NucleoSite : Nuclear Site Selection with Geospatial Analysis

A Desktop Application

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Introduction

Problem Statement

The project aims to develop a Geographic Information System (GIS) tool that integrates various data sources to evaluate potential nuclear power plant sites based on a range of environmental and infrastructural metrics. This tool is intended to help assess the suitability of sites for conversion to nuclear power, ensuring that decisions are informed by comprehensive data analysis and aligned with safety and sustainability standards.

Fig. 1: The Loading Screen of the App

Development Objective

The main objectives of the NucleoSite project were to:

- Develop a GIS tool using PyQt5, enabling users to visualize dam locations and related data within a user-friendly interface.
- Implement features to analyze risk factors associated with each dam, including earthquake risk, water presence, and demographic data.
- Equip users with the capabilities to generate detailed reports from their analyses to support decision-making in infrastructure planning and environmental assessment.

Fig. 2: Logo for NucleoSite
It combines the nuclear symbol with the gps icon, symbolizing the integration of nuclear energy and geospatial siting. The green and black color theme reflects a focus on environmental considerations and safety in nuclear site selection.

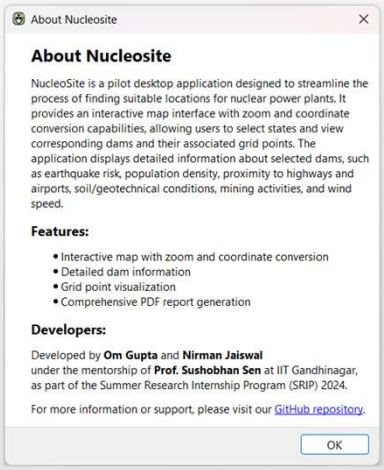

Fig. 3: The 'About' section inside the App

Methodology

Technology Used

- **Python**: Serves as the primary programming language for both frontend and backend development.
- **PyQt5**: Employed to develop the graphical user interface.
- **Matplotlib and Geopandas:** Used for managing geospatial data and rendering plots within the application.
- **FPDF:** Integrated for generating PDF reports.

Development Process

- **UI Design:** Created and implemented the user interface using PyQt5, focusing on ease of navigation and accessibility.
- **Feature Implementation:** Developed and tested core functionalities, including the interactive map, data layer integration, and report generation.
- **Backend Development and Geodata Reading:** Read the shapefile for all dams in India and plotted a grid of potential locations within a 10 km buffer zone at a 1 km distance. For these points, we read raster data such as population density and seismicity, and vector data like the nearest airport and highways.

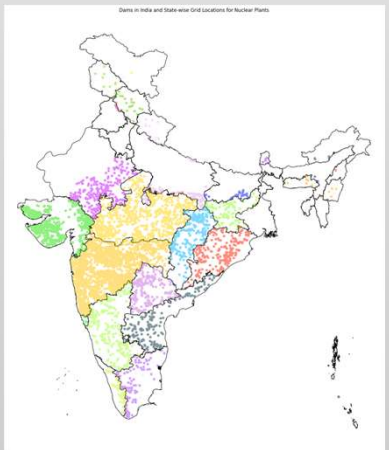

Fig. 4: Dams in India and grid l(potential)ocations for Nuclear Plants

Challenges Encountered

- **Data Authenticity:** Verified data sources rigorously to ensure reliability for critical infrastructure assessments
- **Efficient Spatial Analysis:** Developed buffer-based proximity search algorithms to streamline intensive data retrieval, particularly for dense highway networks, enhancing efficiency in spatial analysis.
- **UI Responsiveness:** Maintaining a responsive and efficient UI while managing large geospatial datasets necessitated several optimizations and ongoing refinements.

