2.2 Impact on indoor air pollution

1) With the improvement of economic development, interior decoration has been very popular, construction and decoration materials, furniture, and household chemicals and so on, have become the city's main indoor air pollution sources. Indoor micro-climate is closely related to the concentration of indoor pollutants.

Studies have shown that temperature is an important environmental factor that affects coatings and paints release volatile organic compounds, a confined environment of temperature and relative humidity is an important environmental factor that affects the rate of precipitation wall radon. After indoor decoration, the concentration of formaldehydeis also closely linked to the temperature and humidity. Indoor micro-climate and outdoor climate is also closely related to climate. In addition, the use of air conditioner may also cause the change of indoor micro-climate. With the background of global warming, there are more and more "stove" whether in summer, large-scale use of air-conditioners makes enhancements confined housing, that is not conducive to indoor pollutants’ discharging, and at the same time, the outdoor air temperature increases.

2) The impact of climate change on indoor air quality in rural area is also obvious, In countryside of China, indoor air pollution is mainly caused by coal burning and accompanied with fluorine and arsenic in some places. Climate change can directly affect the consumption of fuels and thus affect indoor air quality.

3) On the other hand, with the improvement of country dwellers' life level, new constructional and decoration materials are used in farmer houses. This factor may also cause indoor air pollution, but up to now, research on house fitment caused pollution is few.

2 Health effect

There is a great relationship between air pollution and weather conditions. In the context of climate change, the abnormal weather, such as summer heat, winter warming, drought, etc., often emerge, which causes the bad air quality. Especially in the big cities, due to the urban heat island, air pollutants hardly diffuse, which cause serious pollution. Pollutants entered the human body will cause the discomfort reaction of sense and physiological function, result in sub-clinical and pathological changes, clinical signs or the potential genetic effects, occur acute or chronic poisoning or death.

2.1. International perspective

2.1.1 Health effect of ozone

1) Health effect of ozone in stratospheric

The chlorofluorocarbon in the greenhouse gases has tremendous destructiveness to the ozonosphere. The increase of the ultraviolet radiation, especially UV-B, due to the depletion of ozonosphere, can cause the skin cancer, accelerate aging and enhance the morbidity of the skin cancer, cataract and snow blindness. The statistics results of 1971-1972 and 1977-1978 in the United States showed that, along with the increasing of the sun radiation index, the morbidity of skin cancer in white people obviously increased.

2) Health effect of ground-level ozone

Climate warming will speed up the rate of photochemical reaction between chemical pollutants, resulting in an increase of photochemical oxidants. Ozone is the main component of photochemical smog. Exposure to elevated concentrations of ozone is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, allergic rhinitis, and other respiratory diseases, and with premature mortality. Although a considerable amount is known about the health effects of ozone in Europe and North America, few studies have been conducted in other regions.

2.1.2 Allergic reaction

Recent increases in CO_2 have already stimulated plant growth, and projected future increases will continue to do so. However, CO_2 does not discriminate between desirable (e.g., wheat, rice, and forest trees) and undesirable (e.g., ragweed, poison ivy) plant species with respect to human systems. More than 100 different plant species are associated with contact dermatitis, an immune-mediated skin inflammation. Global warming has been shown to increase pollen production of western ragweed by 84 %(Wan et al,2002), and is making the pollen season last longer and attracting insects.

Global warming is making pollen seasons last longer, creating more ozone in the air, and even expanding the areas where insects flourish, putting more people with bee allergies at greater risk.

One of the most common plant-induced health effects is related to aerobiology. Plant-based respiratory allergies are experienced by approximately 30 million people within the United States. Symptoms include sneezing, inflammation of nasal and conjunctival membranes, and wheezing. Complicating factors, including nasal polyps or secondary infections of the ears, nose, and throat, may also occur. Severe complications include asthma, cardiac distress, chronic obstructive pulmonary disease, and anaphylaxis (Gergen et al,1987). The influence of climate change on symptoms of respiratory allergy is still unpredictable. Two opposite effects could be relevant. On the one hand, global warming could increase the length and severity of the pollen season and, as a consequence, of pollen allergy. Moreover, the overall effects on health-related air pollutants seem favorable to an increase in urban air pollution episodes. On the other hand, increases in the earth’s temperature could reduce the effects of cold air on asthma and rhinitis, also making patients less susceptible to upper respiratory infections.

More subtle interactions regarding plants may be related to indirect effects of CO_2 on fungal decomposition. The fungus is also an important source of allergens. For example, increasing CO_2 concentration resulted in a 4-fold increase in airborne fungal propagules, mostly spores (Klironomos et al,1997). The link between spore formation, potential changes in allergenicity of the spores, and the mechanism associated with spore release in the context of elevated CO_2 has not been entirely elucidated.

2.1.3 Effects on air-borne diseases

Microorganisms in the atmosphere include the bacteria, epiphyte, virus and phage. Climate warming is propitious to the prevalence of heat related diseases. The reproduction rate and spread velocity of pathogens may be both accelerated with global warming. Meteorological factors, which can influence the content of microorganisms, include temperature, relative humidity and wind speed. The content of atmospheric microorganism increases with the increased temperature and accelerated wind speed, and decreases with the increasing of relative humidity. Moreover, a study in China found some association between atmospheric microorganism content and air monitoring indexes, there was significant positive correlation between the atmospheric microorganism content and PM_{10} concentration. As the carrier of atmospheric microbial, PM_{10} has become one of important factors to air-borne diseases.

2.1.4 Other effects

Climate change will cause weather factors, such as pressure, flow to change, at the same time, global warming will further aggravate the urban heat island effect, and impact the distribution, proliferation of atmospheric pollutants, such as SO_2, NO_X, PM, then increase the health effects of air pollutants.

Most studies on health impacts of climate change are about weather conditions, and are rarely about climate change in the strict sense. Meanwhile, the effective quantitative models are so scarce used to evaluate the relationship between climate change, air quality and occurrence and development of disease.

2.2 National perspective

In China, the health effects of climate change are carried out only in recent years, focusing mainly on the temperature (extreme heat), as well as infectious diseases of health effects (see chapter 2,3). The data about air quality is less, which focused on health impact of the change of weather conditions.

2.3 Uncertainty of health effect

1) Future air quality will be determined by energy and transportation choices, economic development, and population growth;

2) The degree to which human intervention and planning can minimize changes in vegetation and aeroallergen exposure remains unexplored;

3) The rate and magnitude of climate change in the future will depend on how rapidly and successfully global mitigation and adaptation strategies are deployed;

4) New technologies addressing climate change and air pollution as well as new medical treatments for asthma and/or allergic disease could alter current predictions and trends.

Section 2 Gaps in knowledge

The government and scientific community attach great importance to global warming and its potential impact in the past 20 years. Since the United Nations Conference on Environment and Development, held in 1992, international action coping with global warming and its impact has been at full blast. The countries have launched their own global climate change research and assessment activities. In Germany and Japan, the greenhouse effect and climate change is priority research area priority.

Due to limitations on knowledge and analysis methods, there exist large uncertainties in the present assessment of climate change impacts carried out by various countries. The ecosystems that have received relatively little disturbance from human beings can be used as the reference pointer to assess the observed impacts of climate change.

However, systems like agriculture, water resources and human health are influenced not only by climate change but also by other factors; therefore it is rather difficult to single out the impacts of climate change. Studies indicate that climate change has caused some impacts on China, such as sea level rise in the coastal areas, glacial retreat in northwest area, and the earlier arrival of spring phenophase. It will also bring about significant impacts on China’s natural ecosystems and social economic system in the future. Meanwhile, as a developing country at a low development stage, with a huge population, a coal-dominant energy mix and relatively low capacity to tackle climate change, China will surely face more severe challenges when coping with climate change along with the acceleration of urbanization, industrialization and the increase of residential energy consumption. Existing impact assessment efforts in China have mainly concentrated on agriculture, water sources, ecosystems, and coastal environments. Not many studies have looked at the Potential impacts of climate change on human health and air quality. There are many researches of health effect about single meteorological factors, but combined effects about many weather factors have less study. We will strengthen combined effects about meteorology factors. The similar research in China is still limited. Most of the researches in this field refer to climate change (temperature and humidity) and air-born diseases. In present the researches mainly focus on monitoring and predicting distribution of air pollution because of climate change; lacking of epidemiological studies about health effects, which limited in a small number of large, medium cities, lacking of individual exposure data of different groups about air pollutants on; lacking of combined effects of climate change and air pollution on health, we need to strengthen research in this area.

Section 3 Adaptation measures

As a developing country of responsibility, China attaches great importance to the issue of climate change. The National Coordination Committee on Climate Change was established, and a series of policies and measures to address climate change has been taken in the overall context of national sustainable development strategy, making positive contributions to the mitigation and adaptation to climate change.

1 Expedite the constitution and amendment of laws and regulations

Chinese government has taken great attention on the control and prevention of air pollution and had established a series of regulations and strategies especially, which mainly includes: Law of the Peoples Republic of China on the Prevention and Control of Atmospheric Pollution, Ambient Air Quality Standard, etc, reducing the emission of all industrial pollutants by exercising control on the total emission volume. Check the categories, quantities, concentrations and mode of discharging pollutants.

Energy conservation was effectively promoted through the implementation of the Law on Energy Conservation of the People’s Republic of China and relevant regulations, the development of specific energy conservation plans, the adoption and implementation of technology, economic, fiscal and management policies in favor of energy conservation, the development and application of energy efficiency standards and labeling, the encouragement of R&D, demonstration and diffusion of energy-saving technologies, the importing and absorbing of advanced energy-saving technologies, the creation and employment of new energy conservation mechanisms, and the promotion of key energy conservation projects as well.

In February 2005, the National People’s Congress adopted the Renewable Energy Law of the People’s Republic of China, setting out the duties and obligations of the Government, enterprises and users in development and utilization of renewable energy and a series of policies and measures, including total volume target, mandatory grid connection, price management regulation, differentiated pricing, special fund, favorable taxing, etc. In August 2006, the State Council issued the Decision to Strengthen Energy Conservation. All those documents serve as the policy and legal guarantee to further enhance China's capability in addressing climate change.

China's National Assessment Report on Climate Change commissioned by the Ministry of Science and Technology of China， the China Meteorological Administration，and the Chinese Academy of sciences in 2006，was prepared to summarize the current state of knowledge on the impacts of climate change, the country′s vulnerability to climate change, possible adaptations strategies, and the related uncertainties. Which reviewed systematically the harvest of 15 years' research for climate change and adaptations, providesd scientific basis and technological support for developing adaptations strategies. China National Plan for Coping with Climate Change published in 2007 indicated that our country further promoted the work of climate change. On November 6, 2007,18 departments, such as China's Ministry of Health and the SEPA, jointly published the "National Environment and Health Action Plan (2007-2015)" As the first programmatic document in China's environmental and health field, the Action Plan indicates the development direction and main tasks of China's environmental and health undertakings in the future, defines the jobs and responsibilities of relevant departments and creates a new situation where concerted efforts are made to promote development of the environmental and health cause. It is of practical guiding significance for advancing development of China's environmental and health cause scientifically. Now China CDC have established national pilot monitoring network of air pollution and health impacts in 8 provinces of China.

2 Developing air pollution monitoring

Developing air quality surveillance in city, continuously and systematically collecting the data of climate change and its affecting factors for a long time, strengthening meteorological hazards forecast, establishing prediction, monitoring network, extending preventive epidemic areas, e.g. strengthening forest fire forecast，to reduce the health effect of climate change.

From 2005, air pollution and human health monitoring system has been establishes. It is conveyed by institute for environmental health and related produce safety, China CDC. The pilot cities are Shanghai, Nanjing, Taiyuan, Qingdao, Harbin, Zhang Jiagang, Wuhan and Shenzhen city. Through long-term data collection on meteorological, air and disease, develop the surveillance on exposure risk factors and symptoms or Physical sign. Further, forecasting the health impact events by air pollution, reducing the health impacts by air pollution and improve the capability on early warning, protection and control to the air pollution-related disease, the air pollution and human health monitoring system will continuously play a major role in health hazards monitoring.

3. Ozone warning system

China meteorological administration has built air monitoring network of Yangtze River in Chongming, Jinshan, Pudong region of Shanghai, Lin'an in Zhejiang province and Taizhou in Jiangsu. At the same time, Shanghai Meteorological Center of the Urban Environment Bureau and national center of atmospheric research in United States (NCAR) has set up atmospheric chemistry lab and air monitoring network. They set monitoring pilots in the five regions of the cities and urban O_3 early warning system will be build in 2010 to provide warning information to control the main pollutants such as automobile exhaust.

4 Improving energy efficiency, optimizing energy mix

Beginning from the late 1980s, the Government of China paid more and more attention to the change of the economic growth pattern and the restructuring of economy, and integrated the reduction of energy and other resources consumption, the promotion of clean production, and the prevention and control of industrial pollution into its national industrial policies. From 1990 to 2005, China’s energy intensity (energy consumption per Million GDP at constant 2000 RMB Yuan) went down from 268 to 143 tons of coal equivalent (tce), decreasing by an average annual rate of 4.1%. The energy consumption per unit of energy-intensive products in the industrial sector declined strikingly. In 2004, as compared with 1990, for generators with capacity of 6MW and above, the unit energy consumption for thermal power supply decreased from 0.427kgce/kWh to 0.376kgce/kWh; comparable energy consumption per ton of steel in key companies decreased from 997kgce to 702kgce; and comprehensive energy consumption per ton of cement in medium and large enterprises decreased from 201kgce to 157kgce. As calculated on the year by year comparison, during the period of 1991 ~ 2005, an accumulated 800 million tce of energy were saved by economy restructuring and energy efficiency improvement, which is equivalent to a reduction of 1.8 billion tons of CO_2 emissions, using China’s 1994 emission factor of 2.277 tCO_2/tce.

Under national policy guidance and with financial support, the share of high grade and clean energy was improved by strengthening the development and utilization of hydropower, nuclear energy, oil, gas and coal-bed methane, and supporting the development and utilization of new and renewable energy including biomass, solar, geothermal and wind power in rural areas, remote areas and other suitable areas. Share of coal in China's primary energy mix decreased from 76.2% in 1990 to 68.9% in 2005, whereas the shares of oil, gas and hydro increased from 16.6%, 2.1% and 5.1% in 1990 to 21.0%, 2.9% and 7.2% in 2005, respectively Fig 5-13). In 2005, the utilization of renewable energy in China equaled to 166 million tce (including large hydropower), accounting for 7.5% of China's total energy consumption in that year, equivalent to a saving of 380 million ton CO_2 emissions.

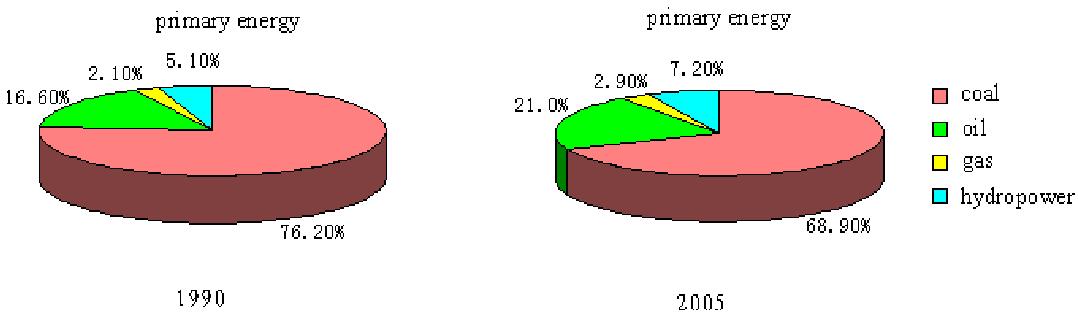


Fig 5-13 The change of China's primary energy mix from 1990 to 2005

5 Strengthening education, training and propagation of the impacts of climate change on ecosystems and human health

Add the contents about climate change in the teaching, and through various media, strengthen the publicity, education and training on the globe climate change, encouraging public participation to enhance the public awareness of protecting the global environment and climate, guide people to establish a life style and consumption mode that helpful for reducing greenhouse gases emissions and to learn about the direct and indirect effects of climate change on air pollution human health, to promote social and economic development.

Chapter 6 Effects of Climate Change on Nutrition and Food Safety in China: Challenge and Strategy

In recent decades, global warming has influenced many countries in different ways. The *Fourth Assessment Report* proposed by Intergovernmental Panel on Climate Change (IPCC) made it clear that greenhouse gases caused by human activities had increased average temperature and sea level by 0.13℃/10a (1956-2005) and 3.1mm per year (1993-2003) respectively（IPCC, 2007）. Although the forecasts are still uncertain, the influences of global warming have become widely acknowledged. Global warming increases the occurrences of many extreme weather events, such as typhoons and tropical storms etc, which will bring loss to human and affect the agriculture, forestry, water resources, and coastal area.

The extreme weather events caused by climate change could influence air, water, food, etc, which are the decisive living condition for mankind. The influence of climate change on food security has caused increasingly attention during these years. It is estimated that the output of rain-fed agriculture in some countries of Africa will reduce to 50% by 2020. The agricultural production including food access will be severely affected, thereby affecting food security and exacerbate malnutrition in the local population (IPCC, 2007). There are several facts will affect agriculture. On one hand, as the main component of greenhouse gases, carbon dioxide could up-regulate the temperature. It is estimated that carbon dioxide in atmosphere will be doubled in next 100 years. Warming make ice of two poles melt. With the oceans warming and expanding, the sea level will rise, threatening coasts and small islands with flooding. Some low-lying lands adjacent to coast might be submerged and the fresh water resources may be polluted which will harm agricultural production. According to a climate model, it predicted that if the current discharge of greenhouse gases remained stable, the average sea level would raise 0.5-meter in 2100. In China, if the sea level rises for 1-meter, 35,000 square kilometers lands would be lost, and 7% of China's population would be obliged to migrate（Kan et al., 2001）. On the other hand, temperature variance of sea will change the patterns of ocean currents and atmospheric circulation, which will lead to frequent disasters, such as typhoon, tsunami, etc. Climate warming would also change ecosystem. The tropical boundary would extend to subtropical zone and the temperate zone would be changed to subtropical zone. The cultivation area of crops may be changed and the diseases of animals and plants will also spread. Warming could speed up the photochemical reaction of plants. Accordingly, photochemical smog would destruct the ozone layer in atmosphere and increase the ultraviolet radiation, which impairs the health of human, animals and plants.

Section 1 Effects of Climate Change on Nutrition and Food Safety in China

In recent years, most parts of China are facing the impacts caused by climate warming. The annual average air temperature has increased by 0.5~0.8℃ in the past 100 years and most of the temperature rising was observed over the last 50 years. From 1980 to 1998, annual average temperature of China increased at a rate of 0.52℃/10-year, which is significantly higher than global rate of 0.19℃/10-year in the same period（Du et al, 2007）. Agriculture is sensitive to climate change, which can directly or indirectly affect crop quality, production, plant diseases and pests. The adverse effects vary depend on several factors, such as crop species, regional difference and environmental conditions, etc. With climate warming, water deficit and shortened growth period of crops become more common in agriculture, which will reduce the crop yield. Warming may also change the current farming system in China, such as the layout of crops planting. The agricultural production, especially grain production has a direct correlation with China’s social stability and persistent development. Furthermore, lack of nutrition caused by food shortage would pose a challenge to the health of people.

1 Effects of climate warming on crop qualities

About 63% of the warming effects caused by greenhouse gases have been correlated with carbon dioxide（ Zheng et al., 2008）. Carbon dioxide could regulate the photosynthesis of crops. As a result, more mineral elements can be absorbed through the root system which will improve the quality of crops. For example, the sugar, citric acid and viscosity in fruits will increase. However, due to carbon content increasing in plants, the amount of nitrogen and protein will relatively reduce which will decrease the quality of crops（Bai et al, 2003）.Some experiments have shown that when the concentration of carbon dioxide reach 565 ppm, the protein content of wheat will decrease by 3% -5%. When the concentration of carbon dioxide doubled, the contents of amino acids and crude protein in soybean will decreased by 2.3% and 0.83% respectively, whereas the contents of crude fat, saturated fatty acids and unsaturated fatty acid in kernel increase by 1.22%, 0.34% and 2.02% respectively. The contents of crude fat, starch and water in kernel of corn will increase, but amino acids, crude protein, crude fiber, amylase and the total sugar will show a decrease trend（Li et al., 2003）.

2 Effects of climate warming on agriculture climate, plant system and crop distributions

When annual average temperature increases by 1℃, the average number of days in which the temperature is equal or more than 10℃ will increase 15 in China. As a result, the growing period of crops would extend, and the growing areas would expand to north. For example, the boundary of winter wheat planting area would move north to currant boundary.

Climate change will also change China's crop planting system. By 2050, most of the two-ripe cropping area in China will be replaced by the three-ripe cropping area and the north boundary of the three-ripe areas will be moved to north by 500 km from the Yangtze River valley to the Yellow River valley. Similarly, the two-ripe cropping area will be moved to north where at present is the central region of one-ripe cropping area and the one-ripe cropping area will be reduced by 23.1%（Li C, et al, 2002）. Some winter wheat, currently growing in North China, may be replaced by other types. Rice, which relatively resists to high temperature, is grown in south of China. With warming, rice growing area would expand to north gradually. The prematurity species of corn in northeast of China will be gradually replaced by middle and late-maturing species（Li C. et al, 2003）. Taking no account of the impact of water, with the heat resources increase and current species and production status still maintain, the agriculture yields will decrease in the future.

3 Effects of climate warming on crop yields

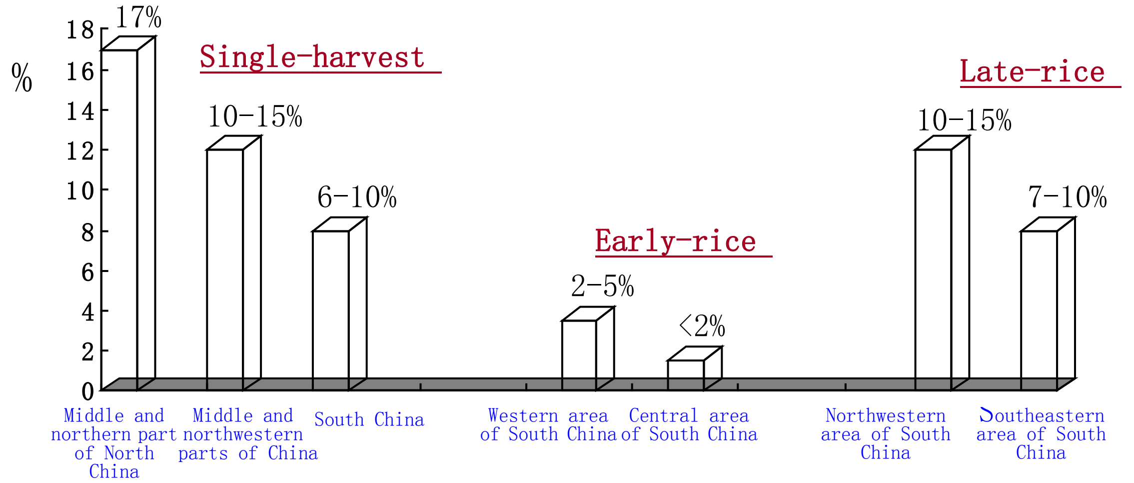
With climate warming and heat resource increasing, prolonged growing period will be benefit to the growth of crops, but when the temperature (or heat) exceeds to a certain limit, the disadvantage of heat will be shown. Furthermore, climate warming will not only affect the germination, growth and photosynthesis of crops, but also affect pests, plant disease and irrigation water supply, etc （WJM Martens, 1998）. As a result, agricultural yield would be reduced.

In China, Extreme weather is the most important factor which causes yield reduction. The direct economic losses of agriculture caused by meteorological disasters every year are more than 1,000 billion yuan, accounting for 3%~6% of the gross national product. The agriculture losses are mainly affected by drought, then by flood and hailstorm. From 1950 to 2001, the annual average rainless areas in China are more than 20 million hectares and the drought disasters occurred in about 9.3 million hectares. The national annual losses of grain due to drought are more than 14 million tons, accounting for 4.7% of the gross grain output in the same period.

3.1 Crop yields will be reduced by climate warming

Climate changes have the greatest impact on cereal yields. In China, cereals account for about two-thirds of food consumption. Researches indicate that the outputs of wheat, rice and corn will be reduced by climate warming. It is estimated that by 2030, the gross outputs of crops in China might be reduced 5% -10%. To the second half of the 21st century, the outputs of major crops in China such as wheat, rice and corn could drop 37%. Climate change will seriously impact on agricultural production and food security in a long periods（Li C, et al, 2002）.

Fig. 6-1 Reduction Rate of Rice Output



Taking no account of water impact, climate change will reduce the outputs of early-rice, late-rice and single-harvest rice. Compared with early-rice, the yield of single-harvest rice and late-rice are affected more obviously. In China the reduction rate of single-harvest rice descended from north to south: about 17% in the middle and northern part of North China, 10% to 15% in the middle and northwestern parts of China, and 6% to 10% in the South China. The yield of early-rice is less affected in the central area of South China (reduced less than 2%) than in its surrounding areas, especially in the western area of South China (usually reduced 2 % to 5%, and 6% in some regions). The yield reduction of late-rice is more obvious in the northwestern area of South China (10% to 15%) than in the southeastern area (7% to 10%) (fig.6-1) (Zhang et al., 1999）.

