

Chapter 3 Impacts of Climate Change and Adaptation

Chinese scientists began to assess the impacts of, the vulnerability and adaptation to climate change since 1990s. The studies were concentrated on the four areas closely related to the national economy, namely, water resources, agriculture, terrestrial ecosystem and coastal zone including offshore marine ecosystems. Because the research of assessing the impacts of and adaptation to climate change in China is still at the initial stage, what is contained in this chapter are mainly the results of a preliminary study by a part of Chinese scientists, and there still exist a lot of uncertainties in some conclusions.

3.1 Methods and models for the assessment

Early assessment of impacts of climate change was mostly qualitative studies on sensitivity under incremental scenarios. In recent years, the study has been carried out based on the quantitative models linked up with projected outputs of the global climate models (GCMs) under transient greenhouse gases (GHGs) emission scenarios.

When assessing impacts of future climate change over China, it is necessary to obtain the regional climate change scenarios in China. There are two sources for these data: the outputs datasets of GCMs issued by the IPCC Data Distribution Centre (DDC) and the simulated results of GCMs worked out by Chinese scientists.

At present, the horizontal resolution of GCMs used for projecting the climate change scenarios is coarse (the horizontal grid box is hundreds of kilometres). When different discipline models are used to assess the impacts of climate change, downscaling the GCMs outputs with statistics and regional climate models (RCMs) has been done by Chinese scientists.

The steps and methods for the impacts assessment are referenced to the IPCC Working Group II Technical Guidelines for Assessing Climate Change Impacts and Adaptations.

The discipline models used by Chinese scientists as assessment tools are as follows: hydrological models including Xin'anjiang model, monthly runoff dry model, variable infiltration capacity model (VIC), etc.; agricultural models including crop models (CERES), grass productivity model (SPUR2), etc.; ecosystem models such as mechanistic ecosystem model (CEVSA); and marine models such as coast-sea level rise projection model.

3.2 Characteristics of climate change in China

3.2.1 Surface air temperature and precipitation

The climate in China has also experienced obvious changes in the context of global warming. It is shown that the trend of the climate change in China in the past century is consistent with the general trend of global climate change, with the 1990s being the warmest periods in the recent 100 years. In terms of regional distribution, the most obvious climate warming is shown in the northwest, the northeast, and north China, while the warming trend is not obvious in the areas south of the Yangtze River. In terms of seasonal distribution, the warming increment is most obvious in winter. China experienced 18 successive warming winters throughout the country from 1986 to 2003 (Figure 3.1). The greatest precipitation occurred in China in the fifties of the 20th century, and then reduced gradually, particularly accompanying with the appearance of a trend of warm-dry climate in north China.



With the help of GCMs and RCMs (eg. RegCM2), the future climate changes in China were projected by Chinese scientists. The simulated results show that under the $2\times\text{CO}_2$ scenario, the temperature increment in the south of China is $2\text{--}2.5^\circ\text{C}$, while that in the north of China is higher to $2.5\text{--}3^\circ\text{C}$. The projected results of the changes in temperature in China in different seasons are shown in Table 3-1.

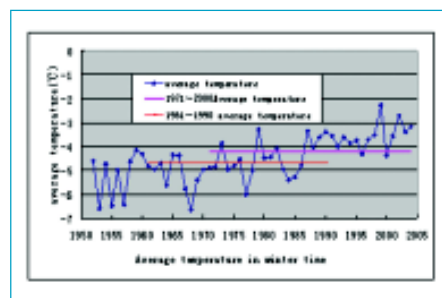


Figure 3.1 Trends of the changes of average temperature in winter from 1952 to 2003 in China

Table 3-1 Changes of surface air temperature and precipitation in China under $2\times\text{CO}_2$ scenario

Season	Changes of surface air temperature ($^\circ\text{C}$)	Changes in precipitation (%)
Winter	3.0	17
Spring	2.6	6
Summer	2.4	19
Autumn	2.1	6

It is shown in Table 3-2 the average results of the future climate change in China projected by about 40 GCMs under four GHG emission scenarios (GG: the equivalent CO_2 concentration of GHG increases by 1% per year from 1990; GS: the trend of GHG concentration change is the same with that of GG, with consideration of the interaction of sulphur aerosols at the same time; A2 and B2: they are two scenarios designed in the IPCC 2000 *Special Report on Emissions Scenarios* (SRES)). The surface air temperature in China would probably increase by $1.5\text{--}2.8^\circ\text{C}$ by 2030, $2.3\text{--}3.3^\circ\text{C}$ by 2050, and $3.9\text{--}6.0^\circ\text{C}$ by 2100. Compared with the surface air temperature, great bias is seen in precipitation projection. Generally speaking, the future precipitations simulated by most GCMs presents a trend of increase under GG, A2, and B2 scenarios. By the end of the 21st century, annual average precipitation in China would increase by about 20% under GG and SRES A2 scenarios and 10% under SRES B2 scenarios.

Table 3-2 Changes in future surface air temperature and precipitation in China projected by GCMs under four GHG emissions scenarios
(Relative to the average values of 1961-1990)

Year		2030	2050	2070	2100
Temperature ($^\circ\text{C}$)	G G	2.8	3.3	4.4	6.0
	G S	2.0	2.3	3.4	5.1
	A 2	1.5	2.3	3.8	5.6
	B 2	1.5	2.4	2.9	3.9
	A verage	1.9	2.7	3.6	5.2
Precipitation (%)	G G	9	14	22	17
	G S	-9	0	14	9
	A 2	-6	7	8	16
	B 2	10	9	7	12
	A verage	1	8	13	14

3.2.2 Extreme climate events

At present, there are few researches undertaken on future extreme climate events in China. The results of limited researches show that under general circumstance of future climate warming, occurrence of extreme-cold events would reduce and that of extreme-hot events and droughts and floods would increase.

3.3 Water resources

3.3.1 Impacts of climate change on water resources

It is shown from runoff observation of the major rivers in China that measured runoff of the six major rivers has decreased in the past recent 40 years. The largest drop occurred in Huangbizhuang in the Haihe River basin, with a decreasing rate of 36.64% per decade, the second largest in Sanhezha of the Huaihe River, with a decreasing rate of 26.95% per decade, and the third in Bengbu of the Huaihe River and Huayankou of the Yellow River, with a decreasing rate of 6.73% and 5.70% respectively. The smallest drops are 0.96% for the Pearl River, 1.01% for Yichang and 1.46% for Hankou of the Yangtze River as well as 1.65% for the



Songhuajiang River.

There have been continuous droughts occurred over North China since 1980s, and annual average precipitations in 10 years in Beijing-Tianjin area, the Haihe-Luanhe basin and the Shandong Peninsula have fallen by 10-15%. Because of reduced precipitation and high surface air temperature, evaporation increased and flow volume reduced apparently. According to preliminary analysis by the Haihe Water Conservancy Committee, annual average surface runoff in the entire Haihe-Luanhe river basin in 1980-1989 was only 15.5 billion cubic metres, 46.2% lower than that in 1956-1979, 28.8 billion cubic metres. In 1990s, drought areas shifted southwestward. The annual average precipitation in the nine years from 1990 to 1998 in the middle and upper reaches of the Yellow River (Shaanxi, Gansu and Ningxia provinces), the Hanjiang river basin, the upper reaches of Huaihe river and the Sichuan basin fell by about 5~10%. From Lijin station of the Yellow River upwards, average precipitation in the same period decreased by 32% (Table 3-3). Moreover, annual runoff volumes in Haihe and Luanhe rivers and the Huaihe river were obviously decreased.

