

## Risk management during the Covid-19 crisis: business responses in the Polish water utilities

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### ABSTRACT

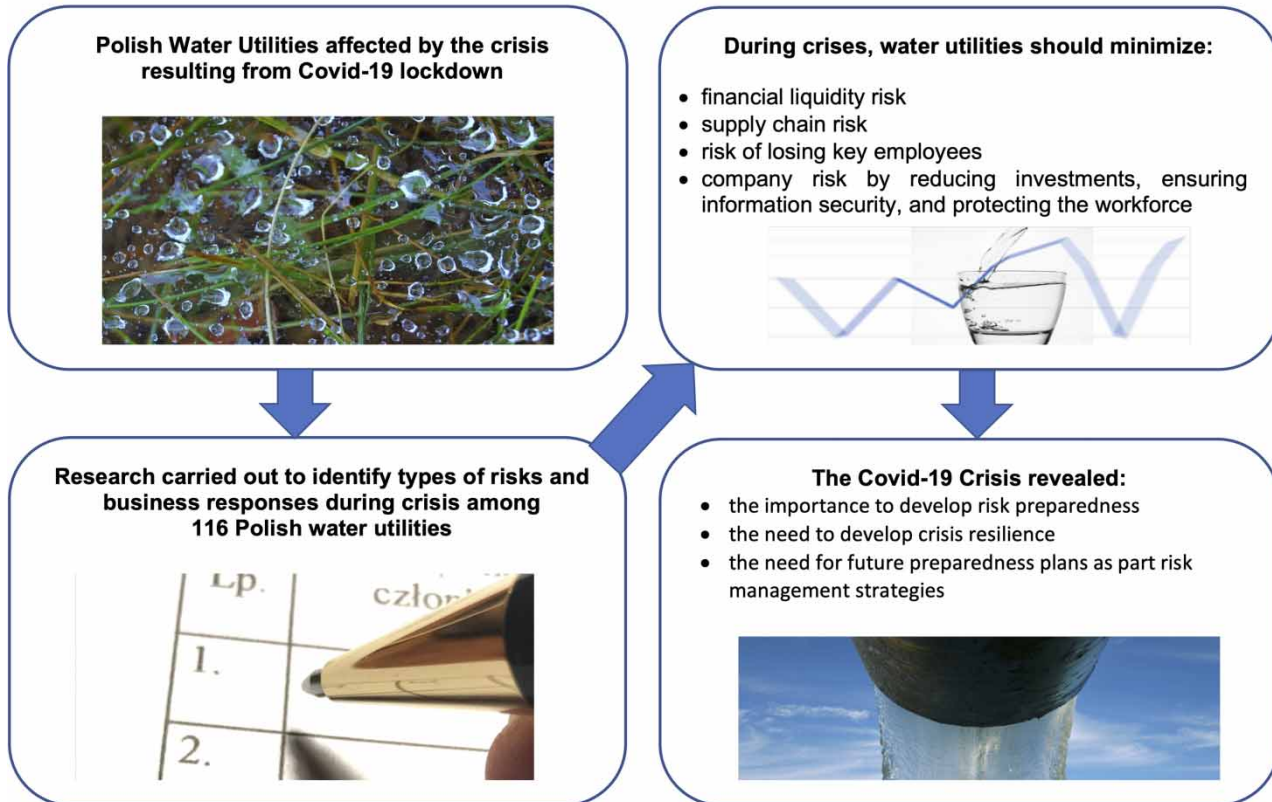
Water utilities are an essential service that helps protect public health during crises. The Covid-19 pandemic revealed that crisis preparedness is a crucial capability that water utilities must possess. The purpose of this paper is to identify managerial actions and responses that were undertaken by water utility managers in order to reduce the risk related to the first economic lockdown caused by the unexpected Covid-19 crisis. As water utilities should learn from Covid-19 so as to strengthen their future risk preparedness, the paper offers some theoretical underpinnings on risk management. As a result of literature analysis, we focus on the risk management framework that distinguishes five types of risk. The survey was carried out among 116 waterworks in Poland in April 2020. The results indicate the importance of minimising liquidity risk and supply chain risk, which is relevant to the adopted theoretical framework. The findings also highlight the importance of a category that was not originally included in the research model – that is human resource risk, an area that requires managerial attention in the water utility sector. The results could also provide useful pointers for other water utilities, especially those operating in the same or similar legislative regime.

**Key words:** Covid-19, crisis, managerial responses, risk management, water utilities

### HIGHLIGHTS

- We present the results of research carried out among water utilities in Poland during the first Covid-19 lockdown, focusing on infrastructure risk, enterprise risk, information safety risk, supply chain risk and new technology risk.
- The results indicate that there is a new element of risk – human resource risk – that requires managerial attention.

