CHINESE GEOGRAPHICAL SCIENCE
Volume 11, Number 2, pp. 163 - 167, 2001
Science Press, Beijing, China

EFFECTS OF AGRICULTURE RECLAMATION ON THE HYDROLOGIC CHARACTERISTICS IN THE SANJIANG PLAIN, CHINA

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ABSTRACT: The Sanjiang Plain is the largest and most concentrated wetland region in China, the total area is about 1.088×10^7ha with rich marsh resources and biodiversity. Before 1949, the Sanjiang Plain was a large untravelled wild plant and waterfowl habitat, and there were some rare swans, red-crowned cranes and thousands of hydrophytes. From 1950, the local government began to reclaim the marsh in the Sanjiang Plain, built the commodity grain base of Northeast China, and developed the industry of grain processing, animal husbandry, etc. Up to now, there are 54 farms which control 3.5087×10^6ha agriculture field. The marsh areas are reduced by 1/2; many rare animals and plants are near extinction. The human activities and agriculture reclamation made a great change on the environment, especially made water balance change and regional climate change. So to study and protect the wetland ecosystem and marsh resource are extremely urgent. This paper focus on the hydrology change and climate change before and after marsh reclamation, including evapotranspiration, run off, soil character, micro-climate on both marsh and agriculture field, and the reason that cause seasonal drought, waterlogging and degeneration of marsh.

KEY WORDS: marsh; agriculture reclamation; the Sanjiang Plain

CLC number: P941.78 Document code: A Article ID: 1002-0063(2001)02-0163-05

1 THE NATURAL ENVIRONMENTAL CHARACTERISTICS

The Sanjiang Plain is located in the northeast of Heilongjiang Province, China. Russia borders this region in the north and east. Its total area is 1.088×10^7ha. The area of plain occupies 61.21% of the total land area and that of hill and mountain amounts to 38.79% of the total land area. It is not only one of the most important regions with large area of fresh water wetlands and with varieties of rare migratory waterfowls, but also has very rich land resources in China. The neotectonic movement has sunk for long time in this region. The various depressions are distributed widely in the region. This region belongs to temperate zone; its climate type is continental monsoon climate. It is characterized with cold and humid. The average annual temperature is about 1.9℃ and average annual precipitation ranges from 550 to 600mm which concentrates from July to September and occupies about 70% of the annual total. There are many rivers and lakes in this region and wide flood plain were formed along the river.

Received date: 2000-09-05
Foundation item: Supported by the National Natural Science Foundation of China (No. 49771002) and the Foundation of the Laboratory of Wetland Process and Environment, Changchun Institute of Geography, the Chinese Academy of Sciences and Key Ninth Five-Year Plan Project of the Chinese Academy of Sciences (No. KZ951-B1-201-03).
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The main vegetation types are marsh and wet meadow. Main soil types are marsh soil, meadow soil and peat soil. Under the long-term action of aforementioned environmental factors, most of this region was favorable to wetland development. Wetland resources are rich in the Sanjiang Plain, which is one of the largest wetland distribution regions in China (Department of Swamp Research, 1983).

2 THE HISTORY OF PROCESS OF WETLAND RECLAMATION

Human activities in the Sanjiang Plain started very early, but up to 1949, there were still limited population and a large area of wetlands in the region (5.345×10^6ha), including marsh, wet meadow, lake and river, which stretched continuously, and accounted for 80.17% of the total area of the Sanjiang Plain.

As recorded in history, four massive reclamation movements of wetlands have taken place in the Sanjiang Plain since 1949. The first reclamation movement started from the spring of 1950, and lasted about 10 years. The total wetlands of 7.26×10^5ha were reclaimed, and the farmland areas increased from 7.873×10^5ha to 1.5133×10^6ha, which took 13.9% of the total area of the Sanjiang Plain. The second reclamation movement started from the beginning of the 1960s and ended in 1977, in this period, the farmland areas increased to 2.12×10^6ha in 1977, it took 19.5% of the total land areas. The third reclamation movement took place during 1978 to 1985, the farmland areas increased up to 2.937×10^6ha by this strong movement, which took up 27.3% of the total land areas. The fourth reclamation movement was started in 1986, and lasted to present. The land reclamation of the Sanjiang Plain has been brought into the National Land Reclamation Plan. This is a comprehensive exploitation plan of wetlands in the Sanjiang Plain, and it contains components of agriculture, forestry and animal husbandry as well as some grain processing industries. Fig. 1 and Fig. 2 show the statistics of farmland vicis situde and land use of the Sanjiang Plain in 1990.

