PRECIPITATION VARIABILITY UNDER CLIMATE CHANGE AT KAIDU RIVER WATERSHED, CHINA

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Abstract

This study considers changes on precipitation at Kaidu River Watershed. Precipitation data from 1961 to 2013 were provided by the National Climatic Centre of China. Excel software was employed to calculate the average monthly and annual values analyzed and presented into graphics with use of Origin Pro.8. The results show similarity of increase of the average month at both streams of the river. However, the average inter-annual average precipitation is higher at the upstream station 260.5 mm across 1961 and 1975 decreasing to 246.79 mm between 1976 and 1990, then considerably increases to 293mm between 1991 and 2005 and 314.38 mm between 2006 and 2013, whilst the downstream total station's average annual accounts decreases from 105.29 mm (1961-1975) rising to 107.57 mm and 133.76 mm in the years of between 1976 and 1990 and 1991 and 2005 respectively then fell to 104.15 mm across 2006 and 2013. This can express that Kaidu River, is likely exposed to increasing precipitation that can generate the flooding which, in turn, may impact human activities and ecosystem. From the above findings, it is suggested to consider climate change and promote public awareness and preparedness for precipitation patterns management and adaptability.

Key words: Climate change, Kaidu River Watershed, Precipitation, China

1. Introduction

Over the last two decades a large amount of evidence has revealed that global climate is rapidly changing, and in turn, increasing/decreasing the precipitation frequency (Houghton et al., 2001). The high altitudes of the Northern Hemisphere's annual precipitation increased 0.5% to 1%, while over the sub-tropic's land-surface rainfall decreased about 0.3% per decade and the tropical land-surface precipitation shows that precipitation has probably increased by about 0.2% to 0.3% per decade over the 20th century (Dore, 2005; Liu et al., 2006; Raible et al., 2004; Rani and Maragatham, 2013; Thompson and Wallace, 2001). China's climate has been observing significant change, the Northwest experienced an increase in precipitation generating floods and severe droughts at Northern part (Basher et al., 2010; Shi et al., 2007; Sun et al., 2010).

Kaidu river watershed is the main source of water in the Xinjiang Urghur Autonomous Region, China. The river's hydrological flow is driven by snowmelt in the spring, rainfall and snowmelt in the summer and perennial glacier melting (Dou et al., 2011; Li et al., 2011). This implies that Kaidu River depends on natural climate variability which in turn affects its dependents like human activities and natural ecosystem. Moreover, some studies have been indicating that how climate change and human activities impact on the runoff of Kaidu River and simulation models were built to help the decision makers incorporating the problem into consideration (Chen et al., 2013; Li et al., 2011; Tao et al., 2007). However, under climate, there is need of continuous assessment of its impact on the River, to improve local community's awareness and preparedness, since the river plays a key role on community's economic activities. The objectives of this study are to (1) evaluate changes on precipitation at both streams of the river and (2) suggest appropriate adaptability measures.

2. Materials and Methods

2.1 Description of the Study area

The Kaidu River watershed is located in the central southern slope of the Tianshan Mountains, China. It approximately covers an area of 22,314 km^2 (42°43' - 43°21' N

82°58' - 86°05' E). The river is almost 530 km long, originating from the Hargat Valley and the Jacsta Valley in the Sarming Mountain with the highest altitude of nearly 5000 m, located in the middle section of the Tianshan Mountains (Basher et al., 2010; Xue et al., 2016). The river's up and downstream are surrounded by meteorological stations, Bayinbuluke station located at the river's upstream and three downstream stations namely; Bailuntai, Yanqi and Kuerle (Wang et al., 2012; Yang and Cui, 2005), which collect rainfall and temperature data.

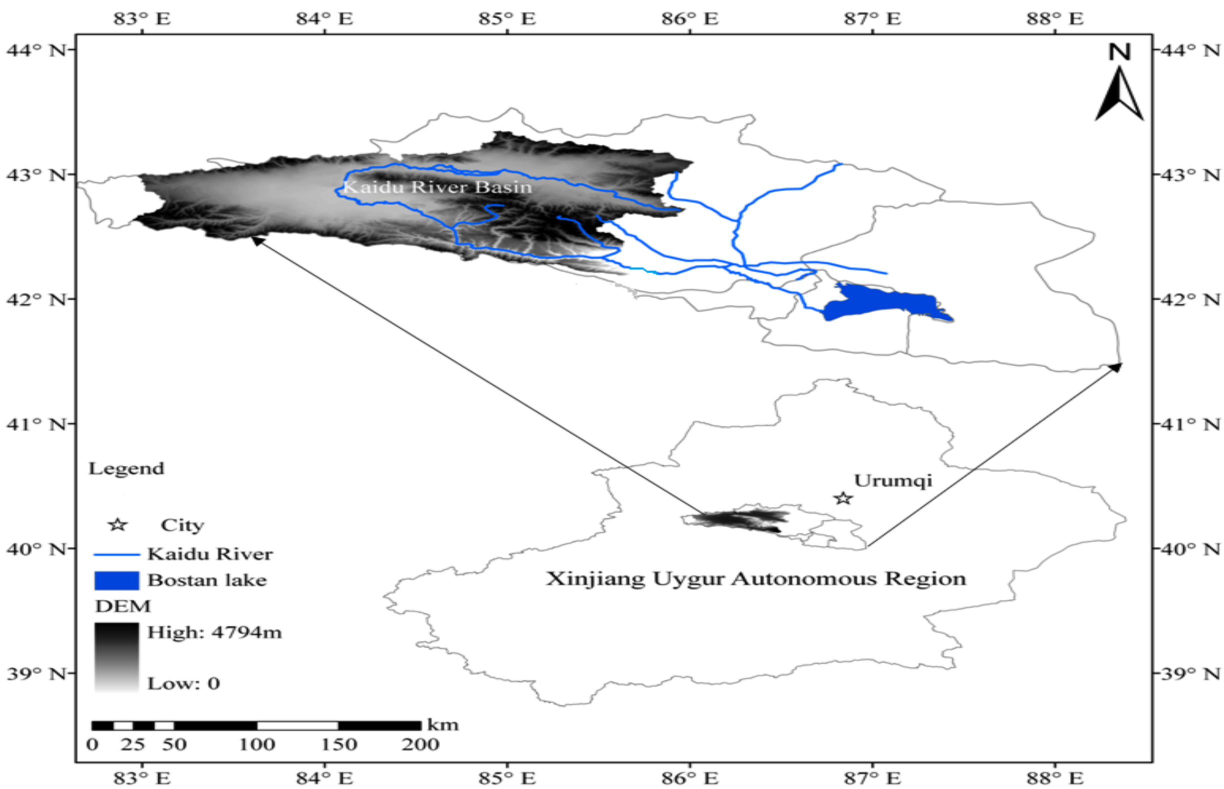

Figure1. Location of Kaidu River Watershed

Yanqi and Kuerle (Wang et al., 2012; Yang and Cui, 2005), which collect rainfall and temperature data.

2.2 Data Collection and Analysis

This study only considered changes on precipitation and used the input data provided by the National Climatic Centre of China, the China Meteorological

Administration from 1961 to 2013. For the historical linear trend interpretation, with use of Excel Software, the input data were converted into average monthly (Figure 2) and annual average values (Table1). The average annual values were divided into period ranges for concrete analysis, the first period starts from 1961 to 1975; the second period is between 1976 and 1990; the third period begins in the years of 1991 to 2005 and the last one from 2006 to 2013. These average monthly values obtained were statistically analyzed and presented into graphics with use Origin Pro.8. Moreover, the report reference and documentation methodology was also adopted to facilitate the analysis and discussion of the results.

3. Results and Discussion

Throughout the period of study considered, the average monthly precipitation recorded by upstream and downstream stations of the Kaidu River was considered.

3.1 Changes in monthly precipitation records

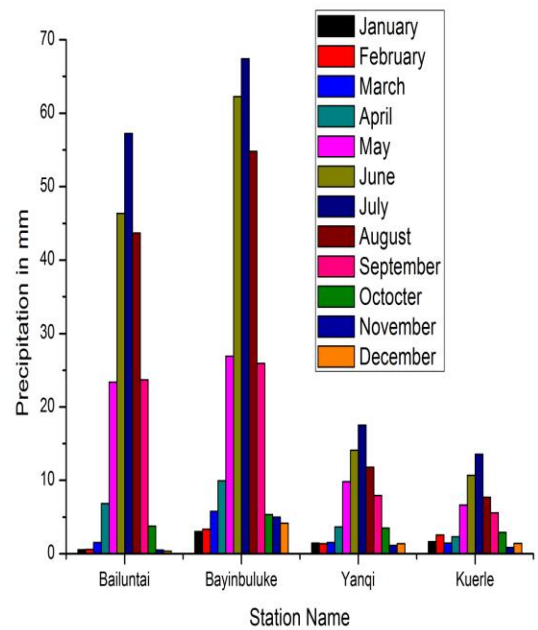

Figure2: Average Monthly precipitation

Figure 2 demonstrates that the first seven months (January to July) at both up and down-stream stations, average precipitation records exhibit an increasing pattern as opposed to the last five months of the year (August to December) which were characterized by a decreasing pattern.