At the same time, flood disasters occurred frequently in China, particularly big-scale flooding that has occurred many times since the 1990s. For example, the flooding in the Huaihe river in 1991, the flooding in the water system of the Dongting Lake in 1994 and 1996, the flooding in the water system of Boyang Lake, the flood in the Yangtze, Zhujiang and Songhua Rivers in 1998 with water level breaking the historical record, the big flooding in the Taihu Basin in 1999 with water level breaking the historical record, and the big floods occurred in the Huaihe river, the Yellow River and the Weihe river in 2003 (Figure 3.3).

Table 3-3 Water resources of the Yellow River, Huaihe and Haihe rivers and the reduction of their runoff into the sea

Basin	Year	Annual precipita- tion (mm)	Annua runoff (mm)	Annual runoff (billion m ³)	Runoff into sea (billion m ³)	Proportion of runoff into sea(%)
Haihe &Luanhe rivers	1956-1979	560	90.5	28.89	16.0	55.5
	1994-1999	515	67.5	21.5	7.6	35.0
	Runoff reduced	45	23	7.3	8.4	
	percentage (%)	-8	-25.4	-25.4	-52.5	
Yellow River	1956-1979	464	83.2	66.14	41.0	62.0
	1994-1999	413	64.3	51.1	11.7	22.9
	Runoff reduced	51	18.6	15.0	29.3	
	percentage (%)	-11	-22.7	-22.7	-71.5	
Huaihe river	1956-1979	860	225.1	74.12	59.1	80.0
	1994-1999	790	172.2	56.3	30.9	54.9
	Runoff reduced	70	52.9	17.88	28.1	
	percentage (%)	-8.1	-24	-24	-47.8	



Figure 3.2 Shortage in supplying drinking water to residents caused by drought in North China



Figure 3.3 Inundation of vast rural areas caused by the flooding in Weihe river in China in 2003



It is shown from statistics that there are totally 46,298 modern glaciers in China, covering an area of 59,406 square kilometres, with ice storage reaching 5,590 cubic kilometres, thus China is one of the countries in the world with the largest number of mountain glaciers. Researches of Chinese scientists have shown the impacts of climate change on the glaciers. As shown in Figure 3.4, the glaciers started to retreat from the 16th century and the shrink rate of glaciers increased apparently in the 20th century. Due to climate warming in the 20th century, the mountain glaciers in China have widely shrunk, and total area of glaciers in mountainous areas in the west of China has reduced by 21% (Table 3-4). Under the scenarios of the climate warming, the melting of glaciers would alleviate to a certain extent the reduction of runoffs from mountains in the near future, but would pose a big threat to the long-term utilization of water resources in the future.



Figure 3.4 Change of Glacier No. 1 at the source of the Urumqi River in Tianshan

Table 3-4 Statistics on the changes of glaciers in west China since the Little Ice Age (LIA)

Mountain-chain	Area of modern glaciers (km ²)	Area of glaciers in LIA (km ²)	Area reduced since LIA (km ²)	Percentage of reduction (%)
Altay	280	431	151	54
Savgur	17	21	4	24
Tianshan	9236	11655	2419	26
Pamirs	2696	3100	404	15
Karakorum	6231	7602	1371	22
Kunlun	12266	13555	1289	11
Algin	275	319	44	16
Qiliang	1931	2390	459	24
Qiangtang Plateau	1802	1946	144	8
Tanggula	2213	2485	272	12
Gangdise	1766	2119	353	20
Nianqing Tanggula	10701	13633	2932	27
Hengduan	1580	2050	470	30
Himalayas	8412	10597	2185	26
Total	59406	71903	12497	21

3.3.2 Projection of water resources

The simulated results (Figure 3.5) of the universal Variable Infiltration Capacity (VIC) distributed hydrological model show that in the next 70-90 years, annual average runoff depth would reduce by 2~10% in northern areas including Ningxia, Gansu, Shaanxi and Shanxi provinces and part of other provinces, while annual average runoff depth in southern areas including Hubei, Hunan, Chongqing, Jiangxi, Fujian, Zhejiang, Guangxi, Guangdong and Yunnan provinces would increase by 24%.

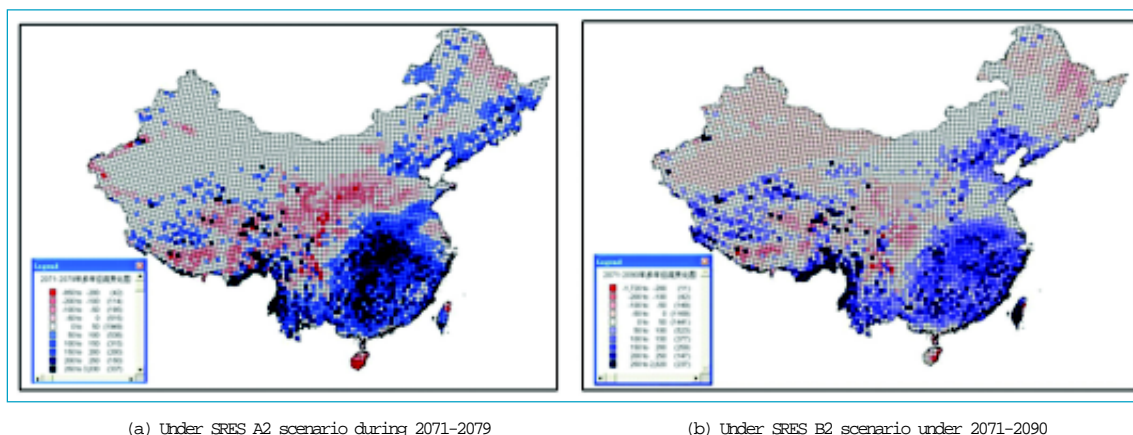
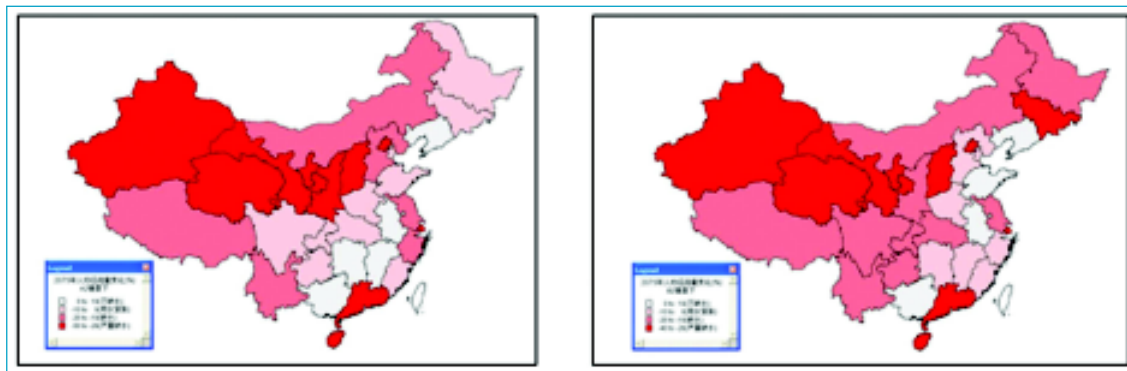