Due to the human activities and development of industry, it made a great pressure on the environment. Up to now, the forest cover decreased from 3.9413×10^6ha to 2.5227×10^6ha and the wetlands decreased from 5.34×10^6ha to 1.4813×10^6ha. Many rare animals and waterfowl lost their habitats nearing extinction. For instance, the Siberian Tiger has been almost disappeared, *Tadorna cristata* has been vanished, Red Crown Crane, Common Sturgeon, Siberian Huso Sturgeon, *Deyeuxia angustifolia* have become endangered species. *Nipponia nippon*, a famous rare and endangered bird, has been stamped out in this region already (SHEN, 1998).

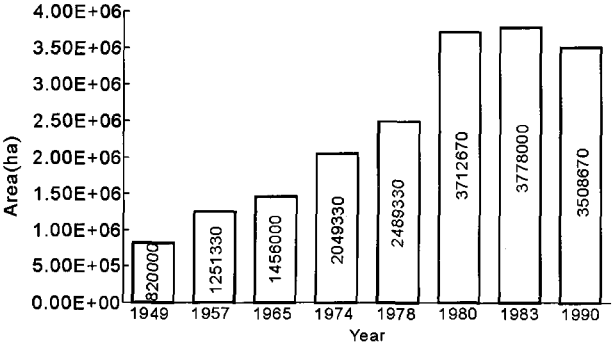

Fig. 1 Change in farmland areas of the Sanjiang Plain ①

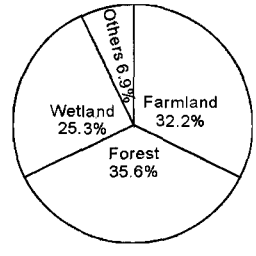

Fig. 2 Land use of the Sanjiang Plain in 1990 ①

3 CHANGES OF WATER BALANCE BEFORE AND AFTER MARSH RECLAMATION

Marsh, one important type of wetland, is a synthetic natural ecosystem, with rich water. Water is the most active factor in this system; it influences plant growth, population distribution and soil formation, controlling development and evolvement of marsh together with thermal condition. The direct impact of

① Data source: LIU Xing-tu, ZENG Shu-sen, 1990. Study on reclamation and utilization of the wasteland in the Sanjiang Plain.

reclamation is the changing of regional water balance; the marsh hydrology and water cycle have been greatly changed because of drainage, especially influencing the evapotranspiration and runoff of marsh.

3.1 Change of Evapotranspiration of Marsh before and after Marsh Reclamation

Marsh evapotranspiration includes transpiration of marsh plants and water evaporation from plants. The *Carex lasiocarpa* marsh and soybean field was chosen as observation objects. E601 tanks were used to observe evaporation of marsh and water surface and micro-weighing lysimeter were applied to observed the farmland evapotranspiration. Table 1 shows that the evapotranspiration of marsh is more than the evaporation of water surface, and the evapotranspiration of farmland is less than water evaporation(CHEN *et al.*,1993).

Table 1 The comparison of the evapotranspiration observed from marsh and farmland in 1999(mm)

Date	Marsh (90% coverage)	Water surface (E601)	Farmland (soybean field)
May	63.8	77.6	58.8
June	70.5	81.8	58.1
July	124.6	119.0	107.7
Aug.	125.1	76.9	98.6
Sept.	112.6	66.2	44.0
Total	496.6	421.5	367.2

3.2 Change of Runoff before and after Marsh Reclamation

Runoff and evaporation are both the main disbursement of marsh water, the change of ground feature after marsh reclamation inferences the runoff and evaporation. The runoff of marsh in the Sanjiang Plain is built up by two parts, one is the surface runoff coming from the surface of marsh, another is the soil runoff coming from the layer of marsh plant root. Since marsh has great water content, when precipitation is normal or less in early stage, the runoff of marsh is less than farmland, if the previous precipitation is more, the soil of marsh is almost saturated, as a result, the runoff of marsh is more than farmland (Table 2) (CHEN *et al.*, 1997).

Table 2 The comparison of runoff of marsh and farmland (1994)

Previous precipitation condition	Types	Time and amount of rainfall (mm)	Runoff (mm)	Quotient of runoff
More	Marsh	16 Aug. (75.9)	66.1	0.870
	Farmland	16 Aug. (75.9)	54.5	0.723
Moderate or less	Marsh	6 – 13 July(85.7)	20.5	0.240
	Farmland	6 – 13 July(85.7)	61.4	0.700

4 CHANGES OF SOIL PHYSICAL PROPERTIES AFTER MARSH RECLAMATION

Soil conditions have been greatly changed after reclamation. The natural marsh soil and cultivated marsh soil were chosen for the research on bulk density, specific gravity, porosity as well as physical properties of water respectively(LIU *et al.*,1994).

