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Resilient Urban Water Services for the 21th Century Society—Stakeholder Survey in Finland

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Abstract: Resilience has become a vital theme in the discussion concerning urban water services. Resilience in this context can be defined as both keeping up a good level of services, as well as rapid and fluent recovery from failures caused by natural disasters, unsound infrastructure or incorrect management. Although adequate water services resilience can be considered as sustainable, resilience is a wider concept than sustainability. In order to call water services resilient, all sections from policy and management to technical operation should be clear and coherent, and their operation in challenging situations also must be guaranteed. This study seeks a resilient approach to water services through a literature review, and a questionnaire to stakeholders; mainly water supply and sanitation experts. The results show that sufficient technology and good water quality are not sufficient for achieving resilient water services, but also education and institutional management are essential issues. These are accomplished by a methodical education system, capacity building, and good governance.

Keywords: good governance; sanitation; sustainability; water supply

1. Introduction

Water services—water supply and sanitation in this context—are essential services for human welfare. Yet, these services are not always organized and operated in an adequately planned and controlled mode of operation, even in many developed countries. Especially in urban areas, systems are vulnerable to internal or external disturbance, which might cause severe health, environmental and economic challenges for communities. These kinds of disturbance can include, for example, technical and economic problems (internal) or changes in environment or policy (external). Climate change is one example in external disturbances affecting raw water resources and wastewater management.

To maintain continuous and acceptable water services, decision makers, public servants, and experts have to be aware of the requirements of the community for adequate operation of the water systems utility. The requirements concern not only water utilities, but the whole process that affects the urban water cycle. Special challenges are faced due to disasters and climate change impacts. To prepare for recovering from these situations as soon as possible, and for providing uninterrupted water services, the water utility must become more resilient. There are several different issues and sectors that must be robust as prerequisites for considering a community's comprehensive water services resilient. Resilience in water services is in this study considered to include (a) ability to operate continuously and resist disturbances and (b) ability to recover after failures.

Applying integrated water resources management (IWRM) Koop and Leeuwen (2015) analyzed 45 municipalities in 27 countries using the improved city blueprint framework (CBF) [1]. They categorized

five different levels of sustainability of urban IWRM, (1) cities lacking basic water services, (2) wasteful cities, (3) water-efficient cities, (4) resource-efficient and adaptive cities, and (5) water-wise cities. They emphasized the importance of effective governance, environmental awareness and community involvement for sustainable IWRM.

Closely related to IWRM and very much applicable when studying sustainability and resilience of urban water services is the concept of integrated urban water management (IUWM) [2]. In this approach drinking water, sanitation and storm water management are not developed, planned and implemented separately, their cross-scale interdependences must be acknowledged. This is a growing aspect especially in large urban centers.

Urban water services include water intake, treatment and distribution, wastewater collection, treatment and discharge back to natural waters. Storm water management also affects urban water services and that cannot be neglected, especially when considering impacts of climate change on urban water management [2]. The abovementioned issues are the main issues of urban water management globally, but their importance is different depending of the meteorological, hydrological, political, environmental and economic conditions of the country and the area [3].

Some areas may have severe problems because of water scarcity, while other areas have enough water sources, but not adequate water policy. In recent years there have been alarming news about water crisis in large urban areas all over the world [4]. Some studies have been carried out to compare resilience of urban water services in developed and developing economies [5], and impact of population and lifestyle changes [6]. The results show that there are parallels between water, human rights and reproductive justice crises in communities, and that e.g., UK may face a supply-demand gap by the 2080s [6]. In the UK, the Water Services Regulation Authority (Ofwat) has prepared a document, which gives proposals on water regulation in future [7]. The US Environmental Protection Agency has defined systems measures of water distribution system resilience for securing drinking water services in future [8]. One remarkable issue is that, when improving resilience, it is most effective when implemented at a local level [9].