Figure 3.5 Changes of the average runoff depth under SRES A2 and B2 scenarios relative to baseline

In the next 50-100 years, climate change would not alleviate the shortage of water resources caused by the increase of population

and social and economic development in China. On the contrary, the shortage of the per capita water resources in Ningxia, Gansu, Qinghai, Xinjiang, Shanxi and Shaanxi provinces would be further aggravated, with a reducing range of 20-40%. The increase of population and social and economic development might exaggerate the pressure on water resources due to climate change in the northern areas.



(a) Under SRES A2 scenario during 2071-2079

(b) Under SRES B2 scenario under 2071-2090

Figure 3.6 Distribution of vulnerable areas regarding per capita water resources in China in 2075

According to the trend of glacier shrinking since the Little Ice Age and the projected changes of summer temperature and precipitation in the future, by 2050, the area covered by glaciers in western China would reduce by 27.2%, and altitudes of the balance lines of oceanic glaciers, sub-continental glaciers and the mega-continental glaciers would be raised by 238m, 168m and 138m respectively. This means that ice storage in the extremely high mountainous region in China would reduce by a large amount and the capacity of the melted water from glaciers for seasonal regulation of runoff in rivers would lose heavily.

3.4 Agriculture

3.4.1 Impacts of climate change on the conditions of agricultural production

Under the scenario of doubled concentration of carbon dioxide in the atmosphere, the majority of areas in China would experience climate warming and heat resources would increase. If the conditions of water, fertiliser and crop variety could meet the demands of such changes, it would be favourable for crop growing and photosynthesis.

After the climate warming, the areas north of the Yangtze River in China, especially in the middle-altitude and plateau areas, the crop growth season would start earlier and close later, and the potential growth season would be prolonged. However, after the climate warming, because the growth of crops is accelerated, the fertility period would be shortened generally. This would produce adverse effects on material accumulation and grain output. At the same time, the trend of drought and the deterioration of soil moisture condition after the climate change would be not beneficial to the wheat growth in China.

3.4.2 Impacts of climate change on the cropping system

The spatial and temporal distribution of climate resources would be affected by climate warming, and the present cropping system would change accordingly. The cultivated area of single cropping system might drop by 23%, the north boundary of double cropping system might move northward to the middle part of the region of the present single cropping system, and the proportion of triple cropping system might change from the present 13.5% to 36%. The northern boundary for triple cropping system would move northward by approximately 500 kilometres from the Yangtze River basin to the Yellow River basin.

With climate warming, a change would take place in the localities of major crop strains in China. Some crop strains currently popularized at some regions for specific climate conditions might not be able to adapt to the changed climate conditions. It is needed to cultivate new crop strains at appropriate time.

The problem of high temperature occurred with climate warming might be offset, to a certain extent, by the adjustment of crop



pattern and structure and also by making use of temperature adaptability of crop. . However, because of the impacts of other factors such as moisture content, it is hard to affirm whether the temperature increase would result in the increase of cropping index, or even total yield.

3.4.3 Impacts of climate change on the yield of major crops

Via simulation of the impacts of climate change on agriculture in China, some studies have shown the impacts of climate warming on the yield of major crops in China under $2\times\text{CO}_2$ scenario. It is found that impacts of climate warming on the yield of spring wheat would be larger than that of winter wheat; regarding single rice, the fall of crop yields would increase gradually from the south to the north with a rate between 6~17%; yield of early rice will drop and the least drop will occur in the central south part of the Yangtze River, while in the surrounding areas, particularly in areas in the west, there would be a considerable reduction in the yield (generally between 2~5%); yield of late rice in the north-western part of the areas south of the Yangtze River would all drop significantly, while that in the south-eastern part would drop less. Spring and summer maize yield would reduce by 2~7% and by 5~7% respectively, and irrigated and non-irrigated maize yield would reduce by 2~6% and about 7% respectively due to the climate warming.

With regard to cotton, each 1°C increase of annual average air temperature would result in an increase of 10 days in frost-free duration. The accumulated temperature ($\geq 10^\circ\text{C}$) in cotton growing season might rise by approximately $150\sim 250^\circ\text{C}\cdot\text{day}$ and the growing season would extend for about 10 days, and the luxuriantly growing period ($\geq 20^\circ\text{C}$) is estimated to continue for additional 7-10 days. When the ripening nature of a strain is not changed, because the air temperature rise in the cotton boll period is favourable to the increase of boll weight, the proportion of opening bolls before frost would increase by 5-10%, and the strength and maturity of cotton fibre would be somewhat improved.

3.4.4 Impacts of climate change on the total production of main crops

Along with the climate change, occurrence of unusual disasters such as drought, flood, high temperature and freezing events might increase. The results of simulation shown that under the assumption of no changes of the present planting system, planting varieties and production level, the total grain production might drop by about 10% due to climate change and extreme climate events during the period of 2030~2050. The production of three major crops – wheat, rice and maize – might all be reduced.

Though climate change would not shake China's capacity of self-supply in grains, it would put a high demand on management techniques of agricultural production and extra input into agriculture.

3.4.5 Impacts of climate change on food quality

The rise of CO_2 concentration would result in the decline of crop quality. Experiments in China showed that if CO_2 concentration reached 565 ppmv, protein content in wheat would drop by 3~5%; and if CO_2 concentration doubled, amino acid and crude protein contents in soybean would fall by 2.3% and 0.83% respectively, but contents of crude fat, saturated fatty acid and kernel unsaturated acid would increase by 1.22%, 0.34% and 2.02% respectively; and crude fat, crude starch and moisture in maize kernel would increase to some extent, but the amino acid, crude protein, crude fibre, amylase and total saccharide would present a descending trend.

3.4.6 Impacts of climate change on the amount of pesticide and chemical fertiliser application and on the inputs in agriculture

According to statistics, the largest agricultural loss in China is caused by crop diseases and pests, accounting for about 20-25% of total agricultural production. The climate warming would change the distribution of agricultural diseases and pests. An analysis shows that under $2\times\text{CO}_2$ scenario, the occurrence of armyworm would generally increase by one generation; over the areas in Qinghai, Gansu and Sichuan where cross-summer wheat stripe rust exist, the surface air temperature increase in winter would be larger than in summer, which would be more favourable for wheat stripe rust to survive in winter and in summer and to spread southward; the warming in winter would be also favourable for weeds spreading. This means that the amount of pesticide and herbicide application would be increased due to the climate change.

The application amount of fertiliser would be altered by climate change. When the temperature increases by 1°C , the released amount of available nitrogen which can be directly absorbed and utilized by plants would increase by about 4% and the release

period would shorten by 3.6 days. Therefore, if the original fertiliser efficiency was expected, the amount of fertiliser applied each time would increase by about 4%. The increase of the application amount of fertiliser would not only cause farmers to increase the input, but also cause damage to soil and environment due to the increase of volatilisation, decomposition and eluviation loss of fertiliser.

Because of the adverse impacts of climate change, cost of agricultural production would increase, including, for example, irrigation cost will increase in areas where the soil moisture would be reduced; increased investment is needed to improve water conservancy facilities, modify and improve soil and preserve water and soil in areas where the soil erosion has been aggravated and erosion by eluviation is serious; and increased input in fertiliser and pesticide is needed because of the loss of organic substance in soil, the decline of soil fertility and the occurrence of plant diseases, insect pests and overgrowth of grass and weeds resulting from the climate change.

3.5 Terrestrial ecosystem

3.5.1 Impacts of climate change on phenophase and vegetation

The vulnerability of an ecosystem is caused by many factors including natural and human factors. Among the natural factors, climate is the most important influencing factor. In accordance with the main causes for bringing about vulnerable ecosystems and assisted with estimation from remote sensing images, the distribution of vulnerable ecosystem in China is mapped (Figure 3.7). It can be seen that the area covered by vulnerable ecosystems in China is approximately 1.94 million square kilometres, exceeding one fifth of the total land territory of China. It is mainly distributed in seven regions, of which five are situated in west China.

There is an obvious impact of climate change on the phenophase in China. As a comprehensive indicator showing the sensitivity of the regional climate change and the organism and natural processes in the ecosystem, phenophase has been widely used in the assessment of the impact of climate change. It is found through analysing the data from phenological observation network for recent 30 years in China that the temperature is the principal factor affecting the phenophase of ligneous plants. The analyses on phenophase observation datasets for recent 40 years in China shown that with temperature increasing in spring in the northeast, north China and the lower reaches of the Yangtze River since 1980s, the phenophase period has been advanced; and with the temperature decreasing in spring in the eastern part of the southwest region of China, the middle reaches of the Yangtze River and south China, the phenophase period has been postponed. If the surface air temperature in spring increases by 0.5°C and 1°C , the phenophase period would be advanced by 2 days and 3.5 days; conversely, if the surface air temperature drops by 0.5°C and 1°C , the phenophase period would be delayed for 4 days and 8 days, respectively. Furthermore, if the annual average surface air temperature increase by 1°C in the future, the phenophase period in spring in China would be advanced by 3-4 days and in autumn, the phenophase period would put off by 3-4 days, the green-leave period would extend by 6-8 days and the mature period for fruit and seeds would be advanced with a larger range than that in spring. Generally speaking, the range of advancement or postponement of the phenophase phenomenon is more obvious in the north than in the south.

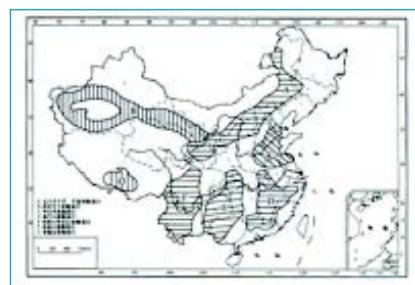


Figure 3.7 Distribution of the vulnerable ecosystem in China

With the help of various statistical models and climate scenarios, Chinese scientists have projected possible changes of various vegetation belts, and obtained the following consistent conclusions: under $2\times\text{CO}_2$ scenario, vegetation belts or climatic belts in China would move towards high altitude or west, and there would be corresponding changes for the scopes, areas and boundaries of the vegetation belts. It is projected that the areas covered by deciduous forests and coniferous forests would reduce obviously, even probably move out of China; In the future, north China and the Liaohe river basin in the northeast China could be transferred into grassland. The natural landscape in the base belt of mountain areas and surface course of plateaus could be changed and removed due to climate change, and even the vertical band spectrum of distribution boundaries would be displaced.

The productivity and carbon flux in the terrestrial ecosystem are highly sensitive to climate change. According to estimation, the



total amount of the net primary production (NPP) and soil heterotrophic respiration (HR) were increased in China in 1981~2000 because of the impacts of increased CO₂ concentration and changes in temperature and precipitation. China's terrestrial ecosystem absorbed CO₂ due to the combined impacts of CO₂ concentration rise and climate change in the past 20 years, and has become a carbon sink (Figure 3.8). It should be pointed out that carbon emission and removal due to human activities, especially the land use changes and disasters, were not considered in the above calculation.

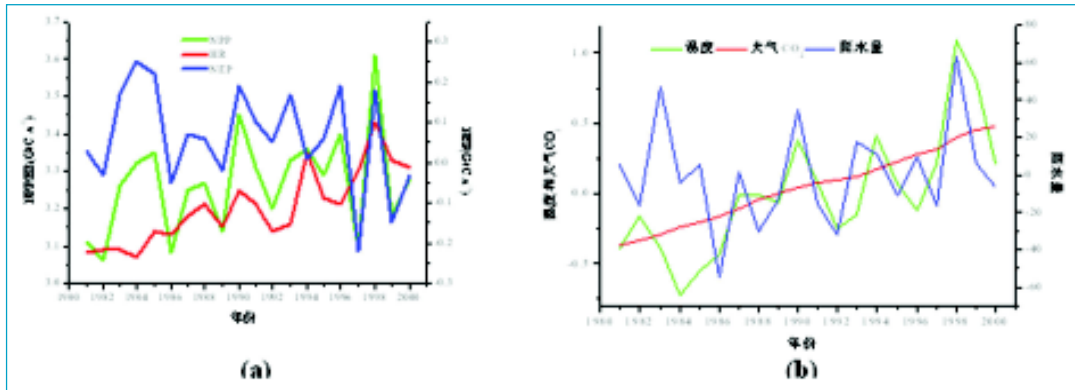


Figure 3.8 Interrelationships between the terrestrial ecosystem productivity, soil heterotrophic respiration and climate change in China

3.5.2 Impacts of climate change on forest

It is shown from the combination of present forest vulnerability index compiled on the basis of the quality of forest land, the composition of forest age, the forest fire and the supply of firewood with the future climate change scenario researches that the forest zones most affected by the future global climate change in China would be mainly distributed in the southwest of, central and south China, roughly similar to the distribution of present vulnerability.

Under the circumstance of future global climate change, the pattern of geographical distribution of the forest primary productivity in China would not undergo any obvious change, namely, forest productivity would decrease progressively from the southeast to the northwest, by various rates. In the tropical zone and sub-tropical zone, forest productivity would increase by 1~2%, in the warm-temperate zone, by about 2%, in the temperate zone by 5~6%, and in the cold-temperate zone by 10%. The productivity of main timber tree species in China would increase in an order from the biggest to the smallest: Xing'an deciduous pine, Korean pine, Chinese pine, Yunnan pine, masson pine and cedar, and the range of the increase would be 1~10%. The impacts of climate change on diseases, pests and forest fires were not considered in the above study.