In China, wheat is the second largest crop, which occupied 20%~30% of the total arable lands. Global warming affects the wheat production particularly in North China, the main producing areas of wheat (Ju et al., 2005). Climate warming has more effects on the yield of spring wheat than winter wheat, more effects on irrigated-wheat than rain-fed wheat, which means that irrigation could counteract some adverse effects of climate change on wheat yield. However, in North China, because of water scarcity, irrigation is not the basic approach to reduce the side effect of warming. So changing the way of planting, choosing new drought-resistant and heat-resistant species might be the more reasonable and effective measures.

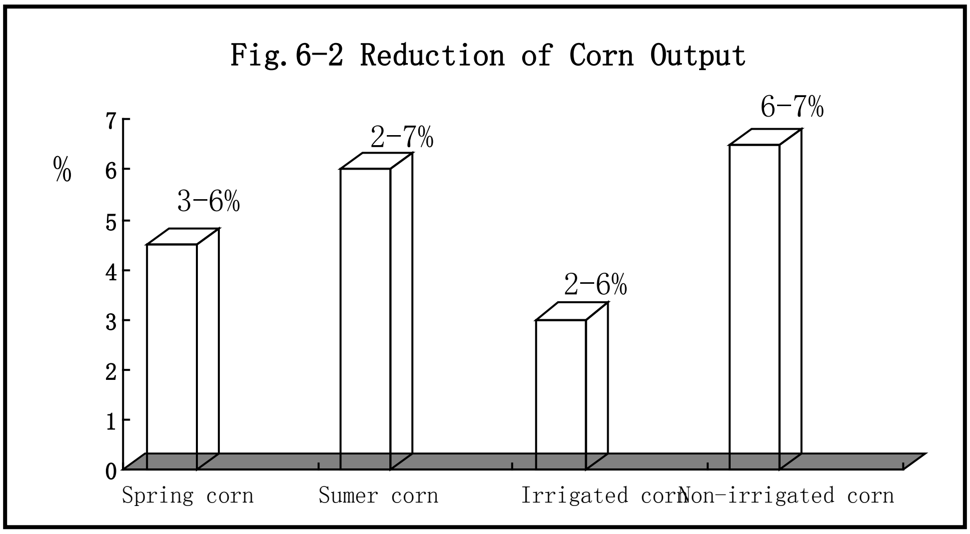


Fig.6-2 Reduction of Corn Output

In China, climate warming causes the gross production of corn reduced 3% to 6% (spring corn reduced 2% to 7%, summer corn reduced 7% to 5%, irrigated corn reduced 2%, and non-irrigated corn reduced 6% to 7%). The results indicated that irrigation could alleviate the yield reduction of corn (fig.6-2). Due to warming, Shortened the reproductive period and suffering high temperature in growth period could lead to yield reduce.

The adaptability of agriculture is different in China. In the high-latitude and colder regions, there is a large space to adapt climate warming. In mid-latitude regions, poor adaptability can be shown in many ways. But through scientific and technological progress the negative impact of climate warming will be reduced. In low latitude regions where the temperatures are always high, the adaptability will be faced a large challenge. The rapid reduction of cultivated land will also threaten food security in the regions.

3.2 Climate warming will greatly affect crop pests

Some ecological features of crop pests, such as growth, reproduction and distribution, have close relation with weather. Recently, the incidence of disaster caused by crop pests increased and as a result the output of crop reduced.

3.2.1 Harmful periods of crop pests prolonged

With climate warming in China, the temperature increases earlier in spring and drops more slowly in autumn. As a result, the crop diseases caused by pests occur earlier and end later which will cause the whole hazardous cycle prolonged. On the other hand, the increase extent of temperature in North China is higher than in the South. Global warming reduces the temperature difference between the North and the South. There will be a marked increase in winter temperatures and the north generation realm of pests in winter will also expand. It is conducive for pests to survive safely during the warming winter and causes the development time ahead, the pace of development increase, the generation cycle shorten and the fertility enhanced, which may extend the jeopardize period and increase the aggravation trend. Although in different regions, seasons and ecological conditions, the warming extents of climate are also difference, the warming trend is conducive to the growth and reproduction of pests. The generation rate showed a accelerate trend and the number of generations may also increase (Shang, 2000).

3.2.2 Overwintering sources of pests increase

With climate warming and especially temperature increasing in winter, the mortality of pests and bacteria in soil will decline and the overwintering source of them correspondingly increase, resulting in the occurrence of plant diseases increasing in the coming year. Effective overwintering source of pests is the growth foundation of the first generation or the second-generation. The amounts of the overwintering source increase, the winter survival rate will also ascend, and in the coming year the amount of first generation from the overwintering source will enlarge, followed by the increasing of the second generations. Because of climate warming, total effective temperatures in one year increase and the propagation generation of pests may increase accordingly. Even if the value of effective temperature is not enough for pests to grow from generation to generation, it will also prolong the damage time of pests in fields and increase the extent of damage. Some pests hibernate by eggs such as oriental migratory locust. If the temperature in locust living area is higher, it will breed another generation (the third generation) in autumn. As a result the harmful period will last longer and the hazard will be aggravated (Li, 1993). From above it suggests that the climate warming will aggravate the harm caused by pests and will lead to the reduction of agriculture production.

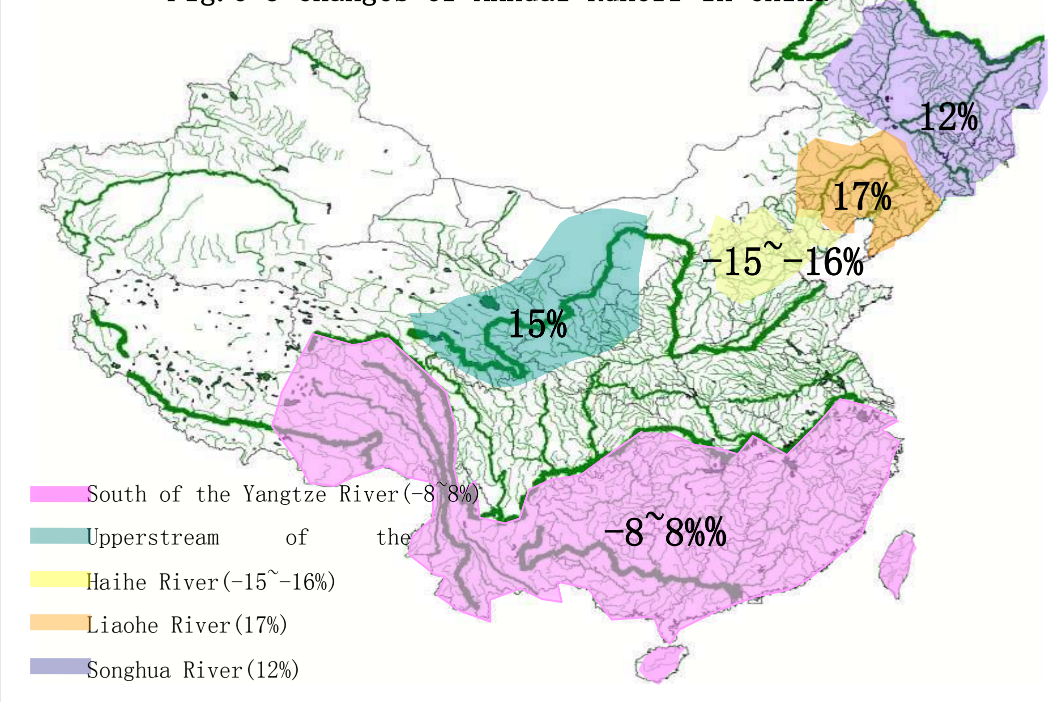
4 Effects of climate warming on water for agriculture

In China, agricultural water is mainly from surface water, such as lakes and rivers. Global warming affects the distribution of rainfall, which in turn affects the amount of surface water, so warming will be bound to influence the agriculture yield. In the past 50 years, the variations of annual and regional precipitation were obvious. Precipitation was high in the 1950's, then significantly reduced in 1960’s, decreased to the lowest in 1970’s, and a slight increase in 1990’s compared with 1980's, but it still not reached the amount of the 1950’s and 1960’s. Precipitation has obvious regional and seasonal features. Precipitation is mainly reduced in summer, and North China is the droughtiest area, and followed by the middle and south of China, then the east and southwest of China (Zheng et al, 2008).

4.1 Flow of rivers have changed

In China, climate warming changes the annual runoff of seven main drainage basins. There are three kinds of runoff change: firstly, annual runoff of main branches reduced all over the country; secondly, decreased in North and increased in South; thirdly, increased in North and decreased in South. Simulation studies have shown that there is a relatively small change in the region, for -8% to 8%; and the largest change in the north of Haihe River (the Huaihe River reduced 15%, Beijing-Tianjin-Tangshan region reduced 16%, the largest increase occurred in Liaohe by 17%, followed by an increase of 15% in the upperstream of the Yellow River, the smallest increase of 12% in Songhua River)(fig.6-3). The reduction of annual runoff is more than 4 times of annual rainfall and it will have a direct impact on agricultural production (Yang, 2006).

Fig.6-3 Changes of Annual Runoff in China



4.2 Water consumption in agricultural

Climate warming has more impacts on water consumption in agricultural irrigation than in industry and human living, especially in the regions where the rainfall tends to decrease or the evaporation tends to exceed precipitation. Four global atmospheric circulation models show that population growth and economic development could cause water scarcity more severely than by climate change. But in years with middle or high level of drought, water scarcity caused by climate change would be greatly aggregated, especially in Luanhe Valley, Beijing-Tianjin-Tangshan area, Yellow River Basin and Huaihe River basin. Water scarcity would pose serious impacts on agricultural economy (Liao et al. ,1999).

4.3 Variance of water quality

With climate warming, increased evaporation would reduce the river flows, which would greatly decrease the water quality and exacerbate the water pollution, especially in dry-season. The rise of water temperature would also accelerate the deposition of pollutants and the decomposition of waste in river.

4.4 Droughts and floods

Climate warming might accelerate the global hydrological circle and increase the average rainfall. The increase of precipitation and evaporation might increase the occurrence of floods and droughts. In recent 43 years, the average dry-wet index in North China evolved with the features of drought. The cycle periods of floods and droughts are 64 ~ 72 months. In North China droughts mainly occur in summer and autumn and even in consecutive two seasons. The continuous drought since 1999 is the most serious drought during the last half a century (Yang, 2006).

Section 2 Diversity between China and other counties on climate warming researches

In China, most researches are focused on the relation of climate warming and agricultural production. The effects caused by greenhouse on agriculture are deeply investigated. These studies play an important role not only in accurately evaluating the effects of climate change on China's agricultural production, but also in establishing strategies to mitigate or avoid adverse effects of climate change. China is taking measures to actively respond all kinds of adverse outcomes caused by climate warming. But little researches on hunger and malnutrition caused by global warming can be found and this kind of researches should be strengthened.

But there are many uncertainties in the impacts of climate change on agriculture, such as the uncertainty of future climate change, lack of regional climate exports and dynamic model for crops, etc. Till now, static or experience based statistical models are still widely used. But due to a number of assumptions and uncertainties, this kind of model is not an ideal model. On the contrary, the dynamic or process models are used less widely, because these models are often confined to small areas or even individual points (Du, 2005). In addition, impacts of climate change on agricultural production also varied with different regions, which need be studied further.

In other countries, researches about the effects of climate change on nutrition and food safety are mainly as follows:

1 Strengthen the related safety researches

In 2003 Earth System Science Partnership (ESSP) started preparing for "Global Environmental Change and Human Health Project" (GECHH) and in 2004 enacted the research program and begin to implement. The project goal is to find out the complex relationship between global change (including climate change, biological diversity loss, global socio-economic changes, etc.) and human health, thus decreasing the health hazards. Several researches are in its important research fields, including food production and human health, vulnerability and adaptability. In 2005, the "Climate, climate change and its health effects" seminar was held in Wengen, Switzerland, the context of climate change and human-related factors were discussed and food safety is one important component. The African Monsoon Multidisciplinary Analysis (AMMA) program put close attention on better understanding of West Africa's climate vulnerability and its impact on water resources, food sustainability and health.

2 Diversity on outputs of crops in different countries and regions

The impacts of climate change would not be the same in different countries and regions. The situation in developing countries will be more severe. The research outputs estimation of the world's three major crops (wheat, corn and rice) in future (2020, 2050 and 2080) indicate that the crop yields will be reduced in some developing countries, while increase in developed countries of northern hemisphere. For example, with a larger population, the grain imports in Asian increases from 2,000 million tons in 1961 to 8,000 million tons in 1998. In the future, the supply and demand of food in Asian will face greater pressure.

3 Concerning the population with malnutrition

Climate change will further increase the number of malnutrition in developing countries. It is estimated that there are about 790 million people with malnutrition in developing countries. In remote regions, trades are not so prosperous and people are more vulnerable to crops reduction and foods shortage. Malnutrition children physically and mentally stunted, declines the work capacity of adults, and increases the possibility of infection. Recent studies have shown that malnutrition is a most important single factor resulting in diseases. In 1990, there are nearly 6,000,000 people died of malnutrition in the world, which is nearly doubled that of people died of smoking (Simon et al.,1997). Most studies show that global warming leads to the rise of food prices, and increase the number of population threatened by hunger. More researches are needed to confirm these results.

In the countries of these regions where malnutrition, low levels of education, poor basic infrastructure and low-income are in common, the groups (including young children, the elderly and physically unhealthy person) will suffer great difficulties to adapt to climate change and have the highest healthy risks. The groups are usually living in small islands, mountain areas, and regions with water scarcity, large cities and coastal areas in developing countries (particularly large-scale cities in the Asia Delta). The groups also include the poor and those who have no health services.

4 The vulnerability to climate change in different regions

With different intrinsic characteristics, natural resources and legal systems, different societies and nature systems have different sensitivity, adaptability and vulnerability to climate change. Because of unstable economy, low level of financial and natural resources, and lack of regulation and technical ability, most developing regions such as Africa, Latin America and Asia show lower adaptability and high vulnerability to climate change. Even in the regions with higher adaptability such as North America, Australia and New Zealand, there are still vulnerable communities, such as indigenous communities, where the ecosystem adaptability is very limited. Southern Europe and the Arctic are more vulnerable than the other parts of the continent.

Under the background of global climate change, it is necessary to correctly assess the region adaptability and take measures to reduce the vulnerability. On the other hand, it is also important to actively seeking international support and cooperation, combining together to take actions for a range of social, economic and health hazards.

5 Effects of climate warming on foods

The climate change may have impact on food contamination from following aspects: foods with pathogens itself (eg. pork with trichinosis), foods contaminated by pathogens in the producing process (eg. polluted ice cream or vegetable salad); foods contaminated in the process of storage, transport and sale (many pathogens of infectious diseases such as dysentery, hepatitis A can contaminate foods by the patients, pathogenic carriers or mosquito).

Global warming may increase the incidence of food-borne diseases. Studies had shown that from 1982 to 1991, the incidence of food-borne disease in British is closely related to the average temperature, and this relation exists only when the average temperature is higher than 7.5 ℃. As a result, it can be forecasted that by 2050, food-borne diseases will increase by 5% to 20% in British. In China, researches about the impact of climate change on food are still less (Tong et al., 2000).

Section 3 Strategies in China

Undoubtedly, climate warming has diverse influences on ecological environment and growth system of agriculture. In turn, with increased investment to agriculture, the concentrations of greenhouse gases in atmosphere will increase further, which will accelerate the warming process. Therefore, when making national development strategies and long-term planning for agriculture, greenhouse effects resulted in climate and environmental change should be taken into account.

1. Enhance adaptability for sustainable development

The best strategy against global warming is to enhance the adaptability to climate, and strengthen the abilities of sustainable development, not only meeting people's basic needs, but also allowing people to choose methods and technology for development.

2. Weaken the sensibility of agriculture on climate change

Protect and reasonable utilize land, mines, water, forest, grassland and climate resources. Improve the ability to comprehensive utilization of resources. Strengthen protection and management of eco-environment. Speed up the construction of key environmental protection and pollution control projects. Reduce the emission of pollutants. Plant trees and grass for wetlands protection. Establish disaster prevention and environmental protection safety system.

3. Strengthen scientific researches on climate change

There are many uncertainties on estimating the future climate changes. These uncertainties are related to the diversity of man-made discharge programs, the uncertainty of climate models, the unpredictable feature of natural climate changes, and the complexity of interaction and feedback of different factors in weather system.

Further research is needed to improve understanding on the changes of climate system, reduce the uncertainty in current researches. Furthermore, it is also essential to further understand the interaction and feedback process of the circles in global climate system, explore the circulation process and mechanism of the greenhouse gases and aerosols, detect and forecast the climate change.

According to the Strategic of Meteorological Development, a series of important researches are undertaking in China, such as China Climate Observation System, Atmospheric Composition Observation System and Climate Simulation Model System. These plans will facilitate us to observe global climate change and its impacts of human activities. By analysis and simulation of climate models, we will enhance the prediction accuracy of climate change.

Additionally, the assessment system for sensitivity, adaptation and vulnerability in response to climate change should be improved and quantified. Emphasis may be placed on the frequency and intensity of climate changes in extreme weather events.

4. Strengthen researches of the effects of climate change on agriculture and food supply

4.1 Regulate agriculture construction and improve cropping system

Gradually shift the areas which are not suitable for farming into the forest areas, pasturing areas, or mixed areas. Increase vegetation coverage rate of soil in order to increase the absorption of carbon dioxide, prevent soil from degradation and desertification. Reform the internal farming system, and adjust the layout of crop planting to adapt to climate change.

Choose crop species which could not only increase absorption of carbon dioxide, but also substantially increase the level of crop production.

4.2 Improve ecological environment of agriculture

Construct agriculture irrigation system, water-saving system, and farmland protection forest to increase the agricultural adaptability to climate change. Develop biotechnology and other new technologies to establish large-scale agricultural cultivation zone of superior species. Take high-yield and stable-yield measures to strengthen the capacity against agricultural disaster. Choose the crop species which has highly photosynthetic ability and strong resistance of superior varieties. These species may not only withstand the abnormal weather, increase the resistance to disease, but also take advantage of increased concentration of carbon dioxide to improve yield.

4.3 Enhance the forecast on climate

Explore suitable measures to defense (or weaken) the adverse effects and minimize the losses caused by climate change. Explore the features and mechanism of extreme weather events to improve the forecasting and early warming capability. Explore the occurrence of crop pests and diseases in climate change to minimize its negative effects on agriculture.

4.4 Prevent and cure for pests

Because climate Change has significant regional features, and the agricultural species varied widely in different regions, regional research is highly target-oriented in guiding the production practice. Although there are some researches in this area, they are mostly in theory and lack of maneuverability.

It is necessary both in theory and in practice to systematically analyze the characteristics and development trends in the regions, such as Northeast and North China, where have demonstrated significant climate change, explore measures to pursue good fortune and avoid disaster in agricultural production. In conclusion, regional research should be strengthened in the future.

5. Enhance the public health system and researches related to climate change

Public health safety should be placed in the most important position in many climate change measures, especially giving priority protection to vulnerable groups.

Different adaptation strategies, especially in the assessment of population nutrition and food safety caused by climate change, should be taken at local and national levels in order to minimize the impact of climate change on people’s health.

More researches are required to explore the relationship between weather, extreme events, food safety, and nutrition among people. Improving the existing public health infrastructure and enhancing climate monitoring capabilities could mitigate or avoid possible health effects caused by climate change.

Chapter 7 Health impact countermeasures of Climate change in China

Climate Change is the major global issues concerned by international society. In response to the climate change, climate change mitigation has been considered very important for a long time, while climate change adaptation haven't get enough attention. In December 2007, the Bali road map got through to put the climate change adaptation into the same important position in United Nations Climate Change conference. Adaptation measures can be taken to reduce the negative impact caused by the climate change and the environment; mitigation measures including control and reduce pollutants and greenhouse gas emissions can lead to slow the rate and extent of climate change and environmental change at the source. In the framework of sustainable development to address climate change, coordinating must be considered to balance the profits and missing.

China as a responsible developing country, paid high attention to climate change and established a national coordinating agency response to climate change. In accordance with national sustainable development strategy, China adopted a series of climate change-related policies and measures including issued the "China National Climate Change Programme" and "China to address climate change science and technology special action". So China has made a great contribution to address climate change.

Section 1 Health impacts adaptation of Climate change

International strategies with Climate change adaptation are mainly focused on three scales.

Firstly, National- and regional- level response. The adaptation strategies can be summaries to establish the early warning systems for extreme events such as the heat wave and infectious disease outbreaks and to make it effective to alert the population and relevant authorities to take a timely response. To be effective in reducing health impacts, such systems must be coupled with a specific intervention plan and have an ongoing evaluation of the system. Public education and awareness is also the important work to in Climate change adaption.

Secondly, the response from the international organizations and agencies. The international organizations and agencies made great contributions to improve the international surveillance system, to promote the communicating and sharing the data and technology, and to perfect the monitoring system and the validity.

Finally, individual-level's response. It is very important for individual's engagement to make sure the effectively work such as early-warning system and/or the other adaptation countermeasures.

At present, the countermeasures and systems to address the Climate change in China is still not perfect. Few studies have been done to elucidate the relationship between the Climate change and health, and the knowledge is very scarce, especially on understand the vulnerability of different regions and populations. Meanwhile Climate change adaptation involves in the integration of several scales. Take the heat wave for an example, building and city construction, national energy and transport and so on are all involved in the adaptation processing. Whereas the multi-sectional integrated action mode are still need to be greatly improved. Besides，there are several limited conditions which constrained the adaptation, such as the limit of knowledge and the social development. Till now，much works have been done to address climate change in China. Here are some works related to climate change health impacts.

1 The environment—disease monitoring system

Establishing the global monitor system of environment—disease is an effective way to control and eliminate the effect of global climate change on health. There have been more than 80 international organizations involved in the global environmental monitoring system all over the world, but further coordination and cooperation with each other are still need to be strengthened. The relatively poor countries always suffer more influence and burdens from the global environment change. Scarcity of monitor equipments and technique make it impossible for the developing countries to establish a satisfactory monitoring system, which means international extensive and effective cooperation are necessary. Establishing the international healthy monitoring network could be used to monitor the influence of climate change and provide useful information to make out the policies for addressing the climate change.

At present, environment--disease monitoring system is composed by two parts in China. One is the disease monitoring system operated by Chinese Center for Disease Control and Prevention (CDC), the other is the meteorological change monitoring system carried out by China Meteorological Administration and other departments.

Meanwhile, China Meteorological Administration and Ministry of Health have began to combine to cope with the public health problems related to climate change, and further to establish the meteorological service system for public health to perfect the monitoring, early warning system and policing system.

1.1 Diseases surveillance system

In 1930s, an epidemiology survey has been carried out in Ding County, Hebei Province, which signs that disease surveillance has been started; in 1950, disease monitoring report system including all province in mainland of China, but it focused on the infectious disease on law; in 1978, Combined disease surveillance system established and began the spot surveillance system. Now, Combined disease surveillance system have been established based on the communicable diseases surveillance system, and it became to the combined by all the disease surveillance system ,and is the important component of National Health information system. Chinese disease monitoring system contains emergency public reporting system, communicable diseases surveillance system, vector biological monitoring system, surveillance system of death, symptom monitoring systems, health-related risk factor surveillance system. Communicable diseases surveillance system is relatively consummate, but actual effect and coordination capacity across different scales should be improved. Monitoring system of environment and health just started.

1.1.1 Communicable diseases surveillance system

China began to establish infectious disease reporting system in 1953, 13 kinds of disease was brought to it. From 1960, the system was gradually improved. From 1950 to 1985, the report paper of infectious disease was passed from country, city, and province to the nation step by step. From 1980, it developed single-disease monitoring report, such as epidemic hemorrhagic fever.

Before the outbreak of SARS in 2003, the type of infectious disease reporting method was lagged, which lead to the higher rate of missing report. And then make it difficult to précised monitoring and controlling the outbreak of infectious disease. Furthermore, though there are dozens of public health information systems working in different regions and departments, these information systems can not share and exchange the data and it is also difficult to realize unified management and standardization. After the outbreak of SARS, whole country engaged in the battle of fighting the SARS and then strengthened the public health system.

In January 2004, the biggest public health information system—Chinese Direct Network Report System of Communicable Diseases and Public Health emergency Events was set up. Based on modern information technology, this report system could get to “individual, timely and online” which is the first time in China. And it covered all the medical agencies including the township health centers. Only in 2005, 4,428,548 cases have been reported through this report system.

During the Sichuan earthbreak in 2008, Mobile report system have been developed and integrated to the existing communicable reporting system.

1.1.2 Vector biological monitoring system

Vector-borne disease is a severe challenges face to all human. With global warming, deeply increasing of urbanization, rapid development of tourism and trade, ecological environment changed continually and new changes have taken place such as the vector species, density and distribution. Not only lead to the original vector-borne disease to expand the scope, increase the frequency and intensity, but also a number of new vector –borne diseases continue to emerge.

