Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

> *"The greatest danger of turbulence is not the turbulence – It is to act with yesterday's logic."*
>
> Peter Drucker

The smart city concept brings together technology, government and different layers of society, utilizing technological enablers, such as the internet of things (IoT) and artificial intelligence (AI). These enablers, in turn, facilitate development of various aspects of the smart city including, e.g., transportation, governance, education, safety and communications. However, the transition towards smarter cities involves not only technological development but also the changing and evolving roles of citizens, service providers and city authorities. In this transition, the key issue is creating and growing roles of collaboration, participation and coordination. Whereas mainstream research focuses on smart city transformation in big cities, aspects of this transformation in the context of small cities has been a widely neglected topic. This paper presents three cases of smart city development in small cities in Finland, each concentrating on a different aspect of smart city development. The cases reveal how a relatively small-sized city may take remarkable steps in smart city development by selecting a specific theme on which to build smart city activities. These examples also emphasize the critical role of public sector actors, showing that the public sector has a key role in creating the foundations for fruitful ecosystem-based development work.

Introduction

It is not just corporations that are seeing rapid changes due to major global challenges, such as globalization, climate change and digitalization. Societies, cities and regions are also experiencing these changes. Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050 (United Nations, 2018). Thus, the speed and complexity of change also challenge leadership, organizational structures, R&D activities, education and training, and value chains. Ecosystem-based development is considered to be an option that will facilitate management of change at governmental, national, regional and company level.

The World Economic Forum report (Fourth Industrial Revolution for the Earth Series, 2018), following the work of Klaus Schwab, terms the period of accelerating innovation in science and technology as the "fourth industrial revolution". The technologies of the fourth industrial revolution have generated growing interest in the opportunities they offer as well as concern about governance, regulation and ethics (Fourth Industrial Revolution for the Earth Series, 2018). Combining artificial intelligence (AI) with big data — not to mention exponential accumulation of data itself —has created a fascinating world of communications, collaboration and interaction, not just between people but also between machines, as well as between people and machines (Salminen, Kantola and Ruohomaa., 2016). As a result, the industry 4.0 framework defines the context for digitalization and industrial IoT. This framework contains the connectivity of devices for effective value chain management using sophisticated data collection as well as data-based optimization and analysis. For this reason, industry 4.0 also provides a detailed and solid framework for development work related to smart cities (Lom, Pribyl and Svitek, 2016) because activities related to data collection, interpretation and analysis (in support of rational decision-making and planning) are central to creating smart city services in the value chain network.

The purpose of this paper is to make a practical contribution to the wide-ranging literature on smart city development by presenting three practical cases on smart city development in small Finnish cities. The cases reveal that the commitment of key stakeholders is essential to sustainable development work in this area. The results also underline the importance of providing a platform for new development and pilot studies of ecosystem-based development. The rest of the paper is organized as follows: section 2 describes a framework for smart cities, based on a concise review of literature in this field, with an emphasis on digital participation and

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

collaborative processes enabled by digitalization. Section 3 presents three case studies about small city development in a rural region of Finland. Section 4 discusses the results and gives guidelines for further research in this field.

Smart City Concept

The smart city concept derives from the intersection of studies in urbanism and information and communication technology (ICT), combined with the dimensions of creativity and humanity (Nam and Pardo, 2011; Pereira et al., 2017). The smart city concept represents new ways of organizing city functions and urban life for environmental purposes, based on digitalization (Öberg, Graham and Hennelly, 2017). In the field of ICT, rapid development of software, hardware and networks has made it technologically possible to connect people and the facilities that serve their everyday needs in cities (Pereira et al., 2017). Thus, the smart city concept brings together technology, government and different layers of society, utilizing technological enablers, such as the internet of things (IoT) and artificial intelligence (AI). These enablers, in turn, facilitate development of various aspects of the smart city, including, e.g., transportation, governance, education, safety and communications. Thus, different and often complementary aspects of asmart city encompass an efficience, technological advancement, sustainability and social inclusivity (Vanolo, 2014). General trends in this kind of development include the transition from global to local production and consumption, a change from competitive to collaborative manufacturing and service provision, and a move from shareholder-based businesses to multiple stakeholder viewpoints (Herrschel, 2013; Öberg, Graham and Hennelly, 2017).

