Data-driven Urban Systems for Sustainable Smart City Development

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Abstract

Spatial development plans that include the civic engagement both in the decision-making and execution processes have started to be used by a growing number of local governments around the Europe. Despite their mostly integrated nature (meaning integrating diverse urban matters at once) and openness of open dialog with city stakeholders, many of them is not even partially executed due to their rather abstract and general character. On the contrary, the strategies and plans concentrated on specific execution measures often lack the integrated context and the development direction that was crystalized in the before mentioned, less concrete form, being therefore much less oriented on sustainable, resilient developmental solutions. This is even more visible in urban development undertakings related to pursuing a smart city agenda, where the implementation efforts are mostly concentrated on single measures.

This discussion paper introduces a new way of approaching the spatial development plans both from planning and execution perspective, using dynamic evaluation tools that not only monitor and measure the performance of undertaken goal-fulfilling processes/projects but also assess their sustainability quality.

The key message behind the research is: smart city in not a new form of a future polis – it is a set of measures that helps to overcome the past, present and future problems in a more integrated, evidence-based way.

Keywords **–** integrated urban development concept; sustainable smart city; civic participation; evaluation tool; sustainability consistency check

1 Introduction

In last two decades the definition of smart city has been continuingly evolving and reshaping the idea of urban progressiveness (Etezadzadeh 2015). Often combined with other concepts such as innovation, inclusion, and sustainability, the image of a connected, multi-problem-solving polis became a part of many spatial development agendas worldwide (Etezadzadeh 2015, Muraszkiewcz 2016). Unfortunately, the urban digitalisation strategies and their mostly project-oriented applications, embody rather an adaptational nature in regard to global technological and economic changes and less a new way of approaching the urban challenges in general (Goldsmith 2017). As such, the initially set objectives of pursuing sustainable and human-centric goals might through their relative abstractness be not adequately transferred into implementation efforts and therefore be only partially if at all carried out (Spec 2016, Niestroy et al. 2019). Due to often missing evaluation and monitoring instruments that would measure the effectiveness of pursuing the development goals in urban-related projects, the actual consistency of undertaken sustainability efforts can be often determined only post factum (Geoghegan 2019, Meyer et al. 2020). This may be especially problematic in areas that already suffer from negative consequences of poor governance practices, like for example regions affected by extreme heat due to negligence of climate change prevention measures (Heat Action Plan 2019) – here an investment in the smart city infrastructure might not only be highly challenging but also simply unsustainable in the long term.

As most digitalisation projects are structured upon broadly understood data, the approach toward understanding the information value (EIP-SCC 2017) and its role in spatial transformative processes is progressively gaining on importance, especially among municipalities and their stakeholders that actively collect and use numerous city-related data (Chiehyeon et al. 2018). In such matter, the city is given multiply layers with respective, structured data containers and is perceived as a system that reflects and corresponds to diverse urban dynamics (Neda et al. 2017). Nevertheless, from a sustainable point of view the IT-architecture and the management infrastructure of smart cities are still a timely tool for an integrated urban development and not a future of a modern polis itself (Deryckere 15.01.2020). Therefore, the motivation behind

the described research is to propose a concrete strategical framework that would be flexible enough to interconnect the complexity of decisions made upon operative measures (in all their execution phases) with a proper consistency check regarding securing an environmental and social added value (Sankowska 2019).

The study and the development of such toll are tested on already existing integrated urban development concept and digital agenda of a German city Ludwigsburg. Through an active cooperation with the city that regards to an exchange of real city data and the continuous feedback loop, the pragmatic and realistic scenario-design is secured.

1.1 Research characteristics and outcome

The research is undertaken in a form of an ongoing external doctoral study with estimated submission date of 31st December 2021. The theoretical, empirical and applied study efforts focus on three main topics: **data-based integrated urban development concepts** with a Leipzig Charter on sustainable European cities from 2007 (extrapolation in 3Q 2020); **sustainable and inclusive** planning and implementation of **smart city** elements into local development agenda; use of people-centric **data science** and **open source platform economy** in urban development.