## GRAPHICAL ABSTRACT

**Risk Management during the Covid-19 Crisis: Business Responses in the Polish Water Utilities****INTRODUCTION**

The water sector is one of the most important services for society in general, and the importance of water services is noticed predominantly during various crises (Zechman Berglund *et al.* 2021). The lockdowns after the coronavirus outbreak also demonstrated that protecting public health during a pandemic is essential, even when other business activities can be limited. As posited by K. Vairavamoorthy: ‘during the pandemic, the sharing of innovation and intellectual property, and access to facilities, demonstrates our willingness and ability to contribute to the larger process of open innovation’ (Vairavamoorthy 2020) in water utilities. The water utility sector was the second line of defence against the outbreak as water was essential for maintaining good levels of hygiene. Therefore, ensuring the continuity of services (water as well as sewage) is even more crucial in the time of an outbreak than in normal times. Decisions taken by managers in the water utilities affect not only those outside the organisation, but also those inside, that is employees who are directly responsible for services, some of whom are in danger of infection from working closely with sewage.

The Covid-19 pandemic revealed the significance of risk preparedness for the water utilities (Sowby 2020) and demonstrated the need to develop crisis resilience and future preparedness in the sector (Gude & Muire 2021). While governments in many countries introduced lockdowns, temporarily closing businesses that were not considered essential (Zechman Berglund *et al.* 2021), the water utilities, which are crucial for sustaining public health, needed to keep operating even during the crisis (Sowby & Lunstad 2021).

In the past, every pandemic generated a crisis that required the use of public resources and changes in daily behaviours, which posed significant challenges for managers of various types of organisations. The Covid-19 pandemic is no exception. The economic lockdowns we have observed in various countries worldwide have had a serious impact on the functioning of economies, have created incredible challenges for leaders and have required the spending of public funds in response to the coronavirus crisis (Kayes *et al.* 2017).

Every unexpected crisis, including a disease-driven crisis, generates a certain amount of risk for organisations. It is, therefore, natural to look at the crisis-generated outcomes from a risk management perspective. As crises affect the continuity of organisations (Scholes 2000), for managers, the crucial information seems to be whether crisis-originated risk is purely coincidental or can be managed (Eastburn & Sharland 2017). The aim of this study is to identify managerial actions and responses that were undertaken by business leaders in order to reduce risk generated by the unexpected Covid-19-related first economic lockdown in March 2020. The paper focuses on conceptualising elements of risk management, and on operationalising them through research among water utilities, which faced challenges during the Covid-19 pandemic and had to respond to the unexpected situation resulting from the March 2020 lockdown.

In the first part of the paper, we attempt to conceptualise risk management with a particular focus on crisis situations. We found it valuable to look for concepts and elements of crisis management in management literature, and then to relate these to the water utility sector. The sector is experiencing a significant shift in the approach to risk management, one that is more and more explicit and has a broader scope (MacGillivray *et al.* 2007). Therefore, we offer some theoretical underpinnings concerning risk management, strategic actions and organisational processes for minimising risk, as well as risk management components that relate to the water utilities. In line with the academic discussion, we posit that risk management is a strategic process which – through proper asset management during unexpected situations – can facilitate the achievement of strategic objectives in spite of threats that may appear (Crovini *et al.* 2020). In order to reduce risk, organisations apply various reactions to crises, such as implementing crisis management plans, developing risk communication channels, securing their workforce, shifting assets and applying changes to supply chains or information systems. All the measures that are taken are part of the risk management process.

This paper seeks to answer the question whether these types of risk exist in practice in the water utility sector and to what extent they are being managed in water utilities faced with unexpected crises. To address this question, we present the outcomes of research on managerial decisions taken as a first reaction to the economic crisis caused by the SARS-CoV-19 virus. The research was carried out among 116 waterworks operating in Poland. The main part of the research was conducted in April 2020, right after the first lockdown. The questionnaire was based on the five categories of risk as proposed by J.K. Engemann (Engemann 2019).

Our study indicates that some of the risk management elements identified in the management literature comply with the business practice of the water utility companies operating in Poland. However, some of the risk factors seem to be sector-specific and relate to the water utilities in particular.

The risks identified through management literature analysis and tested empirically in waterworks business practice call for a more systematic preparedness for unexpected crises, whose frequency, duration and scale are hard to predict.

## THEORETICAL BACKGROUND

### Risk management in times of crises

Covid-19 and other serious epidemics, risks or hazards have an influence on the water utilities. Since safety and stability are vital to the water utilities, pandemics that differ in frequency, duration and scale affect the water sector heavily (Sowby & Lunstad 2021). During the recent Covid-19 crisis, 61% of researched water utilities indicated that they did not have a specific pandemic plan (American Water Works Association 2020).

Diseases such as H1N1, Ebola and the Covid-19 virus have generated serious crises that require the mobilisation of private and public resources, as well as changes in daily life. Every crisis can destabilise an organisation's activities and its workforce, creating a variety of challenges for leaders, such as access to reliable information, the novelty of the situation and unclear and changing goals (Kayes *et al.* 2017).

