Application of Water Balance Model for Evaluation of Water Resources and Climate Change Impact in Upper Panj-Amu River Basin

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1. Introduction

The Panj-Amu River Basin is being shared between four countries in the Central Asia where it is a source of social economic development for two upstream countries Afghanistan, Tajikistan as well for downstream users Turkmenistan, and Uzbekistan. Almost 90% of water is contributed from the two upstream countries (Hagg et al. 2013) on the other hand, in terms of usage most of water is being used by downstream countries, the average annual surface runoff of the basin 78Km^3, but the actual flow depend on the climatic condition and actual year this amount is varying from 47-108 km^3 (Ahmad and Wasiq, n.d.)The two upstream countries need to develop its water resources mainly for hydropower and irrigation, in order to mitigate food and energy securities while the downstream countries using entire water for irrigation purposes they are concerned these developments might impact them. On the other hand, the region is also experiencing the climate change impact which cases severe floods and droughts as well as intense snow and glaciers melts runoff. Furthermore, the temperature fluctuations are severe in the most area during the year. It is mentionable that climate is dry and continental with hot summer and cold winter, in the high elevation areas the climate is arid and semi-arid. The average monthly precipitation is extremely low from July to September and rises in winter from November to March. Therefore, the river flow is mainly depend on the winter snow and early spring rainfall, river flow is rising from May to July which is mainly hot season and crops need water. Because the two upstream countries are the main dominant river flow contributor, and head water is located in the high mountains. The current research will focus on the Upper Panj-Amu River Basin, it is extremely important to understand the water availabilities of the basin. Thus, the aim of this research to understand the balance of available water resources, assess the hydrology of the basin, and the impact of climate change on basin availabilities in the current and future contexts.

2. Study Area and Methodology

The study was conducted in Upper Panj-Amu River Basin total area is 195773 Km^2, which 96800 km^2 is located in Afghanistan, and 98973 km^2 is located beyond the border of Afghanistan in Tajikistan figure 1. The climate varies from arid to semi-arid, and the internal variability of the precipitation is varying over the territory of countries and the precipitation is mainly effect by topography. The variation of mean annual rainfall is 170–1200 mm, and the average is around 400mm/annual. Annual temperature ranges from -20 to 38^{o}C.

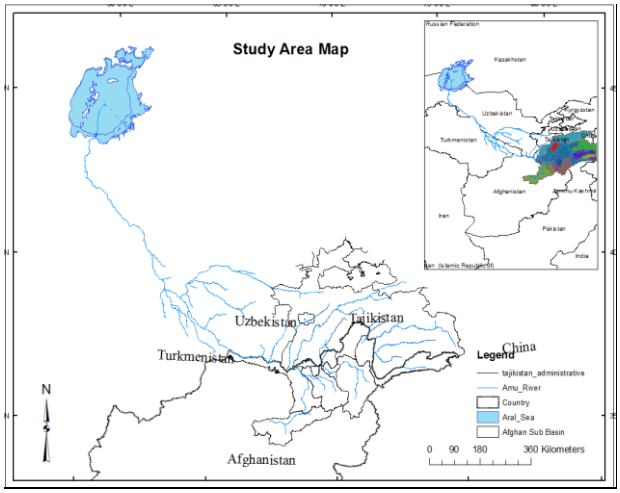

Figure 1 shows the study area

For this purpose Soil Water Assessment Tools (SWAT) Model was selected to assess the basin hydrology in order to underestand the hydrological balance over the basin. Since SWAT model is a physical based, it requires specific informaton about weather and soil properties vegitation and land. The data for Afghanistan side has been collected , but for Tajikstan side the satellite data will be used , in order to justify the data reliability the satellite data will be downscaled , after the bias correction on the bases of Afghanistan observed data because the climate of the both areas are not so different. Therfore, it will be used,at the same time one of objective of this research is to look at the each sub basin monthly water balance, this balance will be conducted to Afghanistan side due to lack of data.

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3. Results

Before to apply the SWAT model to whole basin due to lack of data for Tajikistan side, more focus was given Afghanistan side in order to understand of basin characteristic of the area, the climatic and discharge data was were analysed and sample runoff rainfall ratio method was applied. It is also mentionable that Afghanistan has data gap for 30 years. According to the historical temperature data for Badakhashan and Baghlan cities which are located in the northeast and western of the basin shows slight increase around 0.9 ^{o}C over the past 60 years as indicated in figure 2. On the other hand, the time actual precipitation and runoff is not in the same time as shown in figure 3. Historical and new discharge data were compared for the Kokcha and Kunduz sub basins, flow reduction and slight change in timing were observed as shown in figure 4, and figure 5. In terms of runoff rainfall ratio analysis that was applied to Kokcha sub basin the result shows that ratio has been vary from 0.6 - 1.2 though for arid and semi-arid the ratio may not be that high, it was found that there is also snow accumulation and glaciers were exist in the high altitude where contribute to the runoff as shown in figure 6 and figure 7.

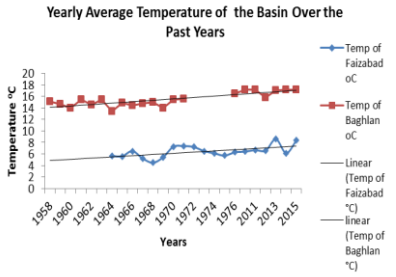

Figure 2.Shows the Increase of temp at the two stations in the basin

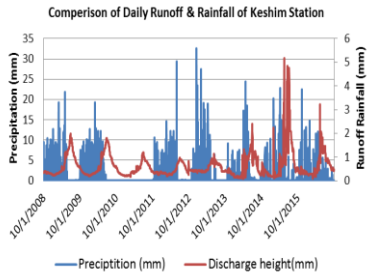

Figure 3.Shows time of precipitation and runoff in the basin

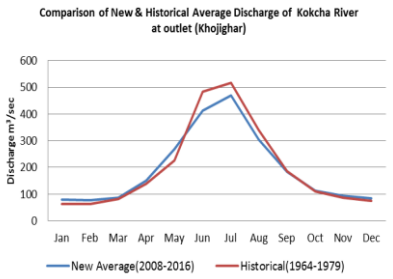

Figure 4. Shows long term flow reduction between historical and new discharge kokcha

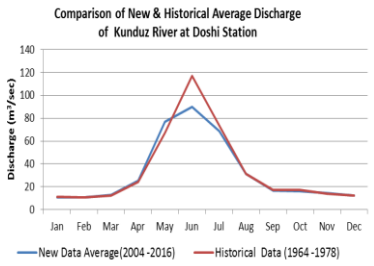

Figure 5.Show the flow reduction at Kunduz sub basin over the past years

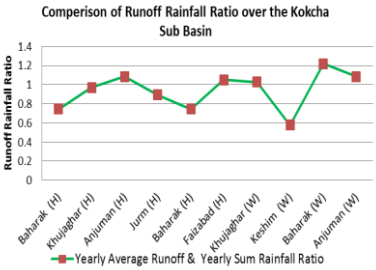

Figure 6.Shows the runoff rainfall ratio in each observation points Kokcha Sub basin

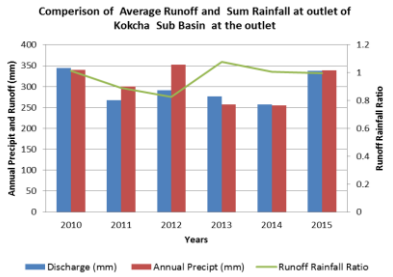

Figure 7.Shows runoff rainfall ratio over years at the outlet of Kokcha sub basin

4. Discussion and Future Scope

It is evident that the basin is already experiencing the flow reduction and increase of temperature which directly impact the water balance of the basin, on the other hand, from the runoff rainfall analysis it was found the river flow is considerably depend on the glaciers and snow melt runoff, therefore it would be important to understand the basin water balance and impact of climate change on the basin. There is a risk of dispute among the users due to water shortage. Thus, the assessment between supply and demand is necessary to overcome the problems and provide possible recommendations for adaptation and sustainability of the resources.

References

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