Evaluation of adaptation solutions to climate change and ocean pattern (Study area: Gavkhoni watershed)

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Abstract

This study analyzed the effect of climate change and the Anso phenomenon on the water resources of Gavakhuni catchment area. CESM2 and IPSL-CM6A-LR climate simulation models were used to simulate climate change and El Nino and La Nino phenomena as two oceanic phenomena. The results of the climate simulation for the period 2020 to 2040 showed that the average precipitation in the whole area has decreased by 14 mm and the average temperature has increased by 0.94. Examining the future conditions of the basin in terms of development indicates a deficit of 411 MCM of underground water resources, which will increase to 431 MCM in the conditions of climate change. The simulation results in the Enso phenomenon also showed that the situation of water resources has improved in the El Nino event and the deficit reaches 311 MCM and in the La Niño event it reaches 481 MCM. The impact of El Niño as an oceanic phenomenon was evaluated positively and La Niño and climate change scenarios were evaluated negatively. The uncertainty of the deficit of underground water resources was simulated in two ocean phenomena with a volume of 163 million cubic meters per year and 14 MCM in three climate change scenarios. 4 solutions of water transfer (S1), reduction of exploitation of underground water resources (S2), increase of water productivity in the agricultural sector (S3) and increase of agricultural efficiency (S4) were evaluated in these conditions. The results showed that although the transfer of water and reduction of exploitation can have a great impact on the balance of underground water resources, according to the environmental, economic and social considerations, it is possible to obtain good results from the solutions to increase productivity and efficiency.

Key words: Gavkhoni watershed, uncertainty, increasing water productivity, efficiency

1- Introduction

One of the most challenging areas in terms of supplying and allocating water resources is the Gavkhoni watershed in the central part of the country. This basin has always faced socio-economic tensions with special conditions in terms of agriculture and industry and water transfer plans, which management requires a proper understanding of the amount of available water resources. Considering the sensitivity and vulnerability of water resources under climatic stresses, including climate change and oceanic phenomena, this study aims to know the degree of impact and also develop a dynamic framework to identify the vulnerable dimensions and then provide adaptation solutions in the supply and demand system of water resources. This area with a high volume of traditional agriculture and irrigation networks is located next to industrial development in Isfahan city and its surroundings. Therefore, planning the allocation of water resources should be done in such a way as to create the least amount of conflicts. One of the aspects of the disruption of the allocation system is the lack of proper balance of precipitation in terms of time and place, which can change under the influence of climate change and oceanic phenomena. Therefore, identifying this issue and formulating a solution can play an important role in reducing regional tensions.

2- Methodology

Considering the effect of large-scale patterns, oceanic phenomena and climate change in the change of hydrological behavior, the evaluation and formulation of adaptation strategies are presented according to Figure (1).

