Validating a Scale for Innovation in Sustainable Water Management in the Manufacturing Sector: A Slovenian Study

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Abstract

Based on the results of our research, we have developed a reliable and valid scale for assessing the innovation success of sustainable development practices, with a specific focus on reducing drinking water consumption in the production sector, where so-called industrial water is used (for production, cooling, or both). We found that the assessment of innovation success in sustainable development management practices, specifically aimed at reducing drinking water consumption in the production sector, comprises two dimensions: measuring success in water use innovations and innovative success in water treatment and conservation. The study also found that the assessment of innovation success in sustainable development management practices, particularly focused on reducing drinking water consumption in the production sector, is influenced by reporting on sustainable water management, innovations in organizational systems, innovations in materials and processes for sustainable water use, and analysis with goal setting in water use innovations. This comprehensive analysis provides organizations without established metrics with a tool to identify potential areas for improvement, thereby enhancing ecological methods and increasing production efficiency.

Introduction

Based on the research findings, organizations in the manufacturing sector are leveraging continuous innovation (the ongoing generation of ideas for product and process improvements) as a potent tool for creating competitive advantages (Hargadon, 2015; Moretti & Markič, 2016; Van Erp et al., 2023). Sustainable innovations in products and processes and organizational system innovations resulting from such efforts also play a significant role in fulfilling environmental and societal responsibilities (Calik, 2023). Andersen & Simensen (2018) define sustainable innovations as the development of new products, processes, materials, and technologies that, while considering the limited quantities of natural resources (including water) and their renewal capabilities, contribute to people's and society's prosperity. Bos-Brouwers (2010) and Calik and Bardudeen (2016) describe sustainable innovations as any new or significantly improved products, materials, technological and organizational processes that yield economic benefits and enhance an organization's environmental and social performance. Water-related sustainable innovations are no exception in this regard.

The social relevance of this topic underscores the primary research problem. Although the innovation performance of organizations in the manufacturing sector, including water use, is influenced by the continuous innovation of various organizational factors related to the structure of the organization and the constant creation of products and technological processes, existing research has tended to address these in a fragmented manner and measured them individually (e.g., studies by Bortolotti, Boscarib & Daneseb, 2015; Dubey et al., 2017; Fayyaz et al., 2020; Aschenbrücker & Kretschmer, 2022; Moretti, 2015; Moretti & Markič, 2016; Sachidananda, Webb & Rahimifard, 2016; Gude, 2016; Menenes, Stratton & Flores, 2017; Harildstad, 2014). These studies often overlooked the concurrent influences of information obtained from the field (e.g., studies by Gallardo-Vázquez & Sánchez-Hernández, 2014) and reporting on socially responsible environmental stewardship (e.g., studies by Orlitzky & Swanson, 2012). While not mandatory for all organizations in the manufacturing sector, socially accountable environmental reporting, according to Gallardo-Vázquez & Ortas (2017), can serve as an effective tool for transparent communication with stakeholders and distinguish successful organizations from unsuccessful ones, affecting public reputation and trust in the organization (e.g., studies by Orlitzky & Swanson, 2012; Gallardo-Vázquez & Ortas, 2017). Therefore, it is crucial to understand all the factors that can measure and encourage innovation capabilities, that is, the factors that measure and promote these organizations' capacities for water-related innovations. Based on the identified research problem, we have discerned a research gap in the absence of integrated studies on the innovation performance of sustainable development practices, specifically focusing on reducing potable water consumption in the manufacturing sector that uses so-called industrial water. We intend to address this gap at least partially with our research.

The primary goal of this study is to develop, validate, and test a multidimensional scale for assessing the innovation performance of sustainable development practices, focusing specifically on reducing the consumption of potable water in the manufacturing sector, which utilizes so-called industrial water (for production, cooling, or both).

Initially, we offer an exhaustive review of the systematic literature survey that underpins our questionnaire (Section 2). This section delineates six dimensions that emerge from our investigation into the innovative practices of sustainable development, particularly emphasizing the reduction of drinking water consumption in the manufacturing sector that employs industrial water. Subsequently, we detail the development process of the questionnaire (Section 3), which leads to a thorough exposition of our method for validation. This part encompasses the assessment of construct validity and reliability, both exploratory and confirmatory factor analysis, Harman's single-factor test, and the assessment of the scale's reliability. The findings of the study are disclosed in Part 4. Section 5 deliberates on the ramifications of these findings. The study is brought to a conclusion in Section 6.

