地理学报(英文版) 2003年第13卷第3期

Impact of climate change and variability on water resources in Heihe River Basin

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Studies indicate that the climate has experienced a dramatic change in the Heihe River Basin with scope of temperatur e rise reaching 0.5-1.1oC in the 1990s compared to the mean value of the period 1960-1990, precipitation increased 1 8.5 mm in the 1990s compared to the 1950s, and 6.5 mm in the 1990s compared to the mean value of the period 1960-199 0, water resources decreased 2.6×108 m3 in the 1990s compared to the 1950s, and 0.4×108 m3 in the 1990s compared t o the mean value of the period 1960-1990. These changes have exerted a greater effect on the local environment and so cio-economy, and also made the condition worsening in water resources utilizations in the Heihe Rver Basin.

Impact of climate change and variability on water resources in Heihe River Basin ZHANG Jishi1,2, KANG Ersi1, LAN Yong chao1, CHEN Rensheng1 (1. Cold and Arid Region Environmental and Engineering Research Institute, CAS, Lanzhou 73000 0, China; 2. Lanzhou University, Lanzhou 730000, China) 1 Introduction The climate conditions of temperature and prec ipitation are of primary importance for arid region and a change of climate in the direction to warmer or colder, wet ter or drier would have large water resources, biological and socio-economic consequences (Raino Heino, 1994; Guido V et al., 2001). Since last century, there has been a warming trend for global climate with greenhouse gases such as CO2 continually increasing. The trend got intensified particularly in the late 20th century with marked regional vari ations, that is, air temperature in some regions rises, but drops in others. The different heated conditions and the change of atmospheric oscillations will consequentially result in changes in distribution of precipitation and runof f. Rising of air temperature in a mountainous area will lead to river flow reduction under the same precipitation con dition (Gong and Wang, 2000; Shi and Zhang, 1995). The Heihe River Basin, the second largest inland river basin in No rthwest China, drains an area of 130,000 km2 (Figure 1). The river flows from headwater area through to the terminal region crossing such geomorphologic units as the piedmont diluvial-alluvial plain, alluvial-lacustrine plain and dese rt as well as three different climatic zones: the cold and humid or semi-arid mountain zone, the mid-stream temperat e zone and the downstream warm temperate zone. All surface runoff in the Heihe River Basin originates from the Qilia n mountainous area situating to the south of it. There is consanguineous relationship between the temporal and spatia l distribution of surface runoff and its amount with the variation process of air temperature in the Qilian mountaino us area, and the variation on air temperature will affect the socio-economic development, and wildlife inhabitat of t he Heihe River Basin to a great extent. So it is of great significance to the research of the variation characteristi cs and the future trend of air temperature in the study area for the purpose of programming and planning future devel opment and utilization as well as management of water resources in the Heihe River Basin in the context of global cli mate warming (Kang et al., 1997; 1998; 1999). On the basis of the Third Assessment Report of the Intergovernmental Pa nel on Climate Change (IPCC), this paper summarizes possible impacts of climate change on water resources and vulnera bility of natural and human systems. Although the IPCC report noticed that anthropogenic activities affect the globa l climate much more than supposed and the situation in the 21st century continues to aggravate, it should be pointed out that climate change is only one of the many pressures facing water resources and their management in the future. 2 Data and methodology The data used for analysing climate variation in the Heihe River Basin (including Qilian count y of Qinghai province, Sunan, Shandan, Minle, Zhangye, Linze, Gaotai, Jiuquan and Jinta counties of Gansu province an d Ejina banner of Inner Mongolia) were the series of annual values of air temperature, precipitation and runoff. The series of air temperature and precipitation are obtained from Yeniugou, Tuole, Qilian, Sunan, Shandan, Minle, Zhangy

e, Linze, Gaotai, Jiuquan, Jinta, Dingxin, Yingluoxia and Zhengyixia meteorological stations and hydrometric station s. The series of runoff are obtained from hydrological stations for each river in the Heihe River Basin. For analyse s of variation of future air temperature in the Heihe River Basin, the series of annual mean value are taken as basi c data. The analysis of precipitation fluctuation is based on series of areal precipitation mean values, which are mo re representative for finding common trends in comparison with the series of individual stations. 3 Variations of met eorological and hydrological elements in Heihe River basin 3.1 Variations of air temperature In the Heihe River Basi n, 13 meteorological stations were chosen to represent air temperature series. Since the 1950s, five time sequences o f air temperature, that is, yearly mean, spring mean (from Jan. to May), summer mean (from April to June), autumn mea n (from July to Sept.), and winter mean (from Oct. to Dec.) have been established, and the variation characteristics and the future trend of the time sequences are analyzed and studied. By positive linear trend for the whole study per iod, the temperature series indicate a very warm of the 1940s as well as the late 19th century, with values comparabl e with the period 1960-1990. Warm period fall mainly to the years 1937-1950 and 1987-1999, being conditioned particul arly by higher temperatures of spring and winter, sporadically also those of the summer. 3.1.1 Deep mountain area In the Heihe River Basin four meteorological stations of Yeniugou, Qilian, Sunan, and Tuole have been set up in the uppe r deep mountains. The results indicate that the variations in air temperature in the Qilian mountainous area are eith er identical to a certain extent with the global climate warming trend or possessing regional and seasonal difference s. The rising extent of winter mean air temperature is larger than that yearly and other seasonal mean air temperatur e, and the 1990s is the warmest decade since the 1950s. On the whole, the variations of the mean air temperature in t he Qilian mountainous area present a discontinuous and tardily rising trend. The rising extent reaching 0.4-1.7oC in the 1990s is compared to the 1950s, and rising extent reaching 0.4-1.0oC in the 1990s is compared to the mean value o f the period 1960-1990. These changes have substantially affected water resources and eco-environment of the mountai n region (Figure 2 and Table 1). 3.1.2 Plain area In plain areas of the Heihe River Basin, we chose 9 meteorological stations representing air temperature series, including Shandan, Minle, Zhangye, Linze, Gaotai, Jiuquan, Jinta, Dingx in, and Ejina stations. The measured air temperature data at the 9 meteorological stations, which are situated in th e central part of Hexi corridor since the 1950s are used to establish four time sequences of air temperature. The res ults indicate that the variations of air temperature in the plain area are either identical to a certain extent with the global climate warming trend or possessing regional and seasonal differences. The rising extent of winter mean ai r temperature is larger than that yearly and other seasonal mean air temperature, and the 1990s is the warmest decad e since the 1950s. As a whole, the variation in the mean air temperature in the plain area presents a discontinuous a nd tardily rising trend. The rising extent reaching 0-1.6oC in the 1990s is comparable to the 1950s, and rising exten t reaching 0.5-1.1oC in the 1990s is comparable to the mean value of the period 1960-1990. These changes have substan tially affected water resources utilization practices and natural oasis eco-environment of the plain area (Figure 2 a nd Table 2). The analysis of linear trends indicates precipitation increase has followed the climate warming since th e 1950s. However it was decreasing at some rain gauge stations. As a whole, the variation of the mean precipitation i n the Heihe River Basin presents a discontinuous and tardily rising trend. The increasing extent reaching -16.2-32.4 mm in the 1990s is comparable to the 1950s, and increasing extent reaching -13.7-18 mm in the 1990s is comparable to the mean value of the period 1960-1990 (Figure 3 and Table 3). 3.2 Variation of runoff In the Heihe River Basin, the runoff formation has two ways, the chief part is produced from the precipitation, and the other part is from the melt ing of snow and ice in mountain peaks. So we chose runoff flowing out of the mountains controlled by hydrologic stati ons to represent the runoff series. During the past 50 years, analysis indicates that the runoff increasing trend fol lowed the global warming in the mainstream and some branches of the Heihe River Basin, but in most branches, the runo ff decreasing trend follows with global warming. Especially, in the 1990s the runoff flowing out of the mountain was generally decreasing. The varying extent reaching -1.216-0×108 m3 in the 1990s is comparable to the 1950s, and varyi ng extent reaching -0.358-0.210×108 m3 in the 1990s is comparable to the mean value of the period 1960-1990 (Figure 4 and Table 4). 4 Conclusions Analysis indicates that the study area witnesses great climate change. The temperature increase extent reaching 0.5-1.1oC in the 1990s is comparable to the mean value of the period 1960-1990, precipitatio n increase extent reaching 18.5 mm in the 1990s is comparable to the 1950s, and 6.5 mm in the 1990s is comparable to the mean of the period 1960-1990, water resources decrease extent reaching 2.6×108 m3 in the 1990s is comparable to the 1950s, and 0.4×108 m3 in the 1990s is comparable to the mean of the period 1960-1990. The temperature and precip itation variations in mountainous areas are obvious in comparison to the plain areas. The small scale precipitation i ncrease cannot counteract the evaporation increase because of temperature rise. So the decrease of runoff flowing ou t of the mountains, snowline rise and ice cover shrinkage as well as vegetation cover degeneration, all induce more o

ccurrence frequencies of natural disasters and degradation of grassland.

关键词： climate change; water resources variability; Heihe River Basin of Northwest China