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O 44. APPLICATION OF MULTI-CRITERIA DECISION-MAKING METHODS IN SUSTAINABLE WATER RESOURCES MANAGEMENT: KONYA CASE

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ABSTRACT: The water problem in the world has become an important issue for all countries. The decreasing amount of water we can leave to future generations has led many researchers around the world to take precautions and conduct studies before this situation becomes irreversible. Our country was a country that did not experience water shortage in the past years, but due to the increase in population and unconscious water use over the years, it is now among the countries suffering from water scarcity. This study aims to predict different scenarios that may arise in the future by determining the effects of water consumption and the status of existing resources after conducting research on the use of water resources of Konya Province. Another goal of this study is offering suggestions for sustainable management of Konya's water resources by using multi-criteria decision-making method or methods.

Keywords: Decision-Making Methods, Water Management, Sustainability, Water Policy, Konya

1. INTRODUCTION

Water scarcity is a growing global issue that is caused by factors including population growth, climate change, and unsuccessful water management practices (UN-Water, 2021). Access to safe and dependable water sources is critical to the sustainability of public health, agriculture, industry, and ecosystems (WHO, 2019). Water loss is one of the main issues to access clean water. The magnitude of losses can be influenced by critical factors such as network connectivity, network age, and the size and configuration of the water distribution system (Ociepa et al, 2019). This phenomenon, known as Non-Revenue Water (NRW), poses a significant challenge to the sustainability of water resources and necessitates comprehensive management strategies. NRW includes both financial losses brought on by inaccurate metering and unaccounted-for usage, as well as physical losses brought on by leaking pipes, infrastructure breakdowns, and unauthorized water use (Farley and Trow, 2005). NRW poses threats to water quality, system resilience, and the equitable distribution of water services, in addition to the financial effects of lost income and the environmental effects of resource waste (Mollinga, 2010). The Analytic Hierarchy Process (AHP) is a potential tool for prioritizing and optimizing water loss management strategies while tackling NRW. By using the AHP, managers of water utilities and decision-makers can systematically evaluate the essential components of their water distribution systems, give each component a relative weight based on its significance, and rank mitigation strategies in order of relevance. By lowering water waste, energy use, and environmental consequences, such a strategy not only improves resource allocation efficiency but also helps achieve sustainability and resilience goals. Therefore, this study, which is based on an inquiry of the use of water resources in Konya Province, aims to estimate various future scenarios by evaluating the effects of water use and the state of the available resources now. Additionally, the study intends to make suggestions using AHP for the sustainable management of Konya's water resources.

2. MATERIAL AND METHOD

2.1. Study area

The city of Konya, is the largest province of Turkey with a surface area of 41,001 km^2, is located in Turkey with coordinates ranging from approximately 36.70˚ to 39.25˚ N latitude and 31.25˚ to 34.43˚ E longitude and its elevation is approximately 1,006 meters. The centrum of Konya is consisted of three urban districts of Meram, Selçuklu and Karatay and the papulation is approximately 1,390,000. Konya is listed as a second-grade drought region in Turkey, and annual precipitation varies seasonally (Asaad

et al. 2022). Groundwater, which was supplied from many groundwater wells, was the main drinking water source of Konya (Nas and Berktay, 2006).

2.2. Analytic hierarchy process (AHP)

Saaty created the analytic hierarchy process (AHP) multi-criteria decision-making technique in order to evaluate and select options within the chosen criterion group in 1990 (Eryürük et al. 2022). Utilizing AHP has as its goal the systematic organization of both tangible and intangible aspects as well as the provision of an organized, straightforward approach to problem-solving (Eryürük et al. 2022).

The AHP-based method intends to provide stakeholders with a support system for the selection of alternatives within the parameters of established criteria and sub-criteria, primarily for the purpose of evaluating quality (Eryürük et al. 2022). The next stage in creating a hierarchical table related to the decision-making problem is to decide how much weight to give to each criterion that has the same level of significance in relation to the others (Thanki et al. 2016). This stage uses Saaty's preference scale, which he graded from 1 to 9, for the portion of weighting in comparison with each other as shown in Table 1 (Saaty, 1987). Through applications in several sectors and theoretical comparisons with other scales, the effectiveness of this scale was determined (Uzun and Kazan, 2016).

Table 2. Pairwise comparison by means of Saaty's 1–9 scale

Weight intensity	Definition	Explanation
1	Equally important	Two activities contribute equally to the objective
3	Moderately important	Experience and judgment slightly favour one over another
5	Strongly important	Experience and judgment strongly favour one over another
7	Very strongly important	An activity is strongly favoured and its dominance is demonstrated in practice
9	Extremely important	The importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate weights	Used to represent compromise between the priorities listed above

By assessing the consequences of water usage and the current state of the available resources, this study aims to anticipate potential future scenarios for the use of water resources in Konya Province using AHP. The suggested structure for managing water loss, which is shown in Figure 1, is organized hierarchically.