In official report system of the infectious diseases, many belong to the vector-borne diseases, such as plague, epidemic hemorrhagic fever, leptospirosis, malaria, dengue fever, endemic typhus, filariasis, and so on; some Digestive diseases through bio-mechanical vectors among humans spread of diseases such as dysentery, typhoid and so on. Effective controlling of vector organisms can reduce their harassment of people and economic losses, but also can prevent and control the occurrence and spread of infectious diseases.

In the past, China has systematically carried out the monitoring on the vector organisms, which played a positive role to vector-borne disease prevention and control. This monitoring system covered a total of 17 provinces, 40 monitoring stations. However, No unified method for data comparison and analysis, the old ways now unsuitable for social development, variation of the prevalence of some vector-borne disease, At the same time, the outbreak of some vector-borne disease in neighboring countries in recent years have been a threat to our country. So strengthening vector-borne monitoring has become an urgent task on disease prevention and control. To this end, in 2005 the Ministry of Health combined with Institute for Infectious Disease Control and Prevention, China CDC , issued the " National Monitoring Program on vector-borne disease," to carry out systematic monitoring of biological vector. This plan not only can provide a basis for the development of biological vector control program, but also can provide early warning information for the prevalence trend of the vector -borne infectious diseases.

1.1.3 Health-related risk factors monitoring

In 2007, “National Environment and Health Action Plan” has been issued and on this plan, emphasized that gradually establishing and perfecting the national environment and health surveillance network is the major task in the field of environmental and health and the national environment and health surveillance network is consist of environment quality supervision and supervision of the impact of pollution on health. At present, China CDC has set up environmental risk factors surveillance pilot in few pilot cities, including water safety and health monitoring network, air pollution and health monitoring network, environmental pollution and health monitoring network and forecast system. At the same time, nutrition and food safety surveillance network and risk assessment system have been carried out.

Establish a monitor network for air pollution and human health: recognize major pollutants in the air that harm people's health and those that indirectly harm people's health via agricultural, husbandry, fishery products, set up a human health monitor index, and set up a state scheme of air pollution and health monitoring; set up monitoring stations in communities to collect information about residents' health; increase the frequency of air quality monitoring and increase their numbers to improve the monitoring of major pollutants.

Establish a monitoring network of drinking water safety and health: consider the tasks and monitoring contents of the national drinking water safety scheme, set up a pollution index in water sources that can be monitored, create an irrigation water quality index & drinking water quality index, monitor sphere of water-caused diseases and other information related with health; draw up a state monitoring scheme, and reasonably distribute monitoring stations.

Establish monitor networks for extreme weather and human health: under provincial levels of supervision, set up monitoring stations in cities and counties to conduct real time monitoring, analysis and evaluation of physical harm happening to people due to extreme weather, enhance their ability during extreme weather to make forecasts and enlarge monitoring regions.

In the networks of health-related risk factors monitoring system, air pollution and human health monitoring system has been establishes earlier. In 2005, it is conveyed by institute for environmental health and related produce safety, China CDC. The first batch of pilot cities are Shanghai, Nanjing, Taiyuan and Qingdao city. This monitoring system conveyed it work focused on the different pollution types and characteristics of different cities. Through long-term data collection on meteorological, air and disease, develop the surveillance on exposure risk factors and symptoms or Physical sign. Further, forecasting the health impact events by air pollution, reducing the health impacts by air pollution and improve the capability on early warning, protection and control to the air pollution- related disease. In 2007, another 4 cities are engaged in the air pollution and human health monitoring system. They are Harbin, Zhang Jiagang, Wuhan and Shenzhen. The air pollution and human health monitoring system will continuously play a major role in health hazards monitoring.

1.2 Meteorological change systems

Nowadays, several large observation network systems have been established such as national climate network, national weather network, national specialized meteorological observation network, ecological system network and national CO_2 flux network.

Several works have been done by National climate center on extreme climate surveillance.

（1）Heat wave real-time monitoring network and service system

National Climate Center of China Meteorological Administration has developed heat wave real-time monitoring network in the whole country to provide service and monitor the happening of the heat wave. And it also takes part in the international heat wave real-time monitoring system as a subsystem to supervise the evolvement of global climate. Through the monitoring system, the researchers can know global climate especially the process of heat wave changes by monitoring the average temperature and average maximum temperature of day-to-day, recent 10 days, recent 20 days, recent 30 days and recent 90 days.

（2） Drought surveillance Usually, several indexes such as drought index (CI), Standardized Precipitation index (SPI) and Percentage Rainfall Bias Rate are been used for drought forecasting everyday or month.

(3)Sea ice and snow monitoring Every month Sea ice and snow monitoring will be surveyed and released.

(4)Beside， El Nino/ Southern Oscillation monitoring and East Asian monsoon surveillance have been developed.

2 The early-warning and forecasting system

The influence of the weather upon health can be prevented in some extent. The relationship between climate change and health showed obviously regional characteristics due to the human adaptation capability and the local weather variety. So it is of great important to carry on the research on the mechanism of the health impacts of climate change, to form the meteorological indexes system and establish the forecast model. The final goal is to convey the most precise meteorological information to the public quickly, and take corresponding preventive measures immediately to minimize the public property loss. For example, many countries have built up Heat Watch Warning System, which can reduce the incidence and morbidity of and the heat-related disease greatly, to reduce the health effect of heat wave.

On disaster weather early warning, the weather data and satellite monitoring system of the National Oceanic Atmospheric Administration (NOAA) in United States are the important basis to carry out effective prevention and control for natural disasters. Rely on satellites data, achieved a 24-hour real-time monitoring and analysis of the climate, and tornadoes, hurricanes, storms and other extreme weather early warning.

In China, The works have been done on monitoring and early-warning are mainly as following:

2.1 Life index and healthy index forecasting

In some cities，such as Hangzhou, Nanjing ,Nanchang ,Guangzhou and Beijing, the meteorological departments release the life index and health index everyday, including: Risk index of disease (hypertension index, cold index, bronchitis index, asthma index, and heatstroke index, ultraviolet intensity index and so on), cerebrovascular disease morbidity tendency forecasting, the respiratory system disease morbidity tendency forecasting, actual pollen density and its changing tendency, clothing index, morning exercise index, mountain-climbing index, swimming index and so on. The citizens can adjust their daily life, such as eating, clothing, according to them so as to reduce the health effect of meteorological conditions.

Health index are usually calculated by multiple regression method. Using the meteorological data in past few years to establish the relationship, and then introduce the value of future meteorological factor to it and the corresponding forecasting index will be got finally.

2.2 Heat Watch Warning System (Tan et al., 2002)

The definition and the determination standard of high temperature are variable in different countries and regions. World Meteorological Organization suggested that if the maximum temperature is over 32℃ and lasting 3 days or more, then it can be recognized to heat wave. Many cities all over the world release the high temperature or heat wave alarm. In America, The National Meteorological Bureau releases the high temperature alarm according to the Apparent Temperature, which takes both the temperature and relative humidity into consideration. When day time Apparent Temperature exceed 40.5℃ for 3 days continuously or exceed 46.5℃ at any time, the National Meteorological Bureau will release the high temperature alarm. In Germany，physiological equivalent temperature（ PET） based on the energy balance model was been used as the heat wave forecasting index. If the PET is higher than 41℃， then the heat-related mortality will significantly increasing. In China, when daily maximum temperature exceed 35℃, the National meteorological bureau will release the high temperature alarm. If the maximum temperature will rising to 37℃ Within the 24h, orange alarm will be released and when it goes to 40℃,then the red alarm will be made.

However, there are many deficiencies in the present early-warning system which is based on the maximum temperature or heat index. First, it supposes that the health effect is only due to the two weather factors, temperature and relative humidity, while ignoring other important weather factors' health effect. Second, it doesn't take the negative health effect of a serious of continuous hot days into consideration. And also doesn't consider that the health effect of heat waves take place in early summer is even more serious than that take place in late summer. Third, the high temperature days determined by maximum temperature or heat index are lack of the verification of morbidity and mortality data. Finally, it is impossible to estimate the morbidity and mortality only by releasing the heat alarm. In fact, the health effect of heat wave is due to many meteorological factors synthetically rather than only one meteorological factor' function. So, an appropriate method to evaluate the association between weather and healthy is to classify a certain place's daily weather condition, and then firm a high dangerous air mass or the " offensive" air mass, there are direct relations between the heat wave days determined by “ offensive” air mass and human’s mortality.

Supported by WMO/ WHO, many cities such as Philadelphia, Rome have already built up the heat wave early-warning system which is based on the classification of the “offensive” air mass. Till 2003, 17 cities have been established the heat watch warning system. In United Status, the first heat wave early warning system is established in Philadelphia and till 2005 more than 20 cities engage in the heat wave warning system. At present, the United States has established a multi-climate observation network to collect various types of meteorological data from land, sea, air and the track round the earth. The way of the heat wave forecasting report is similar to the way of the traditional weather forecasting almost divided into "five-day forecast", "the recent 24-48 hour heat wave movement ", as well as "24 hours of life threatening heat wave warning".

As a middle latitude city, Shanghai is apt to be attacked by heat wave. Related departments have accumulated many meteorology and mortality data. Also supported by WMO/ WHO in 1999, Shanghai meteorological bureau and Health department cooperated with Delaware University of America to develop a health monitoring and early-warning systems of heat wave in Shanghai. The whole frame of system is shown as figure. The system classifies the daily weather condition and forms a weather calendar by using the method of SSC (the Spatial Synoptic Classification) weather classifying method, which is developed by the Delaware University of America, and develops a forecasting function to determine the type of air mass and mortality with the help of death data. Establish the regression equation of excess death number due to heat wave with the weather and death data in 1989-1998 of Shanghai and test it with the data of 1998. The correlation coefficient between the forecast value of excess death number and the actual value is 0.64(being test at 0.001 level). Examine the predictability of the system with the data of 1999. Compared with the actual death number 271, the predicted number 346 of excess death due to heat wave shows that the system is satisfying on heat wave monitoring and early-warning ability.

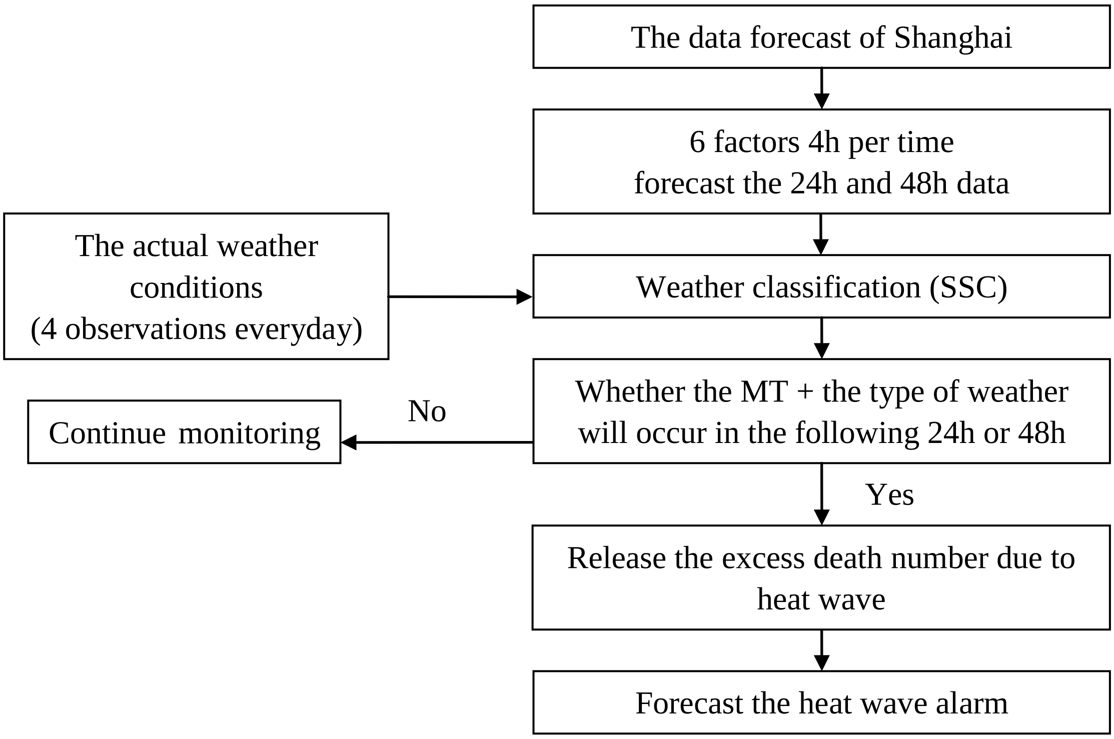


Figure the framework of heat waves monitoring and early-warning system in Shanghai

In 2007, National Climate Center of China Metrological Administration organized Shanghai region climate center, Wuhan region climate center, Shanxi climate center and Chongqing climate center to join the program of <<Heat wave early-warning monitoring system>>. So far, National heat wave monitoring, forecasting and effective assessment system has been established. Two regional-level (Shanghai and Wuhan) and two provincial (municipality)-level (Shaanxi province and Chongqing municipality) heat wave supervision, forecasting and assessment system have been put into practice; Further, the entire corresponding network service programme have been carried out to gone with it.

