Visual Analytics of Global Hydropower and Reservoir Data to Enhance Sustainable Energy and Water Management

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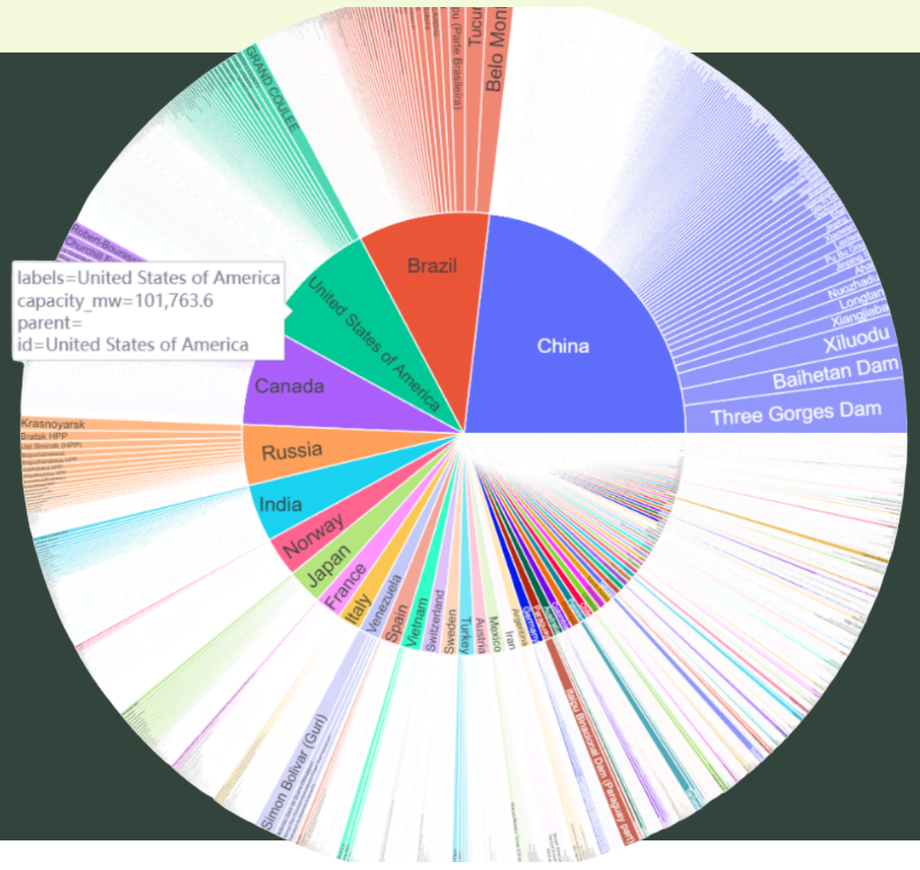
This is the final project submitted to INFOSCI 301: Data Visualization and Information Aesthetics, instructed by Prof. Luyao Zhang at Duke Kunshan University in Spring 2025.

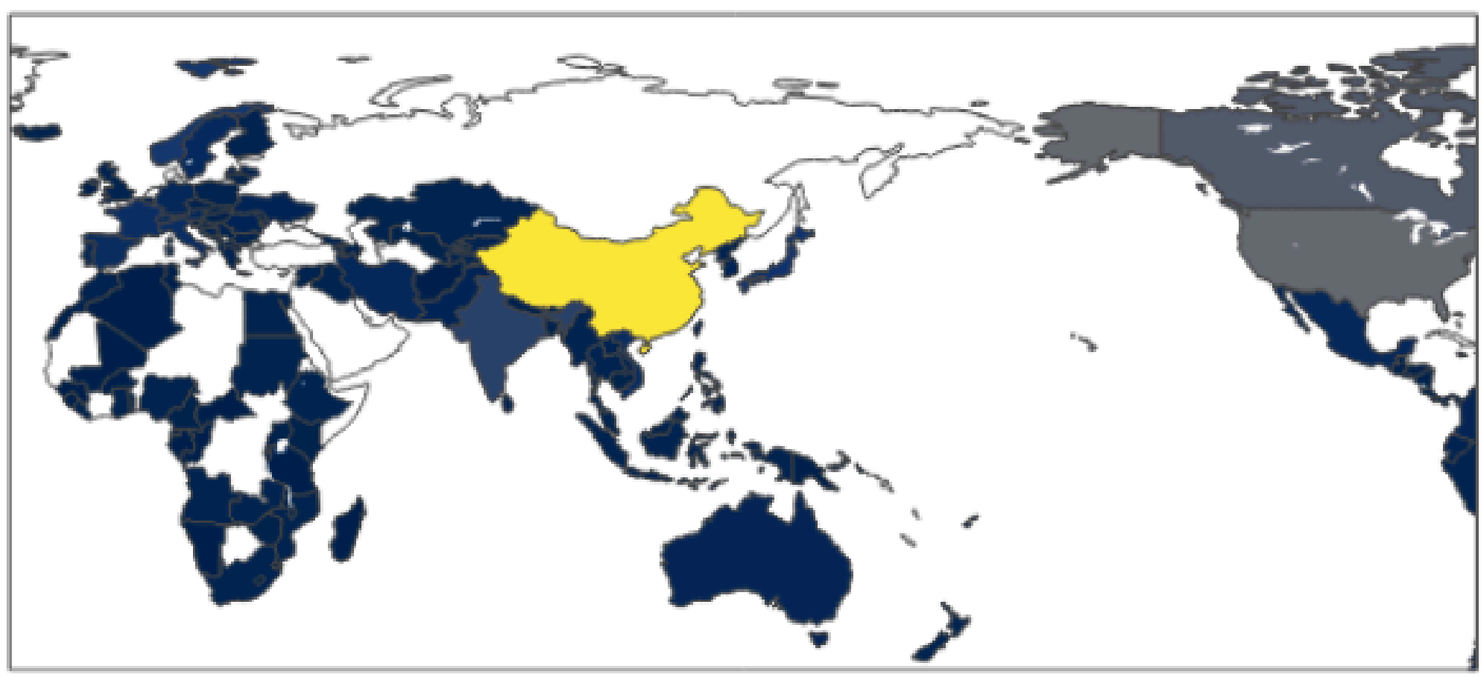
Introduction

This project explores global hydropower and reservoir data through interactive visualizations to support sustainable energy development and water resource management. By combining geospatial, temporal, and hierarchical visual tools, our dashboard uncovers patterns in hydropower capacity, reservoir volume, and infrastructure evolution across countries and years. The aim is to equip researchers, policymakers, and the public with insights that promote better-informed decisions aligned with global sustainability goals.

Methodology

Our project began with the acquisition and cleaning of a global dataset on hydropower plants and reservoir volumes. Using Python libraries such as Pandas and NumPy, we preprocessed the data to ensure consistency in units and completeness across countries and years. We then used Plotly and Dash to develop a suite of interactive visualizations, including choropleth maps, bubble plots, time series, treemaps, and sunburst charts. These visual tools allowed us to reveal patterns in hydropower capacity, spatial distribution, temporal trends, and country-level contributions. Each visualization was designed to promote exploration, facilitate comparative analysis, and communicate insights clearly to both technical and non-technical audiences.





Interactive App QR Code

GitHub QR Code

Team Contribution Statement:
Yuxi Wang: Data integration, GitHub management, visualization dashboard development.
Mohamed Sami Koudir: Machine learning analysis, anomaly detection, visual design optimization.
Yuxing Zhang: Literature review, cross-disciplinary integration, stakeholder communication strategies.

Results

Our results reveal that global hydropower is highly concentrated, with China, Brazil, and the U.S. dominating capacity and reservoir volume. A small number of mega-dams account for a majority of output, while a long tail of smaller facilities supports local energy and water needs. Visual analytics uncover two growth eras, with rapid expansion since the 1990s, especially in Asia and South America. Animated maps show the global spread of hydropower, highlighting emerging regions with untapped potential. These findings offer valuable insights for sustainable energy and water planning.

Intellectual Merit

- Enhances energy data visualization using interactive tools
- Applies machine learning and explainable AI for deeper insights
- Advances methods for analyzing large environmental datasets

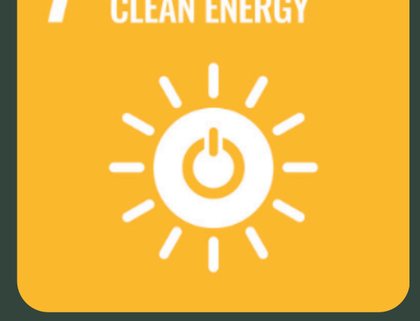
Practical Impacts

- Supports better energy and water policy decisions
- Identifies trends and gaps in global hydropower development
- Aids sustainable planning for vulnerable regions

Contribution to SDGs

Supporting SDG 7: Affordable and Clean Energy

- Increases transparency in hydropower data
- Visualizes global hydropower infrastructure
- Highlights energy access gaps and trends
- Identifies low-impact generation opportunities
- Provides interactive tools for policymakers
- Supports clean energy in vulnerable regions



Acknowledgements

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