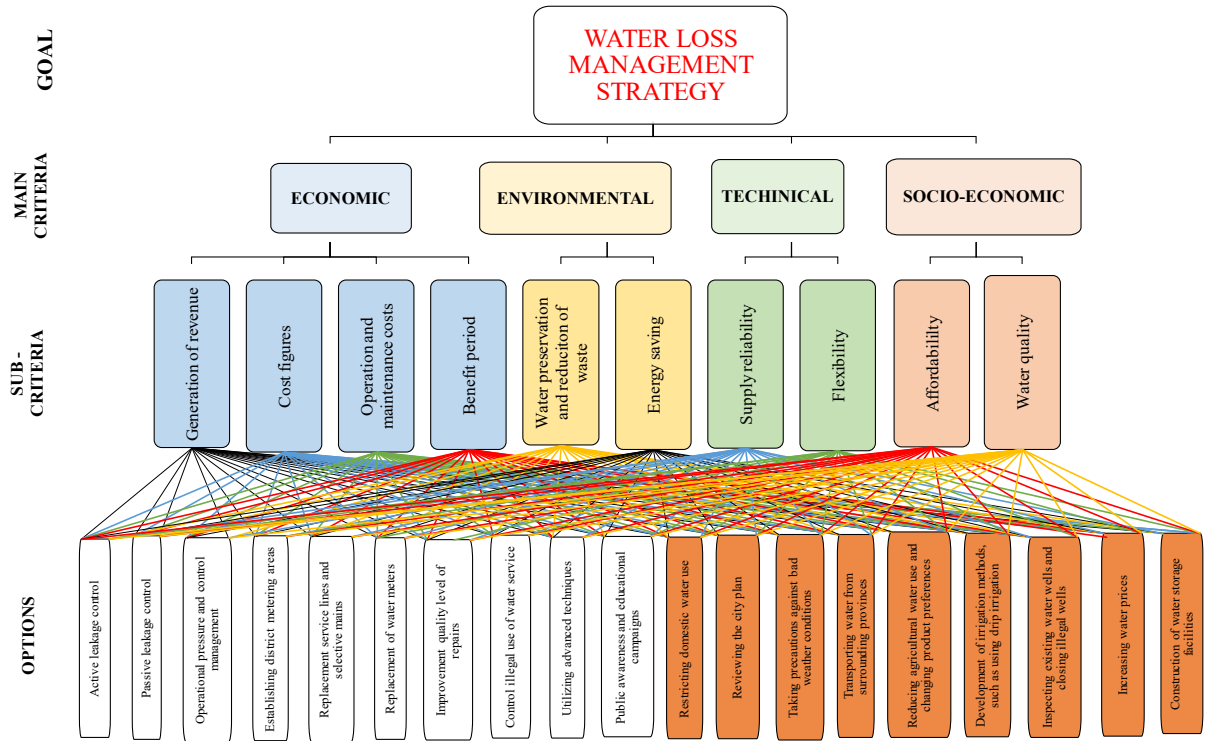

Figure 1. Proposed framework's hierarchical structure for managing water loss (derived from Zyoud et al. 2016)

The objective is the ultimate goal that stakeholders want to achieve, while the options are the alternative courses of action or solutions under consideration. In the case of this study, the problem definition is "Optimizing Sustainable Water Resources Management in the Konya Region."

Main criteria are the high-level categories or dimensions that contribute to achieve the objective. In water resources management study, main criteria could include economic criterion which could be able to evaluate the cost-effectiveness and economic sustainability of proposed solutions. Environment criterion explains the assessing the ecological consequences of water resource management strategies. Socio-economic criterion is considering the level of community support and acceptance. The technical criterion plays a crucial role in delineating the supply reliability and flexibility aspects.

Sub-criteria break down each main criterion into more specific factors that contribute to the overall assessment. Economics main criterion has four sub-criteria representing the economical aspect of the problem in detail. The main criterion as environment aspect consists of two sub-criteria that elaborate on the detailed aspects of the environmental issue. Technical main criterion includes two sub-criteria that provide detailed insights into the technical aspects of the problem. The socio-economic main criterion encompasses two sub-criteria that offer comprehensive insights into the socio-economical facets of the issue.

The objective and options refer to the decision-making context to see overall structure of the mentioned problem. The options could be different water management strategies or projects that can be implemented, such as watershed protection, water recycling, or the construction of new reservoirs.

In the AHP process, decision-makers assign numerical values called pairwise comparisons to evaluate the relative importance of criteria and sub-criteria. These comparisons help quantify the subjective judgments of decision-makers. Through a series of calculations, AHP provides a systematic way to derive priorities and make informed decisions based on a comprehensive analysis of multiple criteria and alternatives.

