Technical Strategies in Water Systems
https://sanad.iau.ir/journal/tsws
ISSN (Online): 2981-1449
Autumn 2024: Vol 2, Issue 3
https://doi.org/10.30486/TSWS.2025.1194093

Research Article

Preparation of a spatio-temporal map of the expansion of modern irrigation systems in the provinces of Iran using the t-map package of the R-Studio software

Iman Ahmadi

Department of Agronomy, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

Corresponding Author email: i_ahmadi_m@yahoo.com

Received: 21 Nov 2024 Accepted: 03 Feb 2025 Published: 06 Feb 2025

Extended Abstract

Introduction

The rapid advancement of technology has revolutionized data analysis, enabling researchers to tackle complex problems across various fields. In agriculture, the adoption of modern irrigation systems has become a critical factor in enhancing water use efficiency and ensuring sustainable farming practices. However, the uneven distribution of these systems across different regions poses challenges for policymakers and agricultural planners. Understanding the spatial and temporal dynamics of modern irrigation systems is essential for effective resource allocation and strategic decision-making.

This study focuses on developing spatiotemporal maps to visualize the expansion of modern irrigation systems in Iran's provinces from 2009 to 2022. By leveraging the t-map library in R-Studio, the study aims to provide a dynamic representation of the progress made in adopting advanced irrigation technologies. Additionally, the study clusters Iran's provinces based on three key criteria: the percentage of completion of modern irrigation systems, the development of irrigation and drainage networks, and the coverage of traditional canals and waterways. This clustering approach offers valuable insights for policymakers, enabling them to design targeted strategies for regions with similar characteristics.

The integration of spatiotemporal analysis and clustering techniques provides a comprehensive framework for understanding the current state of modern irrigation systems in Iran. By identifying trends and patterns, this study contributes to the broader goal of improving agricultural water management and ensuring the sustainability of water resources in the face of growing demand and climate change challenges.

Materials and Methods

The study utilized two primary datasets: spatially referenced data on the development of modern irrigation systems in Iran's provinces from 2009 to 2022 and geographical map data delineating the boundaries of these provinces. The spatially referenced data were obtained from the Agricultural Jihad Ministry's Statistics Center and organized into an Excel file. The cumulative area equipped with modern irrigation systems in each province was calculated, and the percentage of completion was derived by dividing this area by the total irrigated agricultural land in the province. The final dataset, consisting of 434 rows and 23 columns, was saved in CSV format for analysis in R-Studio.

Technical Strategies in Water Systems
https://sanad.iau.ir/journal/tsws
ISSN (Online): 2981-1449
Autumn 2024: Vol 2, Issue 3
https://doi.org/10.30486/TSWS.2025.1194093

The spatiotemporal maps were developed using the t-map library in R-Studio. The process involved integrating the Excel data with the geographical map data and applying the t-map functions to create dynamic visualizations. The study also employed clustering techniques, including K-means, K-medians, and hierarchical clustering, to group provinces based on the three criteria mentioned above. Before clustering, the data were normalized to ensure consistency. The clustering process was facilitated by the factoextra library in R-Studio, which provides tools for standardizing data and visualizing clustering results.

Results and Discussion

By 2022, 2,469,835 hectares (41%) of Iran's 6,014,211 hectares of irrigated agricultural land had been equipped with modern irrigation systems. The development of irrigation and drainage networks and the coverage of traditional canals and waterways stood at 15% and 0.5%, respectively. The spatiotemporal maps revealed significant disparities in the adoption of modern irrigation systems across provinces. For instance, provinces with extensive irrigated agricultural land, such as Khuzestan and Fars, showed lower adoption rates (9% and 18%, respectively) compared to other regions.

The clustering results highlighted the high variability in the development of modern irrigation systems. Provinces like Hormozgan and South Khorasan achieved nearly 100% completion, while others, such as Gilan and Mazandaran, had close to 0%. The coefficients of variation for the development of irrigation and drainage networks and the coverage of traditional canals were 128% and 124%, respectively, indicating significant regional disparities.

The spatiotemporal maps provided a visual representation of the trends in modern irrigation system adoption. They revealed that provinces with larger irrigated areas were slower to adopt these systems, possibly due to the higher costs and logistical challenges associated with large-scale implementation. However, the deployment of modern irrigation systems alone is insufficient to improve groundwater conditions. Effective monitoring of water extraction through smart meters is essential to ensure the sustainability of groundwater resources.

Conclusion

The ability to create dynamic spatiotemporal maps in R-Studio offers a powerful tool for visualizing large datasets and identifying trends in the adoption of modern irrigation systems. This study demonstrated the utility of such maps in analyzing the expansion of advanced irrigation technologies in Iran's provinces from 2009 to 2022. The clustering of provinces based on key criteria provided valuable insights for policymakers, enabling them to design targeted strategies for regions with similar characteristics.

In conclusion, the integration of spatiotemporal analysis and clustering techniques provides a comprehensive framework for understanding the current state of modern irrigation systems in Iran. By identifying trends and patterns, this study contributes to the broader goal of improving agricultural water management and ensuring the sustainability of water resources. However, the successful implementation of modern irrigation systems requires strict monitoring of water extraction to ensure the long-term sustainability of groundwater resources.

Keywords: Modern irrigation systems, Clustering, R-Studio software, Spatial-temporal map