The objective of this study was to determine what kind of institutional aspects should be developed to strengthen the resilience and sustainability of Finnish water services. This study concentrated on Finnish urban water services and their resilience by surveying stakeholders' points of view regarding the value and best practices of community water services. This survey was carried out via a questionnaire to find answers to the following research questions:

1. What is resilience in urban water management?
2. What are crucial aspects for securing adequate water services?

Sustainability and resilience in water services have been studied and applying these principles has been attempted in several countries, e.g., [7,8]. The studies often concentrate on some special subjects or themes, like urban water technology and infrastructure [10], operational management [11], governance [12], or they try to define a method for analyzing the system [13]. The research gap addressed by this study is to develop a wider perspective in technical, institutional and socioeconomic aspects of water resilience. Water resilience and water governance is still poorly understood, especially institutional and governance dimensions of building water resilience [14]. More research should be directed to factors, practices and governance principles that help increase the resilience of people, communities or the environment to water-related risks [15].

2. Materials and Methods

This study was carried out via a literature survey and a questionnaire sent to experts representing key water services stakeholders. Within the stakeholders, 67 individuals were selected from universities, ministries and institutions. In addition, the questionnaire was sent to 338 water utilities, in which there were 403 individual recipients. These 338 water utilities provide drinking water to more than 80.0% of Finland's population. Of these 470 recipients, 99 replied with response rate of 21%. This kind of scope

of study concerning Finnish water services has been applied also in studies carried out in 2010 and 2011 by Technical University of Tampere [16,17]. The questionnaire is presented as an attachment in Supplementary Material S1.

The results of the questionnaire can be interpreted for forming a reasonably good and representative view of sustainable and resilient water services in Finland. The main stakeholders in Finland are ministries (responsible of legislation), regional authorities (one organization responsible of permitting and another of monitoring), municipalities (responsible of organizing water services) and water utilities (operation and maintenance). Other stakeholders to whom the questionnaire was sent were research organizations, universities, consultants, equipment and service providers, as well as some NGOs. The coverage of respondents was as follows: water utilities (44%), other water companies (19%), governmental organizations (14%), private companies (7%), municipalities (6%), universities (4%), and other miscellaneous bodies (6%). The questions are formulated especially to experts of urban water services. Normally the questionnaire was sent to the managing director of a water utility, or respective leaders in other sector bodies. It would be interesting to implement a survey also to customers; institutions and citizens, but then the questions should be different and sampling considerably larger.

The geographical distribution of the replies covered the whole country, largely representing the distribution of settlements: 23% of respondents were from the capital area or other big cities, 27% from Southern Finland (other than the capital area), 20% from Eastern Finland, 19% from Western Finland, and 11% from Northern Finland. This corresponds well to the distribution of the population. Of all respondents, 74% were men and 26% women, while 64% represented management positions and 22% experts.

The questions were formulated to gain an understanding of experts' and stakeholders' points of view regarding the following major aspects. The answers supported the results and conclusions when searching for answers to the research questions formulated in Introduction of this article.

i. Significance of water services failures and their significance in urban water services.
ii. Policy instruments and impact methods for ensuring continuous service in water supply and sanitation: a. pricing policy b. institutional strengthening c. service reliability, d. development planning.

The majority of the 15 questions were formulated, 10 dealt with substance and five with the background of the respondent. In three questions the respondents were asked to assess statements or arguments using a scale from 1 to 5, one question was completely open-ended. The majority of the questions included several alternative means or proposals for improving the current situation out of which from 1 to 3 were selected and ranked. In this way, it was possible to get a balanced overview on how the experts in water services prioritize the selected questions related to resilient water services in Finnish conditions.

This method was considered to suit well for finding answers in this kind of study and to the stated research questions [18]. Before sending the web-based questionnaire, it was pre-tested by five experts. In the beginning of the survey, a short description of all the questions was presented for giving an overview to the respondents before they replied to specific questions. The answers were compiled and analyzed in order to get a good impression and response to research questions that were set in the beginning of the study.

3. Results

3.1. Resilience in Urban Water Services—Literature Survey

Resilience in water services has no definite definitions in literature. The term has been increasingly used, especially during the last few years. However, it can be defined in several ways. Johannessen and Wansler (2017) stated that the resilience concept is generally not operationalized, and they investigated in their study how the resilience concept can be systematized, operationalized and applied better in urban water management [19]. United Nations International Strategy for Disaster Risk (UNISDR)

defined the term resilience as follows: "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner" [20]. According to a thorough study by Folke (2016), resilience thinking is an integrative approach for dealing with the sustainability challenge [21]. It can be viewed as a subset of sustainability science with a focus on social-ecological systems of people, communities, economies, societies and cultures.