Smart city development requires not only technological enablers but also a new way of thinking among cities, businesses, citizens and academia, which includes key development stakeholders. In this manner, close collaboration between universities and the private sector must be maintained, and the main objective should be shared learning (Ruohomaa, Mäntyneva and Salminen, 2018). This kind of long-term cooperation creates a background for new co-innovation and co-evolution.

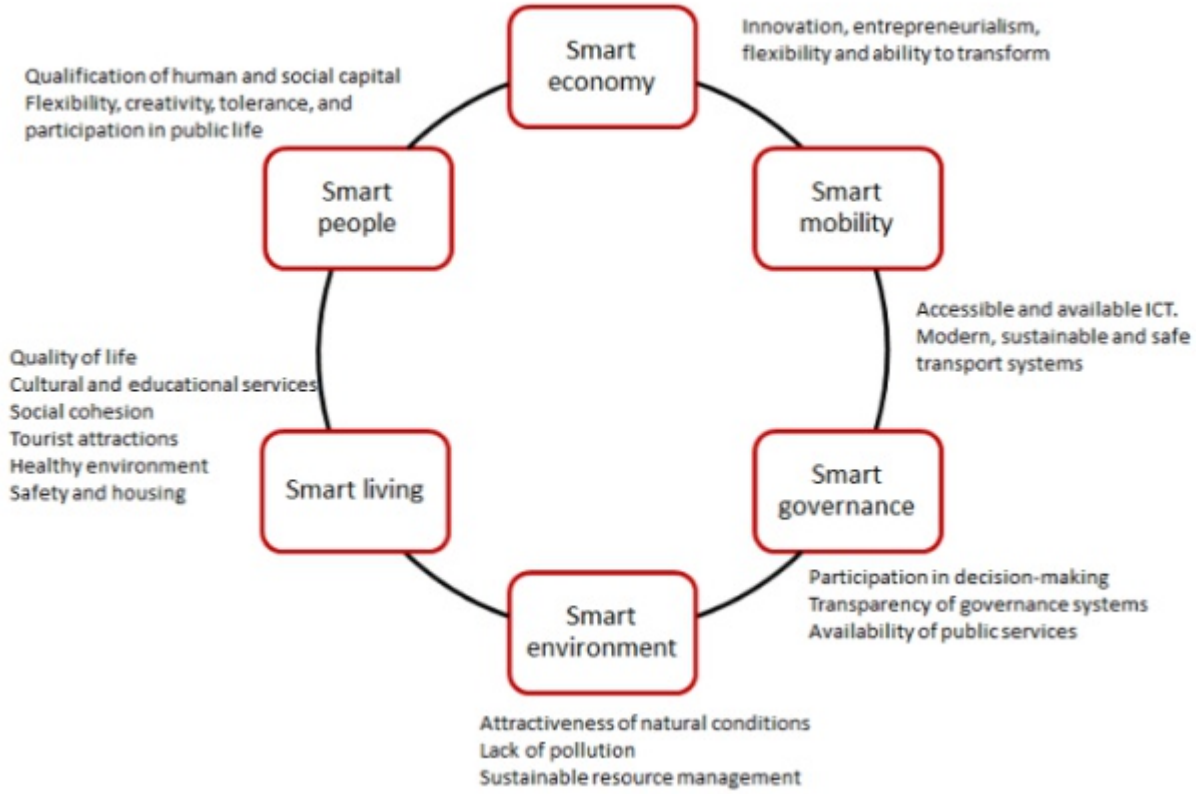

Figure 1. Dimensions of the smart city concept, adapted from Giffinger and Suitner (2015)

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

The transition towards smarter cities involves changing and evolving stakeholder roles (Lom, Pribyl and Svitek, 2016). Citizens should no longer be considered as merely users but rather as stakeholders with an active role; as participants, collaborators and developers in the city's activities. In the same manner, technology should no longer be considered as an asset but as a dynamic enabler in smart city development. Moreover, in this framework, business is no longer viewed as a provider but rather as a collaborative partner. These new roles, together with the ecosystems formed by smart cities, establish a framework for a new kind of development in urban areas. In this framework, it is important to understand that smart city development does not mean merely providing new digital services for citizens. Rather, it is a transformative process involving city structures, governance and functions, as well as interaction and collaboration between city stakeholders (Vanolo, 2014).

Smart city initiatives have recently been merged into a model to make cities better places to live in. The smart city can thus be considered as an ideal of sustainable urban living. It is nevertheless a rather vague concept, defined in various ways depending on the context of smartness (Öberg, Graham and Hennelly, 2017). According to Giffinger and Suitner (2015), the concept of a smart city should incorporate at least one of the following dimensions (Figure 1): 1) a smart economy related to, e.g., innovation, entrepreneurship, flexibility or productivity; 2) smart mobility in the context of sustainable resource management and transport systems; 3) smart governance with implications for participation, decision-making and transparent governance structures; 4) a smart environment that is understood to provide attractive, natural conditions and a lack of pollution, as well as sustainable management of resources and energy; 5) smart living and quality of life; and 6) smart people in terms of qualifications, creativity, education and flexibility (Vanolo, 2014). In this manner, smartness in the smart city context can be associated with very different phenomena. One factor that these phenomena have in common is sustainability, which is included in one form or another in almost all of the above-mentioned dimensions (Öberg, Graham and Hennelly, 2017). Moreover, Herrschel (2013) suggests that the smartness of smart cities has come to include "innovativeness, participation, collaboration, and co-ordination". This highlights the role of smart processes, collaborative practices and ways of working as opposed to pure ICT-based technological development. The latter is seen as an enabler, rather than as a key element of the smart city concept. Despite this rather broadly defined framework, previous literature in the field of smart city development is relatively coherent in suggesting that digitalization and urbanization are making production and consumption less global and more local, thus changing manufacturing from competitive to collaborative and business from a single shareholder basis to multiple stakeholders (Öberg, Graham and Hennelly, 2017). In this context, data-driven service operation can be used to significantly improve service performance, by implementing the right data strategy (Pulkkinen, Jussila, Partanen and Trotskii, 2019).

Figure 2 displays the essential framework for a digital ecosystem in smart city transformation (Ruohomaa and Salminen, 2019). In this framework, the general

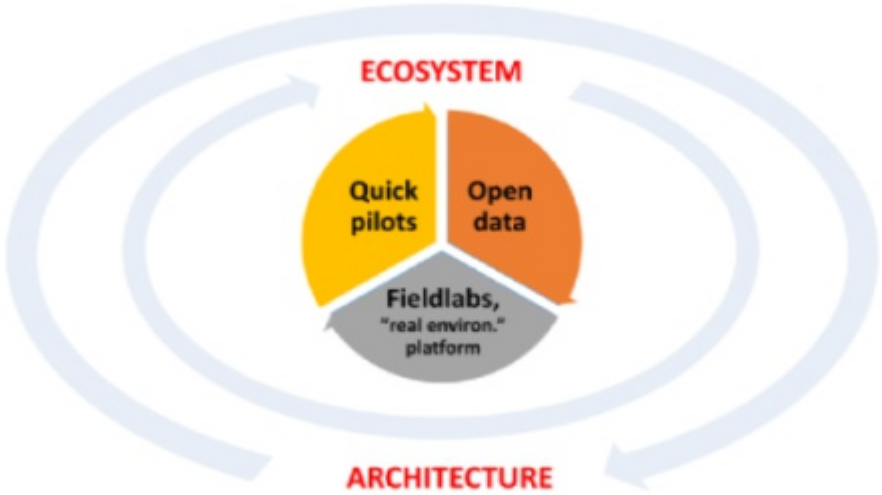

Figure 2. Digital ecosystem in a smart city context (Ruohomaa and Salminen, 2019)

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

architectural layer enables the involvement of private-sector partners. At the same time, the players in this framework form an ecosystem that consists of inhabitants, tourists, companies and the city itself.

The concept of a city's 'smartness' can be understood on three conceptual levels (Lom, Pribyl and Svitek, 2016). Firstly, in the context of marketing, smartness involves user perspective.The smart services related to smart cities are linked to user-friendliness, which means that smart cities require conceptual adaptations to end user needs and interfaces with the city's inhabitants (Marsá Maestre et al., 2006). Secondly, in the context of strategic management and development, the smart city concept is directly related to the strategic and ideological directions taken by urban planning. This is because public actors, such as governments and cities, at all levels, utilize the concept of smartness to distinguish their new strategies, development programmes and policies, as a guideline for the development of urban areas in terms of economic growth, sustainable development and better quality of life. Smart governance (or e-governance) means that various key stakeholders are engaged in decision-making and public services through, e.g., social media, open data or other internet-based participation platforms (Pereira et al., 2017). A key issue in facilitating these kinds of participatory tools and services is collaboration across departments and communities; which tests the real user-centeredness of these services. Thirdly, in the context of technological development, enablers of the smart city concept utilize the methods of artificial intelligence (AI), the internet of things (IoT), and machine learning (which all rely on sophisticated data collection and analysis), to apply these commercially. These technological enablers facilitate the development and deployment of ICT-related aspects of smart cities, e.g., smart transportation, smart energy, smart education, smart safety and smart communication (Lom, Pribyl and Svitek, 2016). Together, these three levels of the smart city concept form a smart city ecosystem, which represents an extension of smart space from personal surroundings to the larger community and entire city. Table 1 illustrates the basic characteristics of the smart city ecosystem.

Table 1. Characteristics of a smart city ecosystem

Context	*General direction*	*User point of view*	*Governance point of view*
Marketing	User perspective is emphasized.	Usable, accessible and user-friendly digital services.	Service process needs to be adapted to user needs and interfaces.
Strategic management and Governance	Governments and cities at all levels utilize the concept of smartness to engage various stakeholders in decision-making.	Citizens are considered as key stakeholders, participating in decision-making and city development through participation tools.	Cities facilitate participatory planning and decision-making by providing citizens with digital participation options.
Technology	Utilization of AI, IoT and machine learning together with data analysis to provide smart services.	Improving quality of life through smart services.	Providing citizens with relevant digital services, facilitating sustainable living in cities.

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

Case Studies

The purpose of this paper is to consider smart city transformation in small cities by focusing on selected areas. In this section, we present three cases, each focusing on one small city in Finland. In the first case, we present the case of Hämeenlinna. In its ecosystem-based development work, this city has faced a cumulative increase of data, and has used new technologies to respond to the rapid change and complexity of the business environment. The case study is based on the smart mobility part of the framework in relation to bikes. The second case considers the town of Riihimäki. Riihimäki relies on smart specialization by adapting digitalization and robotics to improve the overall competitiveness of local business, society, educational environments and city services. The third case presented is that of Forssa. The Forssa case focuses on a circular economy in terms of industrial development and town services. In this manner, experience and understanding of the circular economy and industrial symbiosis have facilitated greater understanding of how to develop smart living, education and tourism in the Forssa region. Table 2 summarizes the key characteristics of each smart city development case.

1. The Case of Hämeenlinna

The city of Hämeenlinna has recently started ecosystem development work aimed at improving the town's competitiveness and sustaining its surrounding region. Key stakeholders involved in ecosystem work include city authorities, local companies, the local university and other educational institutions, as well as city inhabitants. Digitalization and developing smart city services are among the key targets of this ecosystem building work (Kunttu, 2019). Weveral pilot projects have been initiated to develop smart city services in Hämeenlinna.

The pilot project presented in this paper is an electronic bike service, which will be detailed along with data that can be collected for further use (Figure 3). As part of the smart mobility concept, the bike-share operators and cities in which they operate want bike-share travel to become a viable part of the transportation system for city residents. In this manner, bike sharing is a city transport solution and a smart answer to urban mobility, providing a competitive alternative to private cars and existing public transport services (Dennis, 2018). In the Hämeenlinna bike project, yellow-and-green bikes are made available in selected locations around the city (see Figure 4). Users can check the availability of the bikes and rent one by using a smartphone application. Open data provided by the bike-sharing service are utilized in several ways. In the direct data-based service, users are able to see the availability of bikes in the town. In the indirect services, data are used by the bike operators to ensure availability and also to maintain the bikes. The city authorities are also aiming to utilize the collected bike data to plan cycle routes and services for bikers.

2. The Case of Riihimäki

The town of Riihimäki bases its strategy on robotics for developing an attractive business environment. Since robotics has been selected as the strategic focus area for the town, the authorities are committed to long-term development and implementation of robotics in a wide range of life and working environments. Development

Table 2. Characteristics of each city in the case study

	Hämeenlinna	*Forssa*	*Riihimäki*
Number of inhabitants	67,000	20,000	28,000
Focus areas	Education, local governance, military base	Circular economy	Manufacturing industry
Focus area in smart city development	Smart mobility	Smart environment (circular economy)	Smart living (service robotics)
Smart city pilots	Bike-sharing service	Recycling and waste management services	Robotics in education and elderly care

activities in Riihimäki are interlinked, and follow the European industry 4.0 framework to ensure cross-jurisdictional comparability and compatibility. An industry 4.0 framework with robotics can also be used to indicate intent to the European Digital Single Market, and thus attract new business to the town. To ensure implementation, it is necessary to have an open atmosphere so that stakeholders, including citizens, business actors and town authorities, can participate in robotics development and innovation activities. By involving multiple stakeholders, it is possible to reduce resistance to change, increase commitment, and obtain new development ideas.

Utilization of robotics and digitalization requires new skills (not only technical but also multidisciplinary) and a broad approach. For this reason, the town of Riihimäki has invested heavily in educational robotics activities, ranging from nurseries and elementary schools, to university level and lifelong learning for adults, integrating this with the needs of various sectors, including industry, health care, education, and traffic. Education is not only seen as a way of building know-how, but also of reducing resistance to change, speeding up implementation and promoting a positive attitude to robotics. Education is also fundamental to innovation when it takes place in "real-life" environments, in pilots and quick trials. The town has also arranged several events related to robotics, including competitions and development challenges for students. The city has also collaborated closely with the local university on these activities.

The three main areas of robotics development in Riihimäki are production robotics (focusing on industrial automation and manufacturing), service robotics and the robotics of health care. The pilots for these three aspects are being undertaken in various parts of the city. For example, care associations are running pilots for service robotics in the field of elderly care (Bäck et al., 2012; Bäck, Mäkela and Kallio, 2013) in collaboration with the local university.

3. The Case of Forssa

The town of Forssa is in the middle of the Finnish agricultural landscape, located within a triangle formed by the three largest cities in Finland, and with good transportation connections. The largest national research institute for agriculture and bioeconomy is also located in the Forssa region. In addition, the bioeconomy and agriculture departments of the regional university of applied sciences are located there.

The history of the Forssa circular economy business ecosystem dates to the 1990s, when the first EU waste treatment directive was launched. Because of this,

Figure 3. Bike-sharing service at Hämeenlinna railway station

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

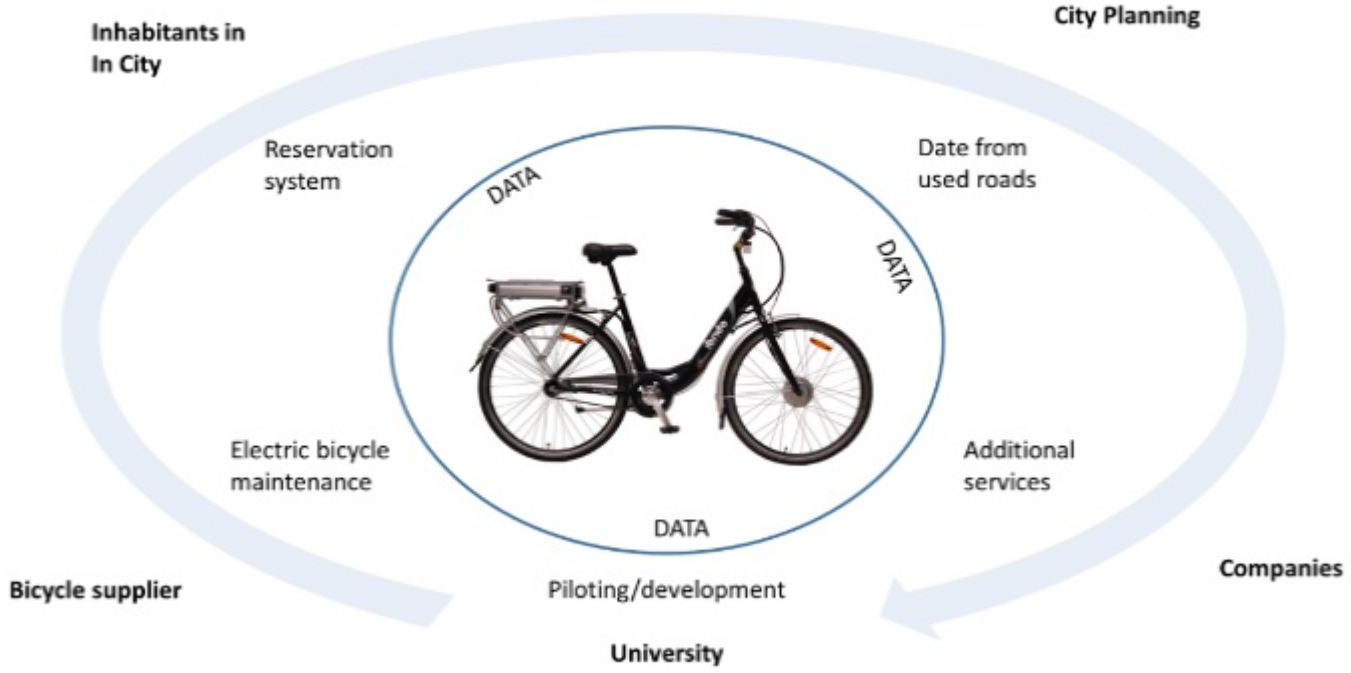

Figure 4. Pilot of the electric bicycle digital ecosystem

Forssa and the surrounding municipalities decided to create a large landfill area, where all the companies involved with waste handling or treatment could be located. Since then, several companies operating in the waste management business have moved to this area. Their close proximity makes it easy for these companies to cooperate with one another, and in this way an ecosystem has been created for a circular economy and industrial symbiosis. The circular economy ecosystem in Forssa is currently ranked the best in Finland.

Nowadays, in the Forssa region, strategic focus is placed on a circular economy. R&D funding is used for the development of this circular economy, and the local university has adapted its degree programmes to support circular economy education. The local authorities are highly supportive of ecosystem-based development, and new start-ups focusing on circular economy activities. Figure 5 presents a visualization of industrial symbiosis of the circular economy ecosystem in Forssa. Based on this, the town of Forssa and its surrounding regions are being branded as the "Smart Green Forssa Region". Also related, Forssa hosts an annual circular economy event for start-ups and growth enterprises (FRUSH) to make its activities visible, attract investors and promote circular economy-related start-ups.

The city of Forssa has also selected the circular economy and smart city development as part of its strategic focus. The reason behind this is the fact that although the circular economy and industrial symbiosis were largely driven by industry at the outset, these developments have had a marked impact on the of city of Forssa, and have led to increased understanding and thinking among its citizens generally. Thus, the city strongly supports resource efficiency and circular economy development in its everyday activities. Circular economy thinking has had a major impact on education, environment, living, services and tourism. A concrete example of this is the local waste management facility, which continuously produces new user innovations for smart recycling and effective resource utilization.

Conclusion

In the existing literature related to smart city development, a wide consensus exists on the need to build new smart city solutions because of urbanization, user expectations, technological development, and environmental challenges. This paper presented practical viewpoints, cases and experiences relating to the planning of smart cities, and the availability of services. We also considered how these examples could

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

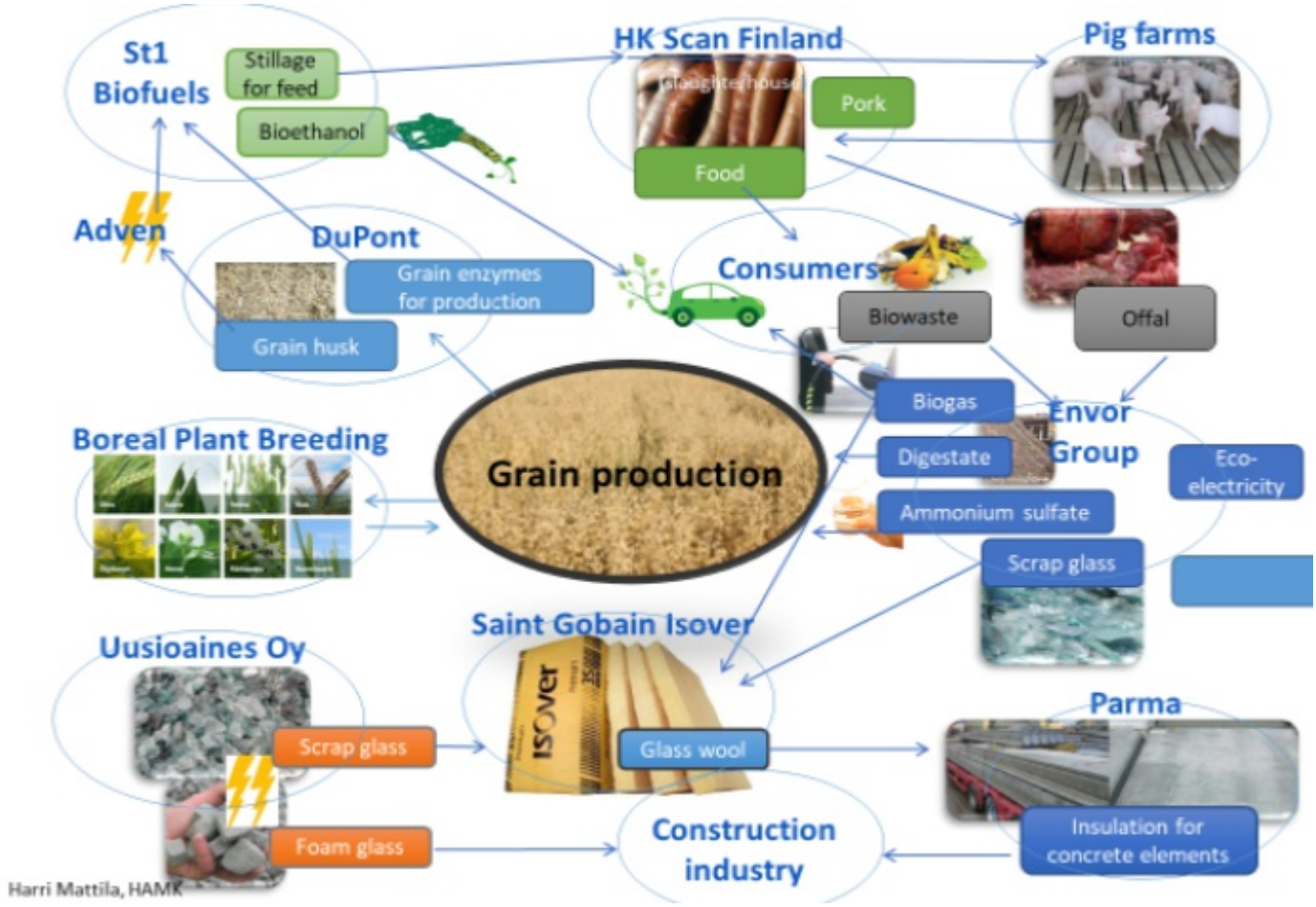

Figure 5. Efforts made in the Forssa region to visualize local bio-based industrial symbiosis

be used as a tool for city planning in a smart city context. In this way, the paper may provide helpful information based on "lessons learned", relevant to all the actors involved and interested to participate in smart city development (and the fundamental services themselves).We presented a case study of three small cities in southern Finland, all of which had selected to undertake smart city development in a clearly defined area directly related to the strategic focus of the city or region. In this manner, a common denominator for the cases was that each town is basing its smart city activities in key strategic areas. In all three cases, the towns were actually platforms for smart city development projects, which enable inhabitants and other stakeholders to participate in planning and development, and thus become part of the ecosystem.

These case studies show that the public sector has a fundamental role in fruitful ecosystem-based development. They reveal larger initiatives where towns are moving their development activities towards ecosystem-orientation. This is changing what it means to be organized so that an ecosystem can be more responsive to the impact of digitalization and increasing amounts of data.

Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

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Towards a Smart City Concept in Small Cities

Heikki Ruohomaa, Vesa Salminen, Iivari Kunttu

About the Authors

Mr. Heikki Ruohomaa is currently as research manager in the HAMK Smart Research Centre at Häme University of Applied Science. He is involved with various research activities, education ja (?) industrial implementation. His areas of expertise include ecosystem-based development, circular economy and Industry 4.0. He has also worked actively for regional development.

Dr. Vesa Salminen is currently acting as research director in the HAMK Smart Research Centre at Häme University of Applied Sciences. He is involved with various research activities, education and industrial implementation. His areas of expertise include innovation leadership, the data-to-service process, industrial service business, competence management and strategic management of business transitions. He previously worked as industrial professor at Lappeenranta University of Technology and spent two years as senior research scientist at the Massachusetts Institute of Technology, MIT, Boston. He has over 25 years' industrial experience, which includes being managing director of Spiral Business Services Corp., technology expert at Technology Industries of Finland, and marketing/sales/project expert at Valmet Corp. Salminen has published over 200 refereed journal articles, book chapters and conference articles, e.g., through Springer Publishing, Elsevier Publishing, Intech Media, IEEE Publishing, ASME Publishing, IST Publishing and IGI Global Publishing.

Dr. Iivari Kunttu holds a PhD degree in Information Technology from the Tampere University of Technology (TUT, 2005), and a PhD degree in Economics (management) from the University of Vaasa, Finland (2017). Currently he acts as Principal Research Scientist in Häme University of Applied Sciences. In 2012-2017, he held an Assistant Professor position in Department of Management at the University of Vaasa. He has also held several R&D Manager and R&D process development specialist positions in the Nokia Corporation, and project manager positions in TUT. His current research interests include R&D and innovation management, data analysis, business development, as well as digital services. His works have been published in such international journals as *Pattern Recognition Letters, Machine Vision Applications, Optical Engineering, Journal of Telemedicine and Telecare, Annals of Long-term Care, Technovation, Industry and Innovation,* and *Technology Innovation Management Review.*

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