2.3 ozone warning system (xinhuanet, 2006)

China meteorological administration has built air monitoring network of Yangtze River in Chongming, Jinshan, Pudong region of Shanghai, Lin'an in Zhejiang province and Taizhou in Jiangsu. At the same time, Shanghai Meteorological Center of the Urban Environment Bureau and national center of atmospheric research in United States (NCAR) have set up atmospheric chemistry lab and air monitoring network. They set monitoring pilots in the five regions of the cities and urban O_3 early warning system will be build in 2010 to provide warning information to control the main pollutants such as automobile exhaust. If the concentration of ozone exceeds permissible standard, the department will give a warning to remind the government to adopt some measurements.

2. 4 **Early warning system of extreme weather events (NEHAP,2007)**

In the background of global warming, the character of atmospheric circulation, the extremely climate events also changed accordingly. Coping with the extreme weather events should be pushed at the important position for addressing the climate change. In National environment and healthy action plan (2007-2015), the health impacts of climate change have been taken to be one of the important assignments. It is particularly emphasized to research on high temperature and heat wave, rainstorm and flood, windstorm, sandstorm, drought, haze, and so on. To focus on those effects on the incidence rate of disease that sensitively to the climate change in all the country. And to explore and establish the early warning system, preparedness plan to response to the emergency and the corresponding methods or technology. Evaluate the validity of the series of countermeasures.

In 2007, the important project that supported by national scientific and technique development planning "crucial skills of monitoring, detecting and forecasting to the primary extremely weather events and the significant meteorological disasters in China" was established. It was lead by the China Meteorological Administration and several departments engaged such as Chinese Ministry of Education, Chinese Academy of Sciences, Chinese Ministry of Water Resources and Chinese Ministry of

Land and Resources. The purpose of this project is to develop and expand the analysis method and crucial skill of monitoring, detecting and forecasting to the extremely weather events and significant meteorological disasters caused by these events in China, to analyze the effect to community economy in China by these climate events and disasters, to set up a professional system up to the international advanced level to defend and reduce disasters in China, it is a system of monitoring, detecting, forecasting, impact assessment, early warning and risk management to the extremely weather and climate events.

It was pointed out in《Response to Climate Change: China's Policies and Actions》promulgated by the State Council in October 2008 that now the capacity building of monitoring and early warning to extreme weather events was improved, and the emergency disposal mechanism to the related meteorological disasters and the derivative and secondary disasters was basically established. The defense to the extreme weather events like violent typhoon and regional rainstorm and flood has rapidly improved, the unified observation system to climate and climate changing was basically established.

2.5 Public events early warning information release system (China Meteorological Administration network)

A complete early warning system for public events should include several parts "monitoring – early warning - messaging- user's responding" and so on. With the gradually developing of early warning, timely information releasing and publicizing the relevance population play a key role on the effectively of the early warning and preventive measures. To this end, China Meteorological Administration set up public events early warning information releasing system based on satellite. No geographical regions 'restrict, easy to set up the terminal devices, and companies by other methods (such as SMS, telephone, etc.) ,the information releasing system can be get to the remote mountain areas, remote rural areas, desert, islands and other regions, which effectively addressed the reception problems of the public event early warning

Information.

3 The preparedness response to health impacts of climate change

The global climate change brings various threats to human health and takes great public health problems at the same time. So the emergency responses to climate change also come to be an important way to measure the working ability of the national public health. In 2003, the outbreak of SARS in China exposed lots of problems of the emergency ability of Chinese public health system. Therefore, the government of China has taken powerful measures to improve the public health emergency system.

3.1 Profile of Chinese public health emergency response system

On May 2003, 《The Regulation on the Urgent Handling of Public Health Emergencies》 was carried out by the State Council. On January 2005, 《The National Emergency Response Program for Public Incidents》was promulgated. The constituents and functions of emergency treatment headquarters of contingency events should to be affirmed. To establish the monitoring and warning system, the system of collection, analysis, report and announce of information, to formulate the classification response scheme of contingency events, to do the work of emergency material reserve and scheduling well, and to improve the establish of contingents. This shows the beginning of legally control on our emergency response management in China. In 2004, CPHP (Center of Public Health Preparedness) was established in China CDC. On January 2006, Ministry of Health established the expert advisory committee of public health emergency events which was formed by public health experts to further improve the warning and emergency treatment work of emergency events comprehensively. In August 30 2007, the National People's Congress passed the "People's Republic of China law to deal with emergencies," further legal level of emergency preparedness and prevention, monitoring and early warning, emergency and rescue, rehabilitation and reconstruction after the , And other activities should be carried out norms.

Now in China, the preparedness response system of public health emergency events includes five aspects: command system, information monitoring system, technique supporting system, technique material reserve system, legal guarantee system. The command system is an emergency unified action system with unified command, level-by-level responsibility, orderly coordination and highly efficient. It was formed by State Council related organizations, local organizations and experts together. The disease prevention and control system has established a four levels work net of “Central-Province-prefecture and county”. Till now there are 3440 disease prevention and control institutions and 20 million staff worked on disease control. And three major contents have been formed including prevention and treatment of infectious diseases, public health and chronic disease prevention and control. In addition, China's rural county, township and village "three-tier rural health network" has been further strengthened. At present, 93.5 percent above the county level medical and health institutions and 70.3 percent of township hospitals have achieved public health emergencies and outbreaks of direct network reported. China's epidemic of infectious diseases, health hazard monitoring, the cause of death, and other important public health monitoring of real-time data management and emergency response capacity markedly improved.

China also joined in the global emergency net system of international organization but still few until now. From 1980s, some countries, international organization and international cooperative projects established ecological, environmental observation and research nets of national, regional or even global scale. Such as, “long-term ecological research net” in America, “environment changing research net” in Britain, “global environmental monitoring system” established on global scale by UNEP. These systems have great value in the early warning and forecasting of infectious diseases especially of the climate, vegetation and media-related diseases in the future.

China joined in the “Global Outbreak Alert and Response Network” of international hygiene organization. This network integrated the human and technical resources of 112 organizations in the world together (include 13 state-level laboratories in China) to identify, recognize and respond the outbreak of international infectious diseases. In view of the system have a set of automated continuation response procedures, so that once the alarm, the emergency system will be activated right away and to make the system response within 24hrs.

3.2 Problems in Chinese public health emergency system and the emphasis of construction（Liu et al., 2006）

3.2.1 Existing problems

1）Crisis and disaster of the consciousness of the health department should get further improvement.

For the information work in Chinese health system started late, and the level is generally lower, extremely unstable developing, so there are differences coping exploding public health events in plague situation consideration, organization structure, work pattern and running mechanism and there exist a series of problems on coping ability, commanding coordinated mechanism. More modern information technique should be applied.

2） No enough in early warning index system and internet

The public health emergency events have the characteristics of the exploding and district. So to confirm the early warning index suit to different areas, the history data, and the general prevailing level according to different diseases in different district should be made. Then the experts build early warning points, comparing the present information with history data such as over the early warning point, computer warning automatically. But at present, there is short of clear early warning point in the plague situation reporting system and the need of automatically monitoring level.

3）The slow reaction speed of monitoring reporting system

At present, infections disease monitoring system (national epidemic situation reporting system ,national disease monitoring system and single disease monitoring system) is relative consummated, but there are still some problems such as multiple management, repeated report content, every system is alone and short of communication, so result in the unclear and not on time of early warning prediction for epidemic situation so that the reaction speed is slow, information not smooth and no command coordination.

4） Short of public heath investment and early warning reaction measures

Lately, though Chinese government has thrown much financial and material resources into public health construction, there is extremely difference from the need of the present public health system。The serious insufficiency of investment resulted in the weakness of soft and hard wire in public health system and the ability of coping with the exploding crisis. At present, there existed lagged behind equipments, professional structure is unreasonable, members’ quality is not high so that they can not adapt to the need of prevention disease work in the new situation in most of the counties, cities’ disease prevention control center. On the other hand, resulting from the shortage of investment, there are no enough emergency equipments to cope with the public health emergency events and no enough rescuers medicine or medical equipments in medical system. When the exploding events happens, there are extremely short of sorts of equipments, medicine and medical equipments.

5）Policy and regulations are weak

At present, China’s relevant laws and regulations are largely located in a field of public health, while the "public health" or "Health Act" are lack that clearly define the responsibility and obligation about functions position, people, nature and interests of public health in social and economic development

It lead to the entire public health system lack of a clear positioning functions，on the other hand, it as well as cause public health system can not become a public health objectives truly，as a direct result, the development of public health lags behind the overall socio-economic development(Chen et al., 2007; Yang et al., 2006).In addition, the preparedness response to public health emergencies related laws and regulations are not sound.

3.2.2 Tendency of development

1）Establishing monitoring and reporting system with consummated function.

The collect manner of public health information based on the three original major monitoring systems of infectious diseases, and should also flexibly establish new diseases monitoring and reporting system to new diseases. In addition, it should be strengthened that the cooperation with other relevant departments and units to improve the health related event monitoring system. After integration and analysis of the variety of information, promulgate out the early warning and forecasting information in time if there is abnormal information. The State Council has decided to invest tens of billions Yuan for hardware and software building of emergency treatment to the contingency public health events, including the improving of epidemic monitoring and reporting system. In the future, epidemic reporting system will be extended to the streets and villages, all medical institutions can input the cases information into the public database of infectious diseases through internet directly when they found the epidemic, which greatly improved the classification access of information. With timely and accurate information, the signs of epidemic can be found early, the early warning system can be start in time, and the best opportunity can be seized to control the epidemic in the least scale.

2） Optimizing the resources allocation of early warning system ,consummating early warning reaction measures

To make full use of existing infrastructure, to increase investment of public health, and to establish the disease prevention and control institutions with a vertical top-down management. To make optimize reorganization to the staffs of the existing public health institutions, insert talents and train the existing human resources, to strengthen the knowledge of epidemiology, health statistics and computer, to increase the training of principle and technique of early warning through monitoring data, to increase the early warning capability of staffs on the contingency public health events. In the hardware, the laboratory building must be strengthened, to equip the advanced equipment to enhance the capacity of rapid diagnostic screening and monitoring of public health laboratories. At the same time, the government should mobilize the relevant departments to strengthen the emergency material reserves and improve the emergency rescue system.

3）Establish the vertical accountability of public health service system

Use the strictly accountability system to clear the responsibility of government, departments, units and the citizens. To enable the government to orderly organize the early warning, prevention and control on emergency through the establishment of clearly responsibility system. When the signs of emergency were found, be able to supervise all the departments and units to reach the provision of jobs soon and take positive measures to do early warning. Affirm the responsibility of citizens at the same time, such as, to accept the isolation treatment of infectious diseases in public health emergencies, to cooperate the investigation of epidemic, to accept the mandatory personal if it is necessary, so that to make the clearly responsibility of the whole society, solidarity and cooperation. At the same time, those units or individual who do not perform their duties should be rigorously pursue their administrative or criminal liability in accordance with the law to ensure the effective disposal of public health emergencies.

3.2.3 Work emphasis (aim at climatic change effect on the health and emergency work)

1）The emphasis is to raise the identification of health and weak and evaluation of intervention study, reduce the Adverse health outcomes and protect the susceptible population of emergency events.

2）Launch public health emergency event service and management system evaluation, strengthen emergency reaction system construction.

3）Strengthen propaganda and training of public health work strategy, raise the public health work efficacy.

4）Raise the Effectiveness of response communication of emergency events

5) Raise the ability of information management and the validity of decision making

6）Strengthen the construction of early warning prevention and cure mechanism for extreme weather disaster and emergency events should be strengthen.

Section2 Mitigation polices and achievements of climate change in China (China's National Climate Change Programme,2007)

As a developing country, China has put the increasingly serious and urgent problems of environmental pollution and shortage of supply of energy resources as the driving force and the entry point for the mitigation of climate change to promote the implementation of the strategy. And China also has laid the reducing carbon emissions as a national energy strategy objective. Therefore, based on taking full account of the long-term national socio-economic development, climate change mitigation strategy and national strategies for sustainable development must be made into harmony.

1 Countermeasures to climate change mitigation

1) Insist on putting the core technology of climate change mitigation to the priority development field. Increase the investment in research and development and speed up the pace of industrialization of advanced technology.