When discussing the limitations of decision-making processes, Eastburn and Sharland suggest that managerial decision-making processes are influenced not only by the information the decision-makers have about the current situation, but also by the unique personal qualities of the managers, so that the decisions taken reflect the emotional thinking processes of management. As a consequence of this approach, the ability to process information is conditioned by managers' thinking patterns, which may be influenced by their unique behavioural characteristics and performance constraints that shape the problem space (Eastburn & Sharland 2017).

Crises usually generate a certain number of risks that can affect the continuity of business operations. During crises, it is important to prepare managers for effective but also ethical risk and crisis management, as well as to formulate a strategic crisis communication plan (Scholes 2000). Scholars emphasise that having the proper planning process helps in managing crises, as it focuses on risk assessment as well as helping in the development and implementation of certain risk mitigation actions and programmes (Wilhite *et al.* 2000). Apart from crisis plans, attention has also been paid to communication preparedness for crises (Brashers 2001), as effective communication is seen as critical during crises resulting from a pandemic (Choi *et al.* 2015). It has been indicated that communication plans should take into consideration involving stakeholders affected by risk management decisions, including various factors in decision-making using broad communication channels (Covello 2003). The need to face up to the challenges of global competition, technological change and the constant search for competitive advantages are the main motivations that encourage managers of organisations to manage risk (Sorenson *et al.* 2008).

By pointing out the complexity of the risks and the negative impact of crises on the functioning of enterprises, Engemann posits that although risks cannot be eliminated, they can be controlled to some extent (Engemann 2019). A similar position is taken by Eastburn and Sharland, who suggest that an individual response to a risk depends on whether it is completely random or manageable. The scientific approach to a risk is closer to the second position, and assumes that if the risk cannot be eliminated, it can at least be predicted and processes can be implemented to reduce its negative impact (Eastburn & Sharland 2017). In an organisation's risk management process, which has the primary goals of protecting life, protecting the environment, protecting assets and continuing operations, management must offer leadership and guidance on strategy choices and define an acceptable level of risk (Engemann 2019). Although the risk management process may not always be formalised, risk analysis should always be carried out (Crovini *et al.* 2020).

Risk management is defined as a strategic process that is a key factor in competitiveness and profitability, the aim of which is to plan, organise, direct and control resources in order to achieve specific objectives in the event of unexpectedly good or bad events (Crovini *et al.* 2020). In turn, organisational risk management can be also seen as a process based on classical decision-making theory, in which risk at the macro level is considered to reflect differences in the distribution of possible outcomes, their probabilities and their subjective values (Massingham 2010).

An interesting insight into risk management can be taken into consideration by using the dynamic capabilities perspective. Indeed, risk management can be seen as a dynamic capability that allows organisations to respond to crises appearing in their environment. However, the results suggest that organisations need different types of dynamic capabilities in order to respond to different dimensions of their environment and different types of changes (Nair *et al.* 2014). The dynamic capability perspective requires looking at leadership skills and risk management. Scholars highlight that in order to respond to pandemic crises effectively, new leadership skills and roles are required, especially in the area of human resources development, such as sensemaking, technology enabling, emotional stability and innovation communication, as well as maintaining the financial health of the organisation (Dirani *et al.* 2020). Other leadership responses include setting shared goals, establishing a coordinated response, preparing a communications strategy, implementing a communications plan and having the readiness to adapt to changes (Beilstein *et al.* 2020).

Accepting the assumption found in the literature that risk is a multidimensional construct (Tudor *et al.* 2014; Featherman & Hajli 2016; Farivar *et al.* 2017), while it requires defining the components of risk, does facilitate the process of its analysis. This is due to the fact that its specific types can be referred to for providing an insight into identifying further threats to organisations, and can bring benefits in ensuring the safety of the organisation (Engemann 2019).

In pointing out the challenge of risk management, Engemann distinguishes five types of risks (Engemann 2019): (1) infrastructure risk, (2) enterprise risk, (3) information safety risk, (4) supply chain risk and (5) new technology risk. At the beginning of our research, we interviewed six top managers of water utilities, whom we asked to identify risks in the water sector. Analysis of their indications verified for us that Engemann's proposal was suited to threats appearing in the water utilities. Although water utility managers also identified other risks such as contamination or infrastructure wear, we posit that these may be covered by infrastructure risk.

As we found it interesting to present the theoretical framework embedded in management science and apply it to the water utility sector, in the first instance, we will discuss each type of risk from the theoretical perspective, attempt to identify the underlying elements and point to certain challenges in the management of such risks. Finally, the theoretically identified elements of each type of risk will be complemented with managerial indications.