A major challenge is to make the now largely invisible infrastructure of water services more visible to decision-makers and citizens. From a historical context, water services are not only necessary but invaluable, and they are a key component of the national security of water supply. Only if water services fail, do they seem to get recognized. Resilient water services and systems are the foundation of well-being, and resiliency is the key for sustainable water services [22]. In considering urban water resilience, it is good to assess various scales in urban water systems depending on users (households, communities, cities), institutions (service providers and regulators), technologies and ecosystems [22]. According to Johannessen and Wansler (2017) [19] resilience in urban water services and defined three levels of disturbances as follows:

i. Socioeconomic disturbance, which is not associated with external hazards but within the urban water service infrastructure and the entities that manage and govern them.
ii. Hazard disturbance, i.e., external hazard, disaster, and crises-related disturbances that are outside the urban water service infrastructure.
iii. Long-term disturbances such as unsustainable resource extraction by the urban water services on the broader social-ecological system and vice versa.

Resilience has also been studied in other environment and infrastructure-related ensembles, such as housing. Miller (2015) concluded that sustainability, environmental performance and resilience are inter-related, and she used technical, social and economic approaches in her study [23]. This paper emphasizes the importance of cooperation and collaborative approach, which can be seen quite clearly also in resilience of water services. Bocchini et al. (2014) compared the terms 'sustainability' and 'resilience' in civil infrastructure and concluded that the proposed perspective and assessment technique is applicable to various types of civil infrastructure systems, although their case concentrated on transportation networks and bridge systems [24].

Linkov et al. (2013) formulated a resilience matrix for measuring overall system resilience, not only fragmented resilience in separate disciplines [25]. They defined four functions with respect to adverse events: (i) planning and preparation, (ii) adsorption, (iii) recovery and (iv) adaptation. In their resilience matrix these events are mapped to four functions:

(i) Physical: sensors, facilities, equipment, system states and capabilities
(ii) Information: creation, manipulation and storage of data
(iii) Cognitive: understanding, mental models, preconceptions, biases and values
(iv) Social: interaction, collaboration and self-synchronization between individuals and entities

This matrix was defined for supporting the decision-making process for perceiving the overall picture of possible disaster management.

It is challenging to combine different stakeholders' views in the same calculations or assessments. One way to navigate this problem is to visualize water supply systems graphically so that different views are illustrated. Using this scheme, Lehrman (2018) used so-called Sankey diagrams for engaging water policy makers on issues of social and environmental justice, ecological water use, sustainability, recreational access and urban/rural issues [26].

Cities generate more than 80% of the gross world product (GWP), so resilience of cities is important to maintain [27]. GWP is the combined gross national product (GNP) of all countries in the world including the total domestic and foreign output claimed by residents of a country. For this, sustainable water services are crucial and in the transition towards smarter cities, water issues play a significant

role. Urban water security is strongly related to resilience [11]. Four issues can be pointed: welfare, equity, sustainability and water-related risks. While public administrations and political scientists are looking for mechanisms of good governance, they underestimate the quality and effectiveness of policy outcomes. Good governance is essential, but it does not guarantee outcomes that are effective in terms of solving the problems at hand. For the level of organizations, the Finnish Technical Research Centre VTT recommended the principle of "flexibility for change" for supporting organizational resilience [28].

In benchmarking water utilities, a wide variety of indicators are used [29,30]. It is important that, in addition to indicators for the performance of the physical infrastructure, there are also indicators illustrating management and financial performance [11]. These indicators point out that "We need to better understand the full potential of water-sensitive design, rainwater harvesting, recycling, reuse, pollution prevention and other innovative urban water approaches" [11].

Hordijk et al. (2014) explored water governance systems in four cities and assessed adaptation practices at three levels: resilience, transition and transformation [31]. They concluded that "the crucial question for the transformation of water governance systems in all cases will be whether, in the long run, participation and deliberative decision-making are extended to decisions about hard infrastructure and the provision of local water and sanitation services, and whether local powers are indeed empowered to hold the approach of water as an economic good to account". This complex problem can also be seen when comparing the combination of centralized and decentralized water systems approaches. In Melbourne, Australia, it was discovered that this kind of hybrid water system both reduced potable water demand and altered wastewater flow and contaminant concentration [32]. This improved the resilience of the water system to variable climate conditions.

In many countries, where water supply and sewer networks in cities are aging, resilience of urban water services is subject to risk of malfunction of deteriorated networks. Krueger et al. (2017) studied how to enhance water and sewer network resilience to external and internal threats [10]. They compared the functional topology of planned urban infrastructure networks to natural river networks draining natural landscapes. As implications, they emphasized the relevance of efficient planning of networks and observation of expected topological features.

Water supply and sewer networks are technically and financially remarkable parts of sustainability and resilience in water services, however these are not the only aspects of water and sewer network management. Sustainable water demand management (SWDM), was defined by Arfanuzzaman and Rahman (2017) in their research in Dhaka city, Bangladesh [33]. In their analyses, they covered the present condition of water demand, supply, system loss, pricing strategy, groundwater level and per capita water consumption. The main idea was to reduce the water footprint and pollution. To achieve SWDM political, financial, technical and legal control, a variety of methods are needed, e.g., 100% coverage of metering, pricing policy on water withdrawal, development of surface water sources and penalty or discount according to meeting the consumption goals.

Schifman et al. (2017) introduced a Framework for Adaptive Socio-Hydrology (FrASH) for planning of using green infrastructure in storm water management [34]. This approach requires cooperation between community organizations and increases stakeholder involvement. Thus, integrated urban water resources management can be a step towards sustainable city development. The authors see also that this concept can be applied to other environmental management plans and projects, and it can be considered suitable for planning sustainable urban water services. One important aspect in IUWM concept is separation of wastewater systems from rainwater drain systems. This was concluded in the Netherlands in a study of three case cities, namely Amsterdam, Rotterdam, and Utrecht [12].

The paradigms of sustainability and resilience in the built environment were the subject matter of research by Lizarralde et al. [35]. They found that there are different interpretations of these terms. This might explain tensions that occur when the paradigms of sustainability and resilience are translated into policy instruments. They name sustainability 'green' and resilience 'blue' and conclude that both academics and practitioners need more refined tools and conceptual frameworks to successfully achieve a turquoise agenda in the built environment.

3.2. Results of the Survey

In our survey, the respondents considered water services the most important part of municipal engineering. However, it must be stated that they represent particularly stakeholders of water services, like water utilities, consultants, researchers and authorities. In water use, water as a source of water supply was considered extremely important (see Figure 1). The exact question was "What is the most important use of water resources?" The respondents were given a scale from one to five, one meaning not important at all and five extremely important. So, the scale from all 99 answers ranges from 99 to 495. The same scale is used in Figure 2.

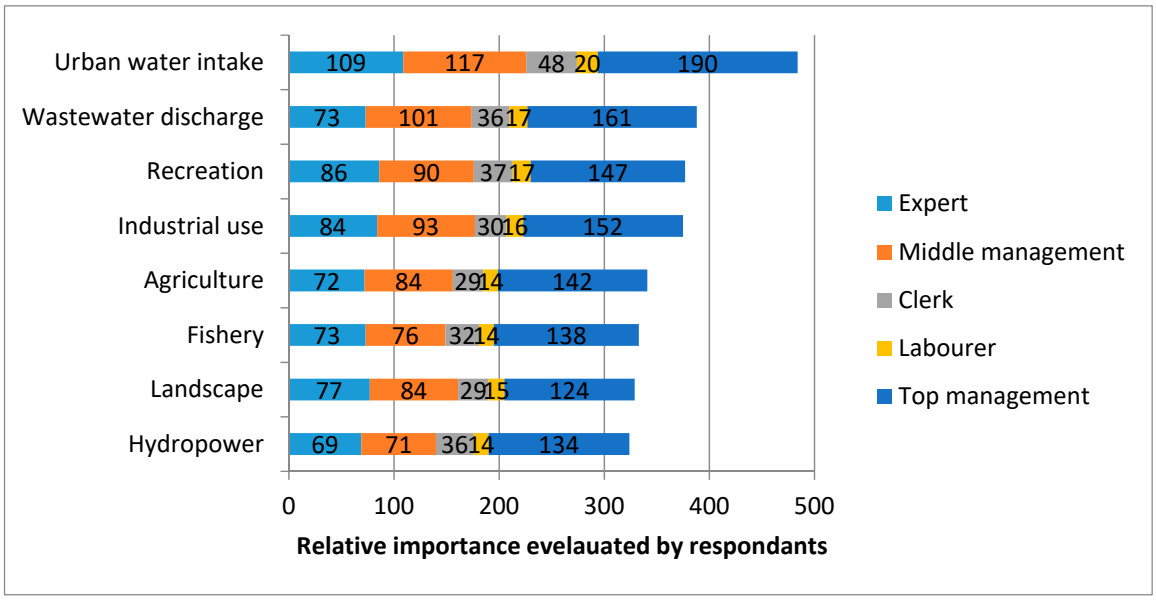

Figure 1. Ranking of water use priorities, illustrated by occupational groups.

