

GREEN BYTES: LEVERAGING KNOWLEDGE MANAGEMENT FOR SUSTAINABLE ORGANIZATIONS

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ABSTRACT

In today's ubiquitous computing environment, organizations rely heavily on Information Technology (IT) to drive business value and economic success. However, true organizational sustainability extends beyond economics to include environmental and social dimensions, particularly in how IT equipment is disposed of, how software is developed, how data is generated and managed, how digital infrastructure is powered, and how end-user behaviour influences energy consumption. Energy-intensive data centers and growing data volumes contribute significantly to carbon emissions, necessitating greener IT practices. This study explores key knowledge management (KM) strategies and tactics that support green IT initiatives to promote organizational sustainability. Based on 539 survey responses, factor analysis revealed three core KM strategies: performance tracking and measurement, dark data management, and knowledge exchange. A multiple-factor analysis further examined the perspectives of KM practitioners, organizational learning practitioners, and data analysts, uncovering a notable divergence between the KM and learning communities versus data professionals. The results are synthesized into a KM strategies and tactics work system designed to guide organizations in aligning KM efforts with sustainability objectives by fostering interdisciplinary engagement and collaboration.

KEYWORDS

Green Information Technology, Knowledge Management, Organizational Sustainability, Dark Data Management

1. INTRODUCTION

The United Nations set 17 sustainable development goals (SDGs) in 2015 in the context of the three pillars of sustainability: environmentally sound, economically viable, and socially equitable (Carlsen and Bruggemann, 2022, Depken and Zeman, 2018). Furthermore, given the recognition that natural resources are limited, the environment cannot be controlled, and individuals and organizations must work within these constraints for the long term,

organizations are under growing pressure to implement sustainability strategies and programs (Rosati and Faria, 2019).

However, organizational sustainability objectives represent a paradoxical situation regarding information technology (IT) (Liang and Li, 2023). On the one hand, the dependence of organizations on IT has contributed significantly to environmental degradation, as building and disposing of hardware, such as servers, monitors, cellular phones, laptops, and personal computers, present environmental challenges; moreover, the rising energy demands to run data centers contribute to increased carbon emission (Liang and Li, 2023). On the other hand, advanced IT and information systems (IS) can play a key role in promoting environmental sustainability, and organizations derive business value from high-performance data processing (Zeng et al., 2020). Organizations can apply several tactics to address their sustainability concerns, such as customer analysis based on big data analytics (Kitchens et al., 2018), knowledge management (Zyngier and Burstein, 2012), electronic commerce (O'reilly and Finnegan, 2010), supply chain collaboration systems (Cui et al., 2022), and enterprise architecture (Liao and Wang, 2021).

Therefore, due to increasing attention on organizational sustainability and the requirement to balance economic, environmental, and social factors, this study investigates the question: "What key knowledge management strategies support green information technology initiatives to advance organizational sustainability?". By gaining insight into effective knowledge management strategies that enhance green IT practices, organizations can prioritize sustainable practices and ultimately improve their sustainability impact. Section 2 provides background to the research study, followed by the research methodology in Section 3. Section 4 contains the data analysis and findings, Section 5 the contribution, and Section 6 concludes the paper.

2. BACKGROUND

Despite advancements in IT and IS, along with innovations in business models, digitalization, and digital transformation (Bresciani et al., 2021, Adama and Okeke, 2024), the rapid growth of data driving transformative changes has created significant challenges for organizations striving to meet their sustainability objectives (Vermesan and Friess, 2022, Imamov and Semenikhina, 2021). Hence, organizations should prioritize and apply different organizational strategies and tactics to address and manage their sustainability objectives (Lau, 2021).

2.1 Sustainability and Green Information Technology

Green information technology refers to the process of minimizing the negative environmental effects of information and communication technologies (ICT) while maximizing the positive organizational impacts and engaging with people, processes, and technologies related to the environment (Göçen and Kurubacak, 2023, Jain, 2011). For organizational strategies related to the environment, the most often used definition is: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs,*" as suggested by the Brundtland Commission (Brundtland, 1987:41). Improving sustainability is an increasingly important environmental, social, and commercial organizational imperative, and because IT is a material contributor to the overall environmental footprint of an organization, adopting green computing can lower the carbon emissions of IT

significantly, thereby substantially helping an organization meet its emission reduction goals (Sharanya et al., 2024, Yadav et al., 2023).

However, as the demand for digital storage and processing solutions leads to higher energy consumption, IT and its associated processes can increase an organization's carbon footprint, which, in turn, results in higher carbon emissions (Masanet et al., 2020). The key to addressing this chain of events may lie in how organizations use and reuse knowledge and data in their daily activities and operations (Jackson and Hodgkinson, 2023). IBM (2024) estimates that more than 50% of an organization's data is considered dark data, referring to collected and stored yet unused data and information sources (IBM, 2024). Therefore, the use and reuse of knowledge within knowledge management (KM) processes can improve dark data management, thus contributing to reduced carbon emissions (Ajis and Baharin, 2019, Zhong et al., 2024).