### Infrastructure risk

In the waterworks sector, modern, safe, protected, sustained and rigid infrastructure plays a crucial role as it assures the highest levels of water purification, production, composition and supply quality (Nogueira Vilanova *et al.* 2015; Morris & McGuinness 2019). Demand for infrastructure and services is growing rapidly in both developing and developed countries seeking higher growth (Gupta & Verma 2020). Infrastructure resilience and risk management literature indicates that key decisions occur in the aftermath of adverse events (e.g., immediate response and later repair of damage), but pre-emptive decisions, which are less common, must be made under uncertainty about the specific disaster to be faced in the future (Gomez & Baker 2019). This is specifically important in the waterworks sector, which needs to be ready and prepared for any undesired events, prompting the implementation of asset management solutions (Amadi-Echendu *et al.* 2010). In this sense, proactivity, not reactivity is required (Chalker *et al.* 2018). Water utilities need to prepare and communicate plans for securing the infrastructure beforehand in the event of a crisis or hazard (Marlow *et al.* 2015).

### Enterprise risk

This is probably a risk that water utility companies do not regard as a priority, which is often due to the reluctance of water company managers to integrate risk management processes into the enterprise management system (Chalker *et al.* 2018). However, managing enterprise risk in the water utility sector and taking quick decisions in order to secure stability, safety and continuity is important. For instance, Chalker *et al.* indicate an increase in technically oriented research on strategic risk management (business risk or enterprise risk) in the international water sector (Chalker *et al.* 2018).

What is crucial is to look at a water utility company in a systematic and holistic way. Hoyt and Liebenberg suggest that unlike traditional risk management, where individual risk categories are managed separately – in a silo style, enterprise risk management (ERM) enables companies to manage risk in an integrated, enterprise-wide manner (Hoyt & Liebenberg 2011). A similar position is taken by Gordon *et al.*, who point out that ERM, through a systematic and consistent approach (or process) to managing all risks faced by an organisation, reduces the overall risk of company failure and thus increases the organisation's efficiency and value (Gordon *et al.* 2009). Nocco and Stulz, on the other hand, suggest that a carefully designed ERM programme can be a source of long-term competitive advantage and value through its macroscale effects at the level of the entire company or business unit (Nocco & Stulz 2006). By pointing out the definition problems related to the description of the nature and essence of ERM, Bromiley *et al.* suggest that three common features can be identified for almost all approaches. Firstly, ERM assumes that risk management in the case of a group's portfolio is more efficient than that of each individual subsidiary. Secondly, ERM covers not only traditional risks, but also strategic risks. Thirdly, ERM assumes that companies should try to define competitive advantages based on risk management (Bromiley *et al.* 2015).

This raises some implications for water utility companies: (1) risk management should concern the whole waterworks system, (2) strategic and managerial risk concerning decisions made during crises is as important as infrastructure risk and (3) proper risk management can define the future advantages enjoyed by water utility companies.

### Information safety risk

Water utility companies are founded on safety and stability and are seen as strategic organisations of the highest importance. As a result, they are becoming increasingly aware of the necessity for information security, which is increasingly an important aspect of their business strategy (Hassanzadeh *et al.* 2020). Using information security risk management (ISRM) to identify threats allows for the development of a security risk profile for critical assets in order to establish plans for dealing with threats in unexpected situations (Shamala *et al.* 2017). The risk related to the quality and timeliness of access to information covers all areas of life. Research in the field of health threats has confirmed that people actively seek information about threats when making decisions that are important for themselves (Alaszewski 2005).

Information flow risks include those related to computer systems and demand forecasts. Finally, issues relating to trade receivables and bankruptcies are the most common economic risks. Higher quality of information involves lower liquidity risk, and the reduction in the cost of capital resulting from this is economically significant. The negative relationship between information quality and liquidity risk is stronger in times of market liquidity crises (Ng 2011). Information security is becoming an important element for water utility companies due to critical infrastructure management processes (Luijff *et al.* 2008; Tabansky 2017). This results in more concern, but also in an organisation's awareness of information security risk management in order to develop effective and economically viable control strategies (Shamala *et al.* 2017).

### Supply chain risk

Market globalisation, shortened product life cycles, a reduced supply base, the need to slim down organisations and the excessive use of outsourcing and offshoring contribute to increased supply chain risk management (SCRM), defined as a coordinated process among elements of the supply chain that reduces the likelihood of risky events and reduces the negative consequences for business after the occurrence of risky events (Sharma & Bhat 2014). In relation to the waterworks sector, it can be said that supply chain risk management refers to reducing the probability of risky events in the water supply chain, including water production, water purification, water supply and sewage (Pawar *et al.* 2013; Yu *et al.* 2021). Mozafari and Zabihi suggest that risk is inherent in any water supply chain, and typically occurs due to climate change, fluctuations in demand and facility failures (Mozafari & Zabihi 2020).

The most frequently mentioned supply chain risks also include those related to material, cash and information flows (Tang & Nurmaya Musa 2011). Uncertainty about the level of demand, unforeseen crises and the weakness of individual links in the chain may cause fluctuations in product, material or services flows. In order to minimise such risks, a holistic approach to supply chain design coupled with proactive, systemic supply chain management are suggested (Uta 2005). It is also important to identify the risks among suppliers and to determine which of them may fail during crises (Trkman & McCormack 2009).

