Optimizing Electricity Infrastructure Management: A Dashboard Approach for Samarkand Region

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Abstract: Electricity infrastructure management plays a pivotal role in ensuring the reliability and efficiency of power distribution systems. In this paper, we present a comprehensive approach to electricity infrastructure management in the Samarkand region through the development and implementation of a dashboard using ArcGIS Online. The dashboard serves as a centralized platform for stakeholders to visualize, analyse, and monitor various aspects of the electricity network. Key features of the dashboard include filters by district and sub-district, as well as options to select specific electricity lines by name and voltage level. This enables users to focus their analysis on specific areas of interest within the region, enhancing the granularity and relevance of the information presented. The implementation of this dashboard represents a significant step towards modernizing electricity infrastructure management practices in the Samarkand region. By leveraging the power of GIS technology and ArcGIS Online, stakeholders are empowered with a user-friendly and intuitive tool for accessing, analysing, and interpreting electricity infrastructure data.

1 Introduction

Effective management of electricity infrastructure is crucial for ensuring the reliability, efficiency, and sustainability of power distribution systems, particularly in regions such as Samarkand where electricity plays a pivotal role in supporting economic activities, providing essential services, and enhancing overall quality of life [1]. However, despite its significance, traditional approaches to electricity infrastructure management often lack the sophistication and granularity required to address the evolving challenges and complexities inherent in modern power distribution networks [2]. The absence of a comprehensive management framework tailored to the unique needs and characteristics of the Samarkand region underscores the pressing need for innovative solutions to optimize infrastructure performance and enhance decision-making processes. In response to this imperative, this paper introduces a novel approach to electricity infrastructure management in the Samarkand region through the development and implementation of a dashboard using ArcGIS Online

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[3]. ArcGIS Online stands as a web-based Geographic Information System (GIS) platform renowned for its capability to create, analyze, and share spatial data and maps [4].

Leveraging the versatile functionalities of ArcGIS Online, our approach aims to transcend the limitations of traditional management practices by providing stakeholders with a sophisticated yet user-friendly tool for visualizing, analyzing, and monitoring various aspects of the electricity network [5], [6]. A distinctive feature of our dashboard lies in its interactivity and flexibility, enabled by a range of customizable filters and dynamic visualization tools. Notably, the implementation of filters by district, sub-district, and voltage level empowers users to tailor their analyses to specific geographical areas and infrastructure characteristics, thus enhancing the relevance and granularity of the insights derived. Unlike conventional management approaches that often rely on static, pre-defined parameters, our dashboard offers a dynamic and adaptable interface that evolves with the needs and priorities of stakeholders [7], [8].

Moreover, the dashboard's integration of dynamic bar charts further enriches the visualization experience, providing stakeholders with valuable insights into the spatial distribution and characteristics of electricity infrastructure within the region. Particularly noteworthy is the ability to visualize the length of selected electricity lines, facilitating informed decision-making regarding maintenance prioritization, risk assessment, and network optimization [9], [10], [11]. The development and implementation of this dashboard signify a significant advancement in the realm of electricity infrastructure management in the Samarkand region. By harnessing the power of GIS technology and ArcGIS Online, our approach transcends traditional management paradigms, offering stakeholders a sophisticated yet intuitive platform for accessing, analyzing, and interpreting electricity infrastructure data. Moreover, the dashboard's interactive features foster stakeholder engagement and collaboration, promoting transparency, accountability, and collective problem-solving within the region's electricity sector [12].

In summary, this paper seeks to showcase the transformative potential of our innovative approach in enhancing decision-making processes, optimizing infrastructure performance, and fostering stakeholder engagement in critical infrastructure sectors such as electricity distribution. Through the development and implementation of our dashboard, we aim to demonstrate the value of leveraging cutting-edge technologies to address complex infrastructure challenges and support the sustainable development goals of the Samarkand region. Dashboards for electricity management serve as powerful tools to drive climate action by enabling informed decision-making, promoting renewable energy integration, and empowering stakeholders to reduce their environmental impact [13], [14], [15], [16], [17], [18]. Through their innovative features and user-friendly interfaces, dashboards play a crucial role in accelerating the transition to a low-carbon, sustainable energy future [19], [20], [21].