According to Jackson and Hodgkinson (2023), KM scholars should explore the relationship between responsible management and organizational knowledge reuse, thereby supporting the global effort to mitigate the impact of digital practices on carbon production. Therefore, organizations should select environmentally friendly practices to develop knowledge-based capabilities in responding to complex workplace dynamics (Chopra et al., 2021).

2.2 Knowledge Management

KM refers to the people, processes, content, culture, and enabling technologies necessary to capture, manage, share, and find information as well as harvest all the insights and experience required for organizational functioning (Sarayreh et al., 2012, Alavi and Leidner, 2001). KM has been applied as an essential resource for storing, finding, sharing, and using knowledge to realize and consolidate competitive advantages for organizations (Bolisani and Bratianu, 2017). In this context, addressing sustainability incorporates multidisciplinary, heterogeneous knowledge and requires acquiring knowledge and skills (the learning organization), developing new behaviours, and cultivating sustainability-oriented norms and values (Sánchez and Mitchell, 2017). Applying KM within the context of sustainability and social and environmental responsibility now holds equal priority to economic viability in organizations. This paradigm shift positions KM as a foundation for sustainable development practices (van Zyl and Smuts, 2021, Klingenberg and Rothberg, 2020). Therefore, organizations should rely increasingly on their knowledge-generating resources (people and data) and treat KM as a means to enhance compliance with the guidelines of economic, environmental, and social sustainability (Chang et al., 2018, van Reijssen et al., 2015). Furthermore, KM and its range of KM practices provide a way to drive insight from data by transforming data into information and knowledge (Jennex, 2009). Organizations must determine the volume of data they need to process to generate useful information and knowledge. As data are converted into information and knowledge, carbon emissions may rise. Therefore, managing data, specifically what is captured, stored, and processed, is a key consideration for organizations (Jackson and Hodgkinson, 2023, Jennex, 2020).

2.3 Knowledge Generation in KM Work Systems

KM refers to the people, processes, content, culture, and enabling technologies in an organization (Hilger and Wahl, 2023). People represent creators and users and the flow of knowledge among them, whereas process encompasses the structured activities and workflows

that manage the generation, sharing, and application of knowledge guided by policies and procedures, roles, and responsibilities (Hilger and Wahl, 2023). Content refers to the actual knowledge assets, explicit or tacit, structured or unstructured, that are captured, organized, and made accessible for use (Hilger and Wahl, 2023). Culture highlights the organizational mindset and values that promote openness, trust, and a willingness to share and learn, and technology provides digital platforms and tools that enable efficient knowledge storage, retrieval, communication, and collaboration (Hilger and Wahl, 2023).

When considering sustainability, organizations should not single out the economy as a special field of knowledge but rather consider, analyze, and model it as a techno-socio-economic environmental system (Engelbrecht and Kitt, 2021). This perspective means integrating the information, data, techniques, tools, concepts, and perspectives of various disciplines to deal with such a complex techno-socio-economic environmental system as a means to understand and analyze organizational sustainability. Therefore, knowledge generation in this context involves integrating knowledge, methods, and perspectives from different disciplines to create a unified approach to a complex issue because, as disciplines are blended, insights not achievable by one field alone can be attained (Kurup et al., 2023, Engelbrecht and Kitt, 2021). A KM strategies and tactics work system may be considered to leverage knowledge-generating resources within this context as such a work system fosters knowledge-sharing behaviour (Abbasi et al., 2021). In addition, this work system enables cross-functional and interdisciplinary engagement and collaboration toward embedding a unified approach (Muukkonen and Kajamaa, 2024).

3. RESEARCH METHODOLOGY

The study utilized a survey research strategy with a questionnaire as the data collection instrument (Fetters et al., 2013). The questionnaire contained a demographic section, a content section using a 5-point Likert scale, and a general section with two open-ended questions to capture any additional comments from respondents. The questionnaire was captured on *SurveyMonkey* (<https://www.surveymonkey.com/>), and a URL to the questionnaire was shared via *LinkedIn* networks, such as KM practitioner, data analytics, and organizational learning groups. Six hundred and six (606) respondents accessed the survey; however, 11 did not provide consent, 23 consented but did not begin the questionnaire, and 33 did not complete the questionnaire, leaving 539 complete responses for analysis.

The data were analyzed in two ways: first, through statistical analysis in *SPSS v29.0.0.0*, including reliability tests applying Cronbach's alpha, one-way analysis of variance, and factor analysis. The factor analysis sought to