Theoretical Background

Sustainable water management reporting

The fourth dimension is concerned with the acquisition and reporting of information on sustainable and efficient water management. The study by Gallardo-Vázquez and Sánchez-Hernández (2014) suggests that the information gathered by employees on actions and awareness of measures related to sustainable and efficient water management, market research outcomes, and participation in seminars, conferences, and workshops positively influences sustainable practices of an organization. This is presumed to extend to manufacturing sector organizations that utilize industrial water for production, cooling, or both. Research by Orlitzky & Swanson (2012) and Gallardo-Vázquez & Ortas (2017) has found that reporting on sustainable and efficient environmental practices can act as a robust tool for transparent communication with stakeholders and distinguish successful organizations from less successful ones. Reporting on sustainable and efficient water management includes disseminating information about these measures in the organization's vision and strategy, codes of conduct, internal reports, websites, and collaboration with other organizations (Moretti, 2022).

Innovations in organizational systems

The model's first dimension pertains to the organizational system's innovation. Current research indicates that invention within the organizational system encompasses several elements, which researchers have historically examined in isolation, measuring individually rather than collectively. The innovation of the organizational system includes the following aspects: fostering an organizational culture that supports and rewards innovative processes, as evidenced by the work of Bortolotti, Boscarib, and Daneseb (2015), Dubey et al. (2017), and Fayyaz et al. (2020); enhancing the organizational climate for innovation as discussed by Bonacci et al. (2020) and Zhang et al. (2022); and reforming the human resource management system to favor employee innovativeness, including reward systems for employees, as explored by Hakoola (2020) and Aschenbrücker and Kretschmer (2022).

Innovations in sustainable water use materials and processes

In the realm of sustainable and efficient water use, the second dimension of the model includes innovations in materials and technological processes. Scholars have identified various innovative strides in this area, including the generation of new ideas and practical suggestions to reduce potable water consumption during product manufacturing, as highlighted by Sachidananda, Webb, and Rahimifard (2016). There has been progress in modifying production processes to incorporate alternative water sources, a transformation discussed by Partzsch (2009), Moretti (2015), and Moretti and Markič (2016). Additionally, innovative wastewater treatment approaches (including technological, cooling, and stormwater) have been developed to mitigate environmental impacts, as researched by Lazarova et al. (2013) and Moretti and Markič (2016). Innovations also extend to adapting production processes for water reuse, as Menenes, Stratton, and Flores (2017) examined.

Furthermore, advancements in information and communication technology (ICT) have been directed at reducing drinking water usage and enhancing water quality and consumption monitoring, as well as the removal of salts and other impurities for water reclamation, as evidenced by the studies of Søgaard (2014), Coca-Prados and Gutiérrez-Cervelló (2011), Moretti and Markič (2016), and Gude (2016). In light of environmental conservation pressures, green innovations are essential for companies to gain a competitive edge, including in the manufacturing sector where industrial water is used. With the fusion and application of digital and emerging technologies such as smart factories, artificial intelligence systems, and robotics, production, and material consumption methods are changing (Skilton & Hovsepian, 2018; Adepoju et al., 2022), including water usage. This represents a revolutionary shift impacting all industries, including the manufacturing sector.

Benchmarking and goal-setting in water usage innovation

The third dimension of the model is composed of elements that researchers have studied in a fragmented manner, assessing them individually: the comparison of achievements planned budgeting, and working groups dedicated to innovating in water usage (Dwivedi et al., 2023), along with defined goals towards the use of alternative water sources (Moretti, 2015; Moretti & Markič, 2016).

Measuring success in water usage innovation

The fifth dimension of the model represents innovation performance in water treatment, reduction of potable water use, and water quality. Innovations in this field can lead to solutions for reducing and reusing water in manufacturing processes (European Commission, 2023). We have utilized performance indicators from Moretti's study (2015) on the reduction of potable water consumption (improvements in materials and technological processes towards reducing potable water use and wastewater treatment, enhanced exploitation of alternative water sources) as a measure of organizational innovation performance in water usage, considering the success (over the past three years compared to previous years) in implementing these innovations.

Innovative success in water treatment and conservation

The sixth dimension of the model reflects innovation performance in the number of approved and implemented change proposals in water usage. A commonality among successful organizations is their continual innovation (Tidd, Bessant, & Pavitt, 2005; Moretti, 2015; Moretti & Markič, 2016) – new and innovative environmental technologies can contribute to economic growth and enable, for example, the maintenance of standards at lower costs or improved environmental protection for less money. To assess the innovation performance/success increase in the adoption of these innovations over the past three years compared to previous years indicators from Moretti's research (2015) regarding the success in the number of approved and implemented change proposals in water usage (increase in employee numbers, the volume of change proposals submitted, the percentage of approved change proposals, the number of implemented change proposals, with the nature of water usage innovations) were used.