2 Materials and methods

2.1 Study area

In the context of electricity management, the Samarkand region plays a critical role in supporting the economic activities and infrastructure development of Uzbekistan. Uzbekistan's economy has experienced substantial growth from 2017 to 2024, facilitated by comprehensive reforms and diversification initiatives. In 2017, the Gross Domestic Product (GDP) growth rate was recorded at 4.5%, which accelerated to 5.1% in 2018. A pivotal reform during this period was the liberalization of the exchange rate, which significantly enhanced investor confidence [5]. As a result, foreign direct investment (FDI) surged, reaching $2.8 billion in 2019. In 2020, despite the adversities presented by the global

pandemic, Uzbekistan's economy exhibited resilience, achieving a modest GDP growth rate of 1.6% [6-7]. Subsequent years witnessed a robust recovery, with GDP increasing by 7.4% in 2021, driven by rebounds in the manufacturing, agriculture, and services sectors. Growth stabilized at 5.7% in 2022, while inflation, which had previously raised concerns, decreased to 10% after peaking at 14% in 2021. Looking forward to 2024, Uzbekistan's GDP is projected to grow by 6%, indicative of ongoing industrialization and an expansion of trade with neighboring countries. The government's prioritization of infrastructure development, renewable energy, and digitalization continues to propel economic growth, positioning Uzbekistan as a significant player in the economic landscape of Central Asia [8]. Effective management of electricity infrastructure in Samarkand is crucial for ensuring the uninterrupted supply of power to residential, commercial, and industrial sectors. From powering homes and businesses to facilitating essential services such as healthcare, education, and public transportation, electricity plays a fundamental role in driving economic productivity and societal well-being. Presently, the nation's power transmission network spans a total length of 271,569 kilometers. Among these, 145,412 kilometers, constituting 53% of the total, are categorized as low-voltage lines, while 80,176 kilometers (29%) fall under the medium-voltage classification, and 39,981 kilometers (18%) are designated as high-voltage lines. In the year 2022, significant efforts were dedicated to the enhancement and reconfiguration of power transmission lines, amounting to a total investment of 15,414 trillion soums. As part of this initiative, a total of 11,394 kilometers of power lines underwent reconstruction and repairs, subsequently being integrated into the operational network.

This study focuses on Samarkand (Figure 1.), which is recognized as the principal economic and demographic center of Uzbekistan and holds significant historical importance. Today, it continues to be a vital centre of commerce, tourism, and industry within the region.

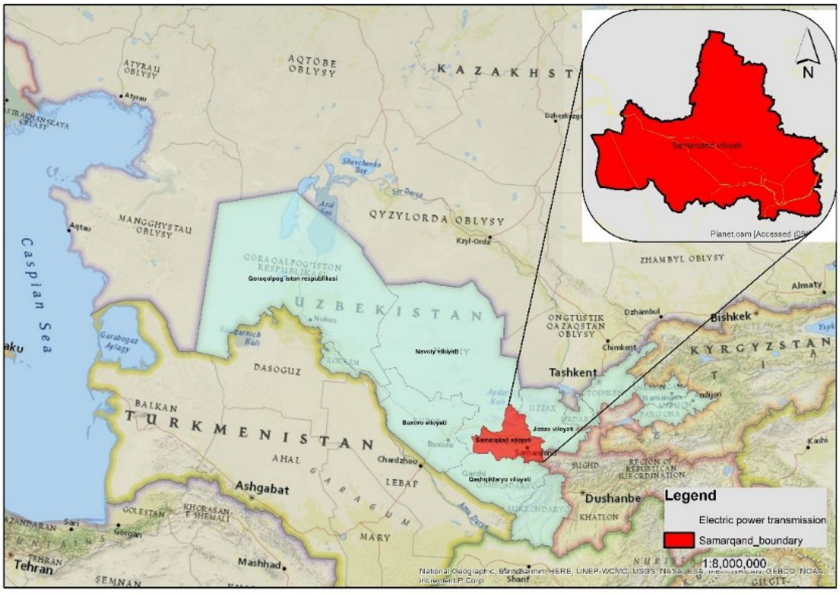

Fig. 1. The location of the Samarkand region, Uzbekistan.

