



MASTER THESIS

DIGITALIZATION OF WASTE MANAGEMENT PROCESSES IN SMART CITIES OR REGIONS

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ABSTRACT

Rapid urbanization caused important economic, social and demographic transformations. Therefore, smart cities are emerging all around Europe, claiming to be the future of urban areas strategies. Due to a lack of agreed definition, this study identifies smart city or region's characteristics and emphasizes the importance of digitalization in waste management processes. A case study will be used to understand organizations' main challenges and key success factors and create a guideline for waste management actors willing to shift towards smart processes. In collaboration with a Dutch waste management company, the aim is to draw recommendations for any waste organization and guide the mentioned company in its willingness to develop a Smart Region initiative. The findings depict the motivations and smart objectives of the actors and insist on the importance of collaboration along with digital tools and processes, to achieve their goals. The benefits and limits of digital transformation are also discussed.

INTRODUCTION

The concept of a city or a region's « smartness » has been introduced recently and rapidly raised the public interest around its complexity. Still today, a smart region is a large concept encompassing diverse definitions. Many different interpretations exist, where academics and organizations try simultaneously to break it down into specific characteristics, to create a standardized framework. For many, the notion of smart region is a consequence of the development of smart cities worldwide. Therefore, it is important to first understand the context in which cities started to evolve into smart cities, and then how the expansion of its networks could reach a regional level. Moreover, the role of technology has increased with the fourth industrial revolution, which has transformed the business context (Kayikci, 2018) and revealed new digital infrastructure and capabilities (Esmailian, Wang, Lewis, Duarte, Ratti & Behdad, 2018).

All around the world, a phenomenon of rapid urbanization has grown. People are attracted by the opportunities a city could offer: jobs but also better access to transportation, better education, diverse cultural activities etc. Moreover, the United Nations predicts an increased level of urbanization up to 66%, worldwide, by 2050 (Yin, Xiong, Chen, Wang, Cooper & David, 2015). This development leveled up the population's standards of living by providing a large water supply, modern residential and office buildings, elaborate transport networks, higher education or health services (ibid.).

However, the expansion and overpopulation of cities has become a key global issue and caused important economic, social and demographic transformations (Yin et al., 2015). For instance, waste generation has become a fast-growing problem of modern societies, particularly in growing urban regions (Esmailian et al., 2018). In 2016, around 2.01 billion tons of municipal solid waste were generated and this number is expected to grow to 3.40 billion tons by 2050 in our current context (Kaza, Yao, Bhada-Tata & Van Woerden, 2018). Meanwhile, cities and countries are rapidly developing without adequate systems in place (ibid.).

These challenges raised a public awareness on the urgency to shift the attention on more sustainable practices of cities, by developing a set of technical solutions to reduce these urban problems (Yin et al., 2015). This strategy has been interpreted by academics as the result of rapid development of digitalization by Information and Communication Technology (ICT),

which facilitated the apparition of “smart cities” seen as the future of urban areas (Yin et al., 2015).

The transition to this futuristic form of cities’ organization appeared for some in the 1980’s, from discussions among scholars and practitioners about smart cities. They based their analysis on the example of the Silicon Valley, seen as a new form of ventures creating an entrepreneurial city, where businesses innovate and adapt to become more competitive on the global market (Glasmeier & Christopherson, 2015). Others say that the term “smart city” was cited for the first time in the 1990’s, when researchers have compared the process of urbanization to the transition to new technologies through innovation and elaboration of global processes (Yin & al., 2015). In the 2000’s, the modern vision considers that smart cities are places transformed by the introduction of technologies rather than places where the informatics sector drives the economy and development of the city (Glasmeier & Christopherson, 2015).

The health of a region depends on the interconnectedness of its networks in urban and non-urban systems, including cities. Therefore, it must be important to see the implementation of an innovative approach in its entirety, connecting all actors susceptible to be impacted or to help in the construction of this new smart organization (Sutriadi, 2018). Smart cities and smart regions therefore share the same components and characteristics and should be analyzed similarly (Kodym & Unucka, 2017).

The urbanization process raised a global interest about the notion of smart city or region and many took up the subject and tried to set a standardized and replicable framework. Numerous authorities tried to define smart areas. An extended list of definitions now exists from several national governments, international organizations or the private sector. Notably, the OECD collected hundreds of definitions and selected the twelve most relevant to depict what has been found so far. From this database, they created a framework of smart cities and summarized the key elements needed to compose one (OECD, 2019). The list included the economy, environment, society and people, governance, mobility, satisfaction and propagation. The wide range of topics covered shows the duty of all actors active in all sectors to get on board and make change happen. However, because of no agreed definition, it makes it very complex for them to evolve homogeneously towards smart processes and develop standardized tools.

One recurrent element demonstrated special attention in playing a key role in planning the sustainable transition of a region: solid waste collection and management. It is considered fundamental due to its inevitable output present in all contexts or places. Waste is a global issue present in each and every frameworks or action plans and at all scales of projects.

A gap exists between the growing interest of cities or regions to become smart and the lack of theoretical information about their characteristics, more particularly towards wastes. Therefore, the aim of this research is to focus on urban area's waste management processes and understand their strategy towards the use of digitalization to improve their activity. This research will answer the question: what are the positive and negative impacts of digitalization in waste management processes, for cities or regions willing to become smart(er)?

First, the theory section will gather previous research and official definitions of smart cities and regions. This will enable the reader to see the evolution of the concept and the importance of waste management within the process. Then, a detailed methods section will describe the reflection behind the construction of the interviews and present the chosen organizations composing the case study. Later, the data collected from each interview will be analyzed to identify the main challenges and key success factors of evolving towards digitalization in waste management processes. Finally, recommendations will be given for waste management actors willing to shift towards smart processes.

THEORY

Definition and opportunities of a smart city/region

As already pointed out, there is no unique definition of a smart region, nor of a smart city because of the newness of the concept. Several institutions, municipalities or organizations developed their definition according to their vision, but also to their context-specific challenges and opportunities. The mentioned OECD report highlights the high number of stakeholders, willing to take up the concept and trying to understand its complexity to create a stable foundation. In a sum, they all agree that smart city is an evolving concept still subject to debates, focused on initiatives using digital and ICT innovations to improve the quality of urban services and create new opportunities (OECD, 2019).

OECD Definition: *“Smart cities are defined as initiatives or approaches that effectively leverage digitalization to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process”*.

The European Union also embraced the topic by creating a new program, the Research and Innovation Strategies for Smart Specialization (RIS3) (Markkula & Kune, 2015). The aim is to support regions to follow Europe’s smart specialization transformation’s agenda. This interactive program includes a regional policy framework, which incites the private sector, universities and the government to leverage regional strengths and capacities.

European Union Definition: *“A smart city is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses”*.

In a sum, the smartness of a region is built upon its interconnectivity among diverse private and public actors to promote the development of their region and fulfill its population’s needs using digitalization and technologies. A smart region must also continuously increase its knowledge by including human resources as part of its development (Sutriadi, 2018).

Smart cities or regions development can open its ecosystem to unexplored opportunities, only if some notions are examined beforehand. It is important to define what improvements new technologies can but also can’t bring, understand the expansion conditions and see how far off those conditions could be applied to the market (Glasmeier & Christopherson, 2015). However, benefits could also be considerable and could solve urgent urban problems while providing the population with a better living environment (Yin et al., 2015).

Main factors constituting a smart city/region

Kodym and Unucka (2017), developed a framework: “The relationship between components and characteristics of Smart Region/Cities”, explaining the influence of three main components: technology, human and institutional factors. In complement, other academics have emphasized the importance of pro-business environments and networking in smart cities/regions’ strategies (Angelidou, 2016).

Technology

Cities are tempted to redefine themselves through new ways of thinking and technologies usage to enhance collective interest. Indeed, technological advancements represent a recent alternative to impact urban life. The omnipresence of new tools in most countries, such as Information and Communication Technologies (ICT) or the Internet of Things (IoT), aspire smart cities to use their unlimited possibilities to improve its human and technological capital, with the potential to increase urban sustainability (Angelidou, 2016). Technologies stand also as a solution to accumulate information and make it accessible to a wide number of people. For instance, most of the digital services and applications integrate waste management to improve the waste collection process (Angelidou, 2016).

Human

Human and social capital advancements have been growing through knowledge, intelligence and creativity. The widespread capacity of people to use technologies, developed new forms of innovation and created another vision of citizenship, which is an essential ingredient of smart cities. The future “smart people” are those possessing sufficient qualifications, flexibility, creativity and are open-minded to engage successfully in the society (Giffinger, Fertner, Kramar, Kalasek, Pichler-Milanović & Meijers, 2017). If a smart city population tends to become smarter over time, it will positively affect the rapid growth of the entire environment (Glaeser & Berry, 2006). However, it is the city’s responsibility to ensure privacy and security of sensitive data to its population (Angelidou, 2017).

Institutional

Cities or regions must take into consideration the local challenges, needs and opportunities to locally adapt general strategies. It includes the location, the infrastructures, the population and the shared culture (Paskaleva, 2011). Institutions also play an important role in top-down coordination to conciliate ethical and political challenges. They must balance short-term political interests with the community’s long-term. Hence, leaders have the duty to foster long-lasting collaboration between governments, industries, cities and citizens while pursuing the triple-bottom-line objectives (Angelidou, 2017). A strategic framework should be set to reflect the structure of the city or region’s initiatives, highlighting the specific priorities in both short and long-terms (ibid.).

Development of business

The business sector advancements are due to two main factors: entrepreneurship and interdisciplinary planning (Angelidou, 2016). New businesses are necessary for sustainable ventures, where innovative environments attract skilled workers, which serve for the development of the region itself. In order to push the present population to launch a business, regions' initiatives should raise from interdisciplinary planning. All specialists should be included in the process to generate new ideas and discover new possibilities (Aurigi, 2006).

Networking

Finally, the last factor composing smart cities or regions is the strong alliances among their actors but also among each other. Collaboration enables better communication, sharing best practices and experiences to complement each other in their weak and strong points, to create diversification and establish economies of scale (Angelidou, 2017). Here, a participatory approach is needed to engage stakeholders in a bottom-up planning of smart projects. Online platforms, applications and smart devices provide unique possibilities to improve and open the social dialogue. Actors must make use of them instead of using most of their energy and resources to compete between each other.

Impacts of digitalization

The five factors identified in this research are needed to maintain a certain equilibrium and involve all the necessary actors from various sectors and industries. More specifically, special attention has been given to digital tools and innovation in Kodym and Unucka's (2017) framework, under the "Technology" category. Many academics discuss the positive and negative impacts of digitalization on operations, logistics, business models or company performance.

On the one hand, digitalization is perceived as beneficial to create knowledge and networks at a faster rate, optimize the efficiency on decision-making processes and speed a company's internationalization strategy (Neubert, 2018). The Internet of Things (IoT) appears to be significant in this digital transition, likely to lead to new software architectures where more open standards will emerge. It shows promise of an optimization of the control and operations in the process industry (Isaksson, Harjunkoski & Sand, 2018). Some studies discovered a large sustainability impact of digitalization in logistics. Companies using digital technologies and

applications could benefit from economic and environmental implications, through affordable and collaborative solutions while reducing greenhouse gas emissions, pollution and waste (Kayikci, 2018). Therefore, digitalization is expected to create more value for society than economy. In this instance, businesses, policy-makers and regulators will need to collaborate to maximize this value (ibid.). Business models must also adapt to welcome digitalization to increase innovation and company's performance. Indeed, some forms of digital transformations fundamentally affect businesses, like the emergence of block chain, forcing them to adapt their strategy to survive in this new environment (Bouwman, Nikou, Molina-Castillo & de Reuver, 2018).

On the other hand, others bring a critical opinion on this over-digitalization phenomenon. Most importantly, data should not substitute human vision insight. Balanced must be found between data and experience in terms of decision-making processes (Serban, 2017). Additionally, a wrong management could lead companies to ineffective and costly investments, when collecting large amounts of data instead of seeking the appropriate one (ibid.). More specifically, digitalization is accused to alter how humans interact with each other and with their environment. Because of its questionable role of surveillance, digitalization could limit people's or organizations' legal rights to privacy, or could lead to dangerous misuses, which could be politically or socially discriminatory (Seele & Lock, 2017).

Focus on waste management in smart cities or regions

Even though waste management has improved considerably across the EU, still 1/3 of municipal wastes are landfilled and only less than 1/2 are recycled or composted (European Law Monitor, 2020).

Once again, the OECD and the European Union include this growing issue in their frameworks and action plans. On the one hand, the OECD selected indicator framework for smart cities mentions seven key dimensions, where waste appears under the "environment" category (OECD, 2019). The European Union, on the other hand, focused on circularity and developed a Circular Economy Action Plan, published in 2019, willing to transform Europe's economy towards sustainability by 2050 (European Law Monitor, 2020). The European Council and Commission set the goal to close the loop of product lifecycles by reducing the amount of waste generated and shifting as much as possible its treatment to recycling.

Cities play a major role to develop their own Resource Management Plan, needed for the country to reach the EU goals. Here again, IoT arises as a promising solution for conducting waste collection and recovery operations in urban areas (Esmailian et al., 2018). The overall system architecture of IoT includes several digital tools, such as RFID tags, capacity sensors, actuators or wireless antennas. All those innovations are seen highly effective for real-time monitoring or optimized waste collection routes. Therefore, the transition to become a successful smart city requires improvements in its waste prevention, collection and value recovery (ibid.).

The topic of waste is largely present in discussion regarding sustainability and regional development, however lacks information and analysis from the academic field. Therefore, this research will try to fill the gap by collecting insights from experts' experience and success.

METHODS

A qualitative approach is used to tackle the specific research question: “What are the positive and negative impacts of digitalization in waste management processes, for cities or regions willing to become smart(er).?”.

Qualitative research

Qualitative research is the most effective method to gather specific data on a place or a community to better understand its challenges. Previous studies in social anthropology demonstrated it doesn't make sense to analyze specific practices, unless having a large understanding of the society it is embedded in as well (Bryman & Bell, 2011). Waste management is deeply embedded in its context, influenced by the city's or region's location or strategy. Therefore, the need to collect specific information is essential to equally ensure validity and reliability in the research findings (Mays & Pope, 1995). This study focuses on four different European regions: the Netherlands, France, Denmark and Finland; all being developed at different levels and facing different challenges. This confirms the necessity to use a qualitative method.

Moreover, the theoretical background of a smart city or region demonstrated a confusion in its definition. When the definition of terms is not clear, academics advise to opt for a qualitative method where the author can explore different backgrounds and opinions on the topic (Sauro, 2015).

One other strength of conducting a qualitative research is the accuracy brought to the information (Cardano, 2020). This method allows the participants to express themselves in their own words and refer to their familiar environment, helping them to approach the topic more easily (ibid.). Therefore, interviews are necessary to explore people's experience and knowledge on the field, very important in this case, because each expert was asked to explain the main challenges and key success factors encountered in the digitalization of their waste management processes.

The aim of this research is to focus on urban area's waste management processes and understand their strategy towards the use of digitalization to improve their activity. For this purpose, ten professionals working in the waste management sector or development of new technologies were interviewed.

Data collection and analysis

An inductive research was conducted about smart cities/regions to research significant elements from theory or previous published articles. Also, triangulation was done by an analysis of each chosen organization prior interviews, using available online data. This preliminary research was necessary to gain a better overview of smart characteristics and compare these findings to what is already implemented in each regional ecosystem. However, because of the lack of information due to the newness of smart cities/regions' concept, interviews must be conducted to answer specific questions and compare the results to draw conclusions.

A semi-structured method was used to construct the questionnaire (see the list of questions in Appendix A). A list of key themes, issues and questions were defined beforehand. However, this type of structure allows to follow the set interview guide while changing or adding questions, depending on the direction the interview takes. Because each interviewee worked in different organizations, countries and tackles different challenges, such flexibility was needed to be able to deepen a potential aspect brought to attention during the interview (Kajornboon,

2004). This method gives the opportunity to explore the interviewee views and opinions, which were not initially considered. Then, a content analysis method was used to analyze the data. It indicates the categorization, tagging and thematic analysis of qualitative data (Medelyan, 2020).

Therefore, to confirm data saturation in this research, firstly ten experts were interviewed, all having a similar expertise in terms of waste management and/or digitalization in the waste management industry. Second, triangulation was used to increase the amount of information and partly overcome the limited sample size.

Coding system

First, the ten interviews were recorded and put into transcripts. Then, a structured reading identified the first key quotes. The data was interpreted using an inductive coding, also called open coding process. Reading a first sample, here one transcript, enabled me to highlight interesting sentences. They became codes when the idea was repeated at least three times by the pool of participants. When reading the other samples, the defined codes were applied and new insights created additional codes. Therefore, the data was first analyzed with an open coding system, followed by two other times using predefined codes. This process has been applied to ensure validity of the findings. Open coding is an iterative but tedious and repetitive process. However, it gives a more complete, unbiased look at the data. It also helps to create linkage between the data and the research question (Rowley, 2012). Lastly, comparable codes were grouped into sub-categories using a flat coding frame, to create the six categories of this paper.

Pool of participants

The ten interviewees were chosen according to their direct contribution and implication in waste management or development of digitalization projects. A basic profile was depicted according to their job role, qualifications, experience or involvement in the sustainability department. The selected professionals were approached by an initial email shortly summarizing the purpose and aim of the research and their expected contribution in terms of information and time, before answering the different questions over phone meetings, lasting between 30 to 60 minutes.

The pool of participants is composed of three professionals operating in municipalities, four in public owned waste management companies and three in private software businesses. Each participant’s position is listed in the recap table below and additional information on the organization and interviewee can be found in Appendix B.

Overview of the research’s participants:

Participant	Position	Type of organization	Country
A	Waste Management Director	Territorial community	France
B	Waste Strategy Responsible	Municipality	France
C	Environmental Expert	Municipality	Finland
D	CEO	Public owned waste management company	The Netherlands
E	Senior Advisor	Public owned waste management company	The Netherlands
F	Program Manager Circular Economy	Public owned waste management company	The Netherlands
G	Environmental Manager	Public owned waste management company	Denmark
H	CEO	Software publisher and integrator	France
I	Marketing Director	Software publisher	France
J	Entrepreneur & Founder	Vocal interface company	France

RESULTS

Tools and processes

Sub-categories: sensors in containers, geolocation systems, pay-as-you-throw techniques, communication channels, voice interface, open data structure.

Implementing digitalization in organization’s processes involves including many new technological tools to their operations. All the interviewees mentioned general and specific tools they started using when they decided to turn towards digital objectives. The one which systematically came up was the usage of sensors in containers, to keep track on their wastes, which helps to recognize easier when the bins are full in order to empty them. Participant I explained: *“We created connected public bins, under which we placed sensors to detect their filling level. The objective was to recover precise data from these sensors and combine the IoT with reports done by the city, where it mentions if they were full, empty, damaged, dirty or even broken”*. Municipalities and waste management companies are often combining this technique with geolocation systems. Participant A mentioned that *“All our trucks are now equipped with vehicle tracking”*. Moreover, some communes started using pay-as-you-throw techniques, as

participant B described: *“Some municipalities are using special pricing systems. It means they charge the trash depending on what the household produces”*. In Finland, digitalization is mainly focused on their communication channels. They developed a waste guide on their website: *“You can go on our website and type the waste you have and the guide will tell you what waste it is and where to sort it”*. Finally, some actors are exploring the benefits of very specific tools, such as voice interface or open data structure, to optimize their processes and create a dialogue between different actors. *“The city is trying to extensively develop open data. On the related website, you will find open information available to everyone, for other actors to spread the word”*.

Motivations

Sub-categories: environmental motivations, economic motivations, population pressure, political pressure.

When implementing a new strategy, organizations have, on the one hand, their own motivating factors related to their industry, level of development or research and development facilities. Those internal motivations were mainly approached by the interviewees on two levels: environmental motivations and economic motivations. Participant C said: *“That’s one of our main motivation, to reduce the amount of wastes as well as the CO₂/carbon emissions”* by using a highly innovative 100% electric waste collection truck. However, financial benefits are also important to be considered *“I would say, even the waste management companies needed to simply analyze their data even to begin the study of their processes, on the financial axis”* (Participant H). Today, it is the ones who have information, that have value in their hands. He believes data is the oil of the next 20-30 years. On the other hand, external motivations also trigger digitalization. First, because of a strong pressure from the citizens: *“The first thing that is certain is that the user - the citizen - is more and more eager to use these media and therefore, for the waste sector as for the others, he also wants us to get there”* (Participant A). A second pressure arises from politics. Participant I explains very clearly this issue: *“There is also, at some point, the political aspect which will play a role, even more apparent in view of electoral periods. There is a global environmental awareness, that’s where it gets interesting: because there is a real pressure from the electors, politics must take up those topics”*.

SMART objectives

Sub-categories: process optimization, quality of life, attract new talents, raise awareness, gain knowledge.

When an organization or urban area decides to invest in technology to meet smart characteristics, they must identify their weaknesses and develop new smart objectives to overcome them. The main goal to adopt this digital strategy, mentioned by all the actors, is to optimize their processes. Indeed, their first objective is to invest in technologies to *“improve their performance, adapt their itineraries by reducing their human resources and material needs, as well as decreasing their CO2 emissions”* (Participant H). Second, the smart city or region approach is initially oriented towards development of technologies, sustainability and quality of life. Participant D thinks: *“The notion of smartness of course involves people’s skills, but also many technological innovations to improve the quality of life”*. To make the population happy, it is important to include them as much as possible in the decisions. Additionally, a region depends on its citizens and their ability to innovate to meet this goal. Therefore, another smart objective for many, is to attract new talents. In the Netherlands, they are thinking of building a Living LAB *“where students or graduates could do some R&D to inspire us, using new knowledge to help the community to build a smart Region”*. However, to make the region attractive it is crucial to find ways to raise awareness around its motivations and ambitions to increase people’s curiosity and willingness to be part of the change. Participant H is convinced that, *“if companies use the benefits of digitalization to improve their processes, they will be more efficient and will then be the first to educate others to follow the lead”*. Finally, a last important objective for those organizations is to gain as much knowledge as possible from those new channels. In Denmark for instance, they use a *“small sorting facility for investigation, to gain knowledge about waste composition and improve our sorting systems”*.

Collaboration

Sub-categories: expand the market, share knowledge, share expenses, create an ecosystem.

Collaboration has been identified as a critical success factor, which increases benefits of digitalization overall. Indeed, digitalization has positive impacts on a single player but would be even more significant on a larger community. As mentioned previously in the theory section, many academics believe that collaboration is essential to make true changes. This has been largely approved by the experts on the field. In the Netherlands, collaboration is seen as the

only way to successfully expand the market: *“we have to cooperate with other companies to scale up. If you scale up, you have influence and you can shape the new market”*. In France, two companies have combined their expertise and knowledge to develop their innovative city connected garbage, *“We brought our platform, they worked on the clean-up garbage, and it was the combination of our two skills that led to a solution; which allows cities and towns to be able to collect data from these connected baskets”*. By collaborating, different actors benefit from each other’s knowledge but also can find financial advantages by sharing the expenses. This is frequently the case in the public sector, where investments in waste management are consequent and not affordable for a small-sized territorial collectivity. Participant A explains: *“It is quite common for communities to organize themselves into associations or have set up cooperation to have shared tools”*. Following this mindset, this expert also emphasizes the assets of creating an ecosystem: *“We are on a multi-stakeholder participation. When you put something online you are no longer the only one resizing something or moving a project forward, you will involve other people via a survey, for example. There is a multi-actor and co-construction notion which is interesting”*.

Benefits of digitalization

Sub-categories: better traceability, better legibility, empower the population, inclusion, speed of action and rapid adaptability, financial benefits.

In the past decades, internet and digitalization revolutionized most of the industries and many businesses found ways to benefit from this transition. In the waste management sector, participant A explains that *“Digitalization brought a sort of traceability and history. We are dealing with jobs where people were used to oral communication, sometimes writing down information on paper sheets. We were unable to keep any tracks or records, that has been brought by digitalization”*. Being able to create a platform where key information can be gathered, is also very beneficial. The French Municipality created a *“unique platform listing data from all the different competences of the region, which provides us a better legibility”*. Once the information is disclosed, it gives the opportunity to the citizens to become more active in their city, it empowers the population. The other French territorial community agrees with this argument because: *“We gain from it. Instead of paying people to check if the containers are empty, full or broken, we can use people’s feedbacks. Moreover, it allows users to be a bit of an actor in the public service”*. Following the same idea, digital tools are also beneficial in terms of inclusion, *“It allowed us to reach another public. If we do the average age of the people*

calling us, it would certainly be around 70 years old because the younger generation does not call anymore. They use social medias, send emails, so we must adapt to our society's new practices" (Participant B). Another argument frequently mentioned is the speed of action and rapid adaptability possible through digital tools. Participant J illustrated her statement: *"In each city, the guidelines change so the applications shouldn't be static. In the city I'm working with, it is important that such online applications stay alive so their maintenance is important"*. Finally, the financial aspect has been mentioned, emphasizing the large return on investment those changes would implicate, *"You can make your equipment better, smarter and then do things cheaper. Those tools also enable you to follow the notion of costs"* (Participant F).

Limits of digitalization

Sub-categories: complexity of processes, inclusion, population's reluctance, employees' reluctance, combining digitalization with field knowledge and experience, danger of new trends, high costs, risk of biased information.

The use of digitalization is in the middle of ongoing debates, revealing large numbers of benefits but raising many concerns as well. First, redesigning new processes could lead to a higher complexity or confusion in its usage. Participant G in Denmark, states: *"If you design a system to gain knowledge or lock your data, you might get a system which is more complex. It might be fine to a certain extend but there could be some levels where it becomes a problem"*. Second, the notion of inclusion comes back, underlying its negative influence this time, because many believe that *"With new technologies we only address a certain part of the population. Inclusion is the true challenge of who has access to digital tools to get more directly information on the topic. When I download the city's application to learn how to sort my wastes, in fact I am already considered as a "sorter" by the city"* (Participant B). Third, the population could stand as an obstacle to the successful implementation of smart initiatives. Indeed, *"People are suspicious. People might fear the impact those technologies could have on their privacy, or the data security"*. The waste management company in the Netherlands does not face any issues for the moment, but anticipates a potential reluctance from the citizens to get on board of projects if they do not feel comfortable with the data collected on their behalf. Fourth, it is true that digitalization develops mistrust not only from the citizens' side, but also from the employees working on the field: *"Even the drivers, who were rather reluctant at first, are quite happy now. There is theory but there is practice on the ground too. We do not work with an audience that is very used to using these types of tools, already in their profession but also in*

their personal life. It creates a real reluctance to change” (Participant A). The fifth argument stems from the previous one, emphasizing the importance of not focusing all the attention on new digital instruments, but rather to combine them with the knowledge and experience gained through the years: “The point of vigilance that I have is that we must not oppose the field and digital. We should not say that now we have that, so we size the tours only using it, without considering the driver’s feedback. We must not confront, but associate the two because they are complementary” (Participant A). Indeed, people can get carried away by new trends and dive into expensive projects, without having the necessary objectivity on the potential outcomes it could generate at the end. This fear has been perceived by the participant C present in Finland, “We have invested in questionnaires to find out how people recycle their wastes and how they think about recycling. We invested in it, were excited when we got the results but afterwards, did not take full advantage of it. Kind of forgot about it”. This has also been mentioned by the participant G, where “We do collect data but not on a regular basis. We lead campaigns to investigate, but they can’t be done too frequently because they are quite expensive and we don’t want to store too much data at once”. Those were the two next limits exposed by the interviewees: danger of new trends and high costs. Finally, the development of some of those new technologies has been criticized, showing the detrimental effect it could have if they were biased because of personal approaches. Participant F warns about potential discriminations, “One example which is related to smartness: the sensors to wash your hands. Those sensors are tested mostly on people with white skin, so won’t work correctly for people with a darker skin. It simply won’t recognize their skin color. That’s very problematic with sensors and smart technology that we all should be aware of”.

DISCUSSION

Now that the key elements have been presented and illustrated by specific quotations, the research will continue with a discussion contrasting the theoretical and practical findings of the main challenges and key success factors of digitalization in waste management processes, for cities or regions willing to become smart(er).

Digitalization has shown great results on organization’s process optimization, with the introduction of new technological tools, able to collect large amounts of data, analyze them and propose alternatives to improve the current systems. In the waste management industry, it leads to better traceability of the different wastes and could improve sorting processes. Moreover, a

better global management frequently results in reduction of equipment, costs and human resources where the organization would benefit financially. Coming back to Kodym and Unucka's (2017) framework, these results follow the idea that new technologies open to unlimited possibilities to improve a city's development thanks to their adaptability and optimization skills.

Theoretically, digitalization stands as a great opportunity to support human workforce. First, by complementing the laborious field work of hundreds of people daily, but it is also a tool to serve the citizens. In times of consumerism, digitalization could be a way to sensitize large groups of individuals and shift mentalities. However, experts on the field raised numerous concerns about the application of such recommendations. They witnessed new technologies also having a social detrimental effect. On the one hand, workers might be and feel set aside, replaced by machines and that their work has been devaluated. On the other hand, inclusion also occurs among users where only a part of the population has access to digital channels. Furthermore, managers fear a loss or informal exchanges which creates essential value, intelligence. Academics must deepen their research on the potential risks of over-digitalization on human efficiency, to engage practitioners to be more aware and anticipate them in their digital transition. Successfully done, technology wouldn't take over human work but rather serve as crutches to lighten the burden of labor.

Moreover, digitalization has the potential to make the region more attractive. Online communication channels enable municipalities to increase the city's legibility on a national and international level. If people are informed, it will raise interest and attract new talents which will then focus on research and development to innovate and create new opportunities in the area. But here again, skepticism arises from companies and municipalities, who fear that by multiplying the tools, it would result in a higher process complexity and heavy costs. Because of their novelty, new technologies are expensive and request large investments for long-term results. Moreover, the risk of disclosing information is to be certain of their validity, which requires to carry out frequent updating measures, being pricy and time consuming.

It is determinant for institutions willing to invest in digitalization to remain critical and step back to analyze the larger picture, as many are tempted to dive into current trends. Stepping back involves making sure the targeted public is ready to embrace change. This must be

anticipated and could be solved by starting to raise global awareness and provide adapted training programs.

Another wave of concern raised from the population. The main concern implies storage of personal information. Many scandals exist around this sensitive topic and raised a public consciousness around its danger. It is the organization's role to reassure their users and ask themselves how open and transparent can they be with their data and where is the limits between personal benefits and intrusion of people's life.

The theory section highlighted the high number of stakeholders involved in smart projects, emphasizing the importance to work together and share knowledge to foster change. Academics focused on different key actors each time, where governments, policy-makers and regulators, businesses, universities and citizens were mentioned. Therefore, we can say that theory has been put into practice when noting that all the interviewed experts in this research have touched upon the importance of collaboration and networking.

More specifically, the Dutch waste management company's CEO has mentioned the significance of referring to the triple helix model: businesses, governments and universities. The triple helix model of the knowledge-based economy, is a concept theorized by Etzkowitz and Leydesdorff (1995), which defines the interactions between university, industry, and government to foster economic and social development. This model focuses on the dynamic formed by negotiations and alliances among the different actors to face pressing challenges (ibid.). In 2009, Carayannis and Campbell introduced a revised version, including a fourth helix to the model: the public. The new framework aims to bridge the gap between innovation and society, claiming that emerging technologies from the triple helix did not always meet the societal needs (ibid.).

All four components were mentioned in the current academic field, however never in one unique paper. Nevertheless, the EU interactive program mentions all the actors from the triple helix in their regional policy framework, without referring to the model. The theoretical background of the smart city and region topic, is unanimous to say that it must be supported by several institutions to strengthen the ecosystem and lead to a successful digital transformation. However, no specific reference has been made to the triple or quadruple helix model.

Theoretical contributions

This master thesis puts to light different notions which could contribute to the theory. First, this qualitative research collects essential information on the limits and risks of digitalization in the waste management industry. Indeed, recent researches exist on the dangers of digitalization in a general sense, however lacks when it comes to the notion of smart cities or regions development. Second, this paper combines uncombined concepts: smart urban areas and the triple or quadruple helix. The limited resources of this research didn't allow me to deepen the findings, however it can serve as a starting point for future researchers to associate them more explicitly. Because of the short period of time allocated to this thesis, those theoretical implications could benefit to be deepened to validate the assumptions made.

On the contrary, because of its highly practical orientation, several contributions have arisen for businesses and are detailed more precisely in the next section.

Practical recommendations

To help the reader understand what and how the overall digitalization processes could be implemented, several recommendations were given by the interviewed experts. Here are the six most relevant propositions, which could be used as a primary guideline for companies or cities to become smart(er).

Proposition 1: Integrate the notion of waste management at the start of projects' development to optimize and profit from those new digital tools.

A general awareness emerged towards the importance of including waste management in the early stage of urbanization projects. Before, waste management was often set aside and municipalities had to construct, rebuild or renovate areas to fit waste containers at strategical locations. Nowadays, many actors feel that they are taken into consideration from the beginning. This permits to include more technological innovations to the comprehensive waste strategy and optimize the processes with appropriate tools.

Proposition 2: Stress the importance of trainings and tailor them to the targeted audience.

Companies or municipalities shouldn't embark on large-scale projects without prior preparation and adapted trainings for all the people involved. There should be specific training programs

for the office managers, field workers or elected representatives. In many cases, when sensors and geo-tracking were used to optimize the waste collection routes, the interface was too complicated and often not used properly on the field. To avoid this situation, the digital tools must be adapted to the public and organizations should train their employees who use it daily.

Proposition 3: To encourage change in mentalities, organizations should focus on their user's feedback and include reward systems.

When companies or municipalities can measure, and disclose data to their users, it generally leads to a change of behavior. If people could know how much waste they produce monthly and be rewarded if they reduce their consumption, they would probably try to change their habits. Raising users' awareness would have substantial benefits in the global waste production. Moreover, used properly, this feedback could motivate organizations to invest more significantly in digitalization and see the benefits they could capture from it.

Proposition 4: Digitalization as a tool to positively influence social interactions.

Digitalization opened the dialogue between actors and users, which has shown to be beneficial on both sides. However, citizens tend to be more intrusive when they have the opportunity. If several people notify that a bin is full in a short period of time, it could firstly be perceived as mismanagement, secondly this intrusion could be taken very negatively by the workers, bringing additional pressure to their daily work. It is this balance to be found between the place of the user and the service expert, and how can the two be combined to sustainably optimize the activity.

Proposition 5: Focus on "quick-wins" instead of trying to implement global strategies at once.

When a project has been put into action step by step, it has shown greater results on the long run. With small and targeted quick wins, an organization can get the people adhere to the vision. Maybe start by the users by asking them what could be improved to their routine, then sensitize them to recycling and the different tools already available for his information. Once the population is ready, try to reach the waste management companies to optimize their processes to answer to a growing demand. This strategy might be time consuming, but would answer immediate needs and use appropriate solutions to answer them.

Proposition 6: Test as much as possible before expanding to larger scales.

Municipalities in Finland adopted the strategy to use test trials in smaller areas with fewer customers, sometimes for a couple of years, to ensure that the equipment works and is adapted to its environment. Their aim is to understand the big picture and see if it makes sense to broaden it to other regions. This technique might be criticized by the population because they feel it might be moving slowly, but the experts believe it is their responsibility to provide a good service and be as prepared as possible before investing largely in new tools.

LIMITATIONS AND FUTURE RESEARCH

One objective of this qualitative research was to combine knowledge from experts in the public and private waste management industry, as well as entrepreneurs developing innovative technological tools, to obtain a large picture of the current digital evolution. However, due to a lack of time and complications because of the COVID-19 situation, the number of interviewees has been reduced and lead to fewer participant in each type of organization. This limitation has been overcome as much as possible by selecting people operating in different sectors but sharing a similar expertise, all able to answer the same questions. To complement the database, triangulation has been done to confirm data saturation. Because of the current lack of academic research, I decided to focus my interest on understanding the main challenges and key success factors of digitalization in waste management processes, to answer a large demand from organizations in the field.

By tackling a broad topic where many factors are involved, further research could focus more specifically on each category found to be essential in the development of digitalization in waste management processes. For instance, only the digital tools mentioned in the interviews were included in the discussion, however many other alternatives exist and could be highlighted in more detailed analysis. Additionally, academics could question a cultural influence on the results. Indeed, countries do not address the matter of digitalization and sustainability similarly, which could affect their perception on the benefits or limits of digital tools. Finally, it has been clear that current theory lacks a standardized definition of smart city or region. A comparative literature analysis of definitions would be relevant to identify and analyze all published definitions to propose a new one. However, the topic being highly context dependent, it makes it harder to be applicable by all in practice.

CONCLUSION

This theoretical and practical research had the objective to show the growing interest about smartness in urban areas and contrasting its positive and negative impacts, in different countries in Europe. Academics characterized smart cities or regions through five main factors, which were all taken up by waste management experts during the interviews. However, this debate divides. Digitalization demonstrated numerous benefits in waste management operations, but raised concerns about its danger in terms of privacy and lack of knowledge, due to the newness of the tools. If successful, waste management could become the starting point of new urban areas' construction, where the strategy could be broadened to the city's other competences, such as energy or water management. Nevertheless, all actors must remain critical as they do not possess sufficient feedbacks to invest heavily in digital tools. New technologies represent a growing market where municipalities and companies should enter step by step, to ensure their successful transition towards digitalization.

REFERENCES

- Angelidou, M. 2016. Four European smart city strategies. *International Journal of Social Science Studies*, 4(4): 18-30.
- Angelidou, M. 2017. The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology*, 24(4): 3-28.
- Aurigi, A. 2006. New technologies, same dilemmas: Policy and design issues for the augmented city. *Journal of Urban Technology*, 13(3): 5-28.
- Bouwman, H., Nikou, S., Molina-Castillo, F. J., & de Reuver, M. 2018. The impact of digitalization on business models. *Emerald Publishing Limited*, 20(2): 105-124.
- Bryman, A., & Bell, E. 2011. *Business research methods* (3rd edition). Oxford, U.K.: Oxford University Press.
- Carayannis, E. G., & Campbell, D. F. J. 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *Int. J. Technology Management*, 46: 201-234.
- Cardano, M. 2020. *Defending qualitative research: Design, analysis, and textualization*. London, U.K.: Routledge.
- Esmailian, B., Wang, B., Lewis, K., Duarte, F., Ratti, C., & Behdad, S. 2018. The future of waste management in smart and sustainable cities: A review and concept paper. *Waste Management*, 81: 177-195.
- Etzkowitz, H., & Leydesdorff, L. 1995. The triple helix--university-industry-government relations: A laboratory for knowledge based economic development. *EASST Review*, 14: 14-19.
- European Law Monitor. 2020. *European Law Monitor*. Accessed online <https://www.europeanlawmonitor.org>. Viewed April 7, 2020.

- Giffinger, G., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. 2017. ***Smart cities - Ranking of European medium-sized cities: Final report***. Vienna, AT: Centre of Regional Science.
- Glaeser, E. L., & Berry, C. R. 2006. ***Why are smart places getting smarter?: Policy brief***. Cambridge, MA: Rappaport Institute for Greater Boston & A. Alfred Taubman Center for State and Local Government.
- Glasmeier, A., & Christopherson, S. 2015. Thinking about smart cities. ***Cambridge Journal of Regions, Economy and Society***, 8: 3-12.
- Isaksson, A. J., Harjunkoski, I., & Sand, G. 2018. The impact of digitalization on the future of control and operations. ***Computers & Chemical Engineering***, 114: 122-129.
- Kajornboon, A. B. 2004. Using interviews as research instruments. ***Language Institute Chulalongkorn University***, Online publication: 1-10.
- Kayikci, Y. 2018. Sustainability impact of digitization in logistics. ***Procedia Manufacturing***, 21: 782-789.
- Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. 2018. ***What a Waste 2.0 - A Global snapshot of solid waste management to 2050***. Washington, DC: The World Bank.
- Kodym, O., & Unucka, J. 2017. Smart life in smart region. ***EAI***, Online publication: 1-15.
- Markkula, M., & Kune, H. 2015. Making smart regions smarter: Smart specialization and the role of universities in regional innovation ecosystems. ***Technology Innovation Management Review***, 5(10): 7-15.
- Mays, M., & Pope, C. 1995. Rigour and qualitative research. ***BMJ Clinical Research***, 311: 109-112.
- Medelyan, A. 2020. ***Coding qualitative data: How to code qualitative research***. Accessed online <https://getthematic.com/insights/coding-qualitative-data>. Viewed May 21, 2020.

Neubert, M. 2018. SMEs perceptions on the impact of digitalization on Internationalization. *11th Annual Conference of the EuroMed Academy of Business*, Valletta, Research Advancements in National and Global Business Theory and Practice, 1009-1017.

OECD. 2019. *1st OECD roundtable on smart cities and inclusive growth*. Paris, FR: OECD.

OECD. n.d. *OECD*. Accessed online <http://www.oecd.org>. Viewed April 7, 2020.

Paskaleva, K. A. 2011. The smart city: A nexus for open innovation? *Intelligent Buildings International*, 3(3): 153-171.

Rowley, J. 2012. Conducting research interviews. *Management Research Review*, 35(3/4): 260-271.

Sauro, J. 2015. *Five reasons to perform a qualitative study*. Accessed online <https://measuringu.com/qualitative-study>. Viewed May 17, 2020.

Seele, P., & Lock, I. 2017. The game-changing potential of digitalization for sustainability: Possibilities, perils, and pathways. *Sustain Sci*, 12: 183-185.

Serban, R-A. 2017. The impact of big data, sustainability, and digitalization on company performance. *Studies in Business and Economics*, 12(3): 181-189.

Sutriadi, R. 2018. Defining smart city, smart region, smart village, and technopolis as an innovative concept in Indonesia's urban and regional development themes to reach sustainability. *IOP Conference Series: Earth and Environmental Science*, 202: 1-12.

Yin, C. T., Xiong, Z., Chen, H., Wang, J. Y., Cooper, D., & David, B. 2015. A literature survey on smart cities. *Science China Information Sciences*, 58: 1-15.

APPENDIX

Appendix A: Questionnaire

General questions:

- To start with, could you please briefly present (company)' mission, and your position and missions as a (function)?
- From where did the smart city/region project first emerge in your area?
- What are the expected benefits from becoming a smart city/region?
- What were the first modifications your company had to implement to adapt to new smart objectives?
- The notion of smartness involves many technological innovations to improve the quality of life in the region. Does (company)'s waste collection/treatment already include technological innovations within its process?
- What were your biggest challenges at the launching phase of the project and how did you overcome them?
- What would be your main recommendations for a waste management company willing to become smarter?

Focus: Waste management companies

- How was the company's strategy influenced by the development of smart initiatives in the city/region?
- What was your involvement, as a waste management company, in the elaboration of the smart city/region's objectives?
 - o Strong= why waste innovations were set as a priority; low= what were the causes and what were the actions considered more urgent?

Focus: Municipalities

- What role plays the municipality's waste department in the development of the smart city/regions project?

Focus: Software Publisher

- Could you briefly present your services and the software?
- What benefits could your software bring to waste management experts?
- Have you been reached by municipalities to launch a smart project in their city/region? If needed, would the software be adaptable to larger scales?

Appendix B: Additional details on the research's participants

Municipalities

Participant A: For almost 50 years, a large inter-communality has been created in a French territorial community, gathering 67 members from 31 municipalities. Household waste collection and management is one of their main service, where they have invested in digital equipment few years ago to improve their daily operations. The community's Waste Management Director has been interviewed.

Participant B: One of the largest French Metropolis stands as an example of ongoing smart City projects. The Employment and Knowledge Delegation has implemented 5 years ago their smart city initiative and rolled out specific action plans for the waste collection and sorting processes. The Waste Strategy Responsible, who worked closely with the Smart City Project Manager (currently a vacant position), was well-equipped to present the different technological tools used and their outcomes on the processes.

Participant C: A Finish Municipality also took part in the discussion through an interview with an Environmental Expert, working in one of the region's Environmental Services. Their waste management strategy (2019-2025) aims to reach a 60% recycling rate in the year 2025. To support their ambitious objectives, the expert detailed their decision to turn towards digital innovations in their waste collection channels, as well as their communication strategy.

Public owned waste management companies

Participant D/E/F: To better understand the objectives and needs of the waste management company operating in the north of the Netherlands, three interviews have been conducted with the CEO, the Senior Advisor and their Program Manager Circular Economy (an independent Technology Consultant). The aim of this public owned company is to develop their region by focusing on circular economy and waste management to become one of the growing European Smart Region.

Participant G: In Denmark, the chosen waste handling company is owned by five municipalities and is located in one of the largest one. Their largest activity is waste incineration but are also a waste-to-energy plant, where they produce electricity in a perimeter of about 50km. The region is known to be highly advanced and pioneer when it comes to urban areas, resources management or new technologies development; one of their Environmental Manager could provide clearer explanations about their strategy and their key success factors.

Private software publisher

Participant H: A French software publisher and integrator, allows waste management private actors and municipalities to manage the entirety of their data feed within a well-established and highly evolving regulatory platform. The company's strength is its experience and expertise on waste management processes. The CEO, who accepted to take part in this research, is proud to highlight his collaboration with ambitious companies, aiming to use digitalization to revolutionize their operations and lead towards full traceability and circularity of their wastes.

Participant I: The Marketing Director of another software publisher focused on a joint project, where they collaborated with an urban furniture designer to develop connected public bins in cities. As one of the project responsible, he could develop the benefits of such collaboration and highlight the main issues of adapting to municipalities' processes, currently primarily empirical.

Participant J: Finally, an entrepreneur presented her new vocal interface, developed to enable the population to quickly ask for information about their city's waste management. Her vision is that people could have access to personalized information simply by using their phone's vocal assistance. This strategy benefits from a strong speed of action and would improve the citizens' awareness and interest on waste.

Appendix C: Consent form

Your Consent and Understanding to Participate in a Case Study on Waste management in SMART Regions

Dear interviewee:

You are invited to take part in an interview as part of a thesis project (Sustainable Entrepreneurship Project), delivered within the master programme Sustainable Entrepreneurship at Campus Fryslân, University of Groningen.

The interview has two purposes. The first is to conduct a research aiming at understanding what role waste management plays in the development of a SMART Region or City. The second purpose is to draw recommendations for waste management companies willing to launch a SMART Region project.

By consenting to this interview, you acknowledge and agree to the following:

1. You confirm and understand what the research is about and that you will have the opportunity to ask questions.
2. You understand that your participation is voluntary and that you can withdraw at any time.
3. For the purpose of conducting research, the interview will be recorded, transcribed and analyzed. Recording and transcription will not be used for any other purpose besides conducting the research. The recording will be immediately deleted after transcribing the text.
4. The data obtained from this interview will be handled confidentially by the researcher (Camille Hue) and her supervisors.
5. The goal of this interview is to collect qualitative data for the research Waste management in SMART Regions.
6. The names of participants will not be published. The participants will be identified with their function. Full anonymity can be requested by the participant. This interview is supported by the student's professor.

Please note that the finalized anonymized research reports will be made available for further study on the University of Groningen's research database.

Interviewee Name + Function:

Business name:

Date:

Signature:

Researcher Name: Camille Hue

Date:

Signature: