MODES OF COLLABORATION IN DIGITAL TRANSFORMATION OF MUNICIPAL WASTEWATER MANAGEMENT

Research Paper

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Abstract

Digital transformation introduces new opportunities for public services, such as wastewater management. The opportunities include better interoperability and data availability, leading to such benefits as predictive maintenance and efficient allocation of resources. To reach the envisioned benefits, inter-organisational collaboration is essential. However, municipal water utilities have varying objectives, expectations, and challenges related to collaboration. This paper reports a field study on the digitalisation opportunities of municipal water services in Finland. We report the observed collaboration forms, rationale, expected benefits, and recognised challenges (i.e., the modes of inter-organizational collaboration) for deploying digitalised operations. This study provides insight into inter-organisational collaboration on the digital transformation of municipal water management. On a theoretical level, the study supports and complements the previously theorised collaboration modes of autonomous development, standardisation, and central service organization. The results also describe why and how limited company mode emerges in the sector, corresponding to the previously described consortium mode.

Keywords: digital transformation, wastewater management, inter-organisational collaboration, benefits realisation

1 Introduction

Digital transformation consists of various digital innovations enabling new practices, structures and values, which consequently change the existing state of the environment (Hinings et al., 2018). In the process of digital transformation, organisations respond to changes in the surrounding environment by exploiting digital technologies (Vial, 2019). Advances in digital transformation shape the expectations in both the private and public sectors (Mergel et al., 2019). The potential benefits include transparency and efficiency of operations, cost reductions, improved real-time view on operational and organisational data, and data integrations (Mergel et al., 2019; Parviainen et al., 2017). To reap the benefits of digital transformation, inter-organisational collaboration is considered necessary (Garrido-Baserba et al., 2020; Juell-Skielse et al., 2017). However, the potential in the public sector remains underexploited (Alvarenga et al., 2020) and collaboration often remains short-term or ineffective due to a lack of clearly identified and realised benefits (Helin, 2020). The expected benefits may vary substantially, impacting the choice of a particular collaboration form (Juell-Skielse et al., 2017). As a concept, a *mode* of collaboration "involves a form of collaboration between organisations with an intention to accomplish certain benefits," differentiating it from a mere collaboration *form* that does not explicitly specify the benefit intention (Juell-Skielse et al., 2017, p. 580).

Inter-municipal collaboration exists in the water sector across the world (Kurki et al., 2016). A typical aim of collaboration is the efficient delivery of public services (Silvestre et al., 2018). Benefits of regional cooperation (in addition to the basic sustainable development aim of enhancing provisioning of safe water and sanitation), such as economies of scale making financial, human and technological resources more efficient, and autonomy increasing organisational competence, have been recognised as important (Kurki et al., 2016; Takala, 2017). However, collaboration involves challenges, such as unbalanced power between varying sizes of municipalities influencing the decision-making process and causing difficulties in aligning various goals to joint actions (Kurki et al., 2016; Silvestre et al., 2018). On the other hand, increased autonomy is suggested to correlate with efficient decision-making (Kurki et al., 2016), but empirical evidence on whether collaboration would lead to improved efficiency remains inconclusive (Silvestre et al., 2018).

Aside from general collaboration in the water sector, digital transformation research has focused largely on advancements such as big data and data utilisation, smart metering, internet of things (IoT), and artificial intelligence (AI) (Garrido-Baserba et al., 2020; Yeram et al., 2020). Collaboration in the digital transformation of the water sector is also important (Corominas et al., 2018; Garrido-Baserba et al., 2020; Sherman et al., 2020), but studies on how different collaboration modes contribute to the digital transformation and realisation of expected benefits have yet to be done. Grotenbreg and van Buuren (2018) emphasise the importance of collaboration when innovating in the water sector as conditions vary even when the same technological innovation is sought.

Different modes of collaborations on the development and exploitation of information and communication technology (ICT) in the public sector, namely limited companies, autonomous modes, standardisation, framework agreements, as well as consortium and central services, have been identified by prior literature (Ferro and Sorrentino, 2010; Juell-Skielse et al., 2017). Drawn upon these studies, this paper focuses on the issue of what modes of collaboration on ICT development emerge among Finnish wastewater utilities and how anticipated benefits and recognised drawbacks influence the preferred modes. The following collaboration modes emerged within the Finnish water sector:

- Autonomous
- Limited Company
- Central Service Contracts
- Standardisation

The analysis reflects upon the previous theoretical propositions related to the collaboration modes (Juell-Skielse et al., 2017). This theoretical frame allowed us to look beyond the context at hand and to accumulate a theoretical understanding of inter-organisational collaboration aiming at digital transformation in the public sector. The results contribute to the understanding of how anticipated benefits and drawbacks influence the collaboration mode in the process of digital transformation. The rest of this article is structured as follows: the next section covers the existing research conducted on digital transformation of wastewater management, modes of collaboration for pursuing e-government benefits and the theoretical propositions, followed by a description of the research process. The fourth section reports the findings, and the fifth section discusses findings about the existing literature, followed by a brief conclusion.

2 Background

2.1 Digital Transformation of Wastewater Management

In digital transformation research, concepts such as smart cities, smart homes, smart manufacturing, and smart energy rely heavily on IoT and have received much attention in recent years (Kim et al., 2017; Kusiak, 2018; Lund et al., 2017; Marjani et al., 2017). Various interactions enabled by IoT and enhanced by AI offer benefits to multiple domains, including smart government (Kankanhalli et al., 2019). Although IoT introduces vast opportunities, it has complicated data analytics as the data is collected and processed by various sensors throughout the IoT environment (Marjani et al., 2017). These advancements also apply to the water sector, providing smart and novel ways to develop water management (Antzoulatos et al., 2020).

Advancements in big data analytics, AI, and machine learning (ML) are inevitably changing the decision-making strategies as well as the ways in which infrastructure services are provided in the water sector (Garrido-Baserba et al., 2020). Novel sensing technologies and smart meters can lead to radical changes in urban water management (Eggimann et al., 2017). Many water utilities in Finland have managed their data analysis with Excel sheets, but when the amount of data grows larger, this method becomes insufficient for effective decision making (Laitinen, 2016). Garrido-Baserba et al. (2020) predict that soon decisions in the water sector are based on big data analysis rather than experience and intuition. Furthermore, the potentially disastrous consequences of pipe failures require a shift to ex-ante predictions which in turn enable risk alleviation (Laakso et al., 2018). Detecting rapid changes or predicting failures requires the ability to draw relevant information from vast data amounts and process it autonomously in real-time (Sun and Scanlon, 2019). In order to be more collaborative, adaptive and accurate, organisations need to exploit their data appropriately (Orenga-Rogla and Chalmeta, 2019). Furthermore, digital transformation in the water industry not only involves technological issues but also requires organisational and cultural changes (Blumensaat et al., 2019).

Poorly interoperable systems cause vast drawbacks in efficiency (Shen et al., 2010) making interoperability, or "the ability of two or more software components to cooperate despite differences in language, interface, and execution platform" (Wegner, 1996), necessary (Mazayev et al., 2017). However, combining new IoT solutions and technology with legacy systems aiming to exploit heterogeneous data from these different sources can be challenging (Kamm et al., 2020; Pang et al., 2015). This is further complicated by vendor lock-in, where the customer is dependent on a single vendor, with limited ability to or a substantial cost for switching. (Opara-Martins et al., 2016). The emerging trend of smart water networks indicates promising benefits, but novel smart devices require interoperable solutions (Howell et al., 2017). However, cloud service providers may also offer non-compatible solutions with proprietary interfaces, complicating the cloud landscape (Opara-Martins et al., 2016). Although private actors may seek to implement their norms and logic into digital infrastructures, the government is able to use its purchasing power to influence standardisation (Hinings et al., 2018). Moreover, the challenges do not merely involve technological aspects, but require collaboration between different stakeholders such as municipalities and third-party vendors, as well as considering various views and interests (Kamm et al., 2020). Consequently, interoperability plays a prominent role in multi-vendor ICT platforms where various systems need to interact efficiently, making standardisation crucial for collaboration (Weyer et al., 2015).

The importance of digitalisation is widely understood, but digital transformation is still perceived as difficult (Parviainen et al., 2017). Sirkiä et al. (2017) have identified that this is the case with small-and medium-sized water utilities in Finland. Although the efficient usage of data is seen as important, developing current information systems with open data, interfaces, and integrations with other systems is perceived as costly by Finnish water utilities (Sirkiä et al., 2017). While smaller utilities are able to process their data in software applications like Excel, larger utilities require more advanced solutions to manage large data volumes (Laitinen, 2016). The utilities have identified that improved data availability, along with better information systems, would provide added value to their business, such as improved daily work, real-time monitoring possibilities, and exploitation of data received from smart meters. Regardless of the identified benefits, however, current technology platforms used by water utilities are not designed to handle large amounts of real-time data (Sirkiä et al., 2017).

Sirkiä et al. (2017) show that development is needed to efficiently utilise data in water service operations. However, they revealed that the costs of modernising the existing hardware and software are creating barriers to digital transformation. Sirkiä et al. (2017) suggest that water utilities could either merge to improve their purchasing power, or solution vendors could adjust fees based on the number of utility customers. Nevertheless, digitalisation and advancements in technology and information systems could also offer different kinds of solutions and opportunities for Finnish water utilities to improve their operations and data-based decision making, effectively assisting in their digital transformation.

2.2 Modes of collaboration for pursuing e-government benefits

Collaboration on ICT development and exploitation in the public sector provides benefits such as economies of scale, know-how, and resources to the innovation process (Sorrentino and Ferro, 2008). Although the importance of collaboration in the digital transformation process is understood (Corominas et al., 2018; Garrido-Baserba et al., 2020; Sherman et al., 2020), studies on how different collaboration modes support digital transformation and benefits realisation are yet underexplored (cf. Juell-Skielse et al., 2017). The hitherto identified modes of inter-organisational collaboration for ICT development and exploitation in the public sector include:

- The **autonomous** mode, in which an organisation implements a system independently, either by in-house development or as an independent acquisition co-operation with a vendor,
- The **standardisation** mode, in which public organisations collaborate to establish standards guidelining the details of their system implementations (such as interoperability),
- The **framework agreement** mode, in which one public organisation establishes a framework agreement for ICT acquisitions with one or several vendors, to which other public organisations can join,
- The **consortium** mode, in which a jointly owned (by public organisations) organisation manages a specific area of ICT services for its member organisations; and
- The **central service organisation** mode, in which a somewhat independently-governed public organisation provides an ICT service to some public sector customer organisations. (Juell-Skielse et al., 2017).

Ferro and Sorrentino (2010) also identified the **limited company** form of inter-municipal collaboration, in which a group of public sector organisations may co-operate with a company to establish and elaborate ICT services and solutions, which can, in principle, sell its services later on in the market.

Juell-Skielse et al. (2017) outlined propositions of the relationship between the collaboration modes and the anticipated (and later on resulting) benefits. Inspired by this theoretical framework, we seek to reflect our results regarding the following previous propositions:

P1. The autonomous mode results in better autonomy on quick implementations and a system and service better adapted to the needs of the service hosting organisation than the other modes.

P2. The autonomous mode requires more locally accumulated competence on the domain of the e-government service in question and related technology, which can be difficult to get and create overlap from the viewpoint of the whole government.

P3. The autonomous mode involves no economy-of-scale related benefits.

P4. The standardisation mode (when involved in e-government service development) results in better interoperability among e-government services and systems than the other modes.

P5. The standardisation mode results in better information availability among the organisations that have chosen it.

P6. The standardisation mode increases initiation costs for such organisations that have adopted non-standard solutions before.

P10. The consortium mode will result in development of more common capabilities and competencies to provide e-government service than the other modes.

P11. The central service organisation mode will result in development of specialised service competences and capabilities distinguished according to their customer requirements than the other collaboration modes.

P12. The consortium and the central service organisation mode, with a common technological solution, will result in lower operation and maintenance costs per participating organisation (in our case, digital archiving costs, software license costs) than the framework agreement (if used separately from other collaboration modes) or autonomous modes.

P13. The consortium central and the central service organisation modes result in better information quality in connection to e-government services than the other collaboration modes.

P14. Involvement in the central service organisation mode and implementation of central e-government services is initially costlier than in the other modes.

As our field study and data showed no signs of the framework agreement mode on joint ICT acquisitions, the related propositions P7-P9 in Juell-Skielse et al. (2017) were omitted from further analysis.

3 Research Setting and Process

The Finnish water sector consists of 1,100 water utilities, most of which have less than 500 consumers and/or 100 m3/d water provided (Gunnarsdottir et al., 2020; Ministry of Agriculture and Forestry, 2020b). Although Finland is regarded as a forerunner in water services, future directions are largely determined by how well challenges such as ageing infrastructure, limited utility resources, and extreme weather conditions are addressed (Ministry of Agriculture and Forestry, 2020a). Water utilities can exploit various opportunities to address the challenges ahead, such as collaboration and new collaboration models, international cooperation, technological advancements, and strengthening of research and development activities (Silfverberg, 2017). Inter-municipal cooperation in the Finnish water sector has existed since the 1950s, and it has been supported by the government providing e.g. financial incentives to build water transfer pipelines between municipalities (Kurki et al., 2016). The growing trend of collaboration has also been observed in Sweden (Kurki et al., 2016). The focus of this study was to understand the digitalisation and data utilisation of wastewater networks in this environment.

The following core ICTs, related to wastewater networks used at the water utilities, were identified:

- Supervisory Control and Data Acquisition (SCADA)
- Network Information Systems (NIS) / Geographical Information Systems (GIS)
- Programmable Logic Controller (PLC)
- Customer Data and Invoicing Systems
- Maintenance Management Information Systems

These ICTs form the foundation for wastewater network operations and are essential in ensuring the service level and operational reliability. Also, there can be other applications in use.

This study is part of the WWData project, funded by the European Regional Development Fund (ERDF), which aims to improve wastewater network data management among Finnish water utilities. Water utilities need to optimise energy consumption, reduce and anticipate leaks and blockages, better manage their capacity, and target repairs to the correct parts of the network. The WWData project enables water utilities, companies, and researchers to exchange knowledge and develop tools and methods for better data handling and network management, such as by utilising cloud services.

Six water utilities were selected to represent the Finnish water sector. However, since the aim was to study the process of digital transformation and related ICT, the smallest water service providers, such as private associations and cooperatives, were excluded from this study. The six selected utilities represent different organisational forms, namely limited companies, municipal enterprises, and regional associations of municipals. While this article focuses mostly on the collaboration modes and benefits from the viewpoint of the water utilities, 12 vendor interviews were conducted within the project, providing complementary information for the theme of this paper.

Semi-structured interviews were conducted with the water utilities and vendor companies. The water utility interviewees represented the key stakeholders—managing directors, water service directors, network managers, development managers, and engineers—responsible for operating, developing, and managing the wastewater networks in the respective municipal water utilities (Table 1). Altogether, 16 interviews were conducted in this round, two to four per utility. All interviews were recorded (except one with a failed recording) and transcribed. The duration of the interviews varied between one and two hours. Such documents as research reports, public reports by ministries, municipalities, and related public interest groups, financial statements, project reports, newspaper articles, and web pages provided additional information on utility operations and the water sector in general. Also, 12 vendor interviews, each approximately two hours, provide complementary views to the results of this article.

	Data sources	Number of interviews	The roles of interview participants
Water Utility 1	Interviews, research project report, newspaper articles, web pages	2	Head of Network Department, Water and wastewater network engineer
Water Utility 2	Interviews, web pages	3	Water and Wastewater Network Manager
Water Utility 3	Interviews, annual reports, master's theses, web pages	4	Development Manager, Network Manager, Automation engineer
Water Utility 4	Interviews, financial statements, web pages	3	Managing Director, Network Manager
Water Utility 5	Interviews, financial statements, annual reports, web pages	2	Managing Director, Utility Operator
Water Utility 6	Interviews, newspaper article, web pages	2	Water Service Director, Planning Director, Operating Engineer
Vendors	12 interviews, product and service brochures, news articles, press releases, web pages	1 per company	E.g. Managing Directors, Chief Executive Officer, Segment Director, Sales Director, Head of Sales, Business Manager, Project Managers, Head of Laboratory, Chief Information & Marketing Officer

Table 1. Data sources

The interviews started with a state-of-the-art mapping about the contemporary ICT architecture with regards to business processes, data, systems and technology used for currently digitalised services. Also, the interviews mapped ICT procurement and development processes and the stances on overall themes on digital transformation, such as open data policies. The interviews continued to focus on identifying the central data assets, together with development objectives and benefits associated with future digital transformation and existing or envisioned inter-organisational collaboration. Altogether, the interviews aimed at capturing the views on the benefits sought by, and the reasons for, the future visions of digital transformation and related collaboration among the water utilities and the surrounding ecosystem. Our data analysis in this paper focuses especially on the discussions of the development objectives for digitalisation of the wastewater data assets and viewpoints on inter-organisational collaboration.

The qualitative data analysis started with the theoretical lens of the collaboration modes in the public sector and 14 related propositions connected with observed benefits and drawbacks (Juell-Skielse et al., 2017). Consequently, the data was organised and contextualised based on the theoretical lens guiding our analysis (Yin, 2014). To ensure robust and systematic analysis, we used NVivo software, which enables us to maintain the chain of evidence. The analysis entailed several iterations where modes were defined further, and attempts were made to identify any misinterpretations (Table 2).

Initial modes of collaboration	Identified modes of collaboration in our study
Autonomous, Central service organisation, Consortium, Framework agreement, Standardisation, Other forms of collaboration	Autonomous, Central service organisation, Standardisation, Limited company

Table 2. Collaboration mode identification and formulation in data analysis.

The identified modes were discussed among the authors to ensure robust interpretations of the data. Complementary sources of data, such as annual reports, financial statements, and webpages, were used to verify or corroborate our views.

We noticed quickly that the collected data involved three collaboration modes (autonomy, standardisation and central service organisation), but also the limited company collaboration form that Ferro and Sorrentino (2010) identified in this context, while not involved in the material of (Juell-Skielse et al., 2017). Hence, we saw the opportunity for a two-fold contribution with our data analysis: 1) to put the previously suggested theoretical propositions of the collaboration modes of autonomy, standardisation and central service organisation to test and deepen our understanding of their identified pre-requisites, sought benefits and drawbacks (cf. Juell-Skielse et al., 2017) – and 2) to deepen our theoretical understanding of the collaboration form of a limited company (Ferro and Sorrentino, 2010) by identifying propositions related to its benefits and drawbacks. Altogether, while the data collection phase did not assume any mode of collaboration on digital transformation beforehand, the three above-mentioned theoretical patterns of "modes of collaboration" identified in (Juell-Skielse et al., 2017) and the "limited company" form of collaboration identified in Ferro and Sorrentino (2010) provided the overall theoretical patterns (cf. Yin, 2014) to structure our data analysis and to enable theoretical accumulation of knowledge on our study.

4 Results

The interviews revealed that variance existed among the utilities regarding the visions and progress of implementing advanced digital solutions, which would allow integrating, analysing and visualising data from different sources by utilising ML and enabling data-based decision making (Table 3). While one utility had a clear vision of the requirements of advanced digital solutions and, moreover, was already utilising them, the rest of the utilities were in various stages in transition towards digital transformation.

	Vision	Advanced digital solutions	Data integration
Water Utility 1	Visions of what is wanted and needed has been formulated	Platform-based ICT architecture with data processing and warehousing in use	Interoperable data utilised widely
Water Utility 2	Visions of what is wanted and needed has been formulated	Platform-based ICT architecture to be developed	Data siloed
Water Utility 3	Visions of what is wanted and needed from digital solutions is under formulation	Different digital solutions under consideration	Data siloed
Water Utility 4	Visions of what is wanted and needed has been formulated	Limited resources to acquire advanced digital solutions	Data siloed
Water Utility 5	Visions of what is wanted and needed from digital solutions is under formulation	Limited resources to acquire advanced digital solutions	Data siloed
Water Utility 6	Visions of what is wanted and needed from digital solutions is under formulation	Data analysis application under consideration	Data siloed

Table 3. Summary of the observed status of digital transformation.

The utilities had identified various benefits resulting from improved data availability and new digital solutions. All utilities acknowledged that a vast amount of data is collected from the wastewater network, and by exploiting that data efficiently, various benefits can be attained. While improved visibility to the wastewater network in general and utilisation of siloed data were considered important, the benefits of digital solutions included predictive maintenance, better energy efficiency, better asset management, better management of leakage water, accurate and efficient allocation of repair activities, and detection of long-term changes. In general, digital transformation would enable knowledge-based management, and if collaboration was done, for example, in parameter definition and data quality matters, the process would improve comparability of the utilities. Yet, at the time of the interview, only one of the utilities had implemented solutions clearly enabling these benefits.

Autonomous. All involved water utilities considered autonomous mode, related to wastewater operations, as the most relevant. The rationale, however, varied between utilities. One utility's operations were on a level where economy of scale was received even from autonomous mode. Other utility's requirements varied too much, often resulting in needs for system customisation. Consequently, joint projects were considered too time consuming and challenging, and the benefits were not considered surpassing the efforts. However, ICT procurement was generally considered challenging, requiring resources, which smaller utilities often lack. Moreover, two utilities considered the water sector in general as having limited ICT know-how, and one utility reported difficulties in identifying unaided what could be required from new solutions. While some participants acknowledged joint development projects for increasing the purchasing power of the utilities, these were not largely initiated, although some exceptions were identified.

The utilities in general considered knowledge sharing and joint innovation an important and somewhat essential part of the Finnish water service sector. Various modes of knowledge sharing and joint innovation were reported in the interviews, such as different research and development projects where experts from private companies, universities and water utilities developed and piloted innovative solutions. Knowledge sharing was done at various venues, such as the Finnish Water Utilities Association (FIWA). Benchmarking was done among the water sector as well as other sectors, such as energy and district heating, and due to joint operations (e.g., in transfer lines and treatment plants), ICT-related knowledge sharing occurred. Although evidence indicated such collaboration is not entirely without problems, in general it took place in all case utilities. The evidence revealed that while collaborations in various forms existed, interestingly, they did not extensively encompass ICT acquisition or development projects. Only one of the utilities expressed interest in joint data platform procurement, which would enable better data availability and assist in the digital transformation. The rest either considered collaboration in this context to be too complex or did not consider it beneficial.

To reflect on these theoretical propositions, our data are in line with P1 regarding the autonomous mode (Table 4). Water utilities prefer the autonomous mode, which leads to quicker implementations providing solutions based on local requirements. One water utility manager stated:

> *"I cannot see benefits from joint acquisition. SCADA systems, used in the water sector, are largely tailored to the specific requirements of the utilities."*

P2 is also supported, although the need to gain know-how was considered challenging at some utilities. P3, which stated that autonomous mode involves no economy-of-scale related benefits, inflicted variance. Our evidence suggests that this depends on the level of operations. While smaller utilities can have challenges in receiving economies of scale from autonomous mode, the large units have wider opportunities. Therefore, we conclude that P3 is partially supported.

Limited company. Although autonomous mode was favoured, other forms of collaboration were identified. Members of the Northern Finland Water Committee (Pohjois-Suomen Vesivaliokunta) had decided to develop their own customer data and invoicing system after one of the major customer relationship management (CRM) systems was at end of life. Limited company was founded for this purpose. Altogether, 16 utilities were involved in the beginning of the system development, with more joining later. The new customer data and invoicing system enabled standardisation of business processes, allowing the utilities to even merge operations. However, combining the requirements of different sized utilities, such as different pricing and invoicing practices, was challenging and required the system to be configurable. Further, interoperability was also an ongoing issue due to various types of sensors and systems needing to be integrated, posing challenges to the development process.

Limited company (based on joint project to develop shared service and ICT solutions) shared similarities with Consortium mode (cf. Juell-Skielse et al., 2017). Hence, limited company reflected with P10 revealed that common capabilities were received because of collaboration in shared ICT solution. A partner of the limited company reported it as one of the goals of the mode:

> *"New system made it possible that utilities can work together and stand in for each other. [...] In case of holidays or sickness, neighbouring utilities can fill in if needed."*

Therefore, our findings support P10.

Central Service Organisation. In some cities and municipalities, ICT services are provided by central service organisations. These services include cloud services and other "off-the-shelf" ICT applications. However, ICT related to the water utilities' operations requires thorough operational know-how, making the acquisitions challenging, if not impossible, via central service organisation. Although benefits such as ICT know-how and interoperability could be gained, autonomous decisions were preferred.

P11 poses an interesting contradiction. The municipal central services organisation mode observed in our study differs from the mode identified in the literature (cf. Juell-Skielse et al., 2017) where central service is organised around domain-specific service (archiving). In our case, the central service organisation provides administrative ICT rather than domain-specific ICT. A head of the Network Department stressed:

> *"Operative systems must be governed by operative departments, because only they have the needed know-how. This is very important [...] IT department on the other hand govern general software and things, like Office, HR, firewalls and information security."*

Furthermore, the limited company identified in our study represents a somewhat similar collaboration mode as consortium. Consequently, we can confirm that P11 is supported by a limited company, but not by the central service organisation mode.

Propositions P12 and P13 are relevant to both limited company and (municipal) central service organisations. The very existence of the limited company producing similar service to smaller water utilities jointly suggests P12 is supported regarding the limited company mode. However, P12 regarding (municipal) central service organisation, as well as P13 in general, remains inconclusive.

Regarding P14, our data involve municipality-specific central service organisation, which suggests a slightly different organising pattern from the Swedish example, in which central service organisation was suggested across state-level government branches in one service domain (Juell-Skielse et al. 2017). Here, the readily existing municipal central service organisation appears feasible for providing basic ICT services, while the domain-specific water utility digitalisation would require either acquisition of in-house specific competence or involvement in inter-organisational, domain-specific collaborations. Therefore, P14 is supported in water utilities where ownership structure allows the use of municipality central services, thus partially supporting the proposition.

Standardisation. The variety of ICT used by different utilities was considered problematic by most of the interviewed utilities and vendors. Due to long life cycles of core ICT, used with operational activities, SCADAs in particular, many utilities reported challenges related to legacy systems. Four out of six utilities considered changing core ICT to be costly and challenging, often leading to vendor lock-in, meaning the utilities depend on the products and services of certain vendors. Furthermore, they considered legacy systems complying poorly with modern requirements and were poorly interoperable, lacking interfaces needed for better usage of data. Due to these data silos, which were in some utilities enhanced by the organisational structures, the utilities had difficulties in finding significant information from large data amounts. In general, the large data quantities remained underutilised.

The interviews revealed that definitions for interfaces and standards are needed. Strong consensus existed on both sides, utilities and vendors, that vendor lock-in is not in accordance with current practices. Furthermore, digital transformation was considered to require better interoperability and data integration, which would consequently enable vendors to offer new solutions more efficiently. When common standards regarding ICT and data exist, they also improve comparability of the utilities. Yet, accounting for the views of some utilities, standards should merely act as proposals rather than rules.

P4, P5 and P6 state standardisation results in better interoperability and information availability than the other modes, but the initiation costs can be high if non-standard solutions have been in use. These aspects were recognised in our study. Some utilities reported issues with legacy systems (e.g., SCADA), in terms of interoperability and data availability due to lack of interfaces or databases, and made system development necessary if new digital solutions were to be implemented. However, legacy system development was considered costly among the utilities. Furthermore, the vendor interviews emphasised the need for defined interfaces, data management and architecture to improve interoperability and data availability. A representative of one vendor organisation said:

"A great challenge with water utilities is that the data is in different places, but data availability for analysis is challenging in which case [wastewater network] optimizing cannot be done. Interfaces are missing."

Hence, standardisation requirements exist, although expectations of different stakeholders vary. Consequently, this leads us to conclude P4 and P5 are and P6 are supported in principle, though the readiness to implement standards may vary.

	Autonomous	Limited Company	(Municipal) Central Service Organisation	Standardisation
Rationale	ICT acquisitions and development are conducted autonomously: • Operations are on a level where economy of scale is received • ICT requirements often vary between utilities • Collaboration challenging • In consideration of corporate-level decisions • If other modes are not suitable • Via package solution, in-house development, or software developing company	Limited company founded for ICT development: • Several utilities have similar ICT requirements to which a commercial solution is developed. • Package-solutions not applicable • Private entrepreneurial owners	Administrative ICT services are acquired from central service organisations: • City / municipality offers general level ICT services	Standardisation (data models, data transfer, APIs, architecture) for collective benefits: • Knowledge sharing considered important • Good solution can be shared with other utilities
Benefits	• Autonomy • Customisation for water utility-specific requirements • Benchmarking supports decision making	• Economy of scale • Sector-level customisation for water utilities • Standard business processes	• Economy of scale • ICT knowhow • Interoperability with other municipal systems	• Economy of scale • Increases comparability of utilities • Interoperability • Data quality • Sector-level benefits • Enables new ICT solutions more efficiently
Adoption Challenges and Drawbacks	• Challenging, requires in-house resources and knowhow • Requires clear vision • Solutions scattered requiring ICT vendors to cooperate • Difficult to define requirements • Low purchasing power • Legacy systems must be considered • Can lead to vendor lock-in • Poor interoperability	• Similar requirements • Collaboration can be challenging with different kinds of water utility organisations. • Poor interoperability with other systems affects the adoption and development	• Limited customisation for water utility specific requirements • Poorly suitable for operative water utility ICT	• Requires resources and knowhow • Challenges with legacy systems can act as barriers to adaptation of standard solutions
Theoretical Analysis	• P1 supported • P2 supported • P3 partially supported	• P10 supported • P11 supported • P12 supported • P13 inconclusive	• P11 unsupported • P12 inconclusive • P13 inconclusive • P14 partially supported	• P4 supported • P5 supported • P6 supported

Table 4. Summary of the observed collaboration modes.

The results presented above, based on observed collaboration modes, views of digitalisation and solutions required for the transformation as well as the expected benefits and related challenges, revealed that while strong demand and desire existed for collaboration, knowledge sharing and joint innovations, ICT acquisitions and development were mainly conducted autonomously. Although other

ICT undertakings were evident, they were used merely as supportive practices. Furthermore, clear requirements and needs for standardisations were observed, but the evidence indicated that standardisations should act as complimentary solutions to the autonomous mode. These variances are discussed in detail in the following section.

5 Discussion

This study set out to ask what modes of collaboration exist regarding digital transformation among Finnish wastewater utilities and how anticipated benefits and drawbacks relate to the preferred modes. Overall, the analysis of six municipal water utilities of varying size and ICT maturity showed variation in the denoted benefits, and four different modes of inter-organisational collaboration were identified. In general, this observation of the varying modes is well aligned with the Swedish multi-case study in the field of digital archiving (cf. Juell-Skielse et al., 2017). In particular, our study complements and deepens previous theoretical propositions (P1-P6 and P10-P14; Juell-Skielse et al., 2017) and understanding of inter-organisational collaboration modes for digital transformation in the public sector in three ways:

1) Our results support and complement previous theorising on three collaboration modes (Juell-Skielse et al., 2017): **autonomous** development, **standardisation** and **central service organisation**.

2) The data and analysis allow for propositions regarding the collaboration mode of a **limited company** (cf. Ferro and Sorrentino, 2010), unincluded in Juell-Skielse et al. (2017), and

3) The study as such provides rare insight into inter-organisational collaboration for **digitalisation of municipal water management** in Finland and similar contexts of municipally organised (waste)water services.

Views preferring the **autonomous** mode of digitising public wastewater services were omnipresent from small water utilities to the big ones in our data. This observation is largely in line with P1 – municipalities, as well as municipal utilities, possess autonomy in the Nordic context and wish to continue to do so. However, informal collaboration for knowledge exchange, initiatives for shared service solutions through the limited company mode, and expressions about needs for data and solution standardisation were expressed in parallel to the starting point of utility-level autonomy. The absence of formalised collaboration in our data aligns well with the recently observed common pattern of municipal ICT co-operation in Finland in general (Helin, 2020). Our analysis of P2 and P3 above suggests, in line with Helin (2020), that the municipal governing bodies (e.g., water utilities) could miss the benefits of digital transformation if continuing with plain informal governance of ICT-co-operation. Here, while the autonomy of municipalities and municipal bodies has a long tradition in the Scandinavian context (cf. Juell-Skielse et al., 2017), we suggest that additional focus could, indeed, be put on parallel collaboration modes such as jointly established limited companies providing well-anchored solutions and service contracts, and standardisation efforts on data models, data transfer, APIs, and service architectures. This seems to apply especially to the smaller water utilities and municipalities with less resources to possess the necessary competencies for governing their digital transformation solely by themselves.

While **standardisation** was identified as a potential future path for digital transformation, confirming the expectations (in line with P4 and P5), the challenge of legacy systems hindering standardisation (P6) was present in the wastewater domain as well. This observation is largely in line with the recent literature (Kamm et al., 2020). The variety of ICT in use was incompatible with the standardisation ideas. This will continue to hinder benefits realisation from new solutions, but also require development to the legacy systems. Poorly interoperable legacy systems are creating barriers to digital transformation and increasing initiation costs if standard solutions are to be acquired (Juell-Skielse et al., 2017; Sirkiä et al., 2017). Nevertheless, for organisations to be more agile, adaptive and accurate, data needs to be in efficient use (Orenga-Rogla and Chalmeta, 2019). This in turn produces significant opportunities for the operations and maintenance of water infrastructure, resulting in economic and environmental resilience (Garrido-Baserba et al., 2020). Standardisation as a tool to establish routines and rules (Ferro and Sorrentino, 2010) was considered to produce benefits such as improved comparability of utilities, more efficient development and implementation of new ICT solutions, and improved interoperability and data quality. Although standards were considered to complement the autonomous mode rather than replace it, establishing common rules can generally be expected to benefit the sector as a whole.

Municipal central service organisation in this context deviates from the central service organisation mode identified by Juell-Skielse et al. (2017), contradicting P11 and P14. While the latter identified a service organisation focusing on one competence-intensive domain of e-government (digital archiving) across governmental agencies, our service organisation provides standard ICT services across municipal service functions. Thus, central service organisation modes can vary with regard to their service scope and foci of digital transformation. Although central ICT services for archiving could provide economies of scale in addition to interoperability and data quality across government units, the evidence collected in our study suggests poor suitability of operative water sector ICT in the context of municipal ICT service, which lacks the domain competence for this case. While utilities can benefit administrative ICT offered by central service organisations, our study revealed that the autonomous mode was required for operative solutions. Comparison to propositions P12 and P13 on this mode remained inconclusive, perhaps even irrelevant, as the municipal ICT service organisations of our study focused on general, basic ICT services rather than a specialised branch of services. Altogether, our analysis revealed a need for re-opening the definition for "central service organisations" as a collaboration mode for inter-organisational public services and re-formulating the propositions.

The fourth identified collaboration mode was **limited company**. Although not included in the previous study by Juell-Skielse et al. (2017), it represents a well-recognised form of inter-municipal collaboration (Ferro and Sorrentino, 2010). In our study, the limited company collaboration mode involved many similarities with the consortium mode (Juell-Skielse et al., 2017). Such benefits as economies of scale, standardisation of business processes, and system customisation required by the water sector in general can be considered to improve common capabilities and competence. Our analysis suggests that propositions P10–P12 could be widened to involve the limited company mode as well (in addition to the member-owned consortium mode). While we regard P13 as possibly applicable for this mode, our data remained inconclusive about this proposition.

While the water utilities in Finland have a long history of collaboration (e.g. in the form of centralised wastewater treatment plants or water transfer pipelines between municipalities; (Kurki et al., 2016), the government guides for or demands little, if any, collaboration on the **digital transformation of water management**. Hence, the water utilities handle their ICT development rather autonomously. This is further complicated by the various legacy systems needing development, such as interfaces. Although the autonomous mode was considered the most relevant, it requires, especially in the adoption of advanced digital solutions, resources and clear development visions. However, the utilities recognised limited ICT knowhow in the water sector as a drawback, suggesting potential of unexploited or even missed benefits resulting from autonomous mode. Moreover, the lack of standard solutions regarding data models, data transfer, APIs, architecture, and the usage of legacy systems further complicate digital transformation.

ICT architectures in the water sector consist of various components requiring a high level of interaction. In these multi-vendor ecosystems, interoperability has a significant role, requiring the adoption of common standards (Weyer et al., 2015). Challenges with interoperability and data availability hinder the opportunities of digital transformation, rendering vendors unable to offer new advanced solutions efficiently. The role of water utilities as a critical infrastructure might also limit the availability of data due to societal security aspects. We recommend further work on common rules and guidelines for efficient and scalable technical solutions and data interoperability. To enable this, standardisation can be adopted as a collaboration mode, even among otherwise autonomously developed utilities, to establish such rules allowing more accurate, synchronous and adaptive services and operations (Ferro and Sorrentino, 2010; Orenga-Rogla and Chalmeta, 2019).

Due to the long life cycles of the core legacy ICT, SCADA in particular, the adoption of standard solutions can be considered costly (Juell-Skielse et al., 2017; Sirkiä et al., 2017). However, digital transformation involves not only technological matters—organisations and culture tend to change as well (Blumensaat et al., 2019). Increasing negotiation power with joint interface development projects or joint acquisition of data platforms could improve the development capabilities of the utilities and thus support digital transformation. Digital transformation, as understood by Hinings et al. (2018), involves innovation at multiple levels, namely organisational, infrastructural and application levels, portraying change as a comprehensive transformation, not merely a technological adaptation. The cost of ICT forms a barrier to modernising ICT in which utility mergers or vendor pricing structures could bring relief (Sirkiä et al., 2017). However, water utilities could also benefit from new collaboration modes in their ICT acquisitions and development. Adopting collaboration modes such as standardisation and limited companies serving as joint-operated alliances of smaller water utilities could produce benefits beyond those anticipated purely from the autonomous mode. Furthermore, this would ensure the ultimate autonomy of individual water utilities, which were considered important among our informants.

Despite our efforts to provide a rich understanding of contemporary phenomena, our study is not without limitations. We report an empirical study relying on the views of various stakeholders. Since the digital transformation in the Finnish water sector is still at an early stage, the interviewees' assessments largely represent opinions rather than outcomes of benefits realised from actual collaboration. While our interviews cover six water utilities of varying sizes, our study in its current form cannot guarantee whether other co-operation constellations could still emerge in co-operation with other water utilities in the Finnish field of over 300 municipalities. However, we still regard that our results warrant a discussion against a previous theory and the propositions from the previous literature by complementing and giving more in-depth insights to those from another domain.

6 Conclusion and Further Research

We reported a field study on the digitalisation opportunities of municipal wastewater management in Finland. Our study focused on observed rationale, expected benefits and recognised challenges alongside implied forms of inter-organisational collaboration for deploying digitalised services. We identified four collaboration modes: autonomous, limited company, municipal central service organisation and standardisation. These findings were reflected upon theoretical propositions identified by prior literature (Juell-Skielse et al., 2017). Our findings support and complement three collaboration modes, namely autonomous, standardisation and central service organisation, and we further proceed to suggest propositions regarding the collaboration mode of a limited company drawn from Ferro and Sorrentino (2010). Altogether, the study suggests that in a specialised field of digital transformation, such as wastewater management, several interorganisational modes of collaboration might need to be cultivated simultaneously to enhance digital transformation and benefits realisation thereof. This study provided a rare viewpoint on inter-organisational collaboration of Finnish wastewater management and a similar context in the process of digital transformation. However, the journey of digital transformation is still beginning. Therefore, future research should focus on studying how different collaboration modes used in parallel could provide stable solutions and service contracts that would enable large-scale benefits of advanced digital solutions.

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