Methodology and Data

The research aims to construct a reliable and valid scale for assessing the innovation performance of sustainable development management practices, specifically targeting the reduction of potable water consumption in the manufacturing sector. The methods included construct validity and reliability, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), common method bias, and scale reliability. The research procedure is as follows.

Development of innovative performance measurement in the field of sustainable water management in the manufacturing sector

The first step was to clarify the goal of measuring innovation in sustainable water management in the manufacturing sector (hereafter ISWMMS) and, based on the theoretical model, set up the concept and purpose of the measurement ISWMMS. Therefore, we developed an integrated conceptual model through a comprehensive literature review. Second, we determined the type of questions and assertions (e.g., type of scale, the subject's objective) suitable for measurement. Third, we conducted a readability review to consider the clarity and conciseness of the measurement scale as necessary to construct a credible and unbiased questionnaire. Fourth, we conducted a study on reliability and validation results. This study used a five-point scale for content validity (1 point = strongly disagree, 5 points = strongly agree).

Construct validity and reliability

Based on a comprehensive literature review, a measurement scale has been developed to assess the innovation performance of sustainable development management practices, specifically targeting the reduction of potable water consumption in the manufacturing sector (measurement ISWMMS). The scale is composed of a total of 34 questions (appendix), organized into themes in the areas of 1) sustainable water management reporting; 2) innovations in organizational systems; 3) innovations in sustainable water use materials and processes; 4) measuring success in water usage innovation; 5) benchmarking and goal-setting in water usage innovation; 6) innovative success in water treatment and conservation.

The online survey was conducted among companies in the manufacturing sector in Slovenia that utilize so-called industrial water (for production and cooling purposes). The sample included individuals directly involved in strategic development in the area under consideration (such as environmental protection officers, ecologists, technology managers, or individuals who may hold multiple roles) within the aforementioned organizations. The questionnaire underwent pilot testing with nine randomly selected employees from the companies under analysis. No issues related to comprehension were reported - no modifications to the questionnaire were deemed necessary.

Responses were collected over five months beginning October 17, 2022. We gathered 217 fully completed responses, from which five were discarded due to untruthful answers. Consequently, the analysis was conducted on 212 fully completed responses. The highest number of completed questionnaires (Table 1) was received from individuals in large organizations (39.2%), while the fewest came from smaller organizations (26.9%).

The majority of responses were from organizations (17.5%) whose main activity is the production of chemicals and chemical products, and the fewest were from

Table 1

Demographic profile of companies under analysis

Characteristics	Descriptor	Distribution (%)
Company Size	Company with 0 to 49 employees	26.9
	Company with 50 to 250 employees	34.0
	Company with more than 250 employees	39.2
Main Business Activity	Food Production	12.7
	Beverage Production	17.0
	Paper and Paper Products Production	13.7
	Chemicals and Chemical Products Production	17.5
	Production of Pharmaceutical Raw Materials and Preparations	0.9
	Production of Rubber and Plastic Products	8.5
	Production of Non-Metallic Mineral Products	13.2
	Metal Production	7.5
	Production of Electrical Devices	9.0

Source: Own research

organizations (0.9%) whose main activity is the production of pharmaceutical raw materials and preparations (Table 2).

Common method bias

There is a potential risk of common method bias in analyzing the entire pool of respondents simultaneously. We applied Harman's single-factor test to mitigate this risk and assess the extent of any bias. A single factor accounting for more than 50% of the variance would indicate the presence of standard method bias (Fuller et al., 2016). We utilised IBM SPSS version 23.

Exploratory factor analysis

We utilized IBM SPSS version 23 to conduct an Exploratory Factor Analysis (EFA). The Principal Component Analysis (PCA) approach was employed to identify the number of factors. Following this, we applied a varimax rotation to simplify the interpretation of the factor analysis outcomes. EFA using the Principal Component Analysis (PCA) method is typically performed when the primary goal is to reduce the data to a smaller set of summary variables and identify the underlying structure in the data. PCA helps uncover patterns in data by identifying highly correlated variables and grouping them into components (Field, 2017).

Confirmatory factor analysis

CFA possesses characteristics akin to a procedure for testing theories, as EFA outcomes might be insignificant when devoid of theoretical foundations. The CFA process confirms the scale's construct validity, examining aspects like model fit, convergent, and discriminant validity, particularly in the preliminary assessments of innovation performance in managing sustainable development, emphasizing reducing drinking water consumption. The CFA incorporated data from all samples previously analyzed through EFA. The scale's validation was achieved using the maximum likelihood method (Kline, 2011; Blunch, 2012; Field, 2017). Initially, the model's fit was evaluated by analyzing the fitness index. For CFA, we used IBM SPSS Amos version 23.

