AN ECOLOGICAL ASSESSMENT OF COUPLED CLIMATE CHANGE AND HUMAN ACTIVITIES ON WETLANDS IN ZHALONG NATURE RESERVE, CHINA

Yankun Sun *
Center for Global Change and Earth Observations, MSU, MI 48823, USA,
Northeast agricultural university, Harbin 150030, China

Jiaguo Qi
Center for Global Change and Earth Observations, MSU, MI 48823, USA

Guoping Lei, Hui Zhang
Northeast agricultural university, Harbin 150030, China

Introduction

Wetlands are land areas that are periodically flooded or covered with water. It is the presence of water at or near the soil surface for more than a few weeks during the growing season that may help to create many wetland conditions (Lyon, 2000).The 840-square-mile (2,175-km^2) Zhalong Nature Reserve (ZNR) is located in the western part of Heilongjiang province of China, bordered by Qiqihar City, Lindian and Dumeng County. It lies in the western part of the Songnen Plain and comprises marshes and lakes in the Wuyuer River watershed, between 46° 52' and 47° 32' N, and 123° 47' and 124° 37' E, at 140-146 m above sea level. ZNR is composed of permanent and seasonal freshwater marshes with numerous shallow lakes and ponds and extensive reed beds in the lower drainage basin of the Wuyuer River. Grassland, reed thickets, farmland, and fish farms surround this reserve. Summer is the most humid season, with the average rainfall of 70% of the total annual precipitation. The site receives most rainfall in July, which is also the warmest month in the year. ZNR became a provincial nature reserve in 1979 initiated by Heilongjiang province government, later became a national nature reserve in 1987 by China State Department, and listed in the World Important Wetland Contents in 1992 by the United Nations. Being well known for its red-crowned cranes and other kinds of cranes, Zhalong is called as 'Crane's Country'. There are total 15 kinds of crane in the world, ZNR has 6 of them. The 1/6 of the total world-wide red-crowned crane population comes to Zhalong Reserve (Zou, 2003).

* Corresponding author address: Yankun Sun, Center for Global Change and Earth Observations, MSU, MI 48823, USA; Northeast agricultural university, Harbin 150030, China; e-mail: sunyanku@msu.edu

Zhalong Nature Reserve is a world important wetland which is well known for its red-crowned cranes. However, in recent years, Zhalong's wetlands have been facing increasingly threats from both intensified human exploitation and recent climate change. Using meteorological observations over the past 50 years, remote sensing images over the past 30 years, field surveys, and geospatial technologies, we conducted an analysis to improve our understanding of the dynamics of wetlands as a function of socioeconomic factors along with climate drivers. In this paper, we attempted to address the following coupled issues: 1) recent climate trend analysis in the Zhalong area, 2) consequences of increasing human activities and changes in policies coupled with climate change, and 3) recommendation for improved protection of ZNR.

Climate trend

Using meteorological observations from the closest weather station, Lindian, over the past 50 years, we analyzed the climate trends of ZNR. Figs.1, 2 and 3 indicate that, over the past 20 years, the annual mean air temperature in the reserve rose significantly; there were only 5 years when the mean annual temperatures were above its 50 year mean (3.2°C) in the prior 30 years (1958-1987), however, in the recent 18 years (1988-2005), all the temperatures were above the mean values. The annual mean temperature increased from its 50 year mean by 0.11, 0.85 and 1.00 °C for the period of 1980s, 1990s and 2000s, respectively, reflecting a 3.5%, 26.6% and 31.3% increases. It is shown from the coefficients of variation (CV) in Table 1 that the temperature in the falls and springs increased sharply with large fluctuations, while the winter temperature increased a little and no change was observed for the summer period. The annual mean minimum

temperature increased significantly, but the maximum values changed little. Fig. 4 showed that the annual mean precipitation of the recent past 11 years (499mm) decreased, as there were only two in the 11 years when annual precipitations were more than the mean over the past 50 years (427.1 mm). After the flood in 1988, the average annual precipitation decreased significantly, with the mean of 1999-2004 being on 358.0mm, a 16.2% decrease in comparison with the mean over the past 50 years. Meanwhile, large annual and seasonal precipitation variations were both showed in Table 3. The average annual relative humidity (RH) from 1996 to 2004 was 59.4%, less than that of the past 50 years (62.1%), the RH in spring was the least one of a year (Fig. 5).