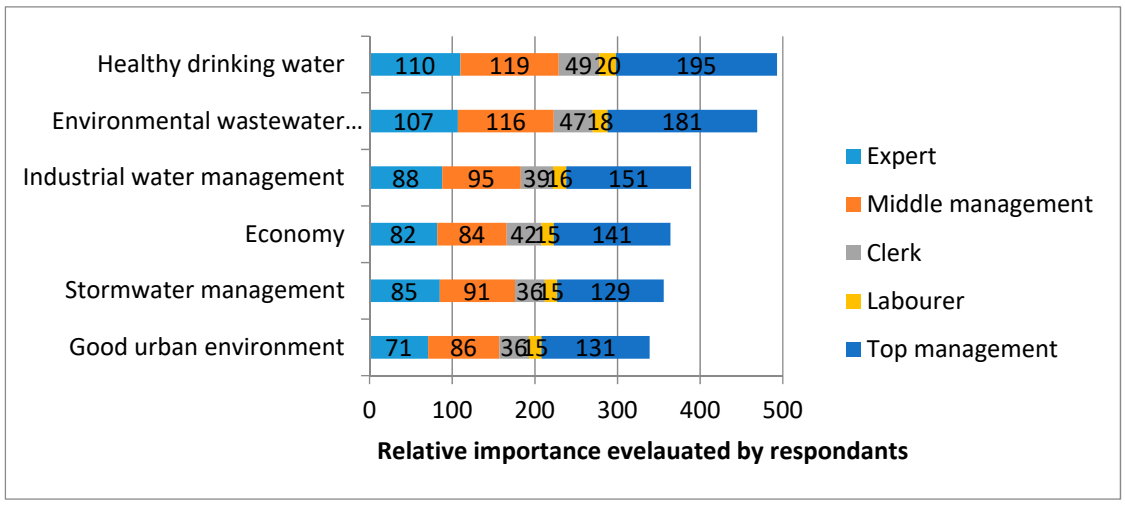

Figure 2. Relative importance of water services according to respondents, illustrated by occupational groups.

In the relative importance of water services, the most important aspect was healthy and secure water supply (scale from 99 to 495) followed by wastewater management that is secure for the environment (Figure 2). Participants responded to the statement 'Importance of functional water services'.

Pricing policy and institutional aspects were explored for getting views on policy instruments. Six statements were given, and respondents were asked to pick the most important one:

- Water fee must be decreased so that everybody can afford water services
- Water fee must be increased so that services can be improved
- Water fee is reasonable, services can be improved by more-efficient operational management
- Payments for owners of water utilities (usually municipalities) must be decreased
- Water supply network leakages should be decreased
- Sewer network leakages should be decreased

Most remarkable is that no-one thought that the water fee should be decreased and 31% thought that it should be increased for improving water services (Figure 3).