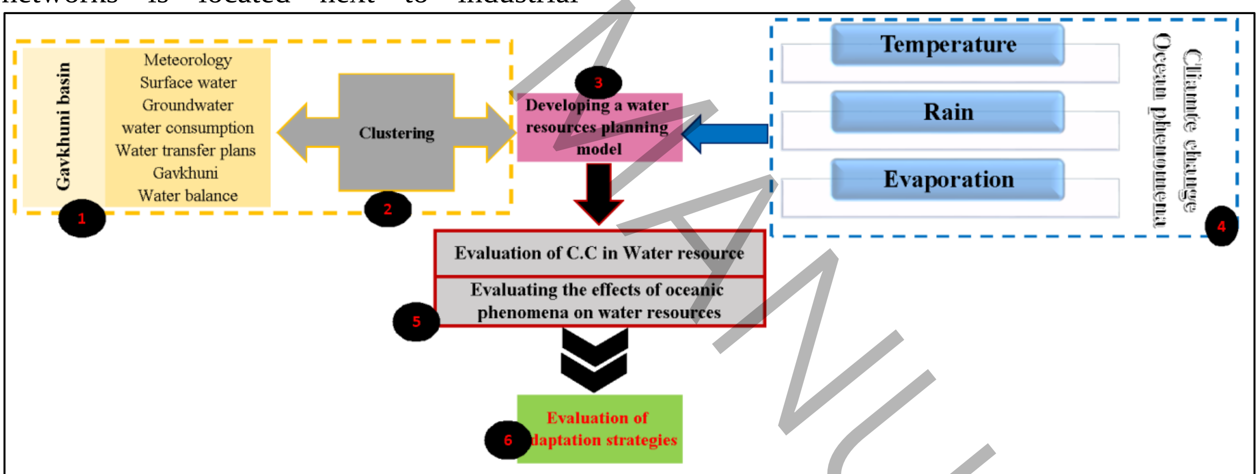

Figure 1. Flowchart of this research

Gavkhoni watershed is one of the most important 2nd grade watersheds in the country with an area of 41,550 square kilometers and consists of two different climatic regions. Its western part is mountainous with high altitude and colder climate, and in the eastern and southeastern part with lower altitude and less rainfall, it has warmer climate. The main and important river of this area is the Zayandeh Rood River, whose main branch flows from the heights of Kohrang Sarchesmeh and flows from west to east in this basin. According to the situation of Gavkhoni catchment basin, the clustering of the basin is done in 4 regions. The first cluster is selected upstream of Zayandehroud Dam, where 6 study areas are located. This cluster has special climatic conditions compared to other parts of Gavakhuni basin and in addition to high average rainfall, it has significant surface flow and transitional flows of the basin. The second cluster is located downstream of Zayandehroud dam and the middle part of the watershed. This cluster has been affected by the inflow and transfer flow from the dam to other parts of the basin, and during the last 2 decades, the volume of underground water resource exploitation has also increased in this cluster. The third cluster is related to the last part of the basin before the lagoon, which is rich in terms of politics and industry. Most of the transmission current enters this range. The fourth cluster is the southern part of the Gaukhoni lagoon, where the flows of the 5 study areas finally enter the lagoon. Based on the clustering of the Gaukhoni watershed, the water resource balance model was designed using a coded model. Evaluation and simulation of climate change in each of the 4 considered clusters, a base station with a suitable statistical period length was selected. Delta transform factor (DCF) method was used for exponential scaling.

3- Results and Discussion

By simulating the climate of IPSL-CM6A-LR and CESM2 models and evaluating the validity of these two models, the effects of climate change were simulated. Also, the effects of two phenomena, La Niño and El Niño, were also analyzed in this case[1]. Therefore, the results obtained in the conditions of climate change and the Anso phenomenon showed that the pressure of exploiting water resources is focused on underground water resources. The biggest deficit of underground water resources is in two clusters Z2 and Z3 due to the high volume of exploitation and the area under cultivation. The analyzed results show that the El Nino phenomenon plays an important role in increasing the amount of precipitation and consequently the surface flows inside the basin and reduces the exploitation of underground water resources. This has caused the deficit of underground water resources to decrease by more than 50% in the two clusters Z1 and Z4 and a tangible decrease in the two clusters Z2 and Z3. On the other hand, the transfer flows to the basin have also had a great impact in reducing water stress and the difference between water supply and demand, which can be reduced by increasing the volume of transfer water. Therefore, in order to adapt to the future conditions, 5 solutions are briefly analyzed. The purpose of evaluating these solutions is to reduce the pressure on underground water resources and the deficit of water resources.

4- Conclusions

The climate simulation results showed that the average precipitation changes in three emission scenarios in 4 clustering regions decreased by 18, 11.6, 13, and 13.3 mm, respectively, and the temperature increased by 0.83, 0.95, 0.97, and 03, respectively. It has been 1/1 degree Celsius. In the conditions of the El Nino event, due to the increase in rainfall in the entire catchment area, the deficit of groundwater resources will reach 311 MCM. The deficit of groundwater resources in the three climate change scenarios will change between 417 and 431 MCM in optimistic to pessimistic mode. Four solutions for transferring water from Beheshtabad and No. Kohrang tunnels (S1), reducing the use of underground water resources (S2), increasing water productivity in the agricultural sector (S3) and increasing agricultural efficiency (S4) were evaluated. The results obtained in this section, without considering the environmental effects, showed that each of these solutions was effective in increasing the volume of aquifers and considering the possible limitations of increasing water efficiency and productivity, it will have slightly more suitable results. The results showed that a 17% reduction in pessimistic conditions and an 11% reduction in optimistic conditions in the agricultural sector will be able to compensate for the deficit of underground water resources. Also, with a 1% increase in water productivity at the level of a volume area of more than 99 MCM and with a 2.5% increase in water productivity of a volume of more than 240 MCM, there will be a reduction in the use of water resources. Also, with the increase in the efficiency of the agricultural sector, the volume of 175 MCM will decrease the exploitation at the level of the catchment area. On the other hand, it is important that the uncertainty of the obtained results due to the nature of the data used in the water resource balance and the uncertainty of the climate change models and emission scenarios can be important in the decision-making results. Examining the uncertainty of the obtained results as interpreted in the analysis of climate conditions under different scenarios can include a range of the balance situation, which uncertainty is less in climate change scenarios than in oceanic phenomena.

5- Refrences

[1] L. Goddard, A. Gershunov, Impact of El Niño on weather and climate extremes, El Niño Southern Oscillation in a changing climate, (2020) 361-375.