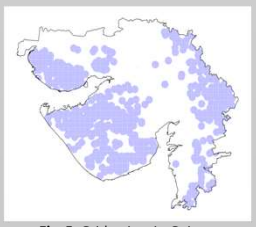

Fig. 5: Grid points in Gujarat

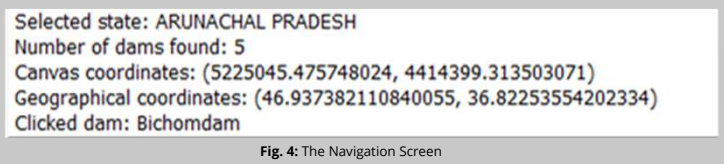

Fig. 4: The Navigation Screen

Results

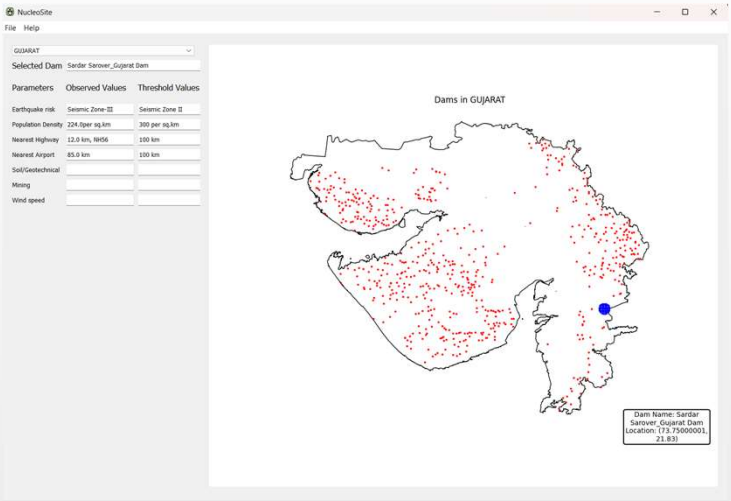

Fig. 7: The App

Interactive Mapping and Data Visualization:

- Successfully implemented an interactive map that displays the location of dams across various states.
- Enabled zoom and detail viewing functionalities, allowing users to click on specific dams to get more detailed information.

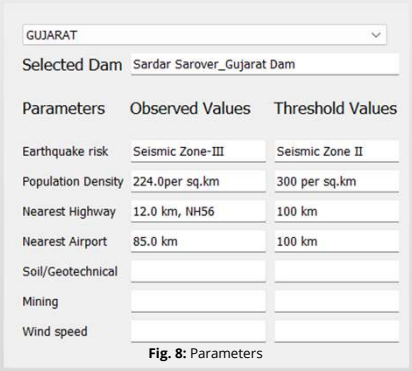

Fig. 8: Parameters

Data Parameters:

- Integrated various data layers such as earthquake risk, population density, and proximity to water bodies, which can be toggled on and off to assess potential impact areas.
- Developed a feature for users to set specific search parameters and thresholds, enhancing the tool's utility for scenario-based analysis.

Dynamic Reporting:

- Incorporated a dynamic report generation feature that compiles user-selected data into a formatted PDF document, facilitating easy sharing and review.
- Reports include visualizations such as maps and risk factor charts, as well as textual data about selected dams.

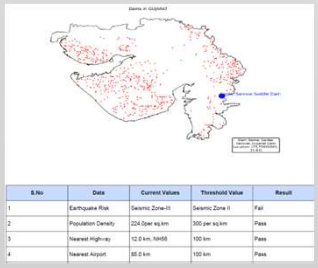

Fig. 9: Screenshot of the report

Conclusion

- **Effective Integration:** NucleoSite combines GIS technology with advanced analytics for dynamic visualizations and comprehensive site evaluations.
- **Enhanced Decision-Making:** The app overlays data on dam safety, environmental risks, and infrastructure proximity, aiding informed decisions for nuclear plant site selection
- **User-Centric Design:** Its user-friendly interface and interactive maps allow users of all technical levels to analyze potential sites effectively.
- **Future Scalability:** Designed for future enhancements, NucleoSite can integrate additional data layers and advanced risk assessment algorithms.
- **Sustainable Energy Goals:** By streamlining site identification for nuclear plants, NucleoSite supports India's sustainable energy and greenhouse gas reduction goals.

Acknowledgements

- **Developers :** Om Gupta and Nirman Jaiswal.
- **Mentor:** Prof. Sushobhan Sen
  (Built Environment Lab, IIT Gandhinagar)

Comprehensive documentation, source code, and installation instructions have been consolidated and committed to a restricted Git repository accessible only to project contributors: