SOME ASPECTS ON OASIS DEVELOPMENT AND ENVIRONMENT CHANGE DURING RECENT 43 YEARS IN THE TAKLIMAKAN DESERT, CHINA

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SUMMARY

Taklimakan desert is one of the distinguished sandy desert of the world. There is a long history of oasis development in the desert. Changes of rise and decline of the Silk Road, and of flourishing and falling of the towns have remained great a lot of natural mysteries. Great changes have experienced in recent years too. The area of oasis, for example, has increased greatly. We are trying to clarify the relationship between the oasis development and environment change, specially climate change in recent years. Meteorological data obtained in several oases in recent 43 years were analyzed. It was obvious that air temperature was increasing in winter, but decreasing in summer. Precipitation in summer has increased 5 to 100 percent. In order to study on the relationship between the human activities and desertification in the Taklimakan Desert, collection of data on the agricultural land use in the oases was tried by interview with the farmers. The present study gives some detailed discussion of the oasis development and environment change and their effects on the climate change in Taklimakan desert, China. As a conclusion the recent oasis development has made the climate becoming better for agriculture activities.

1. INTRODUCTION

Air temperature is increasing in the world according to many observation data analyses, especially since 1977 (Joined and Briffa, 1992). Some simulation models have demonstrate that there will be an increase of precipitation in middle latitude (Folland *et al.*, 1990). However, almost all the research work on the climate change in arid land of China have pointed out that the climate is becoming or will be drier and drier (Geng, 1986; Zhu et al., 1989; Ling, 1990; Zhang et al., 1992; Ye and Chen, 1992). Du (1993a) has done some data analysis on air temperature and precipitation in recent 40 years (1951-1990) of 30 stations of arid China. Du found that variations in air temperature and precipitation in the western part of arid China were different from that in eastern part of arid China. In the eastern part of the arid region of China, air temperature has increased and precipitation seems decreasing both in winter and in summer. In the western part of arid China, air temperature seems increasing in winter, but decreasing in summer. However, precipitation in summer has increased since 1980. By using more detailed data including discharge data for several rivers in Xinjiang, China, Du (1995) suggested that the increase of precipitation in summer in western part of arid China was to be both the global change effects and the local environment change, such as the expansion of the area of oases. The present study gives some detailed discussion of oasis development effects on the climate change and climate change impacts on oasis agricultural activities in the Taklimakan desert.

2. DATA AND SKETCH OF THE STUDY REGION

The western part of arid China characterized as a basin type is mainly distributed in Xinjiang, where arid areas (desert) are manly distributed in four basins, Jungar Basin, Tarim Basin, Turpan Basin and Chaidam Basin. The high peaks (over 5500m a.s.l.) of the surrounding mountains are covered by permanent snow or ice of glaciers. The geographical sketch map of the region is shown in Fig. 1. The climate there is characterized by a great annual thermal range with severe low temperature in winter, scarce precipitation but occasional heavy rainfall, and frequent severe sand and dust storms (Du, 1993b).

Monthly mean surface air temperature and monthly precipitation data from 1951 to 1993 of thirteen meteorological stations were used. Five of the thirteen stations were in Taklimakan desert All the stations are in basins as shown in Fig. 1 and located inside big oases.

In order to clarify the climate change impact on agriculture, Martonne arid index (AI) was used;

$$AI = p / (t + a) \qquad (1)$$

Where p is monthly precipitation (mm) t is monthly mean of air temperature and a is a constant coefficient, here we take a as zero.

In order to study on the relationship between the human activities and desertification in the Taklimakan Desert, collection of data on the agricultural land use in the oases was tried by interview with the farmers in several oases around the Taklimakan desert.

