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Challenges to Finnish water and wastewater services in the next 20–30 years

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Submitted to: E –Water; 24 March, 2011

Abstract

This questionnaire ranked 29 identified challenges for Finnish water services in the next 20–30 years. The respondents consisted of 48 experts representing equally four interest groups: utility experts, consultants, authorities and associations, and researchers and educators. The three most urgent challenges were Aging infrastructure, Vulnerability and risk management, and Human resources and know-how. In a wider context most of the identified challenges are related to aging infrastructure and competence development.

Tiivistelmä

Tässä kyselytutkimuksessa arvioitiin 29 haasteen merkittävyyttä Suomen vesihuollossa seuraavien 20 – 30 vuoden aikana. Tutkimukseen osallistui 48 asiantuntijaa, jotka jakautuivat tasaisesti neljään intressiryhmään: vesihuoltolaitosten henkilöstöön, konsultteihin, viranomaisiin sekä tutkijoihin ja kouluttajiin. Kolme merkittävintä haastetta olivat ikääntyvä infrastruktuuri, haavoittuvuus ja riskienhallinta sekä henkilöresurssit. Laajasti tulkittuna ikääntyvä infrastruktuuri ja osaamisen kehittäminen kattavat suurimman osan identifioiduista haasteista.

Keywords: aging infrastructure, competence development, human resources development, future challenges



1. Introduction

Water supply and wastewater services are one of the most important basic technical services of any community and a major component of their technical infrastructure. In the western world – as well as in many cities of developing and transition economies – these systems were first established in the 19th century. In Finland, the case country of this study, the first 20 cities established their water service systems before independence in 1917. The majority of the systems were, however, constructed after WW II chiefly in the 1960s and '70s.

Current policy discussions often focus on the major changes that the water systems will undergo in the future. They may well happen although in a historical perspective change is a more or less permanent phenomenon as shown e.g. by Kaivo-oja et al [1] and Katko et al [2]. In any case, it is sensible to try to identify future challenges and alternative ways of reacting to them. Futures researchers argue that we should identify possible, probable and plausible futures and visions, and actively search for ways that give us the future we desire [3]. Identifying future challenges can be considered essential for reaching such a future.

Finland has won several international comparisons related to water. For example, the Water Poverty Index (WPI) that ranks countries according to resources, access, capacity, use and environmental impact, placed Finland first in 2002 [4]. According to official statistics, more than 90% of the population is connected to public water distribution networks, and more than 80% are served by public sewer networks and urban wastewater treatment plants. Municipalities own most of the utilities, but there are also numerous consumer-managed utilities, mostly co-operatives, especially in the rural areas. Approximately half a million people get their drinking water from private wells, and some 350.000 households rely on on-site sanitation. [5; 6; 7]. Water resources are plentiful, and in recent decades the quality of water has improved significantly due to higher wastewater treatment efficiency and broader coverage. Thus, it can be said that Finland's water services are in very good shape. However, there are several challenges to the sustainability of high quality water services now and even more so in the future.

Both internal and external factors pose challenges to water and wastewater services. Citizens demand better services more efficiently as the financial situation in most communities is tightening. The aging of technical infrastructure and workforce seem to be problematic for many water and wastewater utilities (hereafter "water utilities" for short). Climate change, again, is a wider global challenge, the impacts of which are difficult to assess. In any case, what is important is that we identify the challenges and start exploring alternative ways of reacting or adjusting to them.

The objective of this article is to describe the main challenges of water and wastewater services in Finland during the next 20–30 years. That will be done by analysing the results of a survey on the views of sector experts. The paper also refers to some findings of other studies, while the focus is strongly on the Finnish case.

2. Research approach and methodology

This study utilises both the quantitative and the qualitative approach. It starts with a questionnaire listing the potential challenges in a wider institutional context based on the PESTEL (political, economical, social, technological, environmental, and legislative dimensions) framework. The list was developed with the help of four experts in 2008 and was tested on seven experts. The latter experts represented the four major interest groups of the study: (i) water and utility experts (2), (ii) consultants (2), (iii) national and local authorities and associations (1), and (iv) researchers and educators (2). This phase produced a total of 29 potential challenges.

A questionnaire consisting of a list of challenges arranged in alphabetical order was produced on the basis of the first phase. The challenges were to be graded on a scale from one to five, where one signified a challenge of low importance and five a challenge of high importance. The respondents were also given the opportunity to explain their grading and to comment on each challenge.

The questionnaire was sent to the 48 experts in October–November 2008 and responses from all were received by December 2008. Twelve experts represented each interest group. Balance between several factors, such as geographical distribution, gender, stage of professional career, international experience, was maintained to ensure a wide range of views.

The grading of different challenges by the respondents was used to create a ranking based on descriptive statistics. An overall ranking and rankings by different interest groups based on arithmetic mean values (\bar{x}) and standard deviations (σ) were created to analyse the possible differences between the groups. The comments by respondents were organised in different categories according to their attitude towards the challenge (whether they emphasised its importance, had a neutral stand, or downplayed it). The loose framework of qualitative content analysis [8] was utilised in analysing the comments. The original survey was carried out in 2008

which allows contrasting the results with the developments and discussions from 2009 until early 2011.

3. Results and analysis

The overall ranking of the 29 challenges as seen by the 48 experts is shown in Figure 1. The grades given ranged from a maximum of 4.6 to a minimum of 2.4. Standard deviation ranged from 1.27 to 0.65. A comparison of the views of the four interest groups revealed differences only on certain issues. Therefore, the results are not presented separately by interest groups. Also, it would be impossible to determine the statistical significance of these differences due to the relatively small sample size. In keeping with the qualitative research tradition, the aim is to provide rich and thick descriptions and analysis of the challenges. A total of 32 (67%) respondents also presented their views in written form in addition to grading.

In this chapter/section we will discuss the 19 challenges ranked among the most pressing ones as well as those most actively commented on by the respondents. The goal is to cover both the challenges considered most pressing as well as controversial or complex ones. It is possible that the comments include some crucial ideas that constitute wild cards or weak signals [9] that could prove to have a significant impact in the future even though appearing irrelevant today.

3.1 Aging infrastructure

In the study, aging infrastructure, especially deteriorating networks, was estimated to be the most significant challenge in the water services sector during the next 20–30 years (Fig. 1). On a scale of 1 to 5, the arithmetic mean \bar{x} of aging infrastructure was 4.6, and had the lowest standard deviation at 0.7. According to the respondents, the condition of the piping systems is already alarming and it will continue to worsen if renovation measures are not increased within the next few years. These results are consistent with Windischhofer's [10] interviews with Finnish water sector experts, who indicated the deteriorating state of infrastructure as one of the top three challenges. The total length of the water supply networks of Finland began to grow rapidly in the 1970s as the large-scale use of plastic piping systems also started. When plastic pipes reach the end of their technical life, approximately 40 – 60 years [11], they should be renovated in order to keep the networks operational and the level of the service high.

FUTURE CHALLENGES FOR FINNISH WATER SERVICES n = 48

Over the next 20-30 years	Relative importance					GRADE	
	1	2	3	4	5	\bar{X}	σ
AGING INFRASTRUCTURE						4.6	0.7
VULNERABILITY & RISK MANAGEMENT						4.4	0.7
HUMAN RESOURCES & KNOW-HOW						4.2	0.9
RESEARCH						4.0	0.9
EDUCATION AND TRAINING						4.0	0.8
WATER QUALITY						4.0	1.0
TECHNICAL PERFORMANCE						3.8	1.0
UTILISATION OF SLUDGE						3.8	1.0
EFFICIENT WASTEWATER TREATMENT						3.7	0.9
TACIT KNOWLEDGE TRANSFER						3.6	1.0
TRANSPARENCY AND OPENESS OF DECISION MAKING						3.6	1.0
MANAGEMENT OF SOCIAL AND POLITICAL RELATIONS						3.5	1.1
CUSTOMER SATISFACTION						3.5	0.9
LEVEL OF LEADERSHIP AND OPERATIONS AT UTILITIES						3.5	0.9
ECONOMIC EFFICIENCY						3.3	1.0
ENERGY RELATED ISSUES						3.3	1.2
ADEQUACY OF WATER RESOURCES						3.2	1.3
WASTEWATER TREATMENT IN DISPERSED RURAL AREAS						3.2	0.9
IMAGE AND ITS IMPROVEMENT						3.1	0.9
ACCESS TO SERVICES						3.1	1.0
DEVELOPMENT OF LEGISLATION						3.1	1.0
DEMANDS FOR HIGHER RATES OF RETURN						3.1	1.2
STORMWATERS DUE TO CHANGES IN LAND USE						3.1	1.0
STORMWATERS DUE TO CLIMATE CHANGE						3.1	1.1
PRESSURES FROM OTHER SECTORS						3.0	0.9
INTERNATIONAL COOPERATION AND VISIBILITY						3.0	1.0
WATER SUPPLY IN DISPERSED RURAL AREAS						3.0	0.9
COMPETITION WITH OTHER MUNICIPAL SERVICES						2.5	1.1
INTERNATIONAL COMPETITION						2.4	1.1

\bar{X} = ARITHMETIC MEAN, σ = STANDARD DEVIATION

ANALYTICAL LEADER: M&E
TKQ/HI 19 March, 2011

Figure 1: Ranking of 29 identified challenges for Finnish water services for the next 20–30 years, as seen by 48 water sector experts in 2008.

Water infrastructure pipe materials have changed a lot: from cast iron to asbestos-cement and from ductile iron to plastic. Especially the plastic pipes, laid after WW II, have shorter estimated life spans than their predecessors. This will increase the demand for renovation over coming decades. According to the respondents, water utilities should prepare themselves for the growing renovation need by putting aside funds and making long-term renovation plans approved by the owner, which in the Finnish case is usually the municipality. The respondents noted that such preparations should be started early enough, because the planning and implementation of rehabilitation takes time. A suggestion on future investment plans along those lines was made in 2010 by a task force for revising the Water Services Act which is an indication that the aging infrastructure has now been put on the agenda.

The majority of respondents gave the grade 5 and expressed the view that this challenge is extremely significant. Yet, a few of them gave the grade 1. The authors' view is that some respondents gave a low grade while holding quite the opposite view because the shape of the water service infrastructure likely varies a lot case by case depending on local conditions. Furthermore, the authors' view is that some water utilities have consciously invested in water supply network renovations because they have wanted to secure employment for their personnel during periods of economic downturn.

Many respondents emphasised that the renovation debt accumulated over the years increases the significance of this challenge. Sometimes it is thought that it is possible to generate substantial savings by reducing the amount of renovations. In reality, that will result in even greater costs due to a growing renovation backlog. According to the 2011 ROTI survey (a Finnish study based on expert panels assessing the state of the built environment), the amount of renovations should be tripled in order to eliminate the accumulated renovation backlog in ten years. [12]

3.2 Vulnerability and risk management

Vulnerability and risk management have become an essential feature of water services. This study found it to be the second most important challenge of the future ($\bar{x} = 4.4$). In the water service sector, it is especially important to recognise that vulnerability and risks, due to their potential consequences, can be fatal: the society as a whole is in danger of being paralysed if water services do not function properly. The water crisis in the Finnish town of Nokia in 2007, where 6000 people were taken ill [13], was a shocking reminder of the severe consequences of a catastrophe that cripples a water delivery system. That incident drew people's attention to the vulnerability and risk management of water services in Finland.

Many respondents emphasised the importance of preparing for risks and actions in practice. Plans and strategies for risk control are important, but it is also recommendable to develop various scenarios. Furthermore, according to the respondents, utilities should be better prepared for various types of external threats. Acts of mischief, and even sabotage, are possible in the future. Climate change may also have various impacts on water and sewage operations. Water works should determine well in advance how climate change will affect their operations and thus be prepared. Challenges related to climate change were emphasised especially by the researchers.

3.3 Human resources and know-how

Human resources and know-how were estimated to be the third most significant challenge ($\bar{x} = 4.2$). The reason provided by the respondents was the large number of sector professionals that will retire during the next few years. According to a 2010 survey, nearly 50% of the workforce of Finnish water utilities was born in the 1940s or 1950s, and nearly 30% in the 1960s [14]. Furthermore, the respondents thought that many of the problems and risks are due to a lack of knowledge and skills. Human resources and know-how were seen to be directly linked to the vulnerability and risk management of water services.

Due to the large-scale retirement of water services personnel, attracting young people to the sector has become a burning issue. The same retirement pattern is evident also in other fields due to the general aging of the population which will make competition for competent and motivated workforce a significant challenge in the future. The respondents raised concerns that the water services sector is not appreciated enough presently as it is not perceived as trendy by the younger generations. Some respondents thought that incorporation of water utilities might alleviate the human resources and know-how related problems.

The average grade given by the researcher group ($\bar{x} = 3.6$) was distinctly lower than the average grade of the other expertise groups ($\bar{x} = 4.3$). Based on the researchers' and educators' comments, they trust that there will be enough professionals in the future if the profession of water service experts succeeds in making the sector more attractive and interesting. One noteworthy point in the written responses was that the replacement of human labour by new technologies was not proposed once.

3.4 Education and training and research

Both research and education and training were estimated to be a significant challenge ($\bar{x} = 4.0$ for both). One key issue raised in the comments was how to make education on water services more attractive to ensure a sufficient number of skilled employees in the future. There is a shortage of students at all degree levels, but the situation is most pressing with bachelor level engineering degrees and in vocational education. A few respondents emphasised that too little attention is paid to practical issues in education. Possible solutions could be, for example, improving the possibilities of gaining practical experience during studies and developing syllabi to respond better to the demands of working life. The respondents argued that such adjustments would also increase



the attractiveness of the sector. Education was seen as highly significant since the credibility and continuity of the whole water services sector has been created and maintained through education.

According to the respondents, the quality and continuity of research work play key roles in the development of water services. They argued that research should be provided sufficient financing in cooperation with water utilities. Utilities could, for example, make a payment to a common fund in proportion to their water sales. In 2003 such a fund was set up in Finland, and as membership is voluntary, the contributions have been quite modest. Yet, this kind of arrangement is thought to have potential if better organised.

Another challenge is the utilisation of research results in their daily operations by water utilities and other stakeholders. The new strategies, technologies and knowledge been created through research should be utilised better in decision-making and daily water services operations. Several respondents also emphasised that internationalisation may increase the significance of this challenge because continuous improvement of competitiveness requires wider and better implementation of research results. Several respondents saw that cooperation between research institutes, universities and other educational institutions should be developed to generate synergy benefits.

3.5 Water quality

People's image of water services is usually based on the quality of drinking water. According to the results of a 2009 survey on technical public services, Finns considered their drinking water to be of high quality [15]. The respondents of this study also emphasised the importance of keeping water quality at a high level. It is not to be endangered or compromised under any conditions. That is the main reason why water quality is considered such an important challenge ($\bar{x} = 4.0$). Catastrophes related to drinking water quality always have significant consequences. According to the respondents, knowledge about health and hygiene has improved in recent decades. In addition, the quality standards of food production have increased. These factors, again, have increased the pressure on the quality of water.

3.6 Utilisation of sludge

The utilisation of wastewater sludge which has been a subject of discussion in Finland was assigned an importance of 3.8 on average by the respondents. People have strong biases and prejudices against the use of wastewater sludge. The continuing growth of the world population



and food consumption may lead to a fight over nutrients at some point. Therefore, the majority of the respondents believed that recycling and recovery of nutrients will be feasible, and even necessary, in the long run.

The lack of a clear strategy for the use of sludge was also raised by many respondents. They emphasised that costs must not rise to an unreasonable level compared to the environmental advantages achieved. Another major issue is how to turn wastewater sludge into a marketable product of high quality and competitive price.

3.7 Technical performance

Technical performance was strongly linked both to the aging infrastructure and human resources and know-how. Many respondents expressed that extra technology will require more maintenance work and technical skills from the workers. Many also saw the possibilities offered by better technical performance. Several experts emphasised that better applications, products and automation will improve technical performance in the future. While meeting the tightening water and wastewater quality requirements, technology should also be more economical and efficient.

3.8 Efficient wastewater treatment

Efficient treatment of wastewater received an average grade of 3.7. The level of wastewater treatment was considered to be of very high quality in Finland. As a matter of fact, several respondents were worried about the tightening wastewater treatment requirements raising the price/quality unreasonably. Particularly the researchers and educators estimated that quality requirements will become stricter for various chemical compounds, such as pharmaceuticals. According to the respondents, the problem will become more challenging because the European Union increasingly participates decision-making. And when the regulations are made for several countries and regions, it is hard to take local variations and conditions into account.

In case of wastewater treatment, the respondents raised the question of the so-called minimum factor, the nutrient that promotes eutrophication, and the removal of which is therefore most critical. Finland argued over this issue with the European Commission for several years. The European Court of Justice gave its decision in favour of Finland in October 2009 [16]. In Finnish conditions, the minimum factor is phosphorous in lakes and parts of the sea while nitrogen is the minimum factor especially in the coastal areas of the Baltic Sea.

In the respondents' comments, the significance of sewerage leakages for the wastewater treatment processes was noticed. Leakages may temporarily multiply the amount of wastewater to be treated. Furthermore, they dilute the wastewater and make wastewater treatment more difficult, especially in biological stages. Thus, the condition of sewer networks has direct effects on the quality of the wastewater treatment processes. By improving the condition of the deteriorating water services infrastructure, leakages can be reduced and thus wastewater treatment improved.

3.9 Tacit knowledge transfer

Tacit knowledge transfer ($\bar{x} = 3.6$) was regarded challenging particularly for small water utilities. There the majority of the knowledge on network locations, used materials and areas, and operation may be known only to one or a few experienced workers. This knowledge must not be allowed to disappear: otherwise technical performance can be severely endangered. Information and knowledge not found in textbooks or computers must be made accessible to future generations. Yet, tacit knowledge transfer does not merely mean its transfer to a new place but also to a new form. In other words, it should not only pass from one person to another but be documented so that it can be widely utilised in the future.

3.10 Transparency and openness of decision-making

According to the respondents, openness and transparency of decision-making are an extremely important issue ($\bar{x} = 3.6$) in public operations to uphold citizens' confidence in decision-makers and decision-making processes. In Finland, water service is a public service and a natural monopoly, which is why it is vital to have the customers' confidence. The respondents, for example, pointed out that customers would probably accept decisions to raise tariffs more willingly, if they understood the reasons for them and had confidence in the decision-making. Yet, the grades between the expert groups varied a lot. Among the researchers and educators, the importance ($\bar{x} = 4.1$) of this challenge was justified by the fact that maintaining confidence requires continuous work on transparency and openness. Thus, in a sense this is a continuous challenge. The majority of water utility experts, however, considered the present level of openness and transparency so good that it is not likely to be a significant challenge in the future ($\bar{x} = 3.0$).

3.11 Management of social and political relations

The management of social and political relations received an average grade of 3.5. According to the respondents, water service professionals have to be aware of what happens in and outside the water services sector. The operational environment of water services has a large number of stakeholders whose actions also affect the water sector. According to the respondents, the social importance of water services should be emphasised in public more than before so that it would be taken into consideration better in decision-making and funding. Some of the respondents did not consider social and political relations a significant challenge mainly due to the monopoly character of water services.

3.12 Customer satisfaction

Customer satisfaction was found to be an equally important challenge as the management of social and political relations ($\bar{x} = 3.5$). The respondents pointed out that customers should be informed of any water distribution interruptions, quality disturbances and other special events in good time and in the right way, if possible. It has often been stated that there cannot be a catastrophe big enough that it cannot be made worse by bad public relations. The Nokia water crisis¹ is a concrete example of the importance of informing. Poor communication and public relations increased the severity of the crisis [13]. The grade given by the researchers' and educators' group (3.1) was lower than that given by the others (3.6). It was justified by the monopoly character of water services. Water services are vital for society and cannot be replaced, which is why customer satisfaction was not considered to be of big importance. Customers cannot change the provider of their water services, unlike the providers of many other services.

3.13 Level of leadership and operations at utilities

Competent leadership is a must for successful operation of a water utility. Several respondents argued that the way utilities react to future challenges is highly dependent on their leadership. They emphasised that in the future the risk of diminishing resources will further increase the importance of leadership. On the other hand, organisational changes and increasing autonomy of utilities were

¹ Nokia water crisis refers to a chain of events that took place in November 2007 in the town of Nokia, Finland. In the wastewater treatment plant an illegal short-cut connection between the treated wastewater and drinking water networks had been installed years ago. As a consequence of this and other undesirable circumstances about 400 cubic meters of purified wastewater was let to flow into drinking water distribution system. Thousands of people became ill and a few deaths are suspected to be caused by the accident. Use of tap water was prohibited for three months."



expected to improve leadership. Current higher education syllabi should also better take into account management and strategic decision-making. The findings of the research are in line with the research results of Katko [17] who argued that education on water services has to be extended to cover also management, institutional and policy issues. According to a few respondents, the social skills of leaders are nowadays more significant than before. One key duty of water utility leaders is to maintain proper social relations with own employees, colleagues, other municipal institutions and decision-makers.

3.14 Economic efficiency

Economic efficiency ($\bar{x} = 3.3$) divided the respondents' written views sharply into two categories, even though the given grades did not vary that much ($\sigma = 1.0$). About half of them considered economic efficiency a significant challenge. They justified their view by the fact that water tariffs are rising very slowly even though energy tariffs rise, requirements become stricter and investments need to be increased. The other half found that the high quality water service in Finland is presently so cheap that water tariffs could even be significantly raised, if necessary. A few respondents noted that economic efficiency can be improved by turning water utilities into more independent economic units. Some also stressed that economic efficiency should never be allowed to compromise the quality of water services.

3.15 Energy-related issues

Energy-related issues are currently topical issues within nearly all branches of industry, also in the water services sector ($\bar{x} = 3.3$). However, they divided the respondents into two categories ($\sigma = 1.2$). Most respondents found that improving the energy efficiency of water services is important from the customers' point of view since rising energy costs will also affect the price of water services. Although the energy efficiency of Finnish water utilities appears to be high, there are still plenty of opportunities for improvement. The significance of reducing leakages for improved energy efficiency was also emphasised. It will result in direct cost savings for both water and wastewater networks. Renovation of aging piping systems will also improve the networks' energy efficiency. A few respondents questioned the tightened requirements for water services which do not take into account the fact that meeting of new requirements often also increases the energy consumption.

3.16 Demands for higher rates of return

The second biggest differences in the average grades of this study concerned the higher demands for rates of return ($\bar{x} = 3.1$; $\sigma = 1.2$). The researchers and educators estimated it to be a more significant challenge than the other experts. Furthermore, the challenge divided the experts sharply into two camps –it was either considered a major challenge or no challenge at all. The consultants emphasised that the existing problem has been widely recognised and legislation will be amended to bring a change. In addition, they reminded that demands for higher rates of return are mainly voiced by big water utilities. Thus, according to many consultants, a challenge of this kind is not faced by the majority of water utilities in Finland. One explanation for the distinctly higher grades given by the researchers' and educators' group is the change in the population age structure which will increase public social and health costs. That will result in extra costs to municipalities and the sale of water and other municipal services are an obvious source of revenue. Several respondents were concerned about the fact that the reasonable rate of return is very vaguely defined in the Water Services Act. However, it is clear that unreasonably high returns to the owner municipalities are against the spirit of the law [18]. The future will show how the Water Services Act is amended in this respect.

3.17 Water services in dispersed rural areas

The question of water services, and especially wastewater in dispersed rural areas ($\bar{x} = 3.2$) drew interesting comments. Many respondents emphasised that water services in dispersed rural areas are at a good level at the moment, but that the situation is expected to change when the people move to more densely populated areas. The respondents also found that people are already demanding higher quality services and that their demands are likely to increase in the future. This is manifested in the equipment level of free-time housing which is increasingly lived in year round. People want about the same or level of services (including water) and equipment there as in their urban homes.

In 2003 a decree which obliges houses in dispersed rural areas to treat their wastewaters more effectively came into force. This decree divided the respondents' opinions deeply. Especially the experts representing authorities considered the decree a successful reform. They firmly believed that the decree will eliminate the problems related to wastewater treatment in dispersal rural areas. Some respondents held the completely opposite view; they thought the decree is the major cause of problems. They argued that the benefits of using required treatment systems are minor compared to the costs. They were also convinced that the demands set for dispersed rural areas



are too strict and cannot be justified. Furthermore, they questioned the functionality and maintenance of the treatment systems and predicted that supervision of the systems' compliance with the requirements of the decree will be a great challenge in the future.

4. Discussion

4.1 Aging infrastructure – the most pressing challenge

There are numerous countries where water related challenges are mainly linked to quantity. Finland is fortunate in this respect as the country has thousands of lakes, which ensures that the availability of water is seldom a problem. The most significant challenge of the future in Finland, as in many other developed countries [e.g. 19], will be the aging of the water service infrastructure. That is no wonder since drinking water is sometimes distributed via pipes more than a hundred years old. Even though pipes that old are fairly rare, a large portion of the network already has reached or will reach the end of its technical life in the next few years. Considering that the length of the water and sewer networks in Finland is about 150,000 km, long enough to stretch nearly four times around the earth, the piping systems are the cornerstone of the water services.

Operational infrastructure is the foundation of high-quality water services. If we allow it to deteriorate, it will be impossible to guarantee the quality of service. Long-range planning and work are therefore needed. In practice, that means renovation and investment plans and successful, far-reaching strategic thinking in decision-making. It should also be understood that although the required decisions may be unpleasant in the short-term, they will be well justified and necessary in the long-term. The challenge of aging infrastructure was recognised already in the 1950s [20]. Has the time to take action finally arrived after more than 50 years of talking? A concrete action could be to raise the tariffs on water services. Many utilities avoid raising tariffs at all costs since that would upset customers and political decision-makers. However, the raising of tariffs is in many cases absolutely vital for allowing the utilities to respond to the challenges facing water services thereby ensuring good quality services also in the future.

One issue related to aging infrastructure is its invisibility. In Finland, water supply networks are buried at a depth of two metres making the visual assessment of their performance and condition impossible. That is probably one factor that limits the funding for renovation of networks. As water services are mainly a municipal service in Finland, funding depends on political decision-making and eventually on the needs and preferences of the citizens. In many cases, the general public is not aware of the state of the infrastructure and the investments needed to produce high quality



water services –the services are often taken for granted. Thus, public support for the funding of renovation is limited. What is out of sight is often out of mind, too. The decision-makers' priorities are frequently focussed on the construction of new and visible infrastructure. Therefore, the real challenge for water service professionals is how to make the “invisible city” more visible to the decision-makers and the general public.

Aging infrastructure has become a topical issue in water services after the survey was conducted. A major pipeline breakdown inside the main railway station in Helsinki in November 2009 [21] imposed significant constraints on local as well as national railway operations. That, together with other incidents, made the aging water infrastructure a topical issue not only among water experts but with the wider population as well. An interesting topic of research would be to determine whether these incidents have really had an impact on the renovation rates of aging infrastructure or whether they only resulted in more discussion.

4.2 Managing risks and vulnerability to ensure good quality of water services

Another very significant future challenge in water services will be the management of risks and vulnerability of a wide spectrum of water service functions and operations. They are connected in one way or another to almost all of the challenges of this study. Other challenges also need to be taken into account as possible risks to be managed. For example, the retirement of professionals and the difficulties of finding new competent workforce to replace them as well as the possible loss of tacit knowledge can significantly increase the vulnerability of water services. Although risk management is crucial, it must be admitted/acknowledged that it is impossible to foresee or even imagine all potential future risks. Thus, we should also be mentally prepared for unpleasant surprises [22]. Reliable supply of safe drinking water and proper wastewater treatment are key elements of public health. Vulnerability has to be examined from the point of view of the infrastructure which is critical to society [23].

Although we are nearly powerless in front of some risks and vulnerabilities, we can learn to live with them. We must have clear action plans in case something undesirable happens. Naturally, mere plans are not sufficient – operations in different exceptional situations must also be practiced. Then, when the unexpected happens, the management, know-how and ability to apply principles and plans into practice come in handy. As noticed in some cases, the consequences of unsuccessful actions can be devastating.

4.3 Competence of the workforce linking all the challenges

The third cluster of challenges is associated with the know-how of the professionals of the water services sector. Besides know-how and human resources, also research, education and training, and transfer of tacit knowledge were ranked as key challenges. Furthermore, it can be said that the development of know-how is an overarching challenge as it is related to all the others. Water sector professionals will need new knowledge, skills and attitudes to respond to all the other challenges facing the field. For example, being able to argue for the importance of investing in rehabilitation of infrastructure in front of decision-makers and the general public will require communication skills. Attitudes will also need to become more favourable toward interaction and communication with others. The subsequent new requirements and improvements in technical performance will then, again, require updating practical skills. Thus, the challenges facing the field must be taken into account throughout the development of education and training in the field – from vocational training to university education. Competent professionals are a key resource in ensuring the sustainability of water services [see also 24].

The future leaders of the water services sector need, in particular, to have a more holistic view, skills to improve social and political relations, capacity for long-term strategic thinking, and last but not least, courage to make the unpleasant decisions today and not allow challenges to develop into major risks that jeopardise the overall sustainability of water services.

Even though technical performance was perceived as a relatively significant challenge, there were no indications that the respondents thought that a competent workforce could be replaced by new technology. The authors also maintain that technological development is necessary but not enough by itself. As Leppälä [25] points out, in addition to artefacts, technology should also include the development of processes and the knowledge related to both of them.

4.4 Assessment of the study

The questionnaire together with the written comments by the representatives of the four major interest groups provided interesting and useful results. The results might have been even more useful if the questionnaire had not only asked about the importance of a challenge but had also asked how well the respondent considered each challenge to have been addressed so far. That would have explained some of the differences between the respondents' views. For instance, some of the water utilities have clearly put effort into rehabilitation and other means of tackling the aging infrastructure, which means that they were likely to give this challenge lower grade. On the



other hand, the comments given helped to remedy that deficiency of the questionnaire by often providing an explanation for the differences in opinion. It might also have proved useful to make the respondents rank differences by allowing them to assign only a certain number of a particular grade or simply asking them to rank the challenges based on their importance. However, it can be said that even without these changes, it was possible to recognise the most important challenges and the clear variation between them. The risk existed that the respondents might have estimated all challenges to be of average importance, but that did not happen.

The questionnaire could also have provided valuable information on weak signals and wild cards if the respondents had not been given a prepared list of challenges, but had been asked to come up with the most significant challenges on their own. That, of course, would have been more time-consuming and could have lowered their interest to participate in the study. Based on the fact that all the invited experts participated in this study, it can be assumed that they felt the list to represent their views rather well. In any case, the overall interest toward the study was high which would appear to indicate that the topic was considered important.

5. Conclusions

The following can be stated as a general conclusion on the challenges for the water services of Finland in the next 20–30 years:

- (i) The core of the high-quality water services – the infrastructure – must be guaranteed and its current deterioration brought under control. The accumulating renovation backlog will make the challenge acute for many utilities.
- (ii) Risk management and the identification of vulnerabilities will be an increasingly important part of the daily operations of the sector in the future.
- (iii) Large-scale retirement of the workforce and the fact that competent staff is essential in responding to future challenges put pressure on all levels of education serving the water services sector. Proper strategies for recruitment and transfer of knowledge are also needed.

All in all, aging infrastructure and competence development, in a broader context, seem to cover the bulk of the identified challenges although we should also be prepared to respond to any current weak signals as potential major challenges of the future.

Acknowledgements

The authors wish to thank the 48 Finnish water sector experts for their valuable contributions. Financial support from the Academy of Finland (Decision No. 135843), The Ella and Georg Ehrnrooth Foundation, Tekes – the Finnish Funding Agency for Technology and Innovation (Decision No. 1049/31/2010), and VALUE (Doctoral Programme in Integrated Catchment and Water Resources Management) is gratefully acknowledged.

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