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MONITORING THE DRYING OUT OF THE CASPIAN SEA AND ITS CHANGES OVER TIME USING GIS TECHNOLOGY

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Summary: The Caspian Sea, the world's largest inland water body, has undergone significant changes over the past decades, primarily characterized by a noticeable drop in water levels. The objective of this paper is to assess the drying out of the Caspian Sea using geographic information systems (GIS) technology over the past few decades. By analyzing satellite imagery, hydrological data, and climatic factors, this study provides insights into the spatial and temporal changes in water levels in the Caspian Sea. The results indicate a consistent decline in water levels, especially after the 1990s, and highlight the significant geographic and environmental impacts of these changes. The application of GIS has proven essential for monitoring and understanding the environmental impacts of this phenomenon, providing a valuable tool for future research and environmental management.

Keywords: Caspian Sea, GIS technology, water desiccation, satellite imagery, environmental monitoring, hydrological data, environmental impact

Introduction: Located between Europe and Asia, the Caspian Sea is the largest landlocked body of water on Earth. It is of critical ecological, economic, and geographic importance to surrounding countries including Kazakhstan, Turkmenistan, Iran, Azerbaijan, and Russia. However, in recent decades, the Caspian Sea has been gradually drying up, characterized by a steady decline in water levels. These changes have raised concerns about their long-term impacts on the region's biodiversity, economy, and local populations. The causes of the Caspian Sea's drying up are many, including climate change, human activities, and natural processes. The decline in water levels has been particularly noticeable since the 1990s, with significant variations observed across the sea. This paper examines the use of geographic information systems (GIS) technology to monitor and analyze changes in water levels in the Caspian Sea over time. GIS technology enables the integration and analysis of various data sources such as satellite imagery, hydrological data and climate information to assess the spatial and temporal dynamics of water levels. The main objective of this study is to analyze the drying trends of the Caspian Sea and the associated ecological and environmental impacts using GIS technology. This study also aims to highlight the importance of GIS as a tool for monitoring large-scale

environmental changes and providing information on future projections for the Caspian Sea.

Methods: Data Sources. This study relies on the following data sources to assess the drying of the Caspian Sea:

1. Satellite Imagery: Satellite data from Landsat and Sentinel satellites were used to record the water level changes in the Caspian Sea over the past few decades. These images provide high-resolution time series data that are essential for monitoring large-scale environmental changes.

2. Hydrological data: Data related to river runoff into the Caspian Sea, particularly from major rivers such as the Volga and Ural, were analyzed. Changes in river runoff are a significant factor influencing the water level of the Caspian Sea.

3. Climate data: Meteorological data including temperature, precipitation, and evaporation rates were collected from relevant climate monitoring stations in the Caspian region. These factors significantly contribute to the change in sea water levels.

GIS Analysis Methods. Geographical Information Systems (GIS) were used to analyze and visualize the changes in water levels in the Caspian Sea. The following GIS methods were applied:

1. Raster Analysis: Raster data from satellite images were used to analyze changes in water surface area and overall water level. These changes were mapped over time to identify trends and patterns. 2. Vector Analysis: Vector data was used to analyze changes in the shoreline and spatial extent of the Caspian Sea, providing insight into the impact of desiccation on adjacent areas.

3. Change Detection: GIS-based change detection methods were used to assess temporal changes in water levels and areas affected by water volume reduction.

Data processing was performed using ArcGIS and QGIS software, which allowed the integration of different datasets and the creation of detailed maps and visualizations.

Results: Analysis of satellite images and hydrological data revealed significant trends in the drying up of the Caspian Sea:

1. Decline in water levels: The Caspian Sea has experienced a consistent decline in water levels, with notable declines occurring in the 1990s and 2000s. The average annual decline in water levels was approximately 5-10 cm, with some areas experiencing steeper declines.

2. Geographical impacts: The decline in water levels has had a significant impact on the coastline, particularly in the southern and southwestern regions of the Caspian Sea, such as Azerbaijan, Turkmenistan and Kazakhstan. These areas have experienced significant land impacts and ecosystem disruption.

3. Ecological impacts: The decline in water levels has resulted in habitat loss for a variety of species, particularly in coastal and shallow water areas. In addition, salinity levels have increased in some areas, impacting marine life and freshwater species.

4. Climate and hydrological influences: The study found that climate factors such as reduced precipitation and increased evaporation, as well as reduced river flow, were key

factors contributing to the drying process. Human activities, including water abstraction for agriculture and industrial use, further exacerbated the problem.

Discussion: The results of this study highlight the significant ecological and environmental impacts of the drying of the Caspian Sea. The decline in water levels has had profound impacts on surrounding ecosystems, particularly in terms of biodiversity loss and habitat destruction. Changes in water levels in the Caspian Sea are closely linked to regional climate variability, hydrological changes, and human activities. Understanding these factors is critical to developing effective management strategies to mitigate the effects of drying.

GIS technology has proven to be an invaluable tool for monitoring changes in the Caspian Sea. The ability to analyze large-scale environmental data over long periods of time provides a comprehensive view of the spatial and temporal dynamics of the sea. The results of this study can be used to inform future research, policy decisions, and environmental management practices in the region. However, further research is needed to examine the long-term impacts of the Caspian Sea ecosystem drying and to develop sustainable water management strategies. Additionally, incorporating more detailed data on human activities and their impacts on the Caspian Sea will provide a more comprehensive understanding of the drivers of water level change.

Conclusion: This study demonstrates the usefulness of GIS technology for monitoring and analyzing the drying of the Caspian Sea over time. The results highlight the need for continuous monitoring of water levels in the Caspian Sea to better understand the ecological, environmental, and socio-economic impacts of drying. GIS-based analysis offers a powerful method for tracking changes in large-scale ecosystems and provides valuable information for environmental management and conservation efforts. Future research should focus on improving the accuracy of predictive models of future water level changes and examining the potential impacts of climate change on the Caspian Sea. These results are of critical importance for policy decisions related to water resources management and ensuring the sustainability of the unique ecosystem of the Caspian Sea.

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