From Table 3 and Table 4, we can find that the

Table 3 The bulk density, specific gravity and porosity of soil before and after marsh reclamation

Types	Depth (cm)	Bulk density (g/cm^3)	Specific gravity	Porosity (%)
Natural marsh	0 – 8	0.59	1.82	74.4
	8 – 16	0.80	1.99	67.3
Marsh soil cultivated for 2 years	0 – 8	0.74	2.13	69.4
	8 – 16	0.87	2.17	65.1
Marsh soil cultivated for 7 years	0 – 8	0.90	2.24	64.6
	8 – 16	1.11	2.30	59.0

Table 4 Changes of physical properties of soil water after marsh reclamation

Types	Depth(cm)	Capillary absorbed water(%)	Saturated water content (%)	Field capacity (%)	Maximum hygroscopicity (%)
Natural marsh	0 – 8	106.5	123.6	85.2	10.30
	8 – 16	74.7	92.8	44.1	8.66
Soil cultivated for 4 years	0 – 8	45.6	53.7	32.7	7.36
	8 – 16	55.8	69.4	41.3	8.30
Soil cultivated for 7 years	0 – 8	50.2	58.4	29.7	6.06
	8 – 16	44.5	54.9	28.8	6.46

bulk density and specific gravity increased after reclamation, but the porosity and physical properties of water decreased.

5 RELATION BETWEEN CLIMATE CHANGE AND MARSH RECLAMATION

Large-scale reclamation made a great change of ground feature in the Sanjiang Plain. Wetland drainage and cultivation cause the regional climate change, especially influence the air temperature and made drought and waterlogging.

5. 1 Air Temperature Analysis

Fig. 3 shows the variation of the mean annual temperature over the years. T_1 is the data by observation, T_2 is the curve of them through moving average with the interval of 5 years, and T_3 is the fitting curve, which clearly show the ascending trend. It is known that the mean annual temperature of Sanjiang Plain during the 1980s was 0. 93℃ higher than that of 1960s. It's obviously greater than the increase of the temperature in the Northern Hemisphere. With the rise of the mean temperature, the annual accumulated temperature above 0℃ ascended too, which is very favorable to the agriculture of the Sanjiang Plain. During more than thirty years of the overall rise of the mean temperature, there were many obvious fluctuations. In view of the curve T_2 the air temperature between the late 1950s and the early 1960s rose always. There was a trough between the which mean temperature fell to 0℃. Since then it reached the towards show increase on the whole, but middle 1960s and 1970s, in there were some acute fluctuations. It reached the maximum 3. 8℃ in 1990 and the minimum 1. 4℃ in 1997.

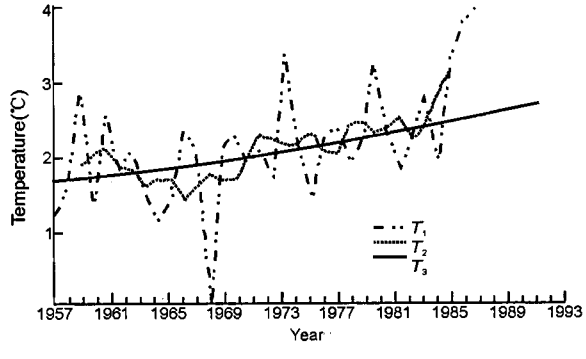

Fig. 3 The variation of the mean temperature over the years

5. 2 Precipitation Analysis

Fig. 4 gives the curves of annual total precipitation over the years. Among them P_1 is the curve of the total precipitation, P_2 is the one handle by the moving average with the interval of 5 years, and P_3 is the fitting one. In light of these curves the precipitation of thirty-four years presents the disturbance type of cosines curve with a shape of high both ends and low middle, which illustrates that the amount of precipitation is dependent upon the adjustment of the atmospheric circulation with its intrinsic cycle. But the careful analysis of curves of P_1 and P_2 can draw the conclusion that the reclamation of the marshland produced some impact on the local precipitation.