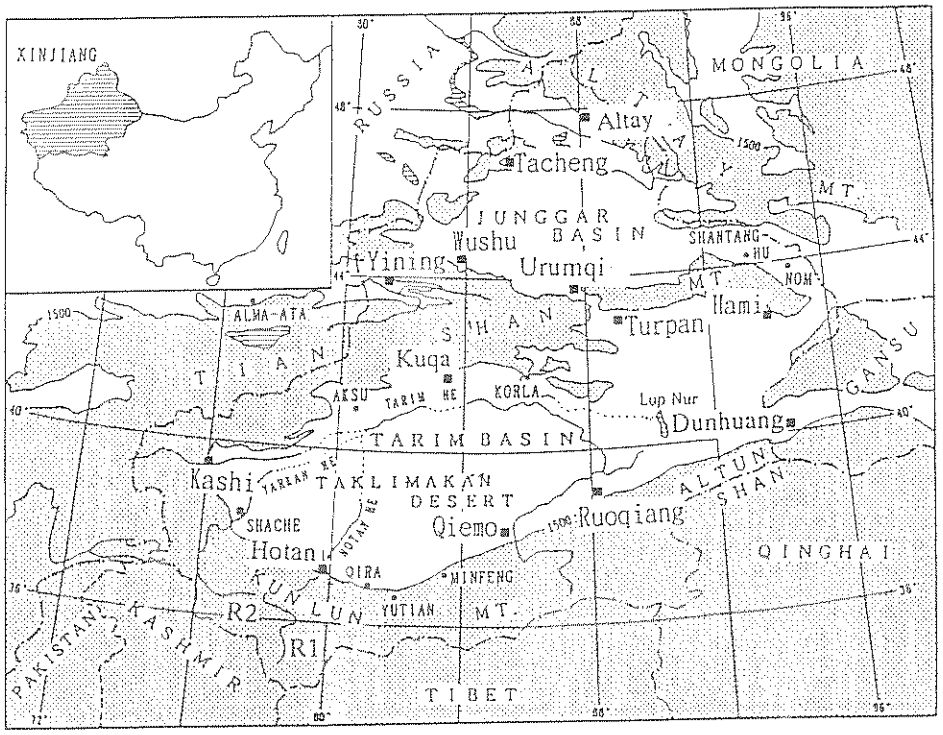

Fig. 1 Sketch map of study region and names of observation stations and rivers

3. AIR TEMPERATURE AND PRECIPITATION CHANGE IN RECENT 43 YEARS

Fig. 2 shows the inter-annual variations of precipitation and surface air temperature for summer (June, July and August) and winter (December, January and February) in the western part of arid China in recent 43 years (1951-1993) (means of 13 stations). Air temperature in winter was increasing obviously in all stations. Mean surface air temperature in Taklimakan desert has increased about 3.0 degree with a range from 2.0 to 9.0 degrees since 1951. The increasing rate reaches to 0.05 - 0.21 degree / year. However, air temperature in the Taklimakan desert has decreased 1.5 degrees. Domroes (1993) has carried out some statistical analysis on the monthly means of air temperature in 7 stations in Taklimakan desert and given a same warming trend in January and a same cooling trend in July. Therefore, the annual range of air temperature in the Taklimakan desert has Contracted.

Although there were many fluctuations and there were no trends in winter, precipitation seems increasing, especially since 1977, in most stations by taken five years running means in summer. Comparing to the mean of 1975-1979, the precipitation in summer of 1989-1993 has increased about 5% (at Ruoqiang) to 100% (at Hotan) as shown in Fig. 3. Monthly mean precipitation of 13 stations in July has increased even 100%. This increasing in precipitation, especially large amount of rain in 1993, has great influence on the vegetation growth there. We found the Gobi desert in Qira near Hotan was covered by vegetation in the summer of 1993, where there used to be no vegetation cover. Although it was said that this kind of scene occurs about once ten years, it existed until the summer of 1994.

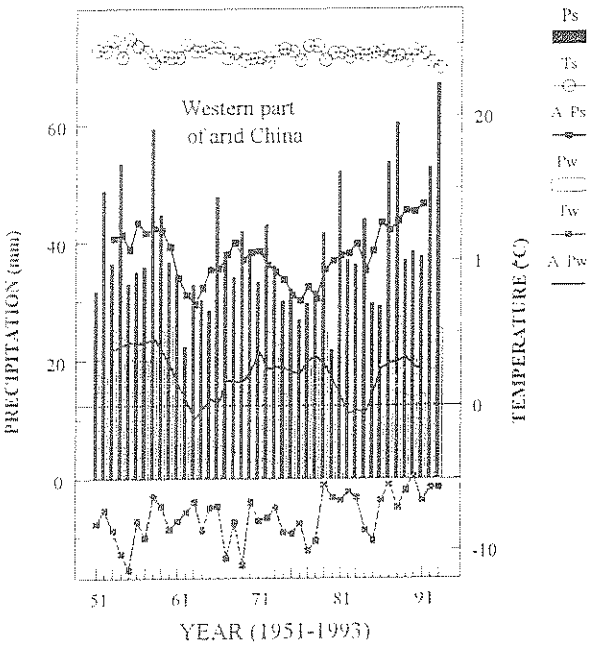

Fig. 2 Inter-annual variations of precipitation (P) and air temperature (T) for summer (s, sum or mean of Jun., Jul. and Aug.) and winter (w, sum or mean of Dec., Jan. and Feb.) in the western part of arid China in recent 43 years (1951-1993)

