University of Tabriz

Journal of Civil and Environmental Engineering
Volume 53 (2023), Issue 2 (Summer), 17-30

EXTENDED ABSTRACT

Country's Catchment Water Stress Management by Large Industries Proper Locating Considering Climate Change

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Received: 23 November 2021**; Review:** 03 December 2021**; Accepted:** 14 December 2021

Keywords:
Budyko-type, Climate change, Renewable water, Sustainable development, Water-Industry Nexus.

1. Introduction

The Earth's climate has been changing since began drastically. Global warming and change in precipitation pattern are consequence of climate change. Climate change and over-withdrawal of water for industrial purposes has increase water stresses around the world. Long-term water stresses may cause disasters. Hence it is necessary to control water stress. This paper proposes a model to manage water stress of different catchments by proper locating of large industries considering climate change.

2. Methodology

In this paper, a model for managing water stresses of different catchments by locating large industries considering climate change is presented. SDG 6.4.2 water stress index (Dickens et al., 2019), is modified based on industries development and employed for measuring water stresses of catchments. Water resources availability that is directly affected by climate change is included in this index by predicting the volume of renewable water resources in different climate change scenarios. In order to model the long-term impact of climate change on renewable water resources availability climate change scenarios B1, A1B and A2 that are defined by the IPCC are considered (IPCC, 2000). To downscale the climate change scenarios, country is divided into selected points with a spatial step of 0.5 degrees. Then, Meteonorm7 is used to extract precipitation height and average, maximum and minimum monthly temperature for the points in each climate change scenario. The amount of actual evaporation of precipitation is calculated using the one-parameter Budyko-type approach known as "fu equation" (Jiang et al., 2015). The development of large industries in the country is modeled through a long-term multi-objective planning problem. In this problem production capacity of each industry and its location in the country are determined by minimizing catchments' water stress indices and transportation costs of raw materials and products considering climate change. The procedure of the proposed model for managing water stress indices is shown in Fig. 1.

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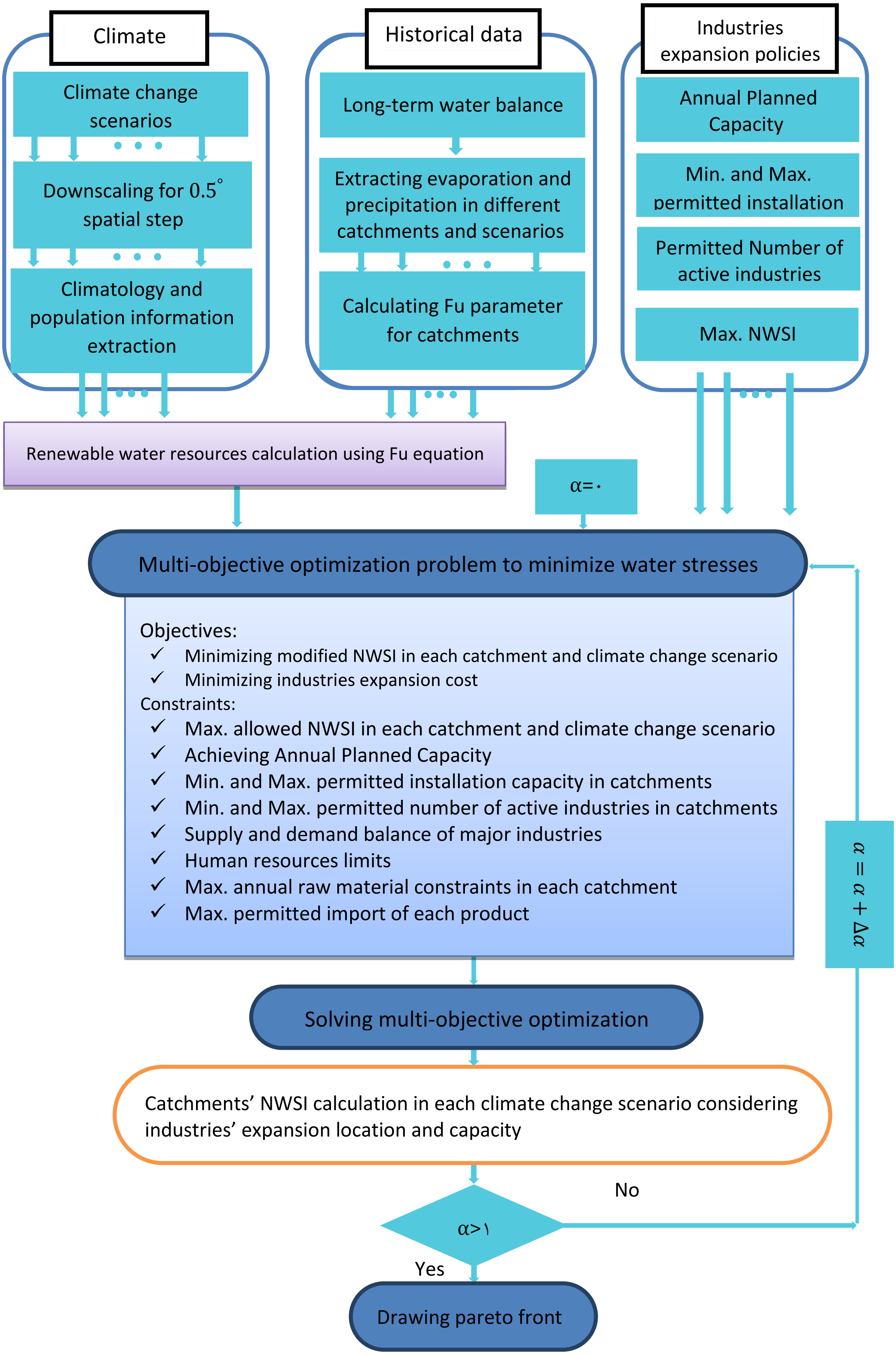