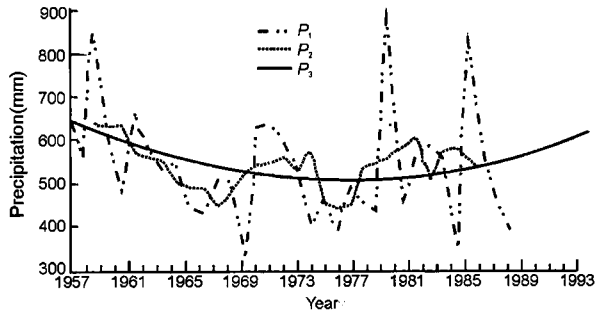

Fig. 4 The curves of annual total annual precipitation over the years

The curve P_2 presents the obvious trend that the amount of precipitation gradually diminished. From the middle 1950s to the middle 1960s, the annual total precipitation basically maintained between 500mm, between the middle 1960s and the 1970s the amount of precipitation mainly varied from 400mm to 550mm. It surpassed 550mm only in 3 years. The highest point of 638. 0mm occurred in 1972 and the lowest point of 326. 8mm was attained in 1970. The amount of pre cipitation maintained below 500mm and the average of

them was only 433.8mm in the successive six years from 1975 to 1980, which is the driest period in the history of the Sanjiang Plain. The decrease of the amount of the precipitation, the increase of the number of the drainage projects and the enhancement of the evaporation led to a widespread lessening of the surface water in the Sanjiang Plain. According to the survey made in 1978, most of marshlands hold no water log and may be crossed at will, which demonstrated that exploitation of marshland can intensify the acidness during the dry climate. Since 1981 excessive and short rain have come out alternately. The record of the maximum amount of annual precipitation is 886.1mm that made the rivers overflow and did damage to the farmland. The one of minimum amount is 340mm that made farmland dried up and plant withered.

All of them show the regulative capacity of the marsh to the climate lessened. It may aggravate drought in the arid period and waterlogging in the rainy day. The local climate of the Sanjiang Plain has become liable to drought and waterlogging(WANG *et al.*, 1994).

6 DISCUSSION AND CONCLUSIONS

After the agriculture reclamation of marsh for many years in the Sanjiang Plain, this region has been becoming a commodity grain base(YANG, 1996). Unfortunately, because of large-scale drainage of marsh, factors of water balance, soil physical properties and regional climate, have been obviously changed, some results are found as follows:

(1) The quantity of evapotranspiration from reclaimed marsh is less than the natural marsh, when the previous precipitation is moderate or less, the runoff from reclaimed marsh is more than natural marsh usually under same precipitation. So the effects of wetlands reclamation are reducing the evaporation and decreasing the modulation of wetlands.

(2) After wetland reclamation, unit weight and specific gravity of wetland soils become bigger, porosity become smaller, water content capability and permeability is degraded.

(3) The annual accumulated temperatures increased and the variations of annual precipitation aggravate in recent years with the high frequency of human activities and agriculture reclamation.

(4) With the marsh exploration, the marsh and wet-meadow has been replaced by cultivated plant, the ecosystem become simple, the biodiversity have been decreased.

REFERENCES

CHEN Gang-qi, WANG Yi-yong *et al.*, 1993. A study on marsh evapotranspiration in the Sanjiang Plain[J]. *Scientia Geographica Sinica*, 13(3): 220 – 226. (in Chinese)

CHEN Gang-qi, MA Xue-hui, 1997. Research on changes of ground feature and water balance of marsh before and after marsh reclamation in Sanjiang Plain[J]. *Scientia Geographica Sinica*, 17(supp.): 427 – 433. (in Chinese)

Department of Swamp Research, Changchun Institute of Geography, 1983. *The Swamp of Sanjiang Plain* [M]. Beijing: Science Press. (in Chinese)

LIU Yin-liang, LU Xian-guo and Yang Qing, 1994. Influence of the wetland reclamation on the soil ecosystem in northeast China[A]. In: *Wetland Environment and Peatland Utilization*[C]. Changchun: Jilin People's Publishing House, 194 – 199.

SHEN Mao-cheng, 1998. An urgent attention to conservation of Sanjiang Plain wetlands[J]. *Wetlands International*, (5): 2 – 5.

WANG Yi-yong, LIU Zhao-li, 1994. Effects of regional climate after marsh land reclamation in the Sanjiang Plain[A]. In: *Wetland Environment and Peatland Utilization*[C]. Changchun: Jilin People's Publishing House, 211 – 217.

YANG Yong-xing, Liu Xing-tu *et al.*, 1996. The problems of ecological environment and exploitation of marsh cological agriculture [A]. In: *Study on Marsh in the Sanjiang Plain* [C]. Beijing: Science Press, 146 – 151. (in Chinese)