Original Article: Challenges and Opportunities of Using Models for Optimal Use of Water Resources Systems

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ABSTRACT

In many large cities, the rapid pace of increasing water needs from the total resources available in the area in the one hand and the mismatch of peak supply with peak consumption on the other hand, has doubled the need for more accurate planning to meet needs and consumption management. These challenges, along with the occurrence of periods of dehydration and wetting, as well as crises caused by the failure of the supply system, transmission or distribution and widespread pollution in the system, have increased the need to develop specific policies for monitoring and operation of the system. To achieve the above goal, it is necessary to increase the readiness of the system to deal with critical situations. The multiplicity of effective and influential components of water resources systems and the uncertainties we encounter in the modeling of these systems determine the need to further develop the necessary tools to assist in the decision-making process. We here deal with the framework of sustainability in water resources management. One of the most important challenges in this framework is to pay attention to uncertainties and the ability to quantify and model them. Among the main causes of uncertainty in water resources are the uncertainties of physical, hydrological, water needs, quantitative and qualitative interactions in the flow of water, hypotheses in estimating parameters and calculations, and uncertainties in forecasts.

Introduction

In addition to the limited volume of available resources, the lack of homogeneous temporal and spatial distribution of available resources is another problem that intensifies the range of problems [1-3]. Transfer of water from one basin to another to establish this balance and homogeneous distribution can be one of the most important and effective ways to meet water needs in these areas [4]. The implementation of such projects should be considered with regard to side effects such as reducing unemployment, improving cropping patterns, feeding groundwater resources, creating ecological sustainability and increasing the sustainability of the study areas [5]. The inter-sectoral water transfer plan should be evaluated in the context of national interests and comprehensive regional studies. If the transfer of water does not harm the social and environmental issues of the region of origin, it can change the social situation of another region and cause economic opening in that

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region. In the first stage, the decision to transfer water, simulation and modeling of the system to determine the appropriate options are discussed. In the next step, to compare different options, multi-criteria decision-making methods with a dispute resolution approach are used. In most cases, the final choice of the appropriate option depends on the financial feasibility, institutional and organizational frameworks and the results of environmental and social impact studies of an area. The position of bargaining models, based on the theory of shortening, is a strong foundation and can be used in systemic confrontations in the face of regional and national conflicts. Water needs and allocations may change over time in response to other system changes [6-8]. A change in one part of the system can cause unwanted changes in other parts of the system. In order to examine the future needs of a region and its associated forecasts, the dynamics of a system or region must be examined. The advantage of using the system dynamics approach in decision making is considering its asymptotes and examining the expected changes [9-10].

This partnership can be considered mainly in the two areas of investing in water resources development projects and influencing policies, which is an important issue that is beyond the scope of this article [11-13].

The main reasons for water stress can include: a) limitation of available water resources and heterogeneous distribution of resources, b) increasing population, c) increasing the vulnerability of different water supply systems due to their complexity, d) increasing the per capita water consumption due to increasing the level of welfare and health of the people, e) increasing the need in different industrial and agricultural sectors according to the development process of these sectors, f) climate change and the need for long-term forecasts, g) pollution of water resources, and h) destruction of resources, especially groundwater due to over-harvesting and lack of management.

Due to sufficient and suitable water resources, the growth index of the origin region has a significant advantage over the destination region in the current situation. After the implementation of the transfer plan, the acceleration (slope) of the growth index of the origin region towards its asymptote may decrease slightly [14-16]. That is if the sale of water does not cause the asymptotic growth to move to a higher level and if this economic opening of water sales is done significantly, then the potential for economic and social growth and development of the region of origin will increase. In the destination region, not only is the trend of increasing the growth index accelerating, but its asymptotes are also moving towards higher thresholds than the initial scale. The result is that from a trans-regional perspective, the differences in the growth indicators of both regions during the operation of the project are reduced and generally lead to an increase in the general (national) growth index. The dynamics of the system, which identifies the asymptotes of regional growth, can be studied in the form of object-oriented modeling, which is one of the new and emerging technologies in the field of planning and management of water resources [17-19]. This type of modeling is able to simulate the physical processes governing a system using predetermined components and elements. In recent studies, this tool has been used to investigate the ability of Karkheh system to supply water in development conditions [20].

