ADOPTION OF SUSTAINABLE TECHNOLOGIES IN SMART CITIES: A GOVERNANCE FRAMEWORK

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Abstract This research presents a literature review on sustainable technologies and smart city governance models and a primary study on people's feedback on the adoption of sustainable technologies in smart cities. Based on the gaps in the available literature and the responses of the study of 100 participants, this research introduces a governance framework to be considered for the adoption of sustainable technologies in the smart cities context. During this research, a survey has been conducted for participants from the information and communication industry to reflect on the main aspects of sustainable technologies, applications, and priorities, link with the United Nations' Sustainable Development agenda. Outcomes of the survey along with an expert interview came to conclude that sustainable technologies should include multiple aspects such as mobility, infrastructure, government, economy, living style, environment, safety, and data privacy. Sustainable technologies are considered as a new life vehicle that can drive not only the application of the technology itself but also human behaviour. The research proposes a Governance Framework practitioners may leverage to classify sustainable technologies in smart cities' context and define more governing parameters for adopting sustainable technologies.

Keywords: sustainable technologies, governance, smart cities, sustainable development, AI

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1 Introduction

Sustainable technologies have been actively utilized in cities to enhance their "smartness". Smart cities are gaining increasing recognition and are meant to be technologically managed urban spaces that leverage technologies to create a better world for citizens (Dameri et al., 2014). Some examples include computational technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, Big Data, Cloud Computing, and Virtual and Augmented reality. Therefore, these emerging technologies contribute vastly towards sustainable development (Rani et al., 2021).

Therefore, to expand on the application of sustainable technologies in smart cities, this research aims to answer the following question: what is the relevant governance framework that may be used to adopt sustainable technologies in the smart cities context? The research targets specified objectives that can be achieved through fundamental questions and are discussed below.

2 Theoretical Background

2.1 Research theoretical framework

To enrich the perspective shown by Activity Theory, the System Dynamics Theory, demonstrates the movement and interaction of different aspects of Smart Cities (Figure 1; Das, 2013). These six aspects – smart people, economy, living, environment, mobility and governance are all interconnected and affect each other. This understanding fit greatly as a visual demonstration of sustainable technology, its users and all the actors within smart and sustainable cities across the globe.

The System dynamics model (Figure 1) showcases that different aspects of the subject are intertwined and co-dependent (Sirovs, 2022, Navarra and Bianchi, 2013a; Navarra and Bianchi, 2013b). Each aspect creates a loop, and each of the loops interconnects with each other, affecting the others. In the case of the Smart City, the research aims to identify how the governance framework can facilitate the adoption of sustainable technologies in the smart cities while fulfilling SDG11, and therefore intercombination of understanding the activity theory and the system dynamic theory, the outcome of the dissertation can be achieved.

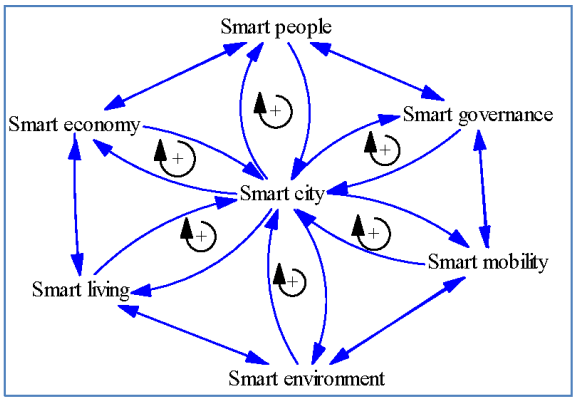

Figure 1: Systems Dynamics Model for Smart Cities
Source: Das (2013).

Sustainable Technologies (object, as per Activity Theory), are utilised across all six pillars and are a variable input to the system of the smart city as a whole. As sustainable technologies are applied by smart cities' technology users (subjects), this enhances smart living through citizen utilisation, increased quality of life and safety, health and well-being as well as housing quality. For instance, sustainable technologies such as smart lighting systems can optimise the energy consumption of electricity per living unit if made more widely accessible.

2.2 Introduction to Sustainable Development Goals

The Sustainable Development Goals (SDGs) were first introduced by the United Nations in 2015 and are supposed to be accomplished by 2030 (United Nations DESA, 2022; United Nations, 2015). In total, seventeen SDGs were developed (Wu et al., 2018).

2.3 Economic impact of sustainable technologies

According to Levi-Jaksic et al. (2018) and Stritch et al. (2018), the impact of sustainable technologies on economic welfare may result in the arrival of the concept known as a circular economy. This concept showcases the production of reusable resources through the transformation of waste, thus creating a circular flow of economic activities rather than linear hence regeneration concept is emphasised

rather than having "end of the lifecycle" (Sempels and Hoffman, 2013; Andersen, 2007). According to United Nations DESA (2022) Wu et al. (2018) and United Nations (2015) if SDGs 1,2,3,8 and 9 are achieved by 2030, the reduction in poverty, hunger, accessibility of good health and well-being, availability of decent work along with stable economic growth.

2.4 Existing smart cities governance frameworks

The balance between all aspects of the smart city can only be achieved with strong data governance established, carefully planned and implemented. Therefore, as the smart city layers must be tackled simultaneously to achieve a sustainable impact, which is in alignment with the SGD11 Goal, various sustainable data-driven initiatives are applied.

One example of technology governance in smart cities includes real-time and interactive data visualisation and cities analytics via cities' dashboards, which can give great insight into what aspect requires attention on priority (Wang & Shirowzhan, 2022). For example, if road infrastructure is overcrowded (such as in the Case of the City of London) (Bibri et al., 2020), the city introduced smart mobility solutions by applying IoT to optimise the traffic and encourage the mindset of usage of public transportation (Wang & Shirowzhan, 2022). On the other hand, the increase in mobility solutions will enable more population to move to urban areas, causing cities to expand or overcrowd yet again. This example highlights the multidimensional complexity and challenge of achieving sustainability (Navarra & Osu, 2021).

Table 1: Top 10 Smart Cities in the world.

Smart City Rank 2021	City	Smart City Rating 2021	Structure 2021	Technology 2021	Smart City Rank 2020	Change
1	Singapore	AAA	AAA	AAA	1	—
2	Zurich	AA	AAA	A	3	▲ +1
3	Oslo	AA	AAA	A	5	▲ +2
4	Taipei City	A	A	A	8	▲ +4
5	Lausanne	A	AAA	A	NEW	—
6	Helsinki	A	AA	A	2	▼ -4
7	Copenhagen	A	AA	A	6	▼ -1
8	Geneva	A	AA	A	7	▼ -1
9	Auckland	A	A	A	4	▼ -5
10	Bilbao	BBB	A	BBB	24	▲ +14

(Bris et al., 2021)

However, the top 3 ranked smart cities that most closely achieved success in establishing smart living, environment, people, economy, mobility and governance are Singapore, Zurich and Olso (ranked 1 to 3 respectively) (Bris et al., 2021, Table 1). These cities are ranked highest in the efficiency of structure as well as the use of technology.

2.5 Data governance framework by Navarra and Osu (2022)

There are various data governance frameworks have been introduced to the literature in this century (Al-Badi et al., 2018; Abraham & Schneider, 2019). However, as the concept of big data has been introduced, updated big data governance frameworks have been established. For example, Navarra and Osu (2022), have introduced a five-pillar framework which covers the data types, data process, protection, technology, applications and target audience. It showcases that the data governance framework is multidirectional and requires an interconnected approach when applying it in the smart cities environment (see Figure 2).

