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## TALAS RIVER WATER FLOW VARIATIONS FOR LAST FIVE-SIX DECADES, KYRGYZ REPUBLIC

**Аннотациясы:** Гидрологиялык система климаттын өзгөрүүсүнө өтө сезгич болуп саналат. Климаттын өзгөрүшү гидрологиялык циклга өз таасирин тийгизет, жаан-чачындардын өзгөрүүсү суунун агымынын көлөмүнө жана убактысына, жер астындагы суулардын көбөйүшүнө, ошондой эле сел жана кургакчылык мезгилдердин жыштыгына жана сыйымдуулугуна таасир тийгизет. Температуранын өзгөрүүсүнүн натыйжасында жалпы буулануу, топурактын нымдуулугу жана өсүмдүктөр да өзгөрүүлөргө дуушар болот. Бул аткарылган жумуштун негизги максаты болуп, суу ресурстарынын учурдагы абалы жана Талас дарыясынын алабына климаттык өзгөрүүлөрдүн таасирин аныктоо жана баалоо болуп саналат. Бир нече ыкмаларды колдонуу менен, биз климаттын өзгөрүшү Талас дарыясынын агымына олуттуу таасири бар экенин көрсөттү. Талас дарыясынын алабы климаттын өзгөрүшүнө өтө сезгич болуп чыкты, айрыкча температуранын өсүшүнө. Ал өз учурунда Талас Ала Тоосундагы мөңгүлөрдүн интенсивдүү эришине жана суунун агымынын өсүүсүнө, көлөмүнүн көбөйүүсүнө алып келүүдө. Бул иш Талас дарыясынын бассейнинде акыркы беш-алты жылдан ашуун убактагы климаттын өзгөрүүсүн изилдеп, иликтөөгө олуттуу салым кошо алат деп ишенебиз.

**Негизги сөздөр:** Климаттык өзгөрүү, Mann-Kendall тестти, температура, жаан-чачындар, суу агымы, Талас дарыясы.

**Аннотация:** Гидрологическая система очень чувствительна к изменениям климата. Любое изменение климата находит свое отражение в гидрологическом цикле и наоборот, изменения в количестве осадков влияют на величину и сроки стока и пополнения подземных вод, а также частоту и интенсивность наводнений и засухи. В результате изменения температуры меняется и эвапотранспирация, влажность почвы и условия инфильтрации, что приводит к изменениям в поверхностной влажности и растительности, которые влияют на испарение и образование облаков, а также поверхностного чистого излучения и в завершение цикла - осадков. Основной целью данной работы является оценка текущей ситуации для водных ресурсов и определение гидрологических тенденций в бассейне реки Талас в условиях текущего изменения климата. Используя несколько методов, мы показали, что изменение климата оказывает существенное влияние на сток реки Талас. Бассейн реки Талас очень чувствительна к изменениям климата, особенно к увеличению температуры воздуха, что способствует интенсивному таянию ледников в Таласском Ала Тоо и повышению стока рек. Эта работа может существенно дополнить знания о климатической изменчивости за последние пять, шесть десятилетий в бассейне реки Талас.

**Ключевые слова:** Изменения климата, тест Менн-Кендала, температура, осадки, расход воды, река Талас

**Abstract:** The hydrological system is potentially very sensitive to changes in climate. Any change in climate is reflected in changes in key hydro climatic elements of the hydrological cycle and vice versa: changes in precipitation affect the magnitude and timing of runoff and groundwater recharge, as well as the frequency and intensity of floods and droughts; changes in temperature result in changes in evapotranspiration, soil moisture, and infiltration conditions, with resulting changes in surface wetness, reflectivity, and vegetation that affect evaporation and the formation of clouds, as well as surface net radiation and – completing the cycle – precipitation. The main purpose of this work is evaluation the current situation for the water resources and definition of the hydrological trends in the Talas River Basin in the conditions of the current climate change. Using several methods, we showed that the climate change had a significant impact on the Talas River runoff in Kyrgyzstan. The Talas River Basin is highly sensitive to the climate change, especially to the increasing of air temperature, which promotes the inten-

*sive melting of glaciers in the Talas Ala Too Range and raising the river runoff. In this situation it is necessary to focus for adaption of these resources for sustainable using. This work will significantly add the knowledge on the climatic variability over the past five, six decades and to understanding of the spatial patterns of variations over the Talas River Basin.*

**Key words:** *Climate change, Mann-Kendall test, temperature, precipitation, water flow, Talas River.*

In the context of global climate change, and along with the rapid increase of population and the development of social economy, the water resources that can be used become less and less, especially in the inland region of Central Asian. Investigations of climate change impacts on available water resources are beneficial for improvement of the water resources management. Estimating the possible effect of climate change on hydrological processes and water resources is particularly important for any work connected with sustainable management and long-term planning of water resources (Chen et al., 2007). The main driving factors of river runoff volume changes include climate changes and human intervention (Li et al., 2012). Water resources play an important role in the sustainable development of society and economic growth in arid and semiarid areas, which have a vulnerable eco-environment (Ling et al., 2011). During recent years, the climate change phenomenon is investigating through current hydrological processes and water resources, which are sensitive indicators of the current changes throughout the world (Li et al., 2012; Barnett et al., 2005; Chen et al., 2005). As results of climate change the temperature and precipitation will increase and intensify the snow and glaciers melting, which lead to acceleration of the hydrological cycles. Over the past 50 years there has been increased runoff of river basins around the world, which are hypersensitive to the climate change (Ling et al., 2011; Huntington, 2006). Climate change have especially drastic effects on water resources in the Central Asian region, which requires more detailed study from regional perspectives (Report of EDB and the EC IFAS, 2009).