The likelihood of an incident involving supply or the inability to meet customer demand, posing a threat to their life and safety, can be said to be at the heart of supply chain risk in the water utility sector (Zsidisin & Smith 2005). At the same time, the perception of supply chain risk by the end customer refers to the total potential loss resulting from the interruption of the supply of a particular item from a particular supplier (Ellis *et al.* 2010). In developed countries, customers expect stable and safe water utilities to guarantee the water supply even in times of crisis (Zechman Berglund *et al.* 2021).

### New technology risk

The pandemic has had a positive impact in accelerating the use of technology to advance and implement projects in the water sector (Renukappa *et al.* 2021). As the water utilities are investing and developing new technologies in infrastructure, chemical treatment and supply safety assurance, the risk of new technologies is related to the water quality, water supply and water safety. This is connected with a company's development opportunities and often involves innovation; hence, it is also called innovation risk, which must be assessed not only in terms of the technology itself, but also in terms of the extent to which the technology is integrated into existing product development processes. The assessment of risk management skills should primarily involve a team of IT specialists and their support in managing the programmes used in the organisation (Freire *et al.* 2018).

Technology risk is defined as the probability of physical, social or financial losses due to the use of technologies and aggregated over the entire product life cycle. High impact technologies include large facilities such as nuclear installations, chemical plants, large dams or waste treatment plants. Furthermore, they also include specific but widespread technologies used by plants that produce genetically modified food, nanoparticles or nanotubes using synthetic biology, artificial intelligence and smart chips, as well as new communication devices (Renn & Benighaus 2013). In order to reduce the risks related to the acquisition of new technologies, the following strategies are offered: (1) competitive benchmarking, (2) employee involvement and (3) quality management (Benjamin 1993).

It turns out that when implementing new technologies, organisations most frequently do not introduce practices related to risk reduction, such as risk identification, probabilistic risk analysis, planning with regard to uncertainty, analysis of cost-benefit trade-offs or analysis of different risks related to different technologies (Raz *et al.* 2002). In contrast, business-to-business technologies linking the business activities of business partners, and increasing the dependence and interconnection between business partners' information systems, can increase the existing inter-company risk and create new risks (Nigel *et al.* 2013). Looking at the water utilities as a whole sector would rather suggest that the risk between companies can be largely ignored. However, the risk of physical, social or financial losses due to the use of technologies can be analysed with regard to water utility companies.

## METHODS AND DATA COLLECTION

### Data collection

The data presented in this study come from empirical research conducted in April 2020 as part of a research project called Sur(VIR)val. The main goal of the project was to identify and evaluate actions undertaken by Polish water utility managers to

reduce risk in the first period after the economic lockdown resulting from the Covid-19 pandemic. The data were collected using the CAWI (Computer-Assisted Web Interviewing) method.

### Sample

The surveyed population consisted of enterprises from the water and sewage sector in Poland, associated in the Polish Waterworks Chamber of Commerce. This Chamber is a member of the Polish Chamber of Commerce in Warsaw, as well as the European Federation of National Associations of Water Services ‘EurEau’ based in Brussels. It associates 495 water utilities companies in Poland. We obtained 116 complete questionnaires. This accounted for 23.43% of the entire population of water utilities associated in the Polish Waterworks Chamber of Commerce. The respondents’ background information is presented in Table 1.

### Variables

The first part of the survey aimed to find out what managerial actions or responses in the waterworks sector were connected with each type of Engemann risk. Through a series of free-form interviews with six managers of water utilities, we identified a list of the most common actions related to each type of risk. We left only those items that all managers agreed on, and discussed the list with them again. We repeated this sequence until a uniform list of actions was created (Table 2).

In the eyes of waterworks business managers, minimising infrastructure risk involves closing part of the plant and reducing production levels. In leaders’ understanding, minimising enterprise risk can be achieved through reducing R&D expenses and reducing investments, protecting employees’ health, organising flexible working time, extending payment deadlines and – in

**Table 1** | Structure of the sample ( $n = 116$ )

Characteristics	<i>N</i>	%
Firm size (employees)		
10–49	28	24.1
50–249	73	62.9
$\geq 250$	15	12.9
Firm age (years)		
$\leq 10$	10	8.6
11–20	20	17.2
21–30	62	53.4
31–40	6	5.2
$\geq 41$	18	15.5

**Table 2** | Engemann’s types of organisational risk and risk management actions

Organisational risks	Risk management actions
Infrastructure	1. Closing down part of the company 2. Reducing production levels
Enterprise	3. Reducing R&D expenses 4. Reduction in level of investment 5. Protection of workers against infection 6. Flexible working time management 7. Reduction in personnel 8. Extension of payment deadlines for commitments
Information security	9. Actions taken to ensure information security
Supply chain	10. Looking for new suppliers and markets 11. Offering new products and/or services
New technologies	12. Searching for alternative technologies

the worst-case scenario – reducing staffing levels. As far as information security risk is concerned, there is one item everyone agreed on, namely all actions ensuring that information is secure. Meanwhile, minimising supply chain risk includes looking for new suppliers and buyers, as well as offering new products or services.