Table 1 Statistics of annual and seasonal temperature

	Annual	Spring	Summer	Fall	Winter
Mean	3.2	5.2	21.4	3.6	-17.7
Stdev	1.0	1.4	0.9	1.1	2.0
CV	30.1	27.2	4.1	31.6	-11.3
MAX	5.0	8.5	23.6	6.3	-14.5
MIN	0.8	2.5	19.5	1.7	-22.2

Note: Here Spring represents March, April and May; Summer: June, July and August; Fall: September, October and November; Winter: December and January and February in next year. The following are the same as this.

Table 2 Statistics of annual, minimum and maximum temperature

	Annual	Minimum	Maximum
Mean	3.2	-2.8	9.3
Stdev	1.0	1.4	0.9
CV	30.1	-48.9	9.5
MAX	5.0	0.0	11.3
MIN	0.8	-5.8	7.2

Table 3 Statistics of annual and seasonal precipitation

	Annual	Spring	Summer	Fall	Winter
Mean	427.1	49.8	304.8	65.9	6.5
Stdev	114.5	26.1	96.1	32.9	4.3
CV	26.8	52.4	31.5	49.9	67.0
MAX	699.5	125.4	571.0	180.7	24.9
MIN	235.4	14.3	129.7	17.6	0.2

Table 4 Areas of different Land cover(km^2)

	1979	1989	1999	2000	2001
Water	61.5	187.5	135.1	132.9	102.2
Wetland	1740.7	1707.2	1526.7	1534.4	1581.2
Cropland	160.8	205.0	389.5	367.1	393.4
Barren	285.3	149.1	197.4	214.3	162.8