Bayinbuluke station located at the upstream average monthly record was 3.03 mm in January that increased up to 67.43 mm in July falling to 54.81mm in August and 4.15 mm in December. Similar to the stations located at the downstream, Bailuntai’s record was 0.55 mm in January and raised up to 57.25 mm in July then decreased to 43.7mm in August up to 0.36 mm in July and decreased to 11.77mm in August and 1.40 mm in December and Kuerle recorded 1.68 mm in January and 13.56 mm in July falling to 7.73 mm in August and 1.43 mm in December. The average monthly records from 1961 to 2013 shows that the first seven months are featured by gradual heavy precipitations, which may be associated with flooding events followed by last five months of decreasing precipitation, that likely, may lead to drier periods. In addition, as it has been reported by Chen et al. (2013), Tao et al., (2007), Wang et al., (2012) and Yang and Cui, (2005), that with climate change, the flood is likely to occur at Kaidu River, as a result of the snowmelt runoff between March and April plus heavy rainfall of July to August. However, even if, the flood may occur, it is also good to note that, the normal calendar of rainfall is changing (Figure2),

December, Yanqi registered an average of 1.47 mm in January reaching 17.54 mm in because it ends by July followed by remarkable decrease of precipitation in August, which can be associated to the changing climate causing variability in temperature and precipitation events, which in turn, impact on the runoff of the river and its dependents like human activities as well as the ecosystem, where adaptation and management measures are to be promoted.

3.2 Inter-annual precipitation variability

Table 1 indicates that upstream station (Bayinbuluke) recorded an annual average precipitation of 260.5 mm across 1961 and 1975 which decreased to 246.79 mm between 1976 and 1990, followed by considerable increase of precipitation between 1991 and 2005 (293 mm) up to 314.38 mm between 2006 and 2013.

Table1. Inter-annual average precipitation

Period range	**1961-1975**	**1976-1990**	**1991-2005**	**2006-2013**
Bailuntai	192.59 mm	187.49 mm	255.39 mm	190.74 mm
Yanqi	65.76 mm	75.65 mm	90.73 mm	63.79 mm
Kuerle	57.51 mm	59.56 mm	55.15 mm	57.94 mm
Total annual average of downstream stations (Bailuntai, Yanqi and Kuerle)	315.86 mm	322.71 mm	401.28 mm	312.46 mm
General annual average of downstream stations (Bailuntai, Yanqi and Kuerle)	***105.29 mm***	***107.57 mm***	***133.76 mm***	***104.15 mm***
Upstream annual average (Bayinbuluke station)	***260.5 mm***	***246.79 mm***	***293 mm***	***314.38 mm***

mm: millimeter and Values in Bold and Italic are the total annual average precipitation values considered for the analysis

Table 1 indicates that upstream station (Bayinbuluke) recorded an annual average precipitation of 260.5 mm across 1961 and 1975 which decreased to 246.79 mm between 1976 and 1990, followed by considerable increase of precipitation between 1991 and 2005 (293 mm) up to 314.38 mm between 2006 and 2013. However, downstream stations total annual average precipitation recorded decreasing numbers compared to the upstream station, from 105.29 mm (1961-1975) rising to 107.57 mm and 133.76 mm between 1976 to 1990 and 1991 to 2005, respectively, then fell to 104.15 mm across 2006 and 2013. This Inter-annual precipitation variability shows that the increase did not remain until the end of 2013 at both streams, only the average annual precipitation records of the Bayinbuluke (upstream station) keeps on increasing, whereas, the total average annual precipitation of the three downstream stations (Bailuntai, Bailuntai and Yanqi) ends 2013 with lower accounts compared to the previous years**.** These findings on precipitation patterns at Kaidu River Watershed can be associated to the report of Xue et al., (2016) highlighting that the annual mean preipitation, temperature and runoff at Kaidu river will keep increasing in the coming time.

Moreover, Trenberth, (2011) and Wang et al., (2008) added on that, significant longer heatwave period are observed in many Asian countries with increase of intense rainfall frequency causing severe floods, landslides, and debris and mud flows. This is evident that the precipitation patterns observed at Kaidu river watershed as indicated by Figure 2 and Table 1, can be a result of climate change where mitigation and adaptation measures should be early introduced, as suggested by Reddy et al., (2013) and Seung-Rae et al., (2015) that the management of the watershed is essential for land and water resources necessary for the development, and the integration of water resources in all aspects of decisions regarding socio-economic development would be a good alternative to adapt to the changing climate.

4. Conclusion

The results of this study show that, under climate change, precipitation patterns are observed at Kaidu River Watershed, likely leading to flooding, which may affect the river's runoff and its dependents, since the river is the main water resource in the region. From the above findings, for the adaptability to climate change, it is suggested to (i) promote the public awareness and preparedness (ii) enhance local participation and integrate traditional and modern knowledge in mitigation, management and adaptation to precipitation patterns and finally, (iii) benefit from the rain through maximum harvest of the water to be used in drier and/or rain shortage periods.

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