In the next quantitative stage of the research, we used an ordinal scale to describe risk management actions, where 0 – meant no action taken, 1 – no impact on the firm’s survival and 7 – very high impact on the firm’s survival. Table 3 summarises the data of the 12 analysed items.

Table 3 also indicates that the most common actions and managerial responses, minimising different types of risk, were actions taken to ensure information security, reduction in the level of investment and protection of workers against infection.

## Methods

As scales assessing organisational risk during the economic lockdown have never been tested before, we used Exploratory Factor Analysis (EFA) to test the scales’ underlying factors. EFA is an interdependence technique whose primary purpose is to define the underlying structure among the variables in the analysis. Broadly speaking, EFA provides the tools for analysing the structure of the interrelationships (correlations) among a large number of variables by defining the set of variables that are highly interrelated, known as factors (Hair *et al.* 2010). The IBM SPSS 26 software package was used to perform arrays of EFA. To extract the relevant factors, Oblimin with Kaiser Normalisation was used as the Rotation Method.

The Kaiser–Meyer–Olkin (KMO) and Bartlett sphericity tests were applied to evaluate the sample adequacy for all variables. The KMO is a test conducted to examine the strength of the partial correlation between the variables (how the factors explain each other). The test measures sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited the data is to factor analysis. KMO values closer to 1.0 are considered ideal, while values less than 0.5 are unacceptable (Dodge 2010).

In turn, Bartlett’s test of sphericity was used to test the null hypothesis that the correlation matrix is an identity matrix. An identity correlation matrix means the variables are unrelated and not ideal for factor analysis. A statistical significance test (usually  $<0.05$ ) shows that the correlation matrix is indeed not an identity matrix (rejection of the null hypothesis) (Snedecor & Cochran 1989).

## RESULTS

The KMO result was 0.734 and the Bartlett sphericity test ( $\chi^2 = 319.007$ ;  $df = 66$ ) showed a significance level of 0.000, which confirmed that the sample is adequate for carrying out exploratory factor analysis. These values are acceptable for this type of analysis (de Vaus 2002). According to Hair *et al.*, factor loadings in the range 0.3–0.4 are considered as meeting the minimal

**Table 3** | Descriptive statistics

Risk managerial actions	Mean	Median	SD
1. Closing down part of the company	0.10	0.00	0.445
2. Reducing production level	1.21	0.00	1.936
3. Reducing R&D expenses	0.95	0.00	1.807
4. Reduction in level of investment	3.47	4.00	2.197
5. Protection of workers against infection	3.66	4.00	2.207
6. Flexible working time management	1.57	0.00	2.196
7. Reduction in personnel	0.35	0.00	1.057
8. Extension of payment deadlines for commitments	1.97	1.00	2.269
9. Actions taken to ensure information security	3.66	4.00	2.214
10. Looking for new suppliers and markets	0.33	0.00	0.656
11. Offering new products and/or services	0.48	0.00	1.138
12. Searching for alternative technologies	0.53	0.00	1.373



level for interpretation of structure, and loadings 0.5 or greater are considered practically significant (Hair *et al.* 2010). In this study, loadings >0.4 are considered significant. The results of the EFA are presented in Table 4.

Based on the factor analysis procedure, three factors (based on an eigenvalue greater than 1) were obtained (see Table 4). This solution explained nearly 55% of the total variance. The three factors have been extracted based on this solution, and we have labelled them as follows:

- (1) *Factor 1 – Liquidity risk connected with searching for new technologies.* The first factor, which explains 28.3% of the variance, is composed of five items: (3) reducing R&D expenses, (2) reducing production level, (4) reducing the level of investments, (8) extending payment deadlines and (12) searching for new technologies.
- (2) *Factor 2 – Supply chain and enterprise risk.* The second factor, which explains 14.55% of the variance, is composed of four items: (10) looking for new suppliers and markets, (11) offering new products and/or service, (1) closing down part of the company and (7) reduction in personnel.
- (3) *Factor 3 – Human resource risk.* The third factor, which explains 12.03% of the variance, is composed of two significant items: (5) protection of workers against infection and (6) flexible working time management.

## DISCUSSION

Water utilities are one of the most important sectors of industry, with water services crucial during various crises (Zechman Berglund *et al.* 2021). The Covid-19 pandemic has highlighted the significance of risk preparedness among water utilities (Sowby 2020), and demonstrated the need to develop crisis resilience as well to strengthen the preparedness of water utilities for future crises (Gude & Muire 2021). The lockdowns introduced after the coronavirus outbreak showed that protecting public health during any epidemic is essential, even if other business activities can be limited or temporarily halted.

Water utilities are essential for maintaining public health, and need to keep operating even during times of crisis (Sowby & Lunstad 2021). Therefore, it is important to identify and address the elements of risk management that water utilities need to be prepared for.