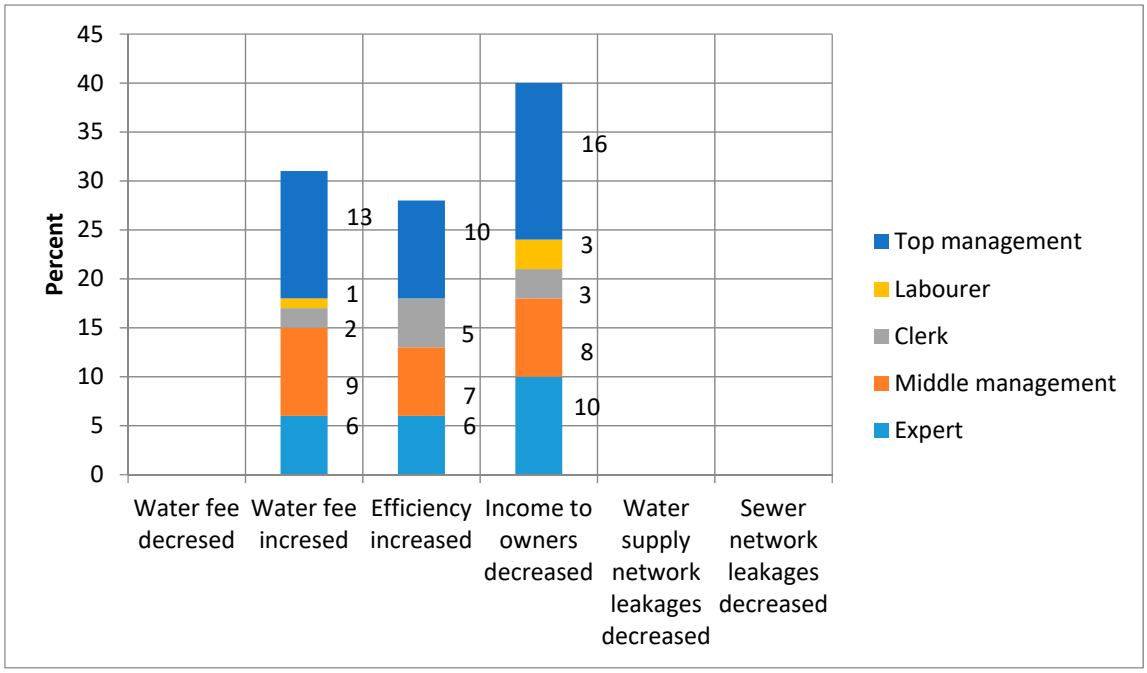

Figure 3. Policy instruments and pricing policy, illustrated by occupational groups.

Municipalities transfer part of water utilities' profits as income for other municipal costs (so-called reasonable rate of return). This might be a considerably large part of funds that could be used for development and renovation investments. Altogether, 41% of respondents had the view that the current rate of return is too high (this is too large a part of the water utilities budget) and it should be reduced.

One remarkable issue in Finnish water services for the time being is renovation of water pipe and sewer networks. Major parts of networks were constructed in the 1950–1960s and now it is time for major investments for maintaining a safe and acceptable level of water services. Considering the most important measures to ensure good water services, 64% of respondents thought that renovation of water pipe networks should be increased and 57% thought that renovation of sewer networks should be increased. Only 5% thought that the quality of drinking water should be improved, which indicates that the quality is good enough in most of Finnish communities.

The measures for ensuring continuous acceptable levels of water services, good data and information management, were considered the most important issues. Other issues identified as important were detailed planning for renovations and modelling as a tool for leakage monitoring. In ensuring the reliability of water services, skillful and sufficient personnel is important. Hence, national-level capacity building should be ensured. Network rehabilitation financing was also considered important for ensuring good-quality water services (see Figure 4).

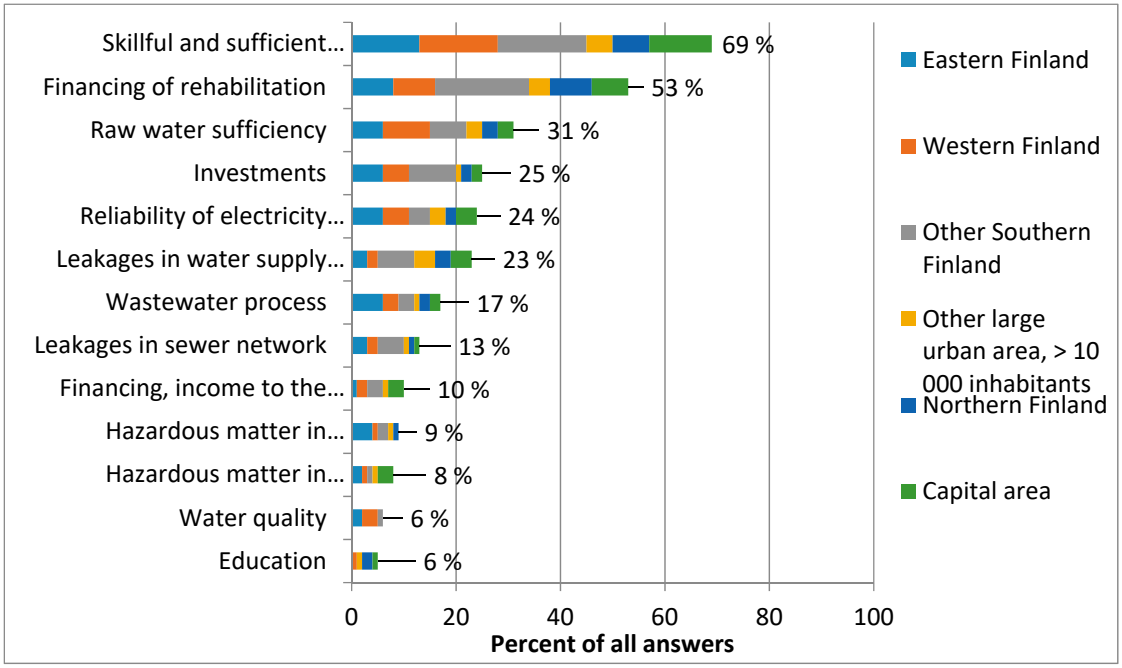

Figure 4. Topics for ensuring sufficient water services, illustrated by regions (in % of all answers).

The questionnaire included one open question: "What is the significance of adequate water services for your organization?" The 102 answers from 63 respondents were divided to seven groups; Operation of community, Health, Environment, Industry, Convenience, Economy, and Image of water services. Altogether, 29 (28%) of the answers emphasized operation of community, 24 (23%) the economy, and 19 (19%) the environment. This indicates that Finnish water experts consider water services as an eminent part of socioeconomic civil services.

The Finnish Act for Water Services says that the municipalities are in charge of water services, but they can outsource operation and purchase services from private or public organizations. This course of action is considered highly functional (89% of respondents) and flexible cooperation between public and private operators is important (70%). Only 1% thought that also private companies could be owners of a water utility.

4. Discussion and Conclusions

This study was carried out via a literature review and a questionnaire to professionals in water services. The coverage of the respondents was quite good when proportioned to the size of the country and the previous studies. This study dealt only with urban water services and its resilience. Issues in rural areas are different and the results could have been different if the questions had concerned also rural water supply and sanitation. In such a case, it would have been more difficult to find specific conclusions to the formulated research questions.

The first two questions in the questionnaire concerned the importance of water services in the field of other critical municipal services and water issues. These sectors are strongly connected, and as public services they must be planned and developed integrated. For example, very often the rehabilitation of water and sewer networks is sensible to implement together with street rehabilitation. Storm water management is also connected with water services, and especially due to climate change impacts, it must be taken into consideration together with water supply and sanitation as well as construction of streets and green infrastructure.

4.1. Results Reflected in the Survey

In the literature survey, the articles can be divided according to how they approached the concerned theme, or the subject they emphasized. According to the subject, most of them deal with water infrastructure and disturbances in service. In terms of approach, the most common concerns are water scarcity and sufficiency as well as water-smart cities. According to this study, the importance of these subjects can be confirmed, but there are also several other issues that cannot be neglected. The most important point of views in addition to subjects mentioned above are education and skilled personnel, good governance, institutional arrangement and financing. As a conclusion this literature survey gives an idea what resilience means in water services and how it can be reflected to the case of Finland.

Countries can learn from each other and by taking the different circumstances into account, they can improve the weaknesses of their own systems. Water scarcity is not a big problem in Finland, which can be seen also through the responses to our questionnaire survey. However, the methods to approach the strategy can be applied in Finnish water management.

One common issue in water services in western countries, reducing resiliency, is the deteriorating water infrastructure, especially water and wastewater networks, and the fact that the knowledge of networks and their real conditions is inadequate. In recent years, it can be seen that water utilities have been able to gain more knowledge and funding for systematic rehabilitation. Also, technical development provides better possibilities to implement thorough surveys regarding the state of networks. The respondents did not consider that water fees are too high in Finland. The average water fee, including drinking water supply and wastewater collection and treatment, is about 5 euros depending on the house type [36]. When average water consumption is about 130 L/person/day, this means that the cost of water services is about 2% of the household's income, assuming that two persons are working and receiving an average salary.

4.2. Results Reflected in Research Questions

The questionnaire was designed so that when analyzing the answers, the answers to research questions would also be gained. The results show that generally reliable water services were considered a very important part of municipal services. Within water services, safe drinking water was considered the most important issue, while environmentally adequate wastewater management was seen almost as important. Noteworthy is that the price of water was not considered a very important concern. This indicates that in Finland the price of supplied water is reasonable and in developing more sustainable and resilient urban water services, the stakeholders considered that willingness to pay is quite high. Concerning water utilities, the economy was still regarded an important part of their operational management. An open question on major concerns in urban water services revealed that 23% of the answers found the economy as one of the most important issues in practice. This is, however, not a concern of pricing, but of revenue sharing within the utility and its owner.

Aging infrastructure was still considered a big problem in urban water utilities, as discovered by Heino et al. already in 2011 [16]. The other topics that were raised as relevant in developing sustainable and resilient Finnish water services, were skilled personnel, financing of rehabilitation, and raw water sufficiency. The last issue, that is growing in significance in Finland too, is that due to climate change, seasonal water scarcities are expected in some parts of the country.

Good governance is a prerequisite for any society to have sustainable water services. Finland is often considered as one of the best countries in the world concerning low corruption, good public services and public private partnership. These institutional aspects are essential in water management, while continuous development and improvement are needed for avoiding regression. The results indicated that there is a clear commitment to this among water experts, and their knowledge should be integrated into decision-making for the good of society.

4.3. Resilient Finnish Water Services in the Future

Recovering from disaster or adversity requires proper technical and institutional preparedness. According to this study, technical resilience is considered strong in Finland. When water utilities are run in accordance to the full-cost recovery principle, it is easy to keep technical preparedness in good order. Institutional preparedness requires good consensus among water professionals, authorities and decision makers. This necessitates continuous discussion and mutual understanding in development and implementation of water services. This is not only a question of technical service, but a question of wider socio-institutional principles, how health and environment issues are dealt with within the whole society.

In the future, to maintain the current standard of water services and to strengthen resilience, some topics can be listed:

(a) Asset management as an important part in water services
(b) Good governance ensured
(c) Economic aspects as full-cost recovery
(d) Continuous improvement
(e) Institutional framework maintained
(f) Capacity building and human resources policy cannot be neglected.

More research could be done, for example, in comparing water services concerning their resilience in different countries with various institutional frameworks. It would also be interesting to study opinions of the customers by a comprehensive questionnaire targeted to the public. Public private partnership is an essential part in resilient water services, and therefore a thorough review of the institutional framework is needed.

4.4. Conclusions

The main achievements of this study are knowledge about main disturbances, which threaten trouble-free water services, and how to develop or keep sustainability and resilience of a water utility. According to this knowledge, a water utility can prepare its strategy and strengthen its resilience in its future operation. These achievements are explained in following aspects and topics.

The main aspects in resilient and sustainable water services in Finland can be concluded as follows:

(a) Maintaining in high-quality education and training at all levels; high school, college and university
(b) Skilled and motivated personnel is considered very important in water services performance
(c) Integrated knowledge in technical development, institutional aspects and socioeconomic needs
(d) Awareness of effects of external disturbances, e.g., climate change (droughts and floods), political situations and the changing urban environment.

This can be secured by regular training and education needs assessment and development, open discussion and cooperation between all operators and stakeholders, and realistic objectives that can be agreed and accepted among all parties. Need for open cooperation between public and private parties is obvious. Answers showed, however, quite clearly that water services should be owned by a public organization, which can purchase services from private companies. This is organized differently in some European countries, but for keeping this basic and necessary function accessible for all people, Finnish public–private partnership or cooperation with public ownership has worked socio-economically fluently, confidently, and equally. This can be ensured by keeping the core functions strictly controlled by the owner of the utility, and outsourcing only support functions, e.g., repairs, accounting, and cleaning work.

Supplementary Materials: The following are available online at http://www.mdpi.com/2073-4441/12/1/187/s1, Supplementary Materials S1: Questionnaire used in stakeholder survey.

Author Contributions: J.L. was the correspondent author and the principal researcher of this study. J.K. and J.J.H. gave their contribution in methodology and validation of the results. T.S.K. acted as a co-writer, and a supervisor together with P.J. All authors have read and agreed to the published version of the manuscript.

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