2） Implementation of the priority energy-saving energy policy, energy production, transmission, processing, conversion to the final use of the whole process of the implementation of energy-saving management;

3） Actively development of renewable energy technology, advanced technology and nuclear energy efficient, clean, low-emissions coal technology and the use of hydrogen energy technology, breakthroughs in key areas of renewable energy power generation technology, building integrated solar technology and biomass liquefaction, gasification technology Actively develop solar photovoltaic technologies;

4）Change in economic growth mode, stick with high technical content, good economic returns, low resource consumption, less environmental pollution, human resources and give full play to advantages of a new road to industrialization;

5）Improve the way of land-use, strengthen the protection of forest resources and management, vigorously promote afforestation combined with the key national ecological construction for comprehensive management of the project.

2 China’s Efforts and Achievements in Mitigating Climate Change

As a developing country of responsibility, China is among the first to formulate a national Agenda 21 entitled China’s Agenda 21 - White Paper on China's Population, Environment and Development in the 21st Century, soon after the United Nations Conference on Environment and Development in 1992, and adopted a series of policies and measures taking into account its specific national circumstances, making positive contribution to the mitigation of climate change.

(1) Restructuring the economy, promoting technology advancement and improving energy efficiency

Beginning from the late 1980s, the Government of China paid more and more attention to the change of the economic growth pattern and the restructuring of economy, and integrated the reduction of energy and other resources consumption, the promotion of clean production, and the prevention and control of industrial pollution into its national industrial policies. The industrial structure has been significantly improved through the implementation of a series of industrial policies to accelerate the development of the tertiary industry and restructure the secondary industry. The share of primary industry declined continuously, the tertiary grew greatly and the secondary industry has slightly grown in the overall share, but its internal composition has significantly changed. During the period of 1991 ~ 2005, China has achieved an annual GDP growth rate of 10.2% with an annual growth rate of 5.6% in energy consumption.

As early as 1980s, energy conservation was effectively promoted through the implementation of the Law on Energy Conservation of the People's Republic of China and relevant regulations, the development of specific energy conservation plans, the adoption and implementation of technology, economic, fiscal and management policies in favor of energy conservation. From 1990 to 2005, China's energy intensity (energy consumption per Million GDP at constant 2000 RMB Yuan) went down from 268 to 143 tons of coal equivalent (tce), decreasing by an average annual rate of 4.1%.. As calculated on the year by year comparison, during the period of 1991 ~ 2005, an accumulated 800 million tce of energy were saved by economy restructuring and energy efficiency improvement, which is equivalent to a reduction of 1.8 billion tons of CO_2 emissions, using China's 1994 emission factor of 2.277 tCO_2/tce.

(2) Optimizing energy mix by developing low-carbon and renewable energy

Under national policy guidance and with financial support, the share of high grade and clean energy was improved by strengthening the development and utilization of hydropower, nuclear energy, oil, gas and coal-bed methane , and supporting the development and utilization of new and renewable energy including biomass, solar, geothermal and wind power in rural areas, remote areas and other suitable areas. Share of coal in China's primary energy mix decreased from 76.2% in 1990 to 68.9% in 2005, whereas the shares of oil, gas and hydro increased from 16.6%, 2.1% and 5.1% in 1990 to 21.0%, 2.9% and 7.2% in 2005, respectively.

In 2005, the utilization of renewable energy in China equaled to 166 million tce (including large hydropower), accounting for 7.5% of China's total energy consumption in that year, equivalent to a saving of 380 million ton CO_2 emissions.

(3) Launching national wide tree-planting and afforestation campaign and enhancing ecology restoration and protection

Since the reform and opening up to the outside world, tremendous achievement has been made in tree-planting and afforestation along with the implementation of key forest ecological projects. According to the Sixth National Forest Survey, theacreage of conserved artificial forests in China was 54 million hectares, ranking the top one in the world, and the amount of growing stock was 1505 million cubic meters. Total area of forest cover in China was 174.91 million hectares, and the percentage of forest coverage increased from 13.92% to 18.21% during the period from early 1990s to 2005. In addition to tree-planning and afforestation, China initiated many other policies for ecology restoration and protection, including natural forest protection, reclaiming cultivated land to forest or grassland, pasture restoration and protection, further enhancing the capacity of forest as the sinks of greenhouse gas. Meanwhile, urban green area grew rapidly in China as well. By the end of 2005, total green area in the built-up urban area in the whole country reached 1.06 million hectares with a 33% green coverage and 8.1 square meters of public green area per capita. The green area helps absorbing CO_2 in the atmosphere. Estimated by relevant experts, from 1980 to

2005, a total of 3.06 billion ton CO_2 absorption was achieved by afforestation, a total of 1.62 million ton CO_2 absorption by forest management, and 430 million tons of CO_2 from deforestation were saved.

(4) Effectively controlling the growth rate of population through family planning

Since 1970s, the Government of China has made it a basic national policy to carry out family planning all along, and the excessive population growth trend has been brought under effective control. According to the statistics of the United Nations, China's fertility rate was lower than that of other developing countries and the world average as well. In 2005, birth rate in China was 12.40‰, and the natural growth rate was 5.89‰, dropped by 8.66 and 8.50 permillage points respectively compared to the level of 1990, making China one of the countries with a low fertility rate in the world. Since the implementation of the family planning program, over 300 million births have been averted nationally by 2005. According to the average per capita emissions from the IEA statistics, the averted births have resulted in an annual reduction of CO_2 emissions by about 1.3 billion tons in 2005. It is a significant contribution that China achieved in the fields of controlling world population and mitigating GHG emissions.

（5）Strengthening laws and regulations, and policies and measures relevant to addressing climate change

To address newly-emerging issues in recent years, the Government of China has advocated for the Scientific Approach of Development and Strategic Thoughts of Building a Harmonious Society, and accelerated the building of a resource-conserving and environmentally friendly society, thus further reinforcing the policies and measures relevant to addressing climate change. In 2004, *China Medium and Long Term Energy Development Plan Outlines 2004-2020* (draft) was approved by the State Council. In the same year, the first *China Medium and Long Term Energy Conservation Plan* was launched by National Development and Reform Commission (NDRC). In February 2005, the National People's Congress adopted the *Renewable*

Energy Law of the People's Republic of China, setting out the duties and obligations of the Government, enterprises and users in development and utilization of renewable energy and a series of policies and measures, including total volume target, mandatory grid connection, price management regulation, differentiated pricing, special fund, favorable taxing, etc. In August 2005, the State Council *issued the Notification on the Immediate Priorities for Building a conservation-oriented Society* and *Several Opinions on Accelerating the Development of Circular Economy*. In December 2005, the State Council issued the *Decision to Publish and Implement the Interim Provisions on Promoting Industrial Restructuring* and the *Decision to Strengthen Environmental Protection by Applying the Scientific Approach of Development*. In August 2006, the State Council issued the *Decision to Strengthen Energy Conservation.* All those documents serve as the policy and legal guarantee to further enhance China's capability in addressing climate change.

（6）Further improving institutions and mechanisms

China established the National Coordination Committee on Climate Change (NCCCC), which presently comprises 17 ministries and agencies. The NCCCC has done lots of work in the formulation and coordination of China's important climate change-related policies and measures, providing guidance for central and local governments' response to climate change. In order to fulfill conscientiously China's commitment under the UNFCCC, beginning from 2001, the NCCCC organized the work on the compilation of the Initial National Communication on Climate Change of the People's Republic of China, and presented the report to UNFCCC at the tenth session of the Conference of the Parties (COP10) in December 2004.

In recent years, the Government of China has strengthened its comprehensive management of energy that is closely related to addressing climate change by establishing a National Energy Leading Group and its office, which has further strengthened its work on energy management. In October 2005, the amended *Measures for Operation and Management of Clean Development Mechanism Projects* was promulgated by the relevant departments of the Government.

（7）Attaching great importance to climate change research and capacity building

The Government of China highly values its capability and capacity to support scientific studies and researches on climate change, and constantly enhances them. It has implemented a number of key research projects, such as *Study on Forecasting, Impact and Countermeasures of Global Climate Change*, *Study on Global Climate Change and Environmental Policies, etc.* *U*nder t*he National Climbing Program* and the *National Key Fundamental Research Program*, projects such as *Study on Formation and Prediction Theory of Key Climate and Weather Disasters in China*, and *Study on Carbon Cycle in China's Terrestrial Ecosystems and Its Driving Mechanism* were conducted. Under the Innovative Research Program, *Carbon Balance Study in China's Land and Offshore Area* has been accomplished. Other key projects related to climate change were also conducted, including *China's Climate, Sea Level Change and Their Trend and Impact*. *China's National Assessment Report on Climate Change* has been completed. All those studies and researches provide scientific basis for developing national policies to address climate change and for China's participation in negotiations under the UNFCCC. Several projects on international cooperation in Clean Development Mechanism capacity building were also conducted by relevant departments of China.

（8）Strengthening education, training and public awareness on climate change

The Government of China always attaches importance to education, training and public awareness on climate change. *The Program of Action for Sustainable Development in China in the Early 21st Century* states that China will vigorously develop all forms of education at all levels, to enhance the public awareness on sustainable development and enhance their scientific and cultural capacity for their participation in the sustainable development by reinforcing personnel training. In recent years, China has intensified its efforts to promote education, training and public awareness on climate change by organizing various kinds of lectures on climate change basic knowledge, conducting climate change training courses for policy makers at central and provincial levels, and organizing conferences such as Climate Change and Ecological Environment, as well as setting up an official bilingual website on climate change (China Climate Change Info-Net http://www.ccchina.gov.cn) in Chinese and English to provide comprehensive information on climate change. Commendable results have been achieved accordingly.

Chapter 8 Conclusions

The international research of climate change and human health began in the late 1980s and early 1990s, while up to the present, the number of science data is limited, and most of them associated with climate variability and extreme events (such as heat waves). After 1995, most research directed towards infectious disease, particularly the effects study on health of the natural climate variability related to the inter-annual change of epidemic diseases and the study of the relation of the daily weather and mortality in the different the population size cities. At the same time, the simulator investigation of the effect on epidemic diseases of various climate change scenarios, while, the information sequence that could be used to measure the effect of the long-term trends of climate change on health is still very small. This report review the present research and results of climate change and health field from the heat-related disease, infectious diseases, water resources, air pollution and food safety, and on the basis of analysis the gap between domestic and foreign research, put forward China's adaptive measures and recommendations, further pointed out the priority areas of the China's climate change effect on the health.

Section 1 Research and problems on health impacts of climate change in China

1 Now, Health impact assessment of Climate Change is mainly focused on agriculture, water resources, natural ecosystems and coastal zones, while little work has been done to assess health impacts of climate change. Establishing assessment indicators system and assessment pattern are need. As well as developing health impacts assessment of regional climate change, including vulnerability assessment, effectiveness evaluation of the interventions and the evaluation of adaptation strategies.

2 On the health effects of climate change, studies mainly focused on heat waves and human health, especially on the morbidity and mortality of heat-related disease; climate change and infectious diseases related to climate change on infectious diseases, as well as the future Climate change on infectious disease incidence and spread of the impact; And few studies have been carried out on the relationship between climate change and air pollution, water resources, food safety and nutrition and so on.

3 Most studies on health impacts of climate change are about weather conditions, and are rarely about climate change in the strict sense. Meanwhile, the effective quantitative models are so scarce used to evaluate the relationship between climate change and occurrence and development of disease.

4 In many cases, the effects of climate change on health mainly reflected by of the impacts of extreme climate / weather events. Strengthening extreme climate / weather events impact assessment and looking into the mechanism. Then it is very important to take active measures to reduce the dangerous levels of climate change and strengthen analysis of the threshold of health impacts of climate Change.

5 The existing climate change - disease surveillance and early warning forecast system is still not perfect, only in a small number of cities carried out the day-to-day climate-related disease risk prediction. Furthermore， due to the difficulties in access to the basic information of the disease, or the poorly integrity, and often is just a regional data, the forecasting result of the disease forecasting model or heat wave warning system are usually limited in the accuracy.

6 lack of disease burden and cost-effective analysis of climate change

7 At present, there are still a lot of gaps existing in China's health system, such as difficult to access the basic data, inadequate health information systems, the lagging of prevention and control measures.

8 Imperfect co-operation mechanism between Meteorological departments and the

health sector, and not perfect sharing information, technology and so on.

Section 2 Adaptation strategy of climate change in China

WHO point out that the impacts of Climate change will be different in various places. Health impacts of Climate change will be subject to a number of conditions, such as development levels, poverty and education, public health infrastructure, land use and political structures, etc. States with severe poverty and malnutrition or weak health infrastructure will face to an enormous challenge in addressing climate change.