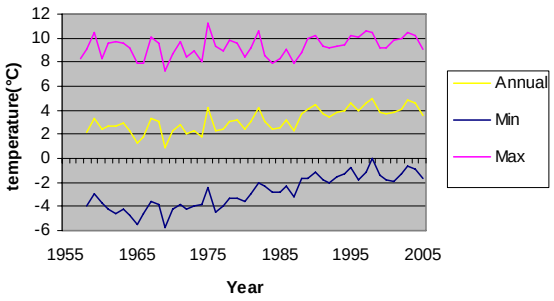

Fig. 1 Annual, minimum and maximum average temperature

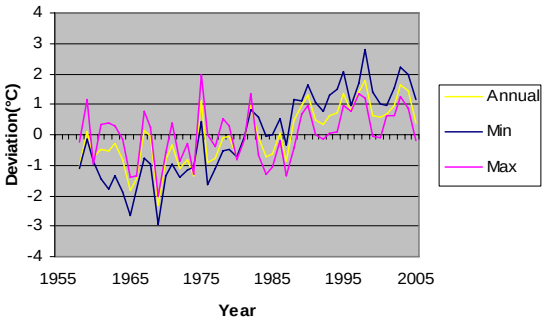

Fig. 2 Deviations of annual, minimum and maximum average temperature

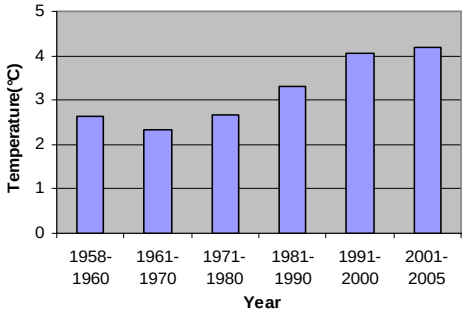

Fig. 3 Annual average temperature in different decades

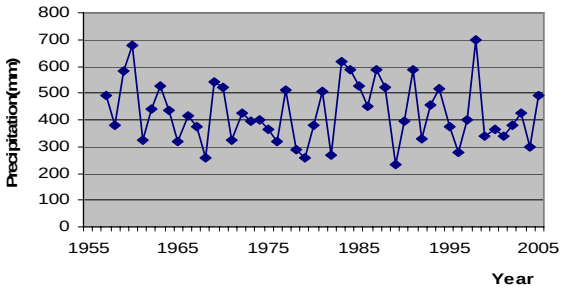

Fig. 4 Annual precipitation

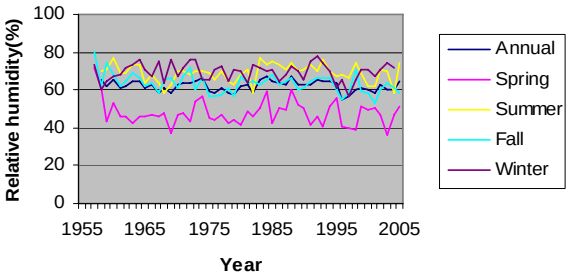

Fig. 5 Relative humidity of annual and different seasons

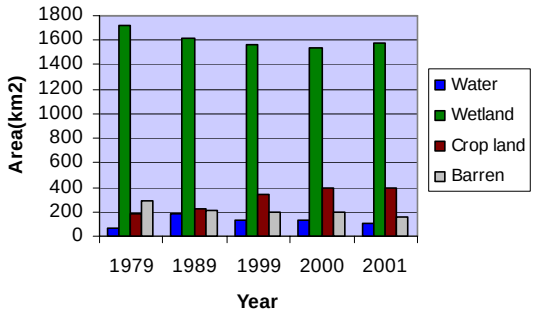

Fig. 6 Areas of different land cover classes

Land cover dynamics

Five years (1979, 1989, 1999, 2000 and 2001) Landsat images and their land cover dynamics were analyzed. From Figs. 6-9 we can see, crop land area increased from 1979 to 2001, water, wetland and barren all showed decreasing trends. Water area in 1979 is the smallest one because of the strong drought in 1977 and 1978. Wetlands fragmentation has been worsened. Road, penstock, rice field and other man-made constructions increased.