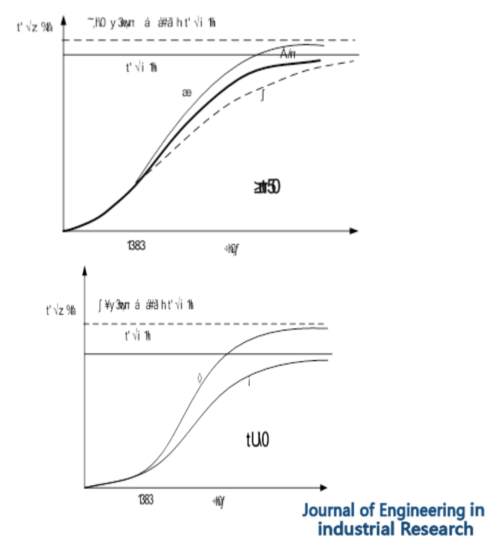

Figure 1. Asymptotes and changes in the growth index of origin and destination areas, before and after the water transfer plan

Lack of Integrated Use of Surface and Groundwater Resources

This is especially important in the case of groundwater resources. If groundwater resources are over-exploited, it will lead to the destruction of these resources and groundwater depletion. In many irrigation systems, groundwater is not used alone and may be available as a supplement to surface water (Figure 2) [21].

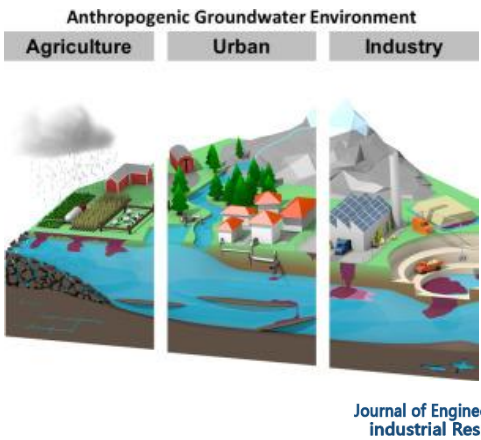

Figure 2. A review of threats to groundwater quality

Therefore, integrated exploitation is one of the managerial analyses in the exploitation of water resources. Also, the lack of proper management of effluents and effluents has caused water resources to be more susceptible to pollution than their self-purification capacity, and as a result, they lose their potential for various uses and become practically unusable. Of course, in the traditional view, less attention has been paid to the interaction of different components of the hydrological cycle in the formulation of integrated exploitation policies [22]. However, recent studies in the case study of River Aquifer have shown that surface and groundwater resources are interacting with each other quantitatively and qualitatively and dealing with them independently in formulating exploitation policies will reduce the comprehensiveness and accuracy of the results, recognize and quantify uncertainties and facilitate dealing with them. For example, studies show that climatic factors such as rainfall, humidity, temperature, wind speed, sunshine hours and the amount of pure radiation have a significant effect on the amount of pure water requirement of different plants, leads to changes in water needs of plants and plants (Figure 3).

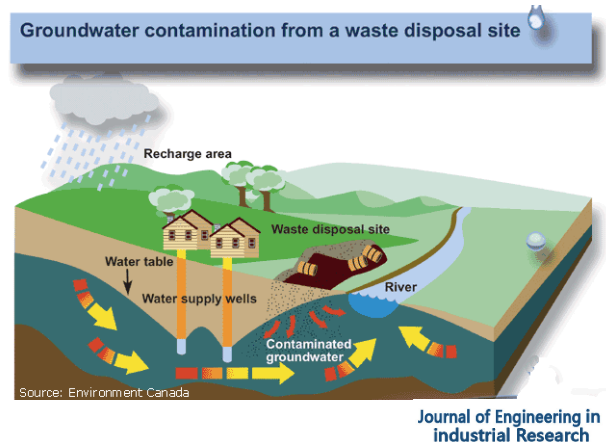

Figure 3. Groundwater can be contaminated from a waste disposal site

Most of the existing exploitation models do not take into account the uncertainty in the need, while according to the studies, the change in need is significant and considering the considerable volume of agricultural needs, considering changes in water needs can have a significant impact on the efficiency of exploitation policies [23-25].

The development of flexible methods has greatly improved how to deal with ambiguities. Flexibility is the mechanism that makes it possible to study the state of water resources in various normal and emergency situations, taking into account uncertainties, in real time. Flexibility tools include artificial information fabrication models such as ARIMA, Bayesian decision theory (BSDP) reservoir utilization models, the use of large-scale climatic signals in long-term precipitation and runoff forecasting, and the use of set theory. Models for the optimal use of water resources are widely used. Understanding the dynamics and asymptotes of system growth in System Dynamics facilitates the understanding of system complexities and is used to analyze the behavior of system components. The ability of this science is such that it can be used to model simple and complex problems and study the changes resulting from the interaction of variables and identify their future behavior in different time periods. One of the important points in analyzing the dynamics of the system is to identify the growth asymptotes in that system or region. Asymptotes of system growth set thresholds for changes in system coordinates, or in other words, system development constraints. System coordinates never go beyond growth asymptotes unless they can be somehow increased by providing more resources and facilities outside the system or region (Figure 4).