Several countries have developed national health impacts assessment of climate change, here are some major findings and adaptation measure.(IPCC,2007)

County	Key findings	Adaptation recommendations
Canada （2004）	Increase in heatwave-related deaths; increase in air pollution-related diseases; spread of vector- and rodent-borne diseases; increased problems with contamination of both domestic and imported shellfish; increase in allergic disorders; impacts on particular populations in northern Canada.	Monitoring for emerging infectious diseases; emergency management plans; early warning systems; land-use regulations; upgrading water and wastewater treatment facilities; measures for reducing the heat-island effect.

Germany （2005）	Observed excess deaths from heatwaves; changing ranges in tickborne encephalitis; impacts on health care.	Increase information to the population; early warning; emergency planning and cooling of buildings; insurance and reserve funds
Spain （2005）	Increase in heat-related mortality and air pollutants; potential change of ranges of vector- and rodent-borne diseases.	Awareness-raising; early warning systems for heat waves; surveillance and monitoring; review of health policies.
Switzerland （2004）	Increase of heat-related mortality; changes in zoonoses; increase in cases of tick-borne encephalitis.	Heat information, early warning; greenhouse gas emissions reduction strategies to reduce secondary air pollutants; setting up a working group on climate and health.
Portugal （2006）	Increase in heat-related deaths and malaria food and water-borne diseases, West Nile fever, Lyme disease and Mediterranean spotted fever; a reduction in leishmaniasis risk in some areas.	Address thermal comfort; education and information as well as early warning for hot periods; and early detection of infectious diseases.

New Zealand （2001）	Increases in enteric infections (food poisoning); changes in some allergic conditions; injuries from more intense floods and storms; a small increase in heat-related deaths.	Systems to ensure food quality; information to population and health care providers; flood protection; vector control.
Bhutan （2006）	Loss of life from frequent flash floods; glacier lake outburst floods; landslides; hunger and malnutrition; spread of vector-borne diseases into higher elevations; loss of water resources; risk of water-borne diseases.	Ensure safe drinking water; regular vector control and vaccination programmes; monitor air and drinking water quality; establishment of emergency medical services.
India（2004）	Increase in communicable diseases. Malaria projected to move to higher latitudes and altitudes in India.	Surveillance systems; vector control measures; public education.
Japan（2006）	Increased risk of heat-related emergency visits, Japanese cedar pollen disease patients, food poisoning; and sleep disturbance.	Heat-related emergency visit surveillance.

From the above facts of international research, we can see that in the face of climate change on people's health, the research core of health sector included several aspects. First, focusing on the follow-up study of the relationships among the environmental change, risk of disease and climate change; Second, enhancing the capability to exactly modeling and forecasting the health impacts of climate change; Third, indentifying the regions and populations with high-risk or high incidence of the disease, especially the populations with particular vulnerable to thermal stress; children and the elderly as well as the poor sensitive areas; in addition, to help educate the public and government awareness about climate change and Health impact information; to help the Government establish and implement emergency response programs, focusing on doing a good job to deal with heat stress, infectious diseases and extreme weather events such as the major preparatory work. The Chinese government in responding to climate change has also done a lot of work in the health sector for the current and future health effects of climate change adaptation has adopted a series of measures and countermeasures, including:

Research Field	**Findings**	**Adaptation countermeasures**
Thermal stress	Heat wave- related disease and death	Early warning system; public awareness on heat wave; health care of medical agency.
Infectious	Climate change is likely to affect the transmission of vector-born diseases	Establishing related

disease	and the reproductive rate of entomophilies. For example, the incidence rate of Malaria in China has showed the increasing trends since 2000； the possibility of water-snail moving to north indicates the scope of the impact of schistosomiasis may be increased；The geographical epidemic areas of dengue fever have been expanded north.	strategies； developing infectious diseases and vector surveillance; developing scientific research and vaccine promoting; public education.
Water resources	Water shortage may be exacerbate; Flood and drought disasters likely to increase ； The incidence of water-borne diseases increased	Establishing related policies to improve water resources management system； enhancing the water infrastructure construction； water-borne disease surveillance； water quality survey； water safety plan; monitoring and early warning; flood and drought control

		and preparedness plan
Air pollution	greenhouse gas emissions increasing Fossil fuel combustion release is serious;	reduce greenhouse gas emissions by reducing vehicle emissions or other transport policy measures could benefit health; implementation of indoor air pollution intervention (changing cooking stoves to furnaces; education)
Food safety and nutritious	Research mainly focused on agricultural production, especially on the impacts of greenhouse effects.	Enhance adaptability for sustainable development；food quality assurance system; public information publicity to common people and health care personal; enhance the development of ecological environment, agricultural production and reduce the sensitivity to climate change.
Climate change health impacts	Relatively well-integrated disease surveillance system; establish the	Further improve the early warning and forecast

countermeasures	environmental related factors monitoring system pilot cities; heat wave early warning and forecast system (part of the national and provincial platform); public health emergency team and emergency preparedness plan	system; to strengthen emergency supplies, technology and construction stocks; emergency measures to improve the timeliness

Based on the status and the problem existing in the adaptation of climate change in China， several research need for health systems to better adapt to climate change are as following：

1) Examination of the factors that affect our current capacity to adapt, including physiological factors, psychological factors (e.g., knowledge, beliefs, attitudes), socio-economic factors, and the characteristics of health care systems

2) Progressive development and implementation of biological and health surveillance measures as adaptations to climate change

3) Further research into the development of preventative adaptation measures, such as the development of vaccines for emerging diseases and alert systems for extreme temperatures

4) Research on the role of emergency management and hazard prevention in reducing the negative health effects (both physical and psychological) of extreme climate events

5) Evaluation of the effectiveness and adequacy of existing measures those are likely to be proposed as possible adaptation tools, such as public health advisories (e.g., smog information, boil-water advisories, and beach closings)

6) Strengthening public institutions and building health systems to make sure them work well

Section 3 Uncertain about the health impact of climate change and key research priority

1 Uncertain about the impact of climate change on health (Xu et al.,2006)

There are many uncertain problems in the health impact of climate change，the reason is that:

(1) Climate change often goes with many other kinds of environment changes, and many diseases are caused by a variety of factors, so, it is very difficult to distinguish its pathogenic role from comprehensive action of other factors.

(2) It is very difficult to ascertain the sensitivity of health impact resulted from climate change, the response can be caused by endogenous features, also can be caused by the environment that people sensitive to it.

(3) It is difficult to forecast climate changes over the next several decades, meanwhile the society, economy, population, technology, health and health care may be change a lot.

(4)There are three kinds of uncertainty in simulating of the impact of climate change on health. The first is the statistic variety of “normal value”; the second is that key parameters value of the model selected by approximately; the third is that the model structure’s imperfect due to the incomplete knowledge.

So, in the future, we should pay more attention to these problems, provide new assessments and model and do study and analysis more carefully.

2 Research priority of health impacts of climate change

2.1 International research priorities

In 2007, Working Group II Report "Impacts, Adaptation and Vulnerability” was released (IPCC Fourth Assessment Report). In this report, several key research priorities were been pointed out include addressing the major challenges for research on climate change and health in the following ways (IPCC,2007):

1) Development of methods to quantify the current impacts of climate and weather on a range of health outcomes, particularly in low- and middle-income countries.

2) Development of health-impacts models for projecting climate-change-related impacts under different climate and socio-economic scenarios.

3) Investigations on the costs of the projected health impacts of climate change; effectiveness of adaptation; and the limiting forces, major drivers and costs of adaptation.

Five priority fields had been identified on the meeting about Climate change on human health effects hosted by Spain Ministry of Health and WHO in October 2008, to develop the relation of the Earth's temperature and health factors and trends (WHO,2008).

These five fields are：

1) Interactions with other health determinants and trends - Climate change does not act in a vacuum. There is an urgent need for a better understanding of how climate change does and will interact with other important health determinants and trends, such as economic development, globalization, urbanization, and inequities both in exposure to health risks and access to care.

2) Direct and indirect effects - Much is known of short-term health impacts of climate change. There is a need for better characterization of the effects of long-term changes such as increasing drought, decline in freshwater resources, and population displacement, ranging from mental health impacts to risks of conflict, with a particular focus on children and other vulnerable groups.

3) Comparing effectiveness of short-term interventions - Different countries have taken a variety of approaches to deal with climate change-related health threats such as heatwaves and floods. Comparative outcome assessments can help rank effectiveness of interventions.

4) Assessing health impact of policies of non-health sectors - There is an urgent need for rapid assessment of the health implications of specific climate change prevention (mitigation) and adaptation policies in other sectors, such as the potentially negative effect of promotion of biofuels on food security and malnutrition; and the potentially positive health effects of sustainable energy and transport policies.

5) Strengthening public health systems to address health effects of climate change. Most health systems interventions to deal with climate change build on basic public health competencies. More knowledge is needed to identify the most effective means of implementing integrated preventive public health strategies that reduce not just climate change related threats but all environmental health risks.

2.2 Research priority of health impacts of climate change in China

1) Strengthening the research of science and policies on the health impacts of

climate change

At present, most of the researches focus on the environment toxicology, and less on the effects of the weather and climate change on the human body, and it need strengthen. To obtain significant results on it, vigorously carry out more cross-disciplinary research be imperative.

Now, climate change is one of the most complicated problems that modern science is facing up to and there are still many uncertain problems have not been solved. So, in order to forecast the effects on human health caused by climate change and take adaptive measures early, we need to strengthen the basic and the forward studies, to deepen and quantify the studies on relationship between climate change and human health and on adaptive policies.

2）Developing health risk assessment of climate change and establishing the assessment system of climate change on human health

Developing health risk assessment could carry out the research of climate and health indeed，achieve the unification of social benefits, environmental benefits and economic benefits really. While the health risks assessment on climate change is more comprehensive cross-disciplinary work across medical science, biological science, environmental science, demography and management of science. How to make the evaluation of scientific research and management of the combine is a priority.

To establish the assessment system of climate change-human health impact, carry out the risk assessments of climate and climate research division for the major epidemic disease, pestilence，determine the importance of prevention and treatment of infectious diseases in the different region and season；study the relationship between climate with the disease breeding, disseminate, and the course of the outbreak, determine the beneficial and adverse weather and climate conditions; study the climate models to assess disease；divide climate disease and determine the focus of prevention and treatment of infectious diseases in different season and different region using GIS technology, integrated disease, climate and other environmental databases. And the regional climate change and health analysis is on the lack.

At the same time, actively carry out the intervention effective evaluation and adaptation strategies evaluation, so as to more effectively deal with climate change.

3) Establishing and improving the climate change -diseases monitoring system, forecasting and early warning system

Under the foundation of existed forecast and serving systems of human healthy life index, weather index of common diseases and frequently-occurring disease, develop the study and serving systems of infectious diseases and establish short, middle and long-term forecast and early warning serving system to prevent and respond to the extreme weather events caused by global warming actively. Strengthen the capability of defending and mitigating natural disasters, relying on scientific and technological progress to enhance monitoring, forecasting, prediction and early warning level constantly. The defense of extreme weather and climate disasters is at the location of vital importance to deal with climate change to improve the monitoring capability, early-warning capability, the resist and reduce disaster capacity of response to extreme weather disaster

Perform the monitoring and early warning works of health impacts of climate change using the national and international satellite meteorological data and combining with diseases data, setting up foundational database on the impacts of climate change on human health; establish monitoring and early warning real time operation system and exploit products manufacturing and distribution system to service for public to provide rich, accurate, timely and authoritative disease monitoring assessment, forecasting, early warning, as well as disease prevention and other services.

4) Multi-sectors and multi-fields take part in international cooperation and

exchanges

Climate warming is the world problem and mitigating climate change and improving sustainable development of globe environment are human's common responsibility. Thus, strengthening bilateral and multilateral international cooperation studies and supporting our scientists to take an active part in international academic activities to enhance our study capability and levels on the impacts of climate change on human health.

Climate and health is a comprehensive multi-disciplinary problem, atmospheric science, need a wide range of community cooperation within climate science, environmental science, medicine and social sciences. It need to be focused to training high-level build comprehensive talented persons (including persons at work on scientific study and administration), and well learn, absorb and make use of overseas' advanced technologies and carry out more cross-disciplinary research, to improve our scientific studies on climate change to reaching the world advance level.

5）Strengthening education, training and propagation of the impacts of climate change on ecosystems and human health

Add the contents about climate change in the teaching, and through various media, strengthen the publicity, education and training on the globe climate change, encouraging public participation to enhance the public awareness of protecting the global environment and climate, guide people to establish a life style and consumption mode that helpful for reducing greenhouse gases emissions and to learn about the direct and indirect effects of climate change on human health, to promote social and economic development

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