Scale reliability

Before verifying the scale's reliability, we conducted a series of preliminary analyses that included descriptive statistics, correlation assessments, and normality checks. Further, we examined various statistical parameters such as mean, standard deviation, skewness, and kurtosis. An evaluation of the scale's internal consistency was carried out using Cronbach's alpha coefficient, and we also assessed the impact of removing sub-items on the overall reliability of the scale. After the initial

Table 2
Water consumption

Characteristics	Descriptor	Distribution (%)
What water sources are near your production facility?	Public Water Supply	94.8
	River Water	34.0
	Lake Water	3.8
	Private Well/Borehole	20.8
	Mill Stream	1.4
	Rainwater (meteoric water)	18.4
	Drainage Water	3.3
What water supply sources do you use in the production process?	Public Water Supply	97.3
	Private Water Supply	6.6
	Private Well/Borehole	16.5
	River Water	10.8
	Lake Water	1.4
	Mill Stream	0.5
	Rainwater (meteoric water)	2.4

Source: Own research

analysis, we evaluated reliability through the split-half methodology to examine variable stability, utilizing both Guttman's and the Spearman-Brown coefficients (also acknowledging a threshold of 0.60). Regarded as an alternative approach, the split-half analysis, often associated with the term 'prophecy coefficients,' verifies test-retest reliability and assesses variables' temporal stability (Field, 2017).

Results

Harman's single-factor test

As mentioned in section 3.3, the data collected in this study were tested for standard method bias using Harman's single-factor test (Fuller et al., 2016). It was found that there is no significant issue with common method bias for this data set, as the total variance extracted by a single factor amounted to 30.670%, which is below the recommended threshold of 50.0%.

Exploratory factor analysis

EFA was performed to analyze the ISWMMS measurement. The Kaiser-Meyer-Olkin statistics (KMO=0.925) and the significance level of Bartlett's test (sig.<0.001) indicate the appropriateness of using factor analysis. A KMO value > 0.5 explains that the use of PCA is sensible (Bartholomew et al., 2011). In our Exploratory Factor Analysis (EFA) of the questionnaire's 34 items, the eigenvalues examination revealed six components, each with an eigenvalue exceeding one, cumulatively explaining 66.016% of the variance. Given that all communalities were above 0.40, no variables were excluded. The Cronbach's alpha values were within an acceptable range (Field, 2017), with all dimensions recording alphas above 0.700 (ranging from 0.789 to 0.934) - Table 3.

Table 3
Results of EFA: Rotated factor matrix, variance, and reliability tests of the scale

Item	Factor					
	F1	F2	F3	PER1	F5	PER2
POR1	0.759					
INFO2	0.751					
INFO1	0.737					
POR2	0.728					
POR3	0.698					
INFO4	0.691					
INFO3	0.680					
POR4	0.672					
IN20		0.832				
IN17		0.808				
IN15		0.749				
IN14		0.715				
IN21		0.697				
IN16		0.689				
IN19		0.688				
IN13		0.604				
IN18		0.517				
IN4			0.748			
IN7			0.736			
IN3			0.691			
IN8			0.668			
IN2			0.654			

Table 3

Results of EFA: Rotated factor matrix, variance, and reliability tests of the scale (cont.)

Item	Factor					
	F1	F2	F3	PER1	F5	PER2
IN5			0.646			
IN9			0.641			
IN5			0.544			
USP7				0.826		
USP6				0.776		
USP8				0.766		
USP5				0.719		
IN11					0.689	
IN6					0.608	
USP2					0.583	
IN10					0.548	
IN12					0.503	
USP1						0.618
USP3						0.528
USP4						0.520
Variance (66.016)	15.033	14.839	13.276	10.248	7.152	5.468
Cronbach α	0.917	0.906	0.891	0.934	0.849	0.789

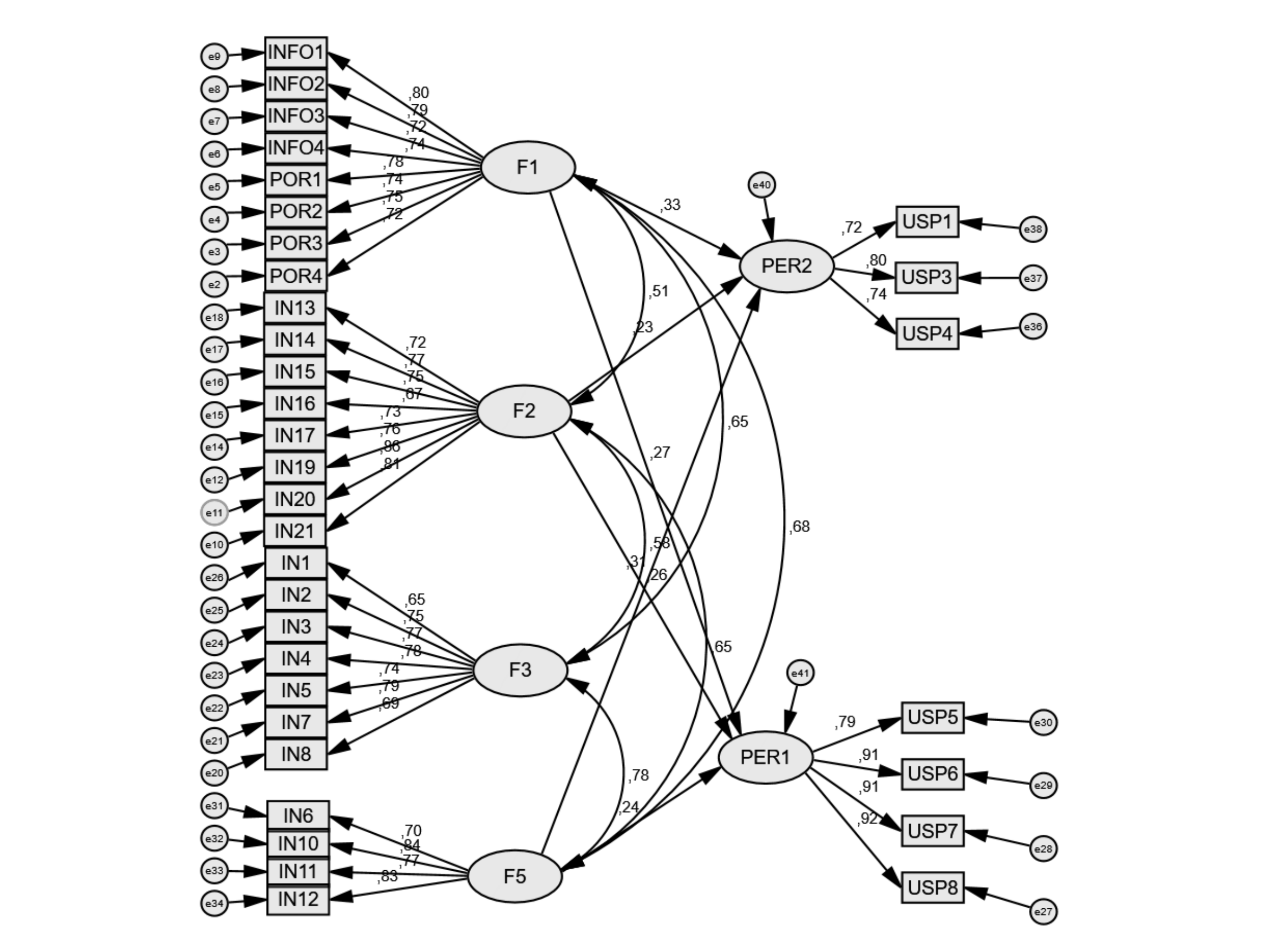
**Factors: F1 – Sustainable Water Management Reporting; F2 – Innovations in organizational systems; F3 – Innovations in Sustainable Water Use Materials and Processes; PER1 – Measuring Success in Water Usage Innovation; F5 - Benchmarking and Goal-Setting in Water Usage Innovation; PER2 - Innovative Success in Water Treatment and Conservation.*
Source: Own research

Confirmatory factor analysis

To confirm the construct validity of the measurement ISWMMS (evaluation of model consistency with data), we also conducted a CFA. The assessment of the normal distribution for indicator variables was conducted through the analysis of skewness and kurtosis metrics. The skewness and kurtosis figures for all indicator variables were under 2, falling within the acceptable range for performing CFA (ranging from −0.737 to 0.413). Several fit indices have been examined to examine the goodness of fit of the measurement model. The model-fit indices were analyzed by using χ^2, RMSEA, CMIN, CFI, GFI, IFI, and TLI (Table 4). We attempted to improve the initial model with modification changes to enhance the appropriateness. In altering the initial model, we considered the following criteria: 1) assessments of structural coefficients and 2) estimated changes in the χ^2 statistic value with potential alterations in the links between variables. This process eliminated the indicators IN9, IN18, and USP2 in several sequential steps. The fit of the final measurement model (Figure 1; Table 5) was good (χ^2=1193.68, sig.>0.001; RMSEA=0.079, CMIN=2.309; CFI=0,922; GFI=0.900; IFI=0.914; TLI=0,926) - the chi-square is statistically significant, the CMIN is less than 0.30, the RMSEA is less than 0.80, the CFI, GFI, IFI, TLI are more than 0.90 (Greenfield, Strand Norman & Wier, 2007; Blunch, 2012; Byrne, 2016). The reliability testing for the new scales was conducted on a sample, yielding results ranging from 0.787 to 0.934. We also used the split-half and Spearman's stability coefficients to assess the complete scale and its individual factors. The test is deemed to be acceptable when its value is above 0.800 (ranging from 0.763 to 0.908). In the case of Guttman's coefficient, a test value exceeding 0.600 (ranging from 0.720 to 0.908) is considered sufficient. Results indicated that both tests met the acceptance criteria for the scale and its three distinct factors, each showing values over 0.700. Within verifying the measurement model, we also reported the correlation coefficients between factors. It is evident that all correlations are statistically significant (p<0.001) - Table 4.

It is evident that the success of water use innovation and the innovation success in water treatment and

Figure 1
Final CFA model for ISWMMS



Source: Own research

Table 4
Descriptive statistics, Skewness, Kurtosis, Cronbach α Guttman's and the Spearman-Brown coefficients and intercorrelations CFA model for ISWMMS

Item	N	Mean	SD	Skewness	Kurtosis	Cronbach α
Sustainable Water Management Reporting (F1)	8	3.24	0.68	0.413	-0.223	0.912
Innovations in organisational systems (F2)	8	3.35	0.88	-0.217	-0.580	0.911
Innovations in Sustainable Water Use Materials and Processes (F3)	7	3.63	0.67	-0.174	-0.292	0.892
Measuring Success in Water Usage Innovation (PER1)	4	2.68	0.78	0.159	-0.737	0.934
Benchmarking and Goal-Setting in Water Usage Innovation (F5)	4	3.06	0.85	-0.110	-0.377	0.866
Innovative Success in Water Treatment and Conservation (PER2)	3	3.45	0.79	0.044	-0.680	0.789
N	8	8	7	4	4	3
Mean	3.24	3.35	3.63	2.68	3.06	3.45
SD	0.68	0.88	0.67	0.78	0.85	0.79
Skewness	0.413	-0.217	-0.174	0.159	-0.110	0.044

Table 4

Descriptive statistics, Skewness, Kurtosis, Cronbach α Guttman's and the Spearman-Brown coefficients and intercorrelations CFA model for ISWMMS (cont.)

Item	N	Mean	SD	Skewness	Kurtosis	Cronbach α
Kurtosis	-0.223	-0.580	-0.292	-0.737	-0.377	-0.680
Cronbach α	0.912	0.911	0.892	0.934	0.866	0.789
Guttman split-half coefficient	0.848	0.879	0.851	0.908	0.873	0.720
Spearman-Brown coefficient	0.849	0.886	0.861	0.908	0.874	0.763
1	1	0.465**	0.587**	0.535**	0.614**	0.513**
2		1	0.513**	0.542**	0.587**	0.513**
3			1	0.442**	0.685**	0.624**
4				1	0.541**	0.587**
5					1	0.565**
6						1

***sig. < 0.01*
Source: Own research

Table 5

Assessment of model fit

Model	df	χ^2	χ^2/df (CMIN)	RMSEA	CFI	GFI	IFI	TLI
Initial model	517	1193.686	2.309	0.138	0.868	0,833	0.849	0.851
Final model	517	1193.686	2.309	0.079	0.922	0.900	0.914	0.926

Source: Own research

conservation in the manufacturing sector are influenced by sustainable water management reporting, innovations in organizational systems, innovations in materials and processes for sustainable water use, and benchmarking and goal-setting in water use innovation.

Implications

Scientific implications

Our study identified the factors most frequently discussed in professional literature that influence the innovation success of water consumption in the manufacturing sector. Building on theoretical insights, we developed a reliable, measurable, and valid scale for Innovation in Sustainable Water Management in the Manufacturing Sector (ISWMMS).

Managerial implications

The scale developed in this research holds managerial or business significance and application, particularly in measuring the innovation success of water usage in the manufacturing sector, where so-called industrial water is utilized (for production, cooling, or both). This can enable managers within these organizations to understand the benefits and recognize opportunities within their practices and the potential for water usage innovations. Moreover, organizations that measure can become aware of their capability level, thereby identifying opportunity areas in their value creation process within the sector in which they operate. Additionally, the scale can assist these organizations in assessing regions of their water usage innovation success that may require further development. This could lead to improved ecological practices and greater efficiency in the production process, potentially increasing their profitability. The scale could also apply to other types of energy used in organizations, such as electricity, natural gas, district heating, liquid fuels, etc., and with appropriate translation and adaptation in other EU countries and beyond.

Policy implications

The ISWMMS scale, developed by this research, can be instrumental for government bodies, providing policymakers with an awareness of the innovation capacity level in sustainable water management within the manufacturing sector. It also offers a benchmark for determining the innovation performance in water usage in production environments that utilize industrial water (for production, cooling, or both). These insights can enable policymakers to discern the strengths and weaknesses of organizations in the manufacturing sector regarding innovations in the field. With this knowledge, policymakers could draft necessary legislation to support or incentivize organizations to develop the required innovation capabilities in water usage. Governments can also encourage organizations to adhere to regulations and set standards, such as pollution norms. Government and its agencies can influence the extent of water usage reduction and the improved utilization of water already in use (for cooling) through their recommendations, policy formation, and external enforcement.

Conclusions

In our research, we thoroughly analyzed the most commonly addressed factors in scholarly literature that affect the innovation performance of the manufacturing sector's water usage. This was done to construct a reliable and valid scale for assessing the innovation performance of sustainable development management practices, focusing on reducing the consumption of drinking water in the manufacturing sector.

Employing a rigorous methodology, this study has determined that the assessment of innovation performance in sustainable development practices, with a specific focus on reducing the consumption of drinking water in the manufacturing sector, comprises two dimensions: the measurement of success in water usage innovation and the innovative success in water treatment and conservation. The study also found that the assessment of innovation performance in sustainable development practices is influenced by sustainable water management reporting, organizational systems innovations, materials and processes for sustainable water use, and benchmarking and goal-setting in water usage innovation. By developing a reliable and valid scale for Innovation in Sustainable Water Management in the Manufacturing Sector (ISWMMS), which applies to a broad and diverse population of organizations in Slovenia, and with adjustments, it will also apply to other types of energy used in organizations: electricity, natural gas, district heating, liquid fuels, etc., and with appropriate translation and adaptation, also in other EU countries and beyond.

This study also has limitations, and suggestions for further research are provided. First, the research was conducted among manufacturing companies in Slovenia that use so-called industrial water (for production, cooling, or both). It is recommended that the research be extended to such organizations in other EU countries and beyond, with results that can be compared across different regions. Second, the study approached the assessment of innovation performance in sustainable development practices from a social science and business perspective without considering the natural science aspect (ecology, chemistry) and expertise or knowledge specific to this field. Future research could incorporate this aspect as well.

Third, in the final version of the ISWMMS scale, we excluded indicators IN9, IN18, and USP2. Future research could reintegrate these indicators to examine their potential impact at that time on innovation in sustainable water management in the manufacturing sector. The research could further be broadened to encompass indicators of digitization and automation, as well as to consider nascent and not yet fully entrenched standards of quality and excellence, such as corporate social responsibility, the EFQM excellence model, risk management, project leadership, and occupational safety and health management, among others.

Appendix

Variables

Variable	Description
INFO1	We are well-informed about measures related to sustainable and efficient water management.
INFO2	We are well-informed about research results related to sustainable and efficient water management.
INFO3	We participate in workshops, trainings, seminars, and conferences on sustainable and efficient water management whenever possible.
INFO4	We implement concrete actions to raise awareness and inform and educate employees about the principles and activities associated with sustainable water management.