The outcome of the is an **open source platform that transforms the urban development goals** derived from already existing masterplans/spatial development concepts/etc. **into dynamic processes with defined stakeholders, timeline, and budget**. The key components of the platform are:

- **data-based evaluation tool** with two data clusters: cluster 1 – abstract content for sustainability consistency check and cluster 2 – evidence-based content for evaluation of process progression based on municipal data (see subchapter 2.1);
- **communication cycle** (see subchapter 2.2);
- **urban performance key components** (uPI) (see chapter 3)

1.2 Methodology

The research is characterized by a polymethodological approach and contains comprehensive literature review and analysis of case studies. The most important part of the research deliverables is a design of an open-source prototype of a cloud-based process platform that operates on data structures described in chapter 2.

1.3 Research questions

The current stage of the research concentrates on two main questions:

1. Is there any uniform structure (or set of adaptable structures) that would pragmatically organise the key information behind the abstract objectives from local masterplans and urban development plans?
2. Is there any dynamic form of a data-based consistency check that would evaluate and monitor the actual sustainability level of pursued efforts?
3. How should such structure be designed to enable an actual implemental process? Hence, how to conduct such process from the project management perspective, since the particparties are the city stakeholders and the budget is the non-flexible municipal household?
4. What are the technical, organisational and legal requirements for building such data-driven urban development instrument (reference country: Germany)?

2 Data

2.1 Data types

In this study, the multi-source dataset for the platform design includes different types of manually extracted data from the text documents (cluster **1** – abstract content) and raw data (cluster **2** – evidence-based content) such as:

- **structured text data (1)** derived from: recommendations of municipality's choice (i.e. Leipzig Charter, Paris Agreement, Cities and Biodiversity Outlook, UNFCCC), urban development goals from local masterplans, planning guidelines, public participation events etc.,
- **statistical data** (2.1) from authorized public and private sources,
- **geospatial data** (2.2);
- **sensor data** (2.3) from authorized public and private sources.

Type 1 represents the set of development goals chosen by municipality – their role is to give a consistent direction in

which creation and execution of the local agenda should be focused on. Type 1 does not only serve as a consistency check but also as a helpful "stop and think" tool in situations where the undertaken measures do not align (enough) with the agreed sustainable development strategy.

Most of the type 2 data is collected from the municipal data bank – those datasets are crucial in showing the eventual gap existing between the real effect of the ongoing development measurements and the particular development goal(s).

Although during the research it is not planned to include 3rd party data (data that is not generated and owned by the local municipality), the requirement for integration of additional data sources will be featured in final recommendation on the platform design. Those will include primarily additional standards towards data types and their quality and approach toward General Data Protection Regulation (GDPR).

2.2 Data integration

To ensure the scalability and cost efficiency of the platform, it is required to maintain the flexibility and adaptiveness of the system behind it. A substantial measure in this case is a comprehensive approach toward data integration due to disparate data types, sources, update intervals, attributes, working methodologies, etc. (Lenzerini 2002). As the research matter related to two different information clusters, it is important to determine two separate data integration approaches:

Cluster 1 (abstract content): the key information from structure text data are needed to be defined by decision-making units responsible for sustainable development. Such selected data is then provided with index (ID) and attributes for evaluation assessment. The complexity of integrating the data from documents with an relatively abstract context should be maintained low, also due to potential for greater participative civic engagement that should be involved in selection and setting of local, developmental goal; data update intervals relates to new release dates of used documents.

Cluster 2 (evidence-based content): it is assumed that in many (also future) cases the data storage will be decentralized, especially if municipal enterprises take part in the data exchange f.e. through an agreement on collaborative action. Therefore, the Common Data Storage (CDS) with a concrete communication methodology within the municipality is seen as a minimum requirement to ensure a sustainable data management and workflow. The data are integrated on web-based process platform/management platform.

As the data integration described below is similar to those undertaken in geoinformation system framework, it is recommended to use at least some data sets for integration and visualisation purposes in like WFS (Web Feature Services) or WMS (Web Map Services) to **maintain a sustainable use of data.**

A brief list of integration steps involves:

1. General agreement on data exchange and data integration accessed by a unit representant with a decision-making power (f.e. head of department, etc.);
2. Selection of following contact persons/group of persons per involved unit: **professional** expertise (not necessarily expertise on data management) and **technical** expertise (direct contact person responsible for data exchange);
3. Set of **data attributes** (attributes' group), **data formats** per concrete data type and subtype (f.e. type: geospatial data, subtype: 5G-relevant physical, technical infrastructure);
4. Set of data update interval;
5. **A:** data integration though a **dedicated team**

   B: data integration though directly to the system, done **separately by technical contact person**(s);
6. Integration with cluster 2;
7. Integration with process platform. Additionally recommended: simultaneous integration/visualisation with/via WFS or WMS / analysis / etc.;
8. Feedback loop / update interval.

As the organisation and implementation efforts related to roll-out and use of urban platforms though the Germany municipalities and their municipal companies is executed in varying pace, the profile of a uniform communal data management across German municipalities is rather ambiguous. Nevertheless, this situation has started to change due to set of obligatory, federal requirements set on municipalities between 2020 and 2022 like Federal Network Agency's Call for action for municipalities (Ger. *Kommunenaktion 2020 der Bundesnetzagentur*) or online access law for municipal services (Ger. *Onlinezugangsgesetz: §9 Gesetzes zur* Neuregelung *des bundesstaatlichen Finanzausgleichssystem*) (Schallbruch

2017) – the evaluation of efforts open for analysis will be included in the research and consolidated with the final form of recommendations on data integration.

3 Preliminary findings

The current findings concentrate on defining the most effective consistency check mechanism called Urban Performance Indicators (uPI) - a set of key information that would measure into what extend a concrete project aligns with the goals of a local policies/masterplan and/or with selected regulations on sustainable development. A single uPI is composed of two or more basic indicators – a formatted (urban) data with a defined data source. For instance, a uPI that measures if (and if yes into what extend, percentage-wise) the goal "zero to <10% share of internal combustion vehicles" set in a fictive Clean Air Masterplan is a composition of following data set: (1) number of registered private ICE vehicles (data source: Licensing's authority report); (2) Number of registered public ICE vehicles (data source: Licensing's authority report); (3) PM 5/10 emission level (data source: municipal sensors); (4) noise pollution level (data source: municipal sensors). The uPI should be ideally established with a help of experts with a field-relevant expertise. This measuring instrument is the first from three elements of a prototype and falls into the category of evaluation and measuring tools.

4 Outlook and further steps

The next step is to examine its possible interface with popular multi-stakeholder project management platforms (f.e. combination of Jira and Confluence). The intention behind it is to design the scaffold system of a participative idea-to-operation implementation process, regardless of the used platform – the description of such system is a second element of the prototype. Considering the fact that municipalities have only a limited financial and human resources, it is essential to concentrate the research and applied efforts on building much more intuitive and affordable tools for managing complex and long-term processes focused on sustainable development. After integrating the uPI-framework with the working platform, the guidelines and recommendations (incl. data-filters, templates, data-formats, data-storage-requirements etc.) for customized participative process-platform for urban development will be created, being the third but also the most important part of this doctoral study. Through a data- and evidence-based aspect of the platform, the stakeholders of the concrete undertaking will be given a tool to make more inform and democratic decisions (Kamlage, Nanz 2018). A working environment that visualizes the goals and back them with structured and proved information would help the governmental units and its co-players to act faster and more independent, especially while addressing the very area-specific civic demand or pressing global matters (Tobari 2018).

Acknowledgements

The pragmatic yet sustainability-oriented, inclusive character of the research would not be possible without a great support from the two representatives City of Ludwigsburg (use case city of the research) – municipality awarded inter alia in 2014 by the federal government with sustainability price - **Michael Gaiger** the head of urban planning department and **Holger Heß**, head of managemental support department settled in mayor's office; both engaged in creation of Leipzig Charter in 2007 and Smart City charter in 2017.

The doctoral study was primarily registered on university of Kaiserslautern (TUK) in Germany. Since Summer 2020 it has been unstructured to double degree doctoral studies after an agreement made between 1st supervisor **Prof. Detlef Kurth** from TUK and Concordia's University **Prof. Ursula Eicker**, Canada Excellence Research Chair in Smart, Sustainable and Resilient Communities and Cities. Prof. Kurth's support emphases the integrated urban development policies and sustainability aspects; Prof. Eicker on smart city and data-driven sustainable urban concepts – part of the work on the platform will be undertaken through the Prof. Eicker's team in Canada. Beginning in Spring 2020 **Dr Junquing Tan**, research associate on Centre for Smart Infrastructure and Construction, University of Cambridge supervises the studies on the topic of urban data systems.

A great merit support as well as financial basis for the doctoral study is provided by seecon Ingenieure GmbH. The corresponding author was given an opportunity to combine a managing and project management position (head of digitalisation unit) with scientific research. All applied aspects included in the studies have been applied in company's completed and on-going projects under a supervision of seecon's 2nd CEO **Florian Finkenstein**.

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