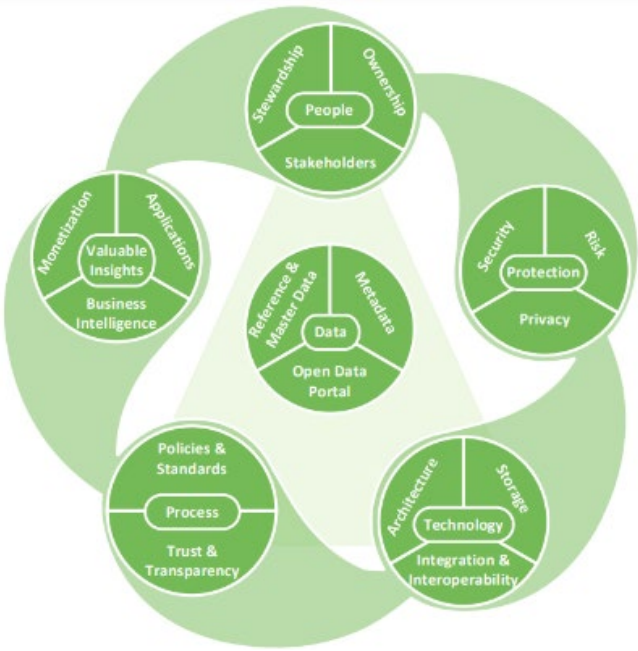

Figure 2: Data governance framework
Source: Navarra and Osu (2022).

3 Methodology

The study's research design evolves from the underlying research philosophies or positions and directly impacts the methodology described later. The primary data is mainly collected through the survey with the voluntary research participants. The survey is to be completed by a sample of 120 participants, who access the survey online through multiple channels such as LinkedIn and WhatsApp groups. The selected participants are working in the Information and Communication Technology Industry (ICT). However, there is an aim to target technology professionals, sustainable development practitioners, smart cities professionals, researchers and Subject Matter Experts (SMEs). The duration of questionnaire takes 10 minutes to complete and includes the relevant questions to achieve the research objectives. Additionally, secondary research has also been undertaken. The essential data to answer the research questions will be obtained by examining scholarly articles, research papers, government websites, business magazines, technology vendors' websites, and international organisations' publications.

4 Results

The primary research conducted via survey has demonstrated that the most important Sustainable Technology application in the future cities is by far the electric vehicles and mobility solutions. This showcases that almost half (49%) of the surveyed population sees a greater impact from this technology solution rather than sustainable energy, smart gadgets and waste recycling. Following Electric Vehicles (EVs), 27% of the participants showed solar panels as the second most important application of sustainable technologies. These indicators may inspire one important dimension to classify any technology application as "sustainable" based on the environmental impact, and demonstrate the criticality of mobility as one of the 6 pillars of sustainable cities (Das, 2013). According to the survey, half of the respondents reported that smart mobility was the most impactful technology that can improve citizen's life and will contribute to sustainable societies, while AI-based citizen services and digital assistants came in the second rank for the same. This leads to the conclusion that mobility and eco-friendly technology applications are perceived as the main criteria for sustainable societies, which correlates with the earlier perception of sustainable technology applications, which corresponds with existing research (Wang & Shirowzhan, 2022). According to the survey, 42% of the

respondents believed that using technology to ensure safety for citizens believe is having the highest impact to accelerate the United Nation Sustainable Development Goal (UNSDG) agendas.

4.1 A proposed governance framework

Based on the above research inputs, comprehensive governing aspects should come all together to formulate a collective of the main parameters to classify a "Sustainable Technology" within the context of Smart Cities. In Figure 3, the research tried to address the following aspects: mobility, infrastructure, government, economy, living style, environment, safety, and data privacy.

Figure 3: The proposed Sustainable Technology Governance Framework for Smart Cities
Source: Authors' elaboration.

Though this proposed framework represents collective criteria for the governance framework to classify sustainable technologies in smart cities' context, it is highly recommended that researchers seek further enrichment and share more thoughts on the guidelines on specific technologies or applications, as well as the implementation of it within smart cities.

5 Discussion and Conclusion

In conclusion of this studying, a wider perspective has been presented to show the importance of adopting sustainable technologies and how the governance framework developed may be used to regulate their adoption. Recommendations for further research include considering future aspects such as: (a) involving non-technology industry practitioners, such as development practitioners, sustainability professionals and also sociologists, as this may give a deeper and holistic understanding of the sustainable technology term, (b) considering sample from different development levels: the economic maturity may influence the participants' responses from the various economic background (developed, developing, and underdeveloped countries), and (c) Considering some qualitative and quantitative indicators to realize the governance framework application. While this research presents an open eye on sustainable technologies and adoption in smart cities, a limitation of this research is that it is still relatively ambiguous and uncertain what the future holds and how the human-behaviour will be shaped accordingly.

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