The results of the study suggest that during the Covid-19 crisis, all of the five risk categories proposed in the Engemann model (Engemann 2019) play an important role. However, three categories have been identified as critical in the water utilities: (1) liquidity risk – minimised by looking for new technologies, (2) supply chain and enterprise risk and (3) human resource risk.

**Table 4** | Factor analysis results (loadings over 0.4 presented)

	Factor 1	Factor 2	Factor 3
3. Reducing R&D expenses	0.747		
2. Reducing production level	0.731		
4. Reduction in level of investment	0.659		
8. Extension of payment deadlines for commitments	0.628		
12. Searching for alternative technologies	0.619		
10. Looking for new suppliers and markets		0.804	
11. Offering new products and/or services		0.779	
1. Closing down part of the company		0.651	
7. Reduction in personnel		0.561	
5. Protection of workers against infection			0.774
6. Flexible working time management			0.727
9. Actions taken to ensure information security			0.481
<i>Eigenvalue</i>	3.407	1.746	1.444
<i>% of variance explained</i>	28.388	14.550	12.031
<i>Cumulative</i>	28.388	42.937	54.968

In the context of these results, it is interesting to see infrastructure risk as not being significant. The results of other studies on infrastructure risk suggest that the demand for infrastructure and services is growing rapidly in both developing and developed countries (Gupta & Verma 2020), though Wang *et al.* indicate that in relation to infrastructure risk, it is difficult to accurately understand, predict and control the overall situation and development trends (Wang *et al.* 2016). Also, in the water sector, research shows the importance of infrastructure risk management and infrastructure management (Amadi-Echendu *et al.* 2010; Marlow *et al.* 2015). The lesser importance that the survey respondents attached to infrastructure risk may be related to the fact that under Covid-19 conditions, the infrastructure for water utilities, which includes buildings and equipment (Engemann 2019), is not at risk, and thus management of other risk categories becomes more essential.

With regards to the validity of the combination of supply chain risk and enterprise risk, it should be noted that the results of our research are consistent with the results related to Industry 4.0 (Alabi *et al.* 2019; Kijak 2021), which has a significant impact on the development of water utilities. Faisal *et al.* suggest that supply chains can be seen as an example of an inter-organisational configuration, where the coordination of logistics processes between organisations is key to above-average results (Faisal *et al.* 2007). In turn, Tiwari suggests that Industry 4.0 supports the integration of supply chain flows, especially those related to information and physical resources flows (Tiwari 2020). A systematic literature review of the interaction between supply chain risk management and information technology has allowed Fischer-Preßler *et al.* to see that the increase in supply chain disruption, a major source of risk for both business organisations and consumers, is increasing the importance of resource investments (Fischer-Preßler *et al.* 2020).

While the importance of the factors explaining enterprise risk is not large, our results still suggest that enterprise risk bears some importance in the overall risk management system, especially in relation to supply chain. As noted by Chalker, this is the result of the reluctance of water utility managers to integrate risk management processes with the enterprise management system (Chalker *et al.* 2018). Similar results indicate that companies manage risk not so much in a silo but in an integrated way, covering the whole enterprise and its task environment (Hoyt & Liebenberg 2011), and this ensures that not only traditional forms of risk are taken into account, but also strategic risk, allowing the enterprise to define sources of competitive advantage in the environment (Bromiley *et al.* 2015).

The results of the study distinguished additional risk categories that did not appear in the Engemann model (Engemann 2019), covering issues related to financial liquidity management, which we call liquidity risk. Although in the Engemann proposal financial issues are hidden under enterprise risk, we posit that in such a severe crisis as Covid-19, which significantly affects the financial resilience of an organisation (Ahrens & Ferry 2020; Johnson *et al.* 2020) the issue of maintaining liquidity becomes crucial. Although liquidity risk is customary in relation to the banking system (Gabbi 2004; Arif & Nauman Anees 2012; Asongu 2013; Riahi 2019), we believe that as the factors that make up this category of risk (reducing R&D expenses, reducing production level, reducing the level of investments and extending payment deadlines) are directly related to expenses, it is legitimate to use the term 'liquidity risk' in relation to water utilities. At the same time, it is evident that waterworks proactively strive to reduce this type of risk by innovating and shifting to new technologies. This is reflected by the item connected with searching for new technologies that belongs to a factor, which is concurrent with some findings (Fischer-Preßler *et al.* 2020).

Another new category that appeared in our research is the human resource risk. Other researchers indicate the fact that unprecedented crises have a large impact on human resources, which have to be skilfully navigated during unexpected shake-ups (Carnevale & Hatak 2020).

## CONCLUSION

Water utilities are one of the most crucial sectors of industry, and the importance of water services means that they face various types of risk during unexpected crises (Sowby & Lunstad 2021). Protecting public health during a pandemic is essential, and the Covid-19 pandemic revealed the importance of risk preparedness for the water utilities (Sowby 2020), as well as the need for them to develop crisis resilience and future preparedness plans as part of their risk management strategies (Gude & Muire 2021).