(A.: 5 years running mean)

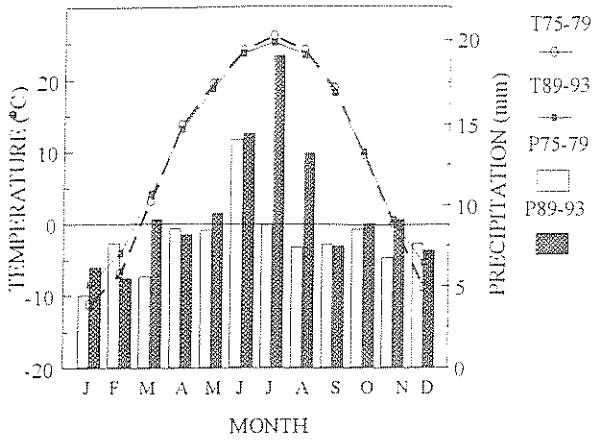

Fig. 3 Comparison of 5 years means of annual variation of temperature and precipitation between 1975-1979 and 1989-1993

4. VARIATION OF ARID INDEX IN RECENT 43 YEARS

In order to asses the climate change impact on the agricultural activities, Martonne arid index was analyzed. The greater the arid index is, the less water is needed for cultivation. Fig. 4 shows the inter-annual variation of standardized arid index for summer (Jun., Jul. and Aug.) in the western part of arid China in recent 43 years (1951-1993) (mean of 13 stations). The arid index shows a progressive increase during recent 15 years, although it was high in 1950s and low around 1963 and around 1977. It has been increased 70% since 1977 for the western part of arid China. That means the Climate is becoming better for the oasis agriculture since 1977.

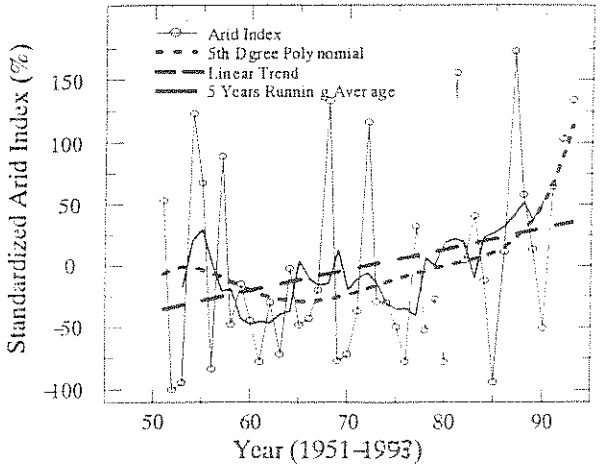

Fig. 4 Inter-annual variation of standardized arid index for summer (Jun., Jul. and Agu.) in the western part of arid China in recent 43 years (1951-1993)

5. LOCAL DEVELOPMENT EFFECT ON THE CLIMATE CHANGE

Local climate change can be caused by (1) global climate change and (2) long-term fluctuations. The increase of surface air temperature in winter is probably mainly due to the global change caused by green gas emission, because the Mongolia High controls this area in winter. It is always fine days in winter and has less influence of cold wave from north (Li, 1991). Furthermore, cold wave influence has become week in recent years. However, local development will make some influence on climate change due to all the meteorological stations used in this paper are situated inside of the oases. According to Sun (1990), Ling (1990), Du and Maki (1994), the climate in oasis is characterized by a comparatively lower wind speed; smaller temperature variation, higher air humidity and evapotranspiration and more precipitation than in the desert area. Fig. 5 shows a comparison of monthly mean of diurnal variations of air temperature between an oasis and desert in Turpan, China for July and December. It is obvious that the air temperature inside the oasis was lower in July and higher in December. This effect is the same as the climate change in recent years.

