TEACHING MATERIAL GUIDANCE

1) Title of the material

Jing, C.; Du, M.; Li, S.; Liu, S. Geospatial Dashboards for Monitoring Smart City Performance. Sustainability 2019, 11, 5648. https://doi.org/10.3390/su11205648

https://www.mdpi.com/2071-1050/11/20/5648

2) Which section of the SUMP it is relevant to?

This paper presents an efficient geospatial dashboard for the smart management of smart cities. Dashboards can gather, visualize, analyze and advise on urban performance to support sustainable development of smart cities. Therefore, the article can be linked to the third, fourth and fifth sections of the SUMP circle related, respectively, to the determination of planning framework, analysis of the mobility situation (in particular the analysis of problems and opportunities for all modes of transport - **Subsection 3.2.**), scenario building and joint evaluation (development of scenarios of possible futures - **Subsection 4.1**.) and vision and strategy development (arguments for stakeholders - **Subsection 5.1**).

3) Which Mobility Manager knowledge this material is the most relevant to?

It is related to Transport and mobility planning (section 1 of the Mobility Manager competencies) especially 1b (employment of ITS/ICT and smart measures) and Data analysis for mobility planning (section 5 of the Mobility Manager competencies) especially 5a (data collection and analysis) as well as Stakeholder involvement tools (section 7 of the Mobility Manager competencies).

4) Problem approached and content overview

Problem approach – general understanding of how to manage data in smart cities. The authors of this paper critically reviewed the research and development of geospatial dashboards, including map integration, spatial data analysis and geographic visualisation for decision support and real-time monitoring of smart city performance. Research on such systems has mainly focused on indicators, information models, including statistical and geospatial models, and other related issues. This article provides an overview of the history of dashboards and key technologies and applications in smart cities, and summarises the main research advances and representative developments by analysing their key technical issues. Based on the review, the visualization model and the validity of models for decision support and real-time monitoring are discussed, which need to be further explored, and some future research directions are recommended.

Dashboards can be categorised into three types based on their role: operational, analytical or strategic. This paper extends this categorisation using geospatial data as follows:

- Operational dashboards provide descriptive measurements of smart cities using indicators based on original geospatial and other related data. These indicators provide evidence of a city's status,
- Analytical dashboards are a diagnostic method for smart cities based on data inferred from geospatial data using spatial analytics, such as patterns and data relationships,
- Strategy dashboards are predictive dashboards used by smart cities to predict the future state of the city based on existing patterns, where data are fed into well-defined models to predict future outcomes.

The objectives of the review were to: explore state-of-the-art geospatial dashboards and key technologies in architecture, design, indicators, visualization, and applications; review the evolution and research on geospatial dashboards to determine if and how geospatial dashboards can be used to monitor smart city performance; and identify the most common design approach for architecture, dashboard design, indicator modelling, and visualization in geospatial dashboards. This paper presents a review of the literature to understand the evolution of geospatial dashboards, examines the key technologies used in the development of geospatial dashboards, and presents applications of geospatial dashboards. Furthermore, current challenges faced by geospatial dashboards in monitoring smart city performance are analysed, followed by recommendations for future research work.

5) Who could be interested in this material?

The article is aimed at students and those looking for inspiration in the implementations of intelligent solutions to manage data in transport systems when such measures are applied in SUMP.

6) What is worth mentioning as an innovative factor for the reader?

Geospatial dashboards have found application in many aspects of smart cities. However, the performance of a dashboard in monitoring smart city performance must be evaluated. Below are the best practices for geospatial dashboards according to the three types of dashboard. The operational dashboard is the most popular geospatial dashboard that uses an indicator to focus on monitoring and visualising smart city performance. The main applications of indicators include indicator visualisation, indicator mapping, and validation of analytical results. Indicators for performance monitoring answer questions like "what is it?". Therefore, they are also called operational or descriptive indicators. For example, indicators inferred from social media data have been used to track the performance of conditions. Adaptive indicators have been used for various visualisation requirements in operational dashboards. Indicators are mapped to discover patterns. Due to the cognitive advantage of maps, indicators can be mapped to discover their distribution or spatial relationships. For example, the distribution of citizen presence is mapped as a heat map for the human mobility indicator on the Skopje dashboard. For location tracking applications, location data streaming is dynamically mapped online. Indicators are used to validate the results. In some applications, the geospatial dashboard

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provides a better validation solution for the results of a third-party analytical model, for example, candidate location resulting from a geospatially based AHP method or footprint information from an analytical model based on a fusion of multiple data sources.

For an analytics dashboard, the analytics model is the core of the dashboard, which is used to explore the reasons behind patterns and outcomes, which includes visual analytics, spatial-temporal analytics, and decision support. To integrate models into dashboards, the most common methods are data exchange and callbacks from the application program interface (API). For example, dashboards integrate some business analysis models to access and interpret city data. Another example is the use of spatial-temporal analysis to extract knowledge from a large repository of extensive and diverse data using a geospatial API.

Strategic dashboards can be used to predict and simulate future situations and outcomes, such as predicting human mobility and inferring city performance. Due to the complexity and inconsistency of the data, the development of such predictive models is challenging. However, it is currently a growing field. In general, from an application perspective, geospatial dashboards should focus more attention on map-context visualisation or knowledge extraction due to the powerful and clear perception obtained from maps. However, existing applications focus on the fusion of different data to provide measurements of city performance, rather than developing a model to analyse large geospatial data for knowledge extraction. Although many geospatial dashboards have been developed, less attention has been paid to forecasting and strategic analysis for decision making. Another problem is that these dashboards put more emphasis on the data and do not pay attention to the uncertainty and veracity of the data or model. Therefore, quantitative and visualisation methods for data uncertainty or model uncertainty should be developed to make the right decisions, which will certainly support the development of forecasting and strategic dashboards.

7) Limitations

Ethical issues and big data technology are equally important and crucial, especially in the geospatial domain. They are essential for handling and managing geospatial data, but are not considered in this study as it focuses on measuring the performance of a smart city.

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