During a crisis, companies experience an increased level of risk, which has a direct impact on their ability to survive. The Covid-19 pandemic in particular has triggered a discussion on the factors that limit the risks borne by companies. The results of our research suggest that the most common actions and managerial responses taken by water utilities to minimise different types of risk were ensuring information security, reducing investments and protecting the workforce from getting infected.

Only a small number of water utilities decided to close down part of the company, make employees redundant or search for new partners in the supply chain (Chudziński *et al.* 2020).

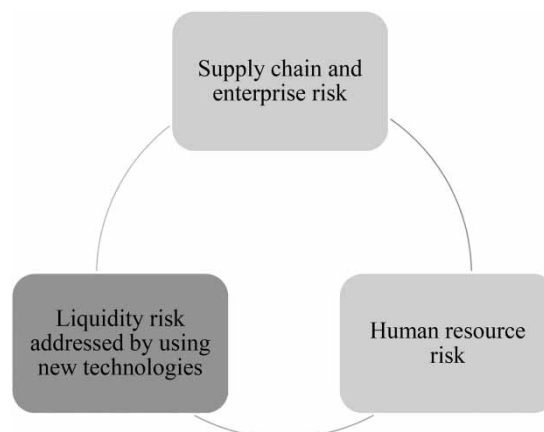
Although the Engemann concept structures risks in five dimensions (infrastructure risk, business risk, information security risk, supply chain risk and new technology risk), studies have shown that the most important categories of risk facing companies are supply chain risk, new technology risk, business risk and information risk. Our research among water utilities in Poland identified a slightly different set of types of risk. While supply chain risk fell into one category with enterprise risk, the research demonstrated two other categories of risk critical to the survival of a company in crisis situations, namely company liquidity risk, addressed by implementing new technologies, as well as human resource risk. The results of the investigation suggest that it is liquidity risk that can be considered the most important for the survival of a company in a crisis. This is depicted in the modified dimensions of the Engemann approach presented in Figure 1.

From a managerial point of view, it seems clear that during a crisis, the greatest importance should be attached to maintaining liquidity and the supply chain. However, an important aspect which rarely appears in the practice of crisis management, is the significance of managing company risk, understood here as a range of measures consisting of a reduction in the level of investment, a limit on expenditure on research and development and extension of payment terms. The latter two are occasionally seen to determine the survival of a company. This also applies to the risk of information in terms of its poor quality and timeliness.

One of the key factors for reducing the level of risk associated with employee infection is the introduction of remote working. However, in order to maintain work efficiency, it is necessary to train employees in the use of remote working tools and to ensure an adequate level of digitisation of the process. It should also be noted that not all processes within a water utility can be carried out remotely, so it is necessary to provide employees who come into contact with waste water with appropriate personal protective equipment. This should be in conjunction with ensuring appropriate rotation of personnel in individual positions and, in extreme cases, also accommodation for employees to ensure their separation from people who may be ill. Although managers of waterworks are obliged to look for the cheapest suppliers at the required quality level, it is important to diversify suppliers. It is also important to consider security of supply in times of crisis, and if necessary turn to local suppliers of services and materials. The search for new technologies in water utilities should be directed towards operational reliability, cost reduction and securing continuity of service during crises.

Naturally, this study has some limitations. Primarily, as we intended to quickly capture the first organisational reactions after the March 2020 economic lockdown, we targeted as many waterworks managers as were willing to take part in the survey. The sample, being a random selection of the first water utilities that responded (23.43% of the entire population of water utilities associated in the Polish Waterworks Chamber of Commerce), is one of the limitations.

The survey design and selection of measurement scales also raises some possible limitations. We are aware that the list of responses during times of crisis is not exhaustive or complete. However, these are the risk management areas that the respondents assessed as important. The scales that we have chosen do not encompass the full scope of the theoretical framework found in the literature.



**Figure 1** | Modified Engemann risk dimensions.

Although Poland represents a rich context for studying crisis responses as it is a country with opportunity-based entrepreneurship, dynamic GDP growth and low unemployment even during the coronavirus crisis, it is not a representative country for the region. Therefore, the conclusions from this study may not necessarily form a basis for overall generalisation.

The issues indicated above could be addressed in future research. Firstly, a more longitudinal approach to the water sector could be adopted. We are currently analysing results from the second lockdown in October 2020, as well as researching the current (March 2021) lockdown. It would be interesting to compare the data and see how the structure and composition of risk management have changed in the water utilities. It would also be possible to carry out similar research to examine the structure and composition of risk management after the coronavirus crisis. For future research, a revised version of the questionnaire could be used, and more precise scales for measuring responses minimising risk could be implemented. Overall, this study represents an attempt to develop new knowledge and understanding of managerial responses aimed at minimising risk in water utilities during unexpected crises. Assuming that a similar situation could occur in future pandemics, this paper may help guide future research in this regard.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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