In the planning and design phase of power transmission infrastructure, a thorough analysis of the topography and natural landscape characteristics is paramount. Such considerations necessitate a comprehensive assessment of various factors, including the

spatial distribution of agricultural land, water resources, hydraulic structures, transportation networks such as highways and railways, as well as residential and other built-up areas.

2.2 Data processing

The methodology outlined above directed the creation and deployment of an ArcGIS Online dashboard for managing electricity infrastructure in Samarkand. It involved data collection, pre-processing, dashboard design, implementation of filters and dynamic visualization features, testing, deployment, and user training. A flowchart was developed to visualize this process, facilitating stakeholder access to and analysis of electricity infrastructure data, thereby enhancing decision-making capabilities in the region.

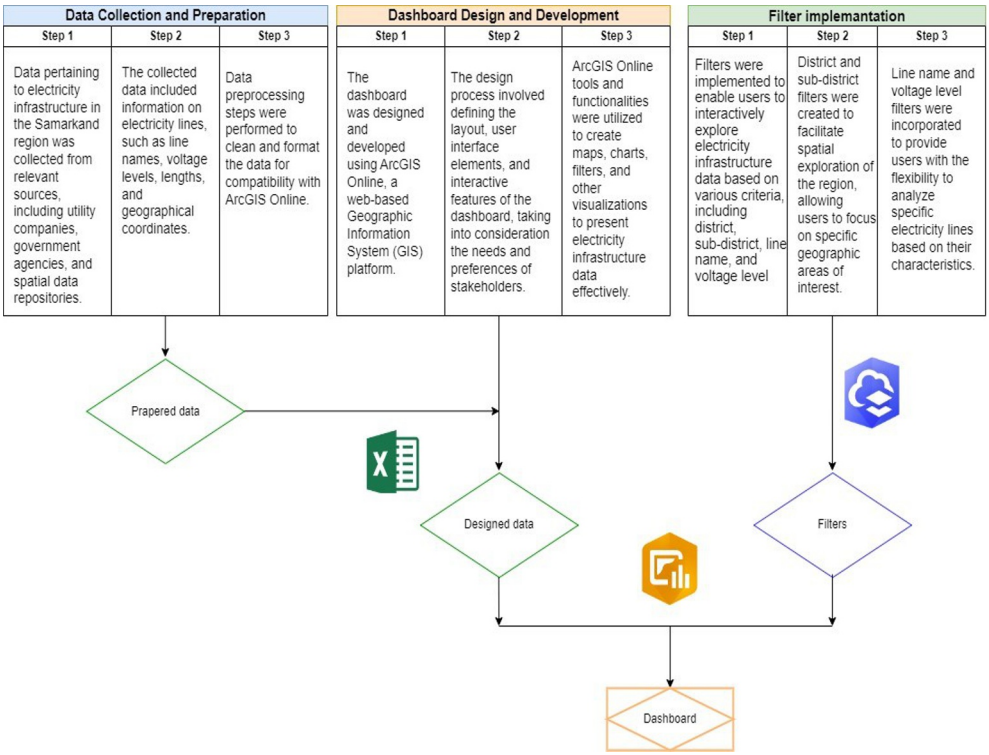

Fig. 2. Flowchart of the methodology.