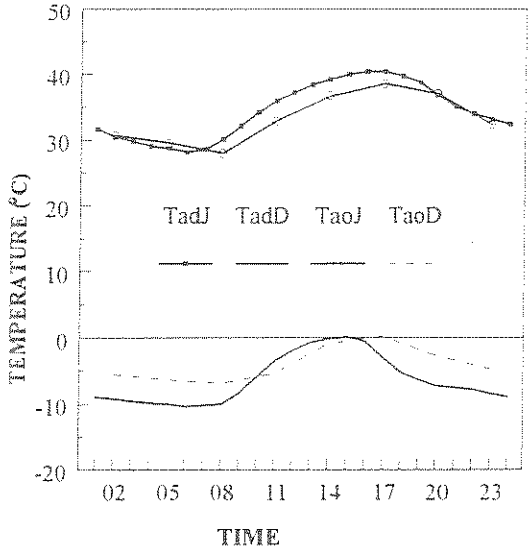

Fig. 5 Comparison of monthly mean of diurnal variations of air temperature between an oasis (o) and desert (d) in Turpan, China for July and December.

Great changes have experienced since 1950. In Tarim river valley (cf. Fig. 1), for example, the cultivation area had increased about 350,000 ha during 1951-1958 (Tang et al., 1992). Cultivation area has increased even 7.5 times since 1951 in some place. On the other hand, living in arid land, people need trees or grasses for fire wood and buildings materials. According to Tang et al. (1992), the natural forest area of Populus trees had decreased 285,000 ha in the Tarim river valley during 1958-1978. These have led about 2,192,000 ha of desertification area occurred.Thus the climate before 1977 did not change

However, although the cultivation area per person in most county has slightly decreased from 1980 to 1988 (SDNSD, 1989), the area of oasis were increased and the decrease of natural forest and severe desertification has been controlled. On the other hand, windbreak forest play very important role for oasis agriculture. Many windbreak forests have been grownup in recent years The interview with the farmers in several oases around the Taklimakan desert has indicated that the income of farmers has increased greatly so that using coal instead of wood has been increased obviously since 1978. Cultivation in arid China need irrigation of water,

which would lead to increase precipitation. If we assume that the bigger the oasis is, the greater the effect of oasis on climate will be, we can concluded that the decrease in air temperature and increase in precipitation in summer is mainly caused by the oasis developments. It is necessary to know the detail of environment changes for further study.

6. DISCUSSION: CLIMATE CHANGE IMPACT ON THE OASIS AGRICULTURE

Climate change will make great impact on human activities in arid land. There are a number of urban and agricultural archaeological remains in the present-day deserts of China. Some researchers have pointed out that the abandonment of most of the remains and the nomadic south ward migrations in eastern Asia have a close relationship with climate change during historical times (Fang et al., 1992). We fund that many people from eastern part of China (such as Sichuan province) have been moving to Taklimakan desert for farm work in recent years. The area of oasis is expanding in recent years as mentioned above. Expansion of areas than will led increase of irrigation of water. This will in turn cause further climate change in future. However, increase in cultivation area will cause the increase of the utilization of ground water for irrigation. Over pumping-up of ground water will be connected to desertification directly. Thus, it is very important to have an efficient use of water for oasis agriculture. On the other hand, due to the increasing population, collecting fuel, building materials and grasses in desert, and over-grazing around the oasis are coming to a limit to utilize. It is important to use coal or other fuel instead of the wood by increasing farmer's income in arid China.

7. CONCLUSION

This study on the oasis development and environment change in recent years in Taklimakan desert led to following results:

(1) The climate in Taklimakan desert as well as in the western parts of arid China does have become better in recent years that expressed as following:

The surface air temperature in winter (Dec., Jan, and Feb.) have increased by about 2.0 to 9.0 degrees during the past 43 years and that in summer (Jun., Jul. and Agu.) have decreased slightly. Thus, the annual range have decreased significantly.

Precipitation in summer has increased by about 5 to 100 % during recent 15 years, although the annual precipitation does not show any significant systematic trend as a whole. This increase in precipitation has made some influence on the desert vegetation.

(2) The increase of surface air temperature in winter is probably mainly due to the effect of global change caused by green gas emissions. The cause for the increase in precipitation and the decrease in surface air temperature in summer is suggested to be both the global change effect and the local environment change due to the expansion of area of oases, increase and grownup of windbreak forest, control and decrease of cutting fire wood in desert area by increase of using coal. The local environment change is probably the main cause.

(3) It is very important to monitor the precipitation and surface temperature variations in near future and to have detailed data analysis on the variations in precipitation and discharge in the mountain area in recent years in order to clarify the water balance variation for future development in the arid land.

(4) The recent climate change is better for the oasis agriculture. The expansion of the area of oases (increase in irrigation) will cause further climate change in future. However, increasing cultivation area will cause the increase of the utilization of ground water for irrigation and over pumping-up of ground water will be connected to desertification directly. Thus, it is very important to have an efficient use of water resource for oasis agriculture.

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