Variables *(cont.)*

Variable	Description
POR1	Sustainable and efficient water management is in our company's vision and strategy.
POR2	Sustainable and efficient water management is present in our company's code of conduct.
POR3	Sustainable and efficient water management is present in internal reports and publications, annual reports, and on our company's websites.
POR4	Our company collaborates with other companies in the field of sustainable water use or water resources.
IN1	The organization of the idea management process (submission of all changes of an innovative nature) towards the use of alternative water sources in product manufacturing is adequate in our company.
IN2	The organization of the idea management process (submission of all changes of an innovative nature) toward reducing potable water consumption in the production process is adequate in our company.
IN3	The organization of the idea management process (submission of all changes of an innovative nature) towards wastewater treatment (technological, cooling, stormwater) in reducing environmental impacts is adequate in our company.
IN4	The organization of the idea management process (submission of all changes of an innovative nature) towards water quality and consumption control and the removal of salts and other impurities from water for reuse is adequate in our company.
IN5	At the company level, we have substantively and financially defined goals for the idea management (submission of all changes of an innovative nature) towards reducing potable water consumption.
IN6	At the company level, we have substantively and financially defined goals for the idea management (submission of all changes of an innovative nature) towards the use of alternative water sources.
IN7	At the company level, we have substantively and financially defined goals for the idea management for wastewater treatment (technological, cooling, stormwater) in reducing environmental impacts.
IN8	At the company level, we have substantively and financially defined goals for the idea management (submission of all changes of an innovative nature) towards water quality and consumption control and the removal of salts and other impurities from water.
IN9	The company's executive management sets the goals for idea management, including the submission of all changes of an innovative nature in the field of sustainable and efficient water use.
IN10	For the needs of idea management, including water use, we annually plan a budget for the necessary financial resources (for rewards, promotion, technical equipment, etc.).
IN11	We regularly compare our achievements in idea management, including water use, with the achievements of other companies.
IN12	The generation of ideas, the introduction of improvements, and the submission of all changes of an innovative nature in the field of water use take place within working groups in the company.
IN13	Our company has an online system for submitting innovative proposals and changes of an innovative nature (intranet portal, dedicated software, etc.).
IN14	Our company publicly awards recognition to innovators.
IN15	The company's reward system is flexible enough to reward 'non-standard' proposals (proposals of a larger scale or with exceptionally high savings).
IN16	The reward for innovation and changes of an innovative nature is integrated into the salary system (affecting the variable part of the salary).
IN17	The reward for an innovative proposal is distributed among the author of the idea and all those who helped implement the proposal in practice.
IN18	Part of the reward for an innovative proposal is also distributed among other employees in the department or workgroup.
IN19	The innovation climate in the company is favorable.
IN20	The organizational culture in the company supports and rewards innovative processes.
IN21	The company's human resource management system (employment, education, training, rewarding, a positive attitude towards innovation, etc.) is conducive to employee innovation.

Variables *(cont.)*

Variable	Description
USP1	In the last three years, our company has improved materials and technological processes towards reducing potable water use.
USP2	In the last three years, our company has made better use of alternative water sources in the production process (where possible).
USP3	In the last three years, our company has improved materials and technological processes towards wastewater treatment (technological, cooling, stormwater) to reduce environmental impacts.
USP4	In the last three years, our company has improved materials and technological processes towards water quality and consumption control and the removal of salts and other impurities from water so that it can be reused.
USP5	In the last three years, the number of employees submitting change proposals with an innovative nature in water use has increased.
USP6	In the last three years, the number of submitted change proposals with innovative water use has increased.
USP7	In the last three years, the percentage of approved change proposals with innovative water use has increased.
USP8	In the last three years, the number of implemented change proposals with innovative water use has increased.

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Potrjevanje lestvice inoviranja na področju trajnostnega upravljanja z vodo v proizvodnem sektorju: slovenska študija

Izvleček

Na podlagi rezultatov raziskave smo razvili lestvico za ocenjevanje inovacijske uspešnosti trajnostnih razvojnih praks, ki se osredotoča na zmanjšanje porabe pitne vode v proizvodnem sektorju, kjer se uporablja t.i. industrijska voda (za proizvodnjo, hlajenje ali oboje). Ugotovili smo, da ocena uspešnosti inovacij v praksah upravljanja trajnostnega razvoja, ki so posebej usmerjene v zmanjšanje porabe pitne vode v proizvodnem sektorju, obsega dve razsežnosti: merjenje uspešnosti inovacij na področju rabe vode in inovativno uspešnost pri ravnanju in varčevanju z vodo. Raziskava je ugotovila tudi, da na oceno inovacijske uspešnosti praks upravljanja trajnostnega razvoja, ki se posebej osredotoča na zmanjšanje porabe pitne vode v proizvodnem sektorju, vplivajo poročanje o trajnostnem gospodarjenju z vodami, inovacije v organizacijskih sistemih, inovacije v materialih in postopkih trajnostne rabe vode ter analiza s postavljanjem ciljev pri inovacijah rabe vode. Ta celovita analiza zagotavlja organizacijam brez vzpostavljene metrike, orodje za prepoznavanje potencialnih področij za izboljšave, s čimer se izboljšajo ekološke metode in poveča učinkovitost proizvodnje.

Ključne besede: inovacije, pitna voda, trajnostno upravljanje, proizvodni sektor, lestvica, Slovenija