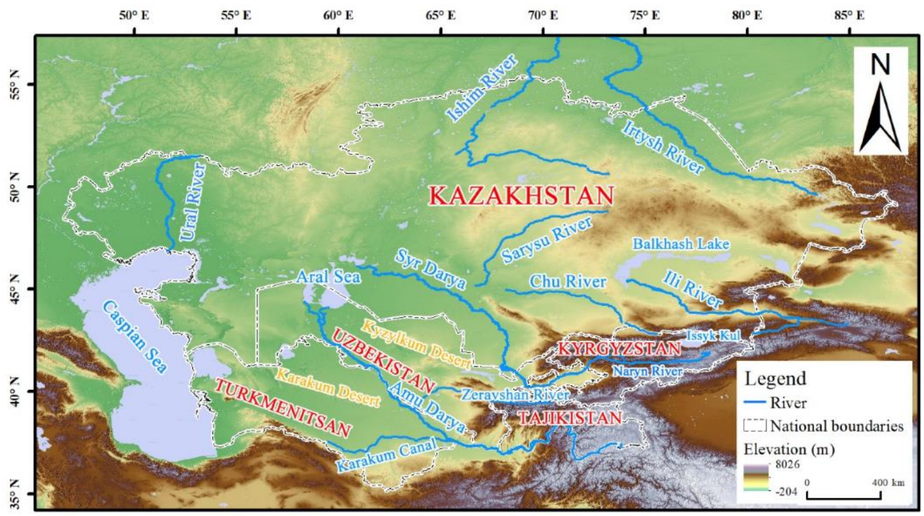

Figure 4. Water | Free Full-Text | Sustainable Use of Groundwater Resources in the Transboundar

Today, with the expansion of human knowledge in relation to the factors that determine the limitations of the system, the use of new simulation models and consideration of policies such as reallocation of resources and reuse of water and the use of management policies to reduce demand and transfer of resources, the possibility of asymptotes are provided. Object-oriented simulation models are one of the latest achievements in the development of simulation models that have the ability to model system dynamics and different system growth curves. This method allows a more realistic simulation of the system by considering the physical conditions of its various components, and thus opens a new window in the optimization of water resources. The graphical capabilities of object-oriented models allow decision makers to present the results of different options in water resource development development plans much more effectively [26].

Comprehensive Management of Water Resources

The purpose of comprehensive water resources management is to create a system that, while linking water resources management with the environment and social and economic development, benefits from their reflection and feedback, and finally, with the participation of different departments, water resources allocation and development decisions are made. An important point that should be considered in comprehensive studies of water resources management is to recognize the components and their uncertainties, to determine and clarify the relationships between components and direct and indirect effects between components to solve a problem and plan a component. Direct effects can be measured. Comprehensive management of water resources is a combination of different strategies and policies such as water storage, aquifer nutrition, water transfer, water saving, pressure and leakage management in water distribution networks, increasing water supply by considering hydrological, hydraulic and hydraulic uncertainties. Also, the desirability of different stakeholders to achieve a stable level of supply and demand is considered. This is where the role of optimal exploitation models in the comprehensive management of water resources becomes clear. After identifying all components and their relationships and considering the direct and indirect effects of different modes of water resources system management, optimal utilization models are developed according to the goal or objectives in the comprehensive management of water resources and decision makers in the selection. Top options help [27-35].

Conclusion

One of the most important and cheapest sources of water supply is groundwater, which has always been disputed among users at the local, regional, national and international levels. Disputes between aquatic operators arise due to the mismatch of geographical boundaries and aquifer area, the extent of a natural aquifer and the number of operators and influencers on it, the impact of various quantitative-qualitative factors such as precipitation, pumping, landfilling of pollutants the use of chemical pesticides, municipal and industrial wastewater. Due to the scarcity of water resources, the methods to improve the efficiency and optimization of operations for the operation, distribution and transfer of groundwater resources have long been considered by researchers. Much research has been done on optimizing groundwater exploitation and allocation. The important point in all previous researches is that each of the perspectives related to the specific operator has looked at the issue of operation of the aqueducts and the optimization has been done only to satisfy the goals of one operator from the total number of operators. In practical terms, however, the rules for the operation of aqueducts should be determined in such a way that, while taking into account the natural considerations of the aqueducts and the limitations governing them, the rules of operation should be regulated in such a way as to resolve the disputes.

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