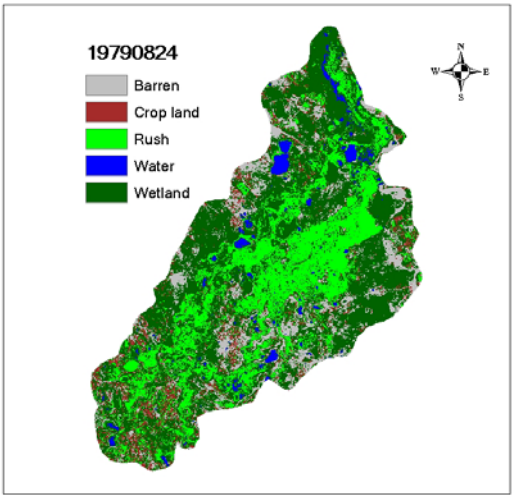

Fig. 7 Zhalong land cover in 1979

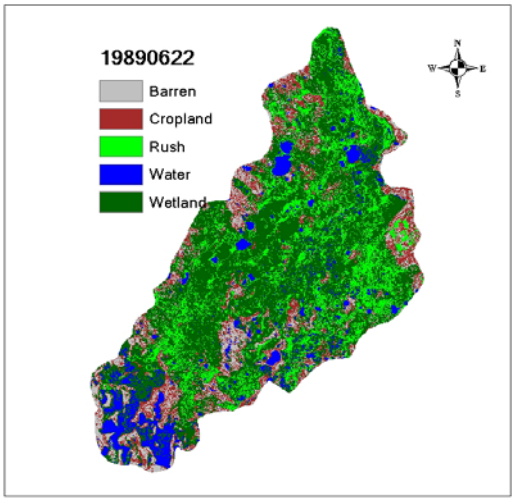

Fig. 8 Zhalong land cover in 1989

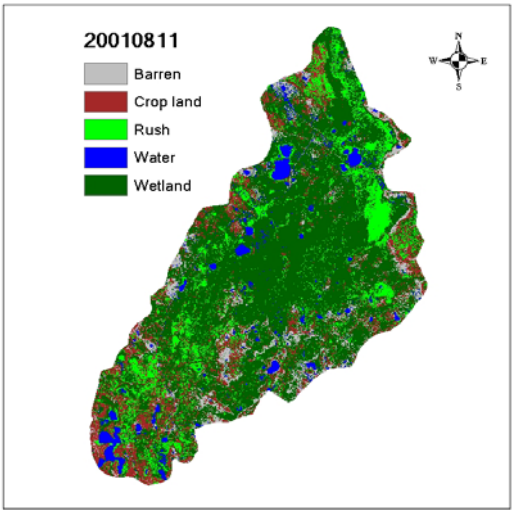

Fig. 9 Zhalong land cover in 2001

Human activities

Since Zhalong Nature Reserve was established, Zhalong wetlands were managed by a special organization - Management Bureau of Zhalong Nature Reserve, which provides some helpful functions on the planning, management, publicizing and protection of the ZNR. Some steps were very important for the preservation of the wetlands. For instance, hunting was forbidden ten years ago; Water citing engineering was actualized since 2001, till April 2004, 950 million m^3 has been supplied to ZNR from Nen river by 5 times; The first special water resources plan focused on wetland preservation -'Planning Report on Water Resources in Zhalong Wetland' was discussed by Songliao Committee in Cangchun city. However, ZNR still faces a lot of threats of some human activities: Since 1990, more than 60 reservoirs have been built in the up stream areas for agricultural and other uses, which have resulted in a significant reduction in water supplies from 680 million m^3 per year to 40 million m^3. The population in ZNR is about 29,000 which is the twice of that in 1979 (Gai, Wang and Wang, 2002), though a wetland emigration plan started in 2003. The project is still on the paper but not been implemented. Until now, 21 construction projects have been suspended within the reserve, therein to the national highway 301 finished in 2002 goes across ZNR with 29.4km distance and 30m width, which severely blocked the water flow between two sides and brought much noise to the red-crowned cranes and other avifauna (Ding, 2005). In September 2004, three man-made dykes with a length of 170-4000m were dug in the center area of the reserve, which destroyed the structure of wetland formed for hundreds of years (Wang, 2004). Tens of millions of waste water from industry, agriculture and residence are been drained into the reserve every year (Sun, 1997), the pollution issue has been noticed for more then ten years, but not resolved yet (Zhao,2005). ZNR is also the production base of fishery, reed product, agriculture and stockbreeding for Qiqihar City, Lindian and Dumeng County, now 0.1 million reed product per year can bring $500 economic value. A 5560 km^2 filler has appeared in Daqing oil-field, ZNR may supply 10 million m^2 water into the underground (Ding, 2005).

Discussions

For the wetland issues, the major concern is that decisions on management of land areas are made sometimes with a poor understanding of the different wetland characteristics and functions (Lyon, 2000). Depending on local and regional interests, activities may be designed address specific questions. For example, why have the frequency and intensity of fire in ZNR increased in recent years? The climate change should be the main reason, since the temperature increased significantly over the past 20 years, the precipitation and relative humidity decreased over the past 10 years, there were more and more warm and dry days in a year over the past few decades, which made it easier to trig fires. The other reason should be a lack of water. Regarding the first important factor for the fires-burning the grass on waste land, the farmer's did it every year but just in recent years (2001 and 2005) the fire frequency and intensity became larger and stronger. Therefore, the climate change enhanced the human and nature damages to the wetland. Some human activity issues such as population, construction, water pollution and production have been existed for a long time but not resolved all along, why? That just divulged the disadvantage of the management system. Does ZNR face threats now? I think so. Although we still can see some good phenomena such as the quantity of red-crowned cranes now (400) is a little bid better than that of 1996-ten yeas ago (346). The total wetland area did not decrease sharply in recent years, but the total amount of avifauna decreased from 100 thousand to less than 10 thousand. The fish has decreased from 46 to 6 or 7, and the fragmentation was believed to be dominant driving force. The water citing program did have an important role for the Reserve, but it can only keep the red-crowned cranes and other a couple of avifauna being in ZNR. However, considering that the interaction of climate change and human activities could enhance the damage on the wetland, we must do something now to preserve the rare avifauna and also the environment which should be more important for human being.

Conclusions

The climate in Zhalong Nature Reserve became warmer and drier, the temperature over the past 20 years increased significantly, meanwhile, the precipitation and relative humidity decreased. The cropping area increased, water area decreased, wetland became fragmentation. Human activities including population, construction, water pollution and production have been threatening the wetland ecosystem. The interaction of climate change and human activities further promote human and nature damages to the wetland. We may not do

much to climate change, but we can restrict human activities to reduce the threat of climate warming to the minimum. At present, for sustainable development of Zhalong reserve and in order to preserve the nature of the reserve to maintain the biodiversity, an scientific logical feasible integrated management approach should be adopted, which focus on how to resolve the human activities issues of water citing, population, construction, pollution and production, meanwhile, deal with well the conflict between the regional economic development and the preserve of wetland.

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