Fig. 1. Purposed approach overview

3. Results and discussion

The proposed model is implemented on Iran to manage water stress of the six main catchments by locating of the steel, cement, sugar, paper and refinery industries as the significant water consuming industries for 2030. The proposed model is simulated in the GAMS in conjunction with MATLAB.

Simulation results show although industry sector development increases water withdrawal, water stress indices can be reduced by optimal sizing and locating of large industries. Simulation results also show that if planners focus on cost minimization, the average water stress index of the country over different scenarios and different catchments will be equal to 0.8840 in 2030. In this case, total annual transportation cost will be at its minimum possible amount that is M$38.627. If planners focus on minimizing catchments' water stress indices, the average water stress index of country in 2030 reduces to 0.7692. In this case, total transportation cost will be M$58.138. Therefore, by shifting the focus from cost minimization to water stress minimization, the average water stress index decreases by 12.98%. This reduction increases transfer costs by 50.22%. The calculated water stress index under different assumptions for the climate change scenario B1 in 2030 shows that the water stress status of catchment No.6 is improve from "Extremely Overexploited" to "Heavily Overexploited" by focusing on water stress reduction while other catchment's status have no changes. The ability to compromise between water stresses and transportation cost is provided for planners by drawing the pareto-front of objectives. The objectives' paerto-front shows that the planner can reduce the average water stress index by 12.06% of by tolerating only 8.62% increase in transporting costs.

4. Conclusions

In this article, the water stresses of the country's main catchments are managed by proper sizing and locating large industries considering climate change. The proposed model, which is robust to climate change scenarios, is defined in form of long-term multi-objective optimization problem. The objectives are to minimize water stress indices as well as raw material and products transportation costs. The water stress indices are limited to ensure sustainability of water resources. The supply and demand balance of industrial products is modeled for each catchment considering inter and intra catchment product transportations and product import. The amounts of imported products are limited based on the planner's policy. Industries and population decentralization are modeled by considering constraints for minimum and maximum production capacity and number of active industries in each catchment.

The main finding of this paper is optimal sizing and locating of large industries despite of increase in water withdrawal due to development of industries can reduce water stress indices. The proposed model provides the planner the ability to make a trade-off between water stresses and transportation cost. Comparing the following two sentences highlights the importance of this trade-off. Minimization of water stresses reduces the average water stress index by 12.98% and increases total transportation cost by 50.22%. However, compromising between water stresses and costs reduces the average water stress index by 12.06% and increases total transportation cost only by 8.62%.

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