3. RESEARCH FINDINGS

This research addresses the pressing issue of sustainable water management in the Konya region, where water scarcity and increasing demand pose significant challenges. Key problems include over-extraction from aquifers, inefficient irrigation practices, and the need for a comprehensive water management strategy.

Research findings indicate variations in water availability throughout the year, with implications for agricultural and domestic water needs. It is clear that sub-criteria might need to include seasonal variations, groundwater levels, and surface water availability. The efficiency of irrigation systems could be identified as a critical criterion, affecting agricultural productivity and water conservation. Some related options should be involved as the adoption of modern irrigation technologies and the assessment of irrigation infrastructure. The research reveals potential ecological consequences of water management practices, emphasizing the importance of maintaining a balance. The recheck might be necessary for sub-criteria to include the impact on local flora and fauna, wetland preservation, and biodiversity.

It is necessary to suggest that involving local communities in water management decisions is essential for long-term sustainability. As addition to that, one or more sub-criteria shall encompass community awareness, participation in conservation efforts, and education programs.

4. CONCLUSIONS AND DISCUSSION

According to this study, there is a necessity to identify decision makers to find out proper options to solve sustainable water resources management problem in Konya. Considering that point, at the beginning of the defining process of decision makers, government bodies at various levels should be identified as key decision makers which are responsible for policy formulation and regulation enforcement. Sub-decision makers may include municipal authorities, provincial water boards, and environmental agencies.

As an addition, local farmers and agricultural associations play a crucial role in decision-making, particularly regarding irrigation practices and water use in agriculture. For that decision maker level, it might be vital to include individual farmers, cooperatives, and agricultural extension services. Furthermore, non-governmental organizations dedicated to environmental conservation and sustainable development are found to be influential decision-makers in advocating for responsible water management practices, contributing valuable perspectives and initiatives to enhance the overall effectiveness of decision-making processes in this domain. Finally, academic and research institutions contribute to decision-making by providing scientific insights, data analysis, and innovative solutions for sustainable water management. Decision makers from that class could include water research centers, universities, and environmental research organizations.

These research findings lay the foundation for the subsequent development of an Analytical Hierarchy Process (AHP) diagram, where the identified criteria and decision makers are systematically evaluated and prioritized to guide sustainable water management decisions in Konya.

REFERENCES

Asaad, M. N., Eryürük, Ş, Eryürük, K., 2022, Forecasting of Streamflow and Comparison of Artificial Intelligence Methods: A Case Study for Meram Stream in Konya, Turkey. *Sustainability*, 14(10), 6319. https://doi.org/10.3390/su14106319.

Eryürük, Ş., Kürüm Varolgüneş, F., and Varolgüneş, S., (2022), Assessment of stakeholder satisfaction as additive to improve building design quality: AHP-based approach, *Journal of Housing and the Built Environment*, 37, 505-528. https://doi.org/10.1007/s10901-021-09855-8.

Farley, M., and Trow, S., 2005, Water Loss Control in Urban Water Distribution Systems: A Practitioners' Guide to Assessment, Monitoring and Control. IWA Publishing.

Mollinga, P. P., 2010, Boundary Work and the Complexity of Natural Resources Management, *Crop Science*, 50(S1), 1-9.

Nas, B. and Berktay, A., 2006, Groundwater contamination by nitrates in the city of Konya, (Turkey): A GIS perspective, *Journal of Environmental Management*, 79, 30-37.

Ociepa, E., Mrowiec, M., Deska, I., 2019, Analysis of Water Losses and Assessment of Initiatives Aimed at Their Reduction in Selected Water Supply Systems, *Water*, 11(5), 1037. https://doi.org/10.3390/w11051037.

Saaty, R. W. (1987), The analytic hierarchy process—what it is and how it is used, *Mathematical modelling*, 9(3-5), 161-176.

Thanki, S., Govindan, K., and Thakkar, J., (2016), An investigation on lean-green implementation practices inIndian SMEs using analytical hierarchy process (AHP) approach, *Journal of Cleaner Production*, 135, 284-298

UN-Water, 2021, Water Scarcity. Retrieved from http://www.unwater.org/water-facts/scarcity/.

Uzun, S., and Kazan, H., (2016), Çok kriterli karar verme yöntemlerinden AHP TOPSIS ve PROMETHEE karşılaştırılması: Gemi inşada ana makine seçimi uygulaması, *Journal of Transportation and Logistics*, 1(1), 99-113.

World Health Organization, (2019), Progress on household drinking water, sanitation and hygiene 2000-2017: special focus on inequalities. World Health Organization.

Zyoud, S. H., Shaheen, H., Samhan, S., Rabi, A., Al-Wadi, F., and Fuchs-Hanusch, D., (2016), Utilizing analytic hierarchy process (AHP) for decision making in water loss management of intermittent water supply systems,Journal of Water, Sanitation and Hygiene for Development, 6 (4): 534-546.