The uniqueness of the methodology lies in its application to the specific context of managing electricity infrastructure in the Samarkand region using ArcGIS Online. In terms of Geospatial Data Integration, the methodology involves collecting, pre-processing, and integrating geospatial data related to electricity infrastructure in the Samarkand region. This includes data on electricity lines, districts, sub-districts, and other relevant spatial information. The methodology focuses also, on utilizing ArcGIS Online, a cloud-based Geographic Information System (GIS) platform, to design, develop, and deploy an interactive dashboard for stakeholders to access and analyse electricity infrastructure data. This approach leverages the capabilities of ArcGIS Online in data visualization, spatial analysis, and collaboration. However, the methodology includes the implementation of dynamic visualization features such as filters, interactive maps, and dynamic bar charts within the dashboard. These features enable stakeholders to interactively explore and

interpret electricity infrastructure data, providing valuable insights into the distribution and characteristics of the electricity network.

3 Results and discussion

3.1 Results

The dashboard provided stakeholders with an interactive platform to visualize electricity infrastructure data, including distribution lines, districts, sub-districts, and voltage levels. Users could explore the spatial distribution of electricity infrastructure and identify patterns and trends. Stakeholders were able to analyse and interpret electricity infrastructure data effectively using the dashboard's dynamic visualization features. Filters by district, sub-district, line name, and voltage level allowed users to focus their analysis on specific areas of interest within the region.

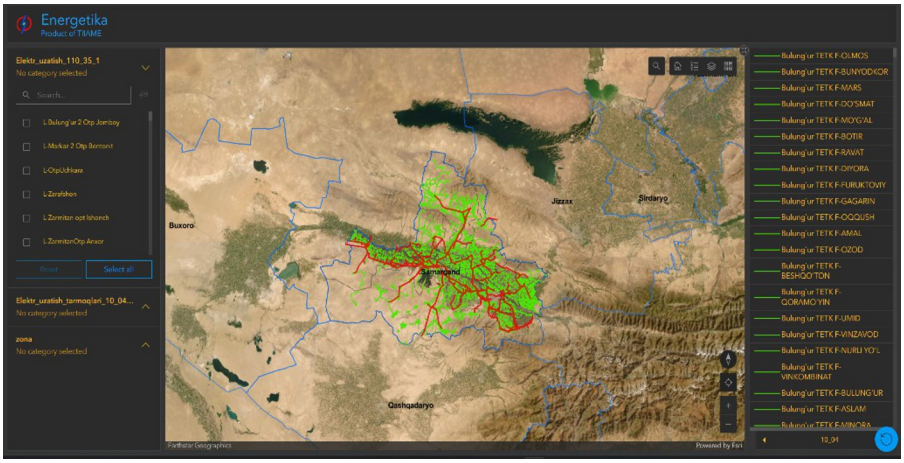

Fig. 3. Interface of the dashboard.

The availability of comprehensive and up-to-date data facilitated informed decision-making processes regarding electricity infrastructure management in the Samarkand region. Stakeholders could prioritize maintenance activities, identify areas for infrastructure upgrades, and optimize network efficiency based on the insights provided by the dashboard. Stakeholder engagement was enhanced throughout the dashboard development process, from requirements gathering to user training sessions. Feedback from stakeholders was incorporated into the dashboard design, resulting in a user-friendly and intuitive platform that met the needs of end-users. Comprehensive documentation was developed to support the deployment and maintenance of the dashboard. This documentation provided guidance on dashboard usage, configuration, and ongoing support, ensuring the long-term sustainability and effectiveness of the dashboard in managing electricity infrastructure in the Samarkand region.

The dashboard provides stakeholders with a user-friendly platform to visualize, analyze, and interpret electricity infrastructure data, facilitating informed decision-making processes and promoting sustainable infrastructure management practices. We encourage stakeholders to explore the dashboard and share their feedback on its usability and effectiveness.