Basin hydrological cycle depends on complex processes such as physical characteristics of the basin, the impact of climate and anthropogenic factors (Chen et al., 2012). Tien-Shan Mountains – one of the natural environment flow formed elements in Central Asia. Maximum impact on river water content is shown in a warm part of the

year, depending on the quantity glaciations area of the river basin and the intensity of melting. Causes of deglaciation are occurring due to warming of the climate and increased pollution of the glacier surface increases the intensity of the melting (Aizen et al., 1996; Dikih, 2004; Narama et al., 2006). Glacier retreat threatens short-term flooding, and in the long term – a decrease in water availability in Central Asia (Report of EDB and the EC IFAS, 2009; Sejrjing & Giese, 2011). The glacier retreat observed in the Tien Shan is most likely a consequence of the general warming trend (Aizen et al., 2006; Narama et al., 2010). However, the air temperature during melting season (July-August) has increased only slightly over past decades, though it was detected prolongation of melting season for September throughout Central Asia (Aizen et al., 1997). In the past 30 years, the most actively processing of reducing the size of glaciers in the Tien-Shan, which began in the second half of the 19th century. During this time, the thickness of the ice declined. Annual retreat of the lower limits of the glaciers is from 0.3 to 13.1 m (Report of EDB and the EC IFAS, 2009). Over the past 30 years, the river runoff, having snow-ice type of food increased by 6.3%, and in the next 20 years is projected to increase runoff by 10%. According to glaciologists, based on an evaluation of deglaciation in the second half of the XX century, changes in water resources due to climate change would reduce the total runoff by 2100 more than double size.

Kyrgyzstan has the largest amounts of glaciers in the Tien Shan Mountains, which are basic source of fresh water resources in the region and can be called as the “water tower of Central Asia”. The scarcity of freshwater resources is the most urgent current issue of all environmental problems, as most rivers, including those in Central Asia, are key resources for agriculture (Sehring et al., 2011). Climatic change is the reason for real and potential reductions in mountain river runoff in the Kyrgyz Republic. In Kyrgyz Republic, there is some increase in water resources (Aizen & Aizen,

1997; EDB Report and the EC IFAS, 2009). The situation is exacerbated by an increase in water consumption, which is related to population growth and rapid development of the region's economies. Expected reduction of flow in the near future due to climate change makes this problem even more acute (Aizen et al., 2006; Amanaliev, 2008; Kutuzov & Shahgedanova, 2009; EDB Report and the EC IFAS, 2009).

These factors have determined the need for a regional analysis of the current state of water resources to taking into account the ongoing climate change, the development trend of this process, population growth and environmental protection requirements to the water. Our aim here is to determine whether, and to what extent, global warming or other factors have any impact on the surface water runoff of the Talas River. Accordingly, this study focuses on the differential hydrologic response of the Talas River Basin to climate warming within the Kyrgyz Ala Too and Talas Ala Too mountains of Tien Shan.

The initial data for this work were used for perennial series of observations and the results of studies conducted to date on climate change and water resources in the region. Certain difficulty in analyzing the data was the fact that the individual climatic characteristics in the archive data were not available for all regions of the observation stations. To relieve the supply and demand of water resources, the public responses are focus on the water resources increasingly. Therefore, based on the Mann-Kendall non-parametric test and correlation analysis, this study investigated the temporal and spatial changes of temperature and precipitation for last five-six decades, and analyzed the impact of climate change (e.g. air temperature and precipitation) on the dynamics of the water flow variations for last several decades in the Talas River Basin, Kyrgyz Republic. The detailed results of this study are as follows:

Constructing the database of meteorological and hydrological time series for last five-six decades, and analyzing the features and trends of annual average precipitation and temperature changes in the Talas River Basin. Our results showed that the air temperature in the Talas River Basin has increased for all seasons, especially in winter time, with average growing of 1.8°C during entire observed period. The amounts of precipitation fluctuated differently over season:

changed insignificantly in autumn and spring time, but had abrupt increasing during the winter and significant decreasing during the summer time. Furthermore, upper reaches of the Talas River had insignificant changes of the precipitation amounts, while lower reaches demonstrated the slight decreasing of its amounts.

The runoff in the Talas River exhibited an upward tendency over the past several decades, and the recharge proportions from precipitation and glaciers are different in different rivers. The runoff in the northern slope of the Talas Ala Too Mountains, with the recharge proportions from glaciers, are increased significantly; while as the runoff in the southern slope of the Kyrgyz Ala Too Mountains, with the recharge proportions from precipitation, which has insignificant increasing trend.

In addition, we analyzed the relationship between climate change and hydrological processes of the Talas River Basin, and concluded that the runoff of the Talas River Basin is highly sensitive to the climate changes. The rivers, which are located on the northern slope of the Talas Ala Too Mountains and with the recharge proportions from glaciers have increasing trends with rising of air temperature. In contrast the rivers, which are located on the southern slope of Kyrgyz Ala Too of this basin and with the recharge proportions from precipitation, have repeated trends of precipitation and increased their runoff volume with rising of precipitation amounts.

Investigations of water resources in major rivers of Kyrgyz Republic have showed some changes. The main input data for modeling flow hydrograph are daily precipitation and mean daily air temperature at the meteorological stations located in the basin. The calculated results of previous work showed, that they expect significant reduction in runoff for all most probable scenarios.

The main purpose of this work was evaluation of current water resources conditions and their changes in the background of climate change and determining of this process trends. Presented thesis will help to determine the current climate change and its impacts on the water resources in the region and it will be the fundamental instrument for the sustainable management of water resources in the Talas River Basin in Kyrgyz Republic and entire Central Asia.