Based on the GCMs scenario projection and ecological index of different tree species, the impacts of climate change in 2030 on the distribution of the main tree species for afforestation was assessed. The results shown that areas suitable for various tree species would decrease, for Xing'an deciduous pine, Chinese pine and masson pine by about 9% and for cedar by 2%. In the future 60 years, under the scenario of average surface air temperature increasing by 2~3°C and precipitation increasing by 5%, the northern boundary for cedars would move northwards by 2.8 latitudes and the lower limit of the height above sea level would rise by 110 metres. The southern boundary for deciduous pine in north China would move northwards by 3 latitudes and the lower limit of the height above sea level would rise by 300~400 metres, but due to insufficient water in the northern boundary, it would not move very far and the distribution area would shrink to present a belt-form distribution. The northern boundary of the masson pine would move northwards by about 6 latitudes and the upper limit of the height above sea level would rise by 330 metres. There would be no obvious trend for Yunnan pine to move northwards, and the upper limit of the height above sea level would rise from the present 2,800 metres to more than 3,080 metres.

3.5.3 Impacts of climate change on grassland, frozen soil, wetland and desert

The population composition and the productivity of grassland would change corresponding to the CO₂ concentration rise and climate change. The impacts of climate change on the productivity of grassland varies in different grassland areas. Water is the principal limiting factor for the growth and development of pasture in the arid and semi-arid pastoral areas, therefore the impacts of the temperature rise would not be obvious for pasture growth; while in areas where water is in serious shortage, evaporation

would be accelerated by temperature rise, leading to a drier soil and aggravated damage on pasture. In wet-cool and extreme cold regions where water supply is usually sufficient, temperature is the principal limiting factor for the productivity of grassland, so temperature rise might lengthen the growth period of pasture, increase the accumulated temperature in the production season and raise the efficiency of photosynthesis, thus lifting the productivity of grassland.

Under $2\times\text{CO}_2$ scenario, the climate in pastoral regions in northern China would become dryer and warmer, pasture lands would move forward to the humid areas and the present boundaries of grassland would move eastwards. The boundaries of alpine pasture and grassland in Qinghai-Tibet Plateau, Tianshan Mountains and Qiliang Mountains would move upwards correspondingly. If temperature increased by 3°C , corresponding boundaries of various grassland regions would move upwards by 380–600 metres.

Frozen soil is very sensitive to climate change. Since the 1980s, maximum frozen soil depth in China began to reduce. After 1990s, the scale of this reduction in many areas became more obvious. It is shown from the simulation assessment that intrinsic changes on frozen soil would not occur in the next 20–50 years for the permafrost, but if the average surface air temperature on the plateau rose by 3°C , permanent frozen soil in the Qinghai-Tibet Plateau would undergo a obvious change. The proportion of disappearance would be as high as 58%, and the majority of the permafrost in the eastern and southern parts of the Plateau would disappear.

Statistics shows that the amount and area of natural wetland in China would be reduced continuously, the capacity of retaining water, storing water and regulating floods would drop gradually, and many rare species dwelling on the wetland ecosystem would disappear. Besides human impacts, climate change would also be an important factor. Since 1950s, most of inland lakes and wetlands in the northwest China have shrunk, and even dried up. Apart from human impact, long-term warm-dry climate in the northwest China is an important reason for that. As simulated, the area of swamps in the northeast of China would reduce under the future climate change scenarios.

The area of desertification in China has expanded continuously, which is closely related with climate change. Based on the data of 1,914 weather stations over China from 1981 to 1990, Chinese scientists defined the scopes and boundaries of arid, semi-arid, and sub-humid regions in China, and at the same time, assessed changes of bioclimate-type areas due to future desertification in China. The results show that by 2030, with the global air temperature increasing, the area of desertification in the arid and semi-arid, and sub-humid areas in the north China would expand.

3.5.4 Possible impacts of climate change on biodiversity

The key areas of biodiversity in China are mainly located in Changbai area of Jilin Province, the north part of Hebei province, Qinling Taibai Mountains in Shaanxi Province, high mountain and canyon in western part of Sichuan Province, high mountain and canyon in western part of Yunnan Province, uplands in the neighbouring area of Hunan, Guizhou, Sichuan and Hubei provinces, Nanling upland in the neighbouring area of Guangdong, Guangxi, Henan and Jiangxi provinces, Zhejiang-Fujian upland, the central upland in Taiwan, the upland in the southeast part of Tibet, Xishuangbana of Yunnan Province, the limestone area in the southwest part of Guangxi Zhuang Autonomous Region, the south central part of Hainan Island, Hoh Xil of Qinghai province, etc. The future climate change would have impacts on the environment of those areas, thus affecting the distribution of biodiversity.

The future climate change would also pose a threat to species diversity in China. In particular, it might pose a threat to the habitat of endangered species and upland species adaptable to a narrow scope of climate, species that adapt to cold climate in the Qinghai-Tibet Plateau and species that are weak in the capacity of removal, such as giant panda, Yunnan golden monkey, *cevus albirostris*, *Taiwania flousiana*, *Ammopipthus monogolicus* and chiru, etc.

The future climate change might also influence the distribution of intruding species by means of impacting pests, diseases and weeds. Climate change might cause the spread of pests and diseases to an expanded scope, the increase of the insect density and the change in the geographical distribution of diseases and pests.

3.6 Changes in sea level, coastal zone, and offshore ecosystem

3.6.1 Change in sea level



According to the Bulletin on the Sea Level in China in 2000, in the past 50 years, China's coastal sea level has risen at an annual rate of 1.0~3.0 mm on average. In 2000, China's coastal sea level ascended by 51 mm compared with normal sea level (referring to as the mean sea level in 1975~1986). The general trend of the change in sea level rise is that: the change along the southern coast is relatively great, while that along the northern coast small; among the coastal provinces (autonomous regions or municipalities directly under the central government), the greatest sea level rise was recorded along the coastal zone in Hainan and Guangdong provinces, while the smallest along coastal zone in Tianjin, Hebei and Liaoning provinces. According to the Bulletin on the Sea Level in China in 2003, the sea level rise rate in the East Sea is highest among the sea areas of China, reaching 3.1 mm/a, slightly higher than the global average rate of sea level rise. Among key marine areas, the coastal sea level rise of the Yangtze River delta and the Pearl River delta is at an average rate of 3.1 and 1.7 mm/a, respectively.

Chinese scientists projected the relative sea level rise in five coastal zones in China in the future by using a Chinese sea level rise model. The results are shown in Table 3-5.

Table 3-5 Projection of the sea level rise in five coastal areas in China

Coastal area	2030		2050		2100	
	Amplitude of rise	Best estimation	Amplitude of rise	Best estimation of rise	Amplitude of rise	Best estimation
Coast from Liaoning to Tianjin	10~13	11	16~23	20	49~69	60
Coast along Shandong Peninsula	-3~1	-1	-1~6	3	21~40	31
Coast from Jiangsu to eastern part of Guangdong	12~16	14	19~25	23	54~74	65
Coast adjacent to mouth of Pearl River	4~8	6	9~15	12	31~56	47
Coast from western part of Guangdong to Guangxi	12~15	14	19~26	23	54~174	65

3.6.2 Coast erosion

The coast erosion in China is rather serious, and presented a trend of continuous expansion since 1950s. According to statistics, about 70% of current sandy beaches and the majority of the muddy beaches in the open water areas are in the state of erosion-induced retreat. The length of the eroded coastal line has accounted for over one-third of the total length of the coastal line of the mainland of China. Generally speaking, it is more serious in the north of the mouth of the Yangtze River than in the south.

The storm surge disaster and sea level rise caused by climate warming are two most apparent natural factors for coast erosion. The death of coral caused by the sea water temperature rise, human exploitation and the destruction of mangrove are also the causes for coast erosion.

The interactions of waves and storm surges would be enhanced by continuous sea level rise and water depth increase caused by future global climate warming, which would aggravate the coast erosion process in China.

3.6.3 Sea water intrusion

Since 1970s, sea water intrusion in the coast areas of China has become increasingly serious, occurring mainly in the Liaodong Peninsula, Qinhuangdao area and the Shandong Peninsula. Currently, affected area of the sea water intrusion in the coasts of China has exceeded 800 square kilometres, with the greatest intrusion distance of approximately 10 kilometres and the greatest intrusion rate of 495 metres a year. Aside from the sea level rise, the drying up of the underground water and the decline of the underground water level are both causes of intrusion.

The sea water intrusion has brought about the salinization of large stretches of land, leading to the continuous reduction of agricultural production, erosion to coastal structures, the difficulties for plants to grow in areas of coastal zone and the destruction of shelter forests.

With the future global climate warming and the continuous sea level rise as well as the shortage of fresh water resources in coastal areas in China and the continuous over-extraction of underground water, the sea water intrusion would become more and more serious, affecting people's life and the economic development in the coastal regions.

3.6.4 Impacts of the sea level rise on the deltas

There is a large area of river mouth deltas and littoral plains with low altitude along the coastal zone in China. It is calculated that along the coastal line, land area with elevation being smaller than or equal to 5 m is 143,900 square km, of which key vulnerable areas are the Pearl River Delta (including Guangzhou), the eastern part of the East China Plain (including Shanghai), the North China Plain (including Tianjin) and the southern part of the Lower Liaohe Plain (including Yingkou). With the most developed economy, most concentrated city distribution and densest population along the coasts in China, those areas play a decisive role in the sustainable development of the Chinese economy. In accordance with the highest historic tidal level and the present state of coastal sea dykes, Chinese scientists estimated the scope of possible submerged area of the Pearl River Delta under the scenario of future sea level rise by 30 cm (Figure 3.9)

The elevation in vulnerable areas along China's coastal zone is fairly low, generally between 1.5 to 5 m, subject to the attacks of floods. In the areas of the lower reach of river and the river mouths, due to silting at the river mouths in the lower reach caused by the soil erosion in the upper and middle reach, the sea level rise is bound to prop up and elevate the floods, thus increasing the threat of floods.

Owing to sea level rise, the tide moves upstream further along the rivers, affecting the supply of fresh water on river banks and lowering the water quality. Though the tidal range in the Pearl River Delta is not large (1.0~1.5 m), the tide flows far upstream along the river. The impact of salty tide would be more deep-going with sea level rise. The upward shift of the convergence point and the salty water wedge would not only bring about a change of the sedimentation of mud and sand in the riverbed, but also bring up new problems to urban water supply.



Figure 3.9 The possible submerged area by sea water under the scenario of sea level rise of 30 cm on the condition of the present tide-protecting facilities and the highest historic tidal level in the Pearl River Delta

3.6.5 Impacts on the marine ecosystem

There is a large area of wetlands along the coastal zone in China. The sea level rise would not only reduce the area of wetlands, but also cause their functions to experience drastic regression. The loss of wetlands would seriously harm vegetation and animal communities living in low places, leading to a serious decline in their functions of ecological service such as water-body purification, nutrients transformation and transportation and biological habitat. Wetlands are closely related to climate change, particularly wetlands at river mouths. The wetland area would reduce due to the decrease of water and sand carrying caused by the reduction of river run-off volume, runoff break and a change of river course.

Over 400 kinds of corals have been collected and identified in China, of which close to 200 are hermatypic corals, accounting for two thirds of total hermatypic corals in the region of the Indian-Pacific Oceans.

According to the survey on the coral reefs since 2000, bleaching and death of coral were found in different degrees in the coasts of Hainan, Guangxi, Taiwan, Hong Kong and other areas of the South China Sea (Figure 3.11 and Figure 3.12). Coral bleaching is mainly due to sea water temperature rise caused by global climate warming. The bleaching would make corals to lose nutrients gradually, and finally lead to death.



Figure 3.10 Wetlands at the Yellow River Mouth



Figure 3.11 Coral bleaching in Weizhou Island in Guangxi.



Figure 3.12 Coral bleaching in Qingge, Qionghai, Hainan, China

There are 16 families, 20 genera and 37 species of mangrove in China. They are naturally distributed in the coastal waters of Hainan, Guangxi, Guangdong, Zhejiang, Fujian, Taiwan, Hong Kong and Macao. The northern boundary of the natural distribution is Fuding City, situated in the northernmost part of Fujian Province. It is shown from the national survey of mangroves in 2002 that the total area of the existing mangroves in China is 15,000 hectares and most of them are secondary shrub forests (Figure 3.13).

It is estimated by Chinese experts that natural distribution of various mangrove plants along the coasts in China may extend northward by 2.5 latitudes under the scenario of 2°C increase of surface air temperature, and the northern boundary of the natural distribution of mangroves might move from Fuding City of Fujian Province at present to the vicinity of Chengxian County of Zhejiang Province in the future.

Sea water aquaculture on the coasts would be impacted by global climate warming. For example, in the winter of 1995, sea water temperature in the north part of the Yellow Sea were about 1°C higher than the previous year, which made the mortality rate of scallop spat in the sea area to rise. However, in Laizhou Bay of the Bohai Sea where water temperature was normal, scallop spat contracted fewer diseases. Similar situations occurred in regard to the growth of oyster spat in the Pacific Ocean.



Figure 3.13 Mangrove in Guangxi, China

3.7 Adaptation measures

Up to now, study in China on policies for adaptation to climate change is still at the initial stage, and a systematic strategy for adaptation to climate change has not yet taken form. However, some policies and measures that have been adopted have played a positive role in the adaptation to climate change. In a certain period in the future, China will, in its own capacity, continue to adopt policies and measures in favour of the adaptation to climate change.

3.7.1 Water resources

There are two objectives for adaptation policies with regard to water resources. One objective is to promote sustainable development and utilization of water resources in China, and the other objective is to reinforce adaptive capacity of the water resource system and reduce the vulnerability of the water resource system caused by climate change. In applying policies for adaptation, uncertainties about the impact of climate change should be taken into account and non-regret policies should prevail, namely, adopting all policies and measures which can be adapted under current standards and regulations.

(1) Adopted measures

The Law on Water Resources of the People's Republic of China has been promulgated to safeguard and normalize the management of water resources. The Project of South-to-North Water Diversion has been launched in order to alleviate the pressure of lack of water resources in Beijing, Tianjin and the Shandong Peninsula. Key water conservancy projects such as Three Gorges Project in the Yangtze River, Linhuaigang Project of the Huaihe River, Ni'erji Project of the Nenjiang River, Baise Project in Guangxi, Shapotou Project in Ningxia, and Zipingpu Project in Sichuan were constructed to increase the capacity for preventing floods and reducing disasters. The Project for Addressing the Supply of Drinking Water for People and Animals in Rural Areas were implemented, which supply drinking water for 15 million people in rural areas. The construction of upgrading projects for water-saving in 226 large irrigated areas and 200 demonstration projects for water-saving irrigation were launched to raise water use efficiency. The National Plan for Protecting Ecology and Safeguarding Water Resources in the Grassland of Pastoral Regions were formulated and the construction of water conservancy experimental projects in pastoral regions was launched. The construction of small projects for water conservancy and soil conservation was intensified. The Plan for Building Silt Dams in Loess Plateau Areas was completed and the project was launched. Experimental demonstration projects have been launched for restoring ecosystem in key areas in seven major river basins, in the origin regions of Three Rivers (the Yangtze River, the Yellow River, and the Lancangjiang River), in the ecologically vulnerable areas in the northwest and in the 'three transformations' (sandification, degeneration and salinization) areas, to give impetus to the implementation of closing hillsides to livestock grazing on a large scale in all parts of the country. Series pilot projects for building water-saving society in Zhangye of Gansu Province, Mianyang of Sichuan Province and Dalian of Liaoning Province were launched and initial positive results were achieved. A series of measures to convert and supplement water for the Heihe river, the Yellow River and the Tarim River were carried out, which alleviated serious water shortage in some key cities and restored the ecosystem deteriorated by water shortage and pollution. The work of formulating a national comprehensive planning on water resources have been stepped up and achieved progressing results.

(2) Adaptive measures being and to be adopted

Establishing a modern water conservancy management system and strengthening the unified management and protection of water resources;

- Building up a water-saving agriculture and industry, vigorously popularizing water-saving irrigation, developing sprinkle irrigation and dripping irrigation, extending the use of water-saving facilities so as to increase water use efficiency;
- Increasing the capacity of reservoirs and river dams to prevent floods, tapping water sources to increase water-supply capacity, planning and building the trans-valley water converting project and achieving optimized allocation and utilization of water resources cross valleys;
- Enhancing the protection and building of ecosystem, restoring vegetation cover, preventing and controlling soil erosion and loss; and
- Protecting the water environment, preventing and controlling the water pollution, increasing the rate of treating sewage, improving the renewal and utilization of sewage, as well as achieving the benign cycle of the ecology and environment.

3.7.2 Agriculture

With regard to the adaptation in agriculture, there are two aspects: first, the spontaneous adaptation; second, active and planned adaptation, namely, the government provides guidance for carrying out agricultural restructuring to raise the capacity of agriculture to resist the adverse impact of climate change and as a result, enhancing adaptation capacity.

(1) Adopted measures

- Adjusting the agricultural structure and the cropping system, i.e. expansion of the area of paddy-rice fields in the areas of northeast China, and a shift from the dual structure in the traditional farm production in some areas in China to a ternary structure of coordinated development of food crop, fodder crop and cash crop, etc.;
- Raising multiple cropping index;
- Selecting, cultivating and popularizing stress-resistant varieties;
- Improving management measures, i.e. active popularization of water-saving agricultural measures, technologies of optimized fertilization and deep fertilization and technologies of comprehensive prevention and control of soil erosion, etc.;
- Constructing and improving agricultural infrastructures, i.e. fundamental construction of farmland, fundamental construction of water conservancy, building of agricultural ecosystem, construction of farmland with high and stable yields, conversion of unduly reclaimed land to pasture, etc., which, to a certain extent, have increased the adaptive capacity of China's agriculture to



climate change.

(2) Adaptive measures being and to be adopted

Adjustment of the structure of agricultural production. The cropping system would be adjusted in a scientific way to adapt to climate warming. In northeast China, due to warming of future climate, planting areas of winter wheat would be expanded and new varieties of maize and paddy rice with a long growing period and high yield would be selected. In North China Plain, because water supply in growing season would be affected and the water shortage would be enhanced in winter and spring, water-saving agriculture would be popularized vigorously. In the lower reaches of the Yangtze River, vertical climatic conditions in hilly and mountainous areas will be made full use to develop sub-tropical cash trees such as tea plants, oranges and tangerines. In South China, various kinds of one-year triple-cropping systems would be developed, and some rapid-developing and early-maturing crops with short growing period would be planted by means of inter-planting and mixed sowing. In southwest China, multiple cropping acreage would be expanded, patterns of planting wheat-rice-rice, rape-rice-rice or wheat-rice-secondary rice with inter-planted late rice would be popularized, and various philotherm and thermophilous crops and subtropical and temperate fruit trees as well as under-growth medicinal herbs with high economic value would be developed. In northwest China, multiple cropping index would be raised step by step and dry-land agricultural technologies would be popularized to store water and preserve soil moisture and foster soil fertility.

The selection and cultivation of new varieties. Stress-resistant varieties would be cultivated or selected, and new technologies, including biological technology, would be developed. On the basis of collection and screening of germplasm, a great number of new fine animal and plant varieties that have high yield potential, fine intrinsic quality, outstanding comprehensive resistance and widespread adaptability would be bred, so as to enhance the adaptability of agriculture to climate change.

The comprehensive management techniques. Techniques on optimised fertilization and deep fertilization would be popularised, and the problem of inadequate amount of fertiliser and improper fertilization would be solved. Apart from enlarging the proportions of concentrated fertiliser, complex fertiliser, formula fertiliser and biochemical fertiliser in the production of chemical fertiliser and a gradual input of trace nutrient elements, utilization of organic fertiliser (such as green manure, animal manure and biogas residue) would be encouraged. Techniques of precision management of soil nutrients and balanced application of fertiliser should be studied and popularized, and the technique of scientific method of applying fertilisers and scientific field management should be disseminated.

Research and manufacture of pesticide should be based on the research on pest insects, natural enemy and the physiology and ecology of crops, in order to achieve high effect, low toxicity and environmentally sound and prevent the generation and development of drug resistance of pests. The techniques for preventing and controlling the plant diseases, pests, overgrowth of weeds and multiplication of mice would be popularized.

Irrigation methods would be improved, research, popularization and application of water-saving agriculture and scientific irrigation would be strengthened, techniques for preserving soil moisture would be developed and other measures for field management would be taken. Unitary water-saving techniques used in the past would be changed and developed in the direction towards a highly synthesized comprehensive technique and fully use of integrated effects. Same importance would be given to the storage of water, the increase of water, the retaining of water and the highly effective use of water, and agronomic water saving, biological water saving and engineering water saving would be achieved at the same time. The water-saving agricultural technique should be encouraged to develop in the direction of the quantification, standardization, modelization and integration as well as in a high effectiveness and sustainable way, so as to raise water use efficiency.

The precision farming technique based on automization and intellectualization should be studied and popularized to realize modern management of agriculture, reduce production cost for agriculture and raise the utilization rate and output ratio of land.

Unduly reclaimed lands would be reconverted to pastures reasonably, vegetation of grassland would be restored, the covering rate of grassland would be increased, function of soil conservation would be enhanced and desertification would be prevented from further expansion. The number of livestock would be determined by the amount of grass. The animal carrying capacity would be

controlled to bring a turn to the present situation of excessive grazing and the serious over-carrying of grassland. Artificial grasslands would be built and grass seeds with high temperature-resistance and drought-resistance would be chosen with a big attention being paid to the diversity of grass seeds to avoid the pasture degradation.

Agricultural infrastructural facilities would be improved to raise the capacity of agriculture to meet emergencies and the level of it in combating disasters and reducing disasters. Climate change would make rainfalls in some arid or semi-arid areas in the north become more unstable or dryer. For those areas, soil improvement and water control should be regarded as the central task in the future in order to strengthen farmland fundamental construction, improve the ecosystem of agriculture, build high-yield and stable-yield farmlands and continuously raise the capacity to meet emergencies caused by climate change and the level of combating disasters and reducing disasters. At the same time, farmland irrigation projects and facilities would be reasonably improved and construction of engineering facilities for a comprehensive prevention and control of natural disasters would be intensified.

3.7.3 Terrestrial ecosystem

The adaptability of terrestrial ecosystem comprises two aspects: one is the capacity of the self-regulation and self-restoration of the ecosystem and the nature; the other is the anthropogenic activity, especially the basic social and economic condition, the anthropogenic impacts and interference, etc.

(1) Adopted measures

Various laws and regulations related to the protection of terrestrial ecosystem have been formulated and implemented, including the Law on Forest of the People's Republic of China, the Law on Land Administration of the People's Republic of China, the Regulations on Returning Cultivated Land to Woodland, etc., in order to control and stop the deforestation, establish the natural conservation areas and forest parks, protect the existing forests and vigorously develop the projects for building forest ecosystem.

(2) Adaptive measures being and to be adopted

Enhancing the protection of the existing forests through management. Measures being adopted include: controlling and stopping the deforestation and the ecological damage, implementing the policy for the protection of natural forests, providing strict protection for preserving forest to resolutely stop the felling of forests, changing the current felling pattern of natural forests to achieve the transformation of the timber production by cutting and utilizing natural forests to the direction of managing and using artificial forests, improving and expanding the natural forests being protected, improving the national network of natural reserves to establish a corridor of natural reserves, and preventing and controlling other human damages and natural disasters such as forest fires and forest diseases and pests.

Enhancing the storage via management. The measures being adopted include: increasing the area and carbon density in the comprehensive ecosystem of natural forests, artificial forests and agro-forests, increasing the timber products, especially the long-lived and passivated timber products to expand the carbon storage, and expanding the soil carbon storage.

Developing the substitution via operation. The measures being adopted include: greatly developing the fuelwood forests to reduce or substitute for fossil fuels and developing the long-life timber products.

Developing a strategy of management and operation adaptable to the future global climate warming. The main measures include: developing high-quality varieties, developing drought-resistant tree species and formulating a policy for the management in the intermediate cutting and in the rotation.

3.7.4 Sea level and coastal zone

(1) Adopted measures

National and local laws on the sea have been enacted, including the revision of the Marine Environmental Protection Law of the People's Republic of China, the publication of Regulations on the Marine Environmental Protection and the formulation of the Regulations on Mangrove Protection and the Regulations on Coral Reef Protection by Hainan Province. The construction of the system for stereo monitoring of marine environment has been intensified and a national network for monitoring marine environ-



ment has been established. A national survey on marine ecology has been carried out, directed at typical issues on marine ecology. Ten red tide monitoring districts have been set up in the coastal marine aquicultural zones and the discovery rate of red tide has been raised. In order to protect the diversity of marine organism, national-level and local-level marine natural protection areas have been established. In order to improve public awareness about the protection of marine environment and deepen the public understanding of the marine environment, marine disasters and marine ecosystem, competent authorities of the State Oceanic Administration have issued the Bulletin on Marine Environment in China for the preceding year in the first season of each year, comprising the Bulletin on the Quality of Marine Environment in China, the Bulletin on Marine Disasters in China and a three-year Bulletin on the Sea Level in China.

(2) Adaptive measures planed to be adopted

The construction of coastal facilities for the protection against sea level rise would be strengthened. In order to adapt to the increasing trend of sea level rise due to global warming, standards designed for sea dikes would be raised from the present standard for meeting maximum sea level occurrence in 20 years, 50 years or much longer. The existing coastal facilities would be heightened and reinforced. In constructing environmental protection facilities and drainage works in the coastal cities, impacts of sea level rise should be put into consideration.

The technical level for the renovation and reconstruction of the coastal ecosystem would be raised. The whole-set technique for forestation with seeds of mangrove, techniques of introducing high-quality tree seeds and their cold-resistance in the northward migrations and the technique of transformation of secondary-forest would be researched and applied. Methods for determining and assessing the effects of protection for mangrove would be formulated. The index for marine environment suitable for planting mangrove would be set up. Experiments and researches would be conducted for transplanting corals, and the structure, function and restoration mechanism for the diversity of the coral reef ecosystem would be studied.

The construction of coastal monitoring system would be strengthened. Various high-tech monitoring approaches, especially satellite remote sensing and geographical information system would be used to strengthen the monitoring of the change of sea level in the coastal areas, the change in the ecosystem of sea-side wetland, mangrove and coral reef and various influencing factors, so as to bring about a long-term, continuous and stable monitoring system. Inter-sector technical cooperations and exchanges of datasets would be carried on and the network sharing of monitored information would be promoted.

3.8 Uncertainties and priorities for further study

Up to now, assessments on the impact of climate change in China still contain considerable uncertainties. This is because: methods for projecting future climate change are not perfect enough and social-economic scenarios are not certain; it is difficult to identify the impact of climatic factors from that of other factors; the method used for assessing the impact is not yet perfect, and most models for assessment are static models and have not been given sufficient parameter rating and validation.

In order to reduce the uncertainties in the assessment, it is necessary to improve the projection of the GCMs, develop the RCMs suitable to China, vigorously develop impact assessment models established by Chinese scientists, and carry out a sufficient validation and improvement for foreign models.

Present impact assessments in China are mainly concentrated on agriculture, water resources, terrestrial ecosystems and coastal zones. Aside from continuing efforts in strengthening, improving and expanding the assessment of impacts of climate change on those fields, study should be conducted on the fields of human health, tourism, energy, national key projects and building facilities. There is a vast area in China with various landscapes, so the impacts of climate would be different across regions. There is a particular need to conduct a thorough study on the impact of climate change on different regions, so as to find out concrete adaptive measures suitable to the circumstances of different regions.

It is shown from the reality that the impacts of extreme weather/climate events on all sectors are very strong, but relevant study in this regard is very limited. Therefore, study on the occurrence of extreme weather/climate events and their impacts should be strengthened.