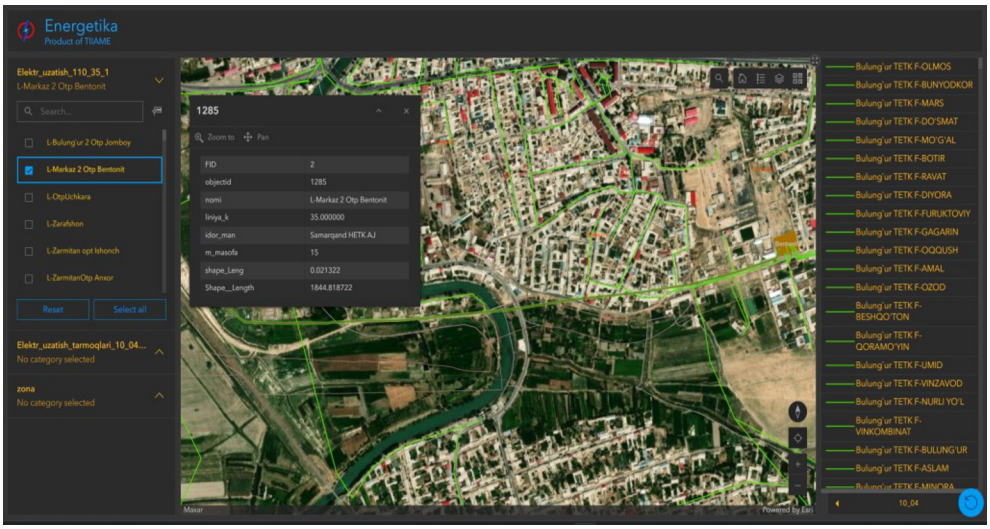

Fig. 4. The working process of the filters in the dashboard.

3.2 Discussion

As outlined in the analysis, the Samarkand region holds a pivotal position in Uzbekistan's economic landscape, with its rich history, strategic location, and growing urbanization driving the demand for reliable electricity supply. With a vast network of power transmission lines spanning over 271,000 kilometers, managing this infrastructure efficiently is essential to meet the region's energy needs, support economic activities, and enhance overall quality of life. In this context, the completion of significant reconfiguration efforts in 2022 underscores the ongoing commitment to improving power infrastructure in the region. However, traditional management approaches may fall short in providing the necessary granularity and flexibility to address the evolving challenges and complexities inherent in modern power distribution networks. Enter the dashboard developed for electricity management in the Samarkand region. Leveraging the capabilities of ArcGIS Online, our dashboard offers a comprehensive solution to visualize, analyze, and monitor various aspects of the electricity network. With features such as filters by district, sub-district, and voltage level, stakeholders can tailor their analyses to specific geographical areas and infrastructure characteristics, enhancing the relevance and granularity of the insights derived.

Furthermore, the dashboard's dynamic visualization tools, including interactive bar charts, provide stakeholders with valuable insights into the spatial distribution and characteristics of electricity infrastructure within the region. By enabling informed decision-making regarding maintenance prioritization, risk assessment, and network optimization, the dashboard empowers stakeholders to enhance the efficiency and reliability of power supply in Samarkand.

4 Conclusion

In conclusion, the development and implementation of the ArcGIS Online dashboard for managing electricity infrastructure in the Samarkand region have demonstrated significant advancements in enhancing infrastructure management practices. Through the utilization of geospatial data integration, dynamic visualization features, stakeholder engagement, and comprehensive documentation, the dashboard has provided stakeholders with a powerful tool to access, analyse, and interpret electricity infrastructure data effectively.

The interactive nature of the dashboard allows stakeholders to gain valuable insights into the spatial distribution and characteristics of electricity infrastructure, facilitating informed decision-making processes and promoting sustainable infrastructure management practices. By enabling stakeholders to prioritize maintenance activities, identify areas for infrastructure upgrades, and optimize network efficiency, the dashboard has contributed to improving the reliability, efficiency, and safety of the electricity supply in the Samarkand region. Moving forward, continued collaboration and feedback from stakeholders will be essential to further enhance the functionality and usability of the dashboard. Additionally, ongoing monitoring and evaluation of the dashboard's effectiveness in supporting infrastructure management decisions will be necessary to ensure its long-term success.

Overall, the development and deployment of the ArcGIS Online dashboard represent a significant step forward in leveraging geospatial technology to address the complex challenges associated with managing electricity infrastructure. By harnessing the power of data visualization, spatial analysis, and stakeholder engagement, the dashboard has the potential to serve as a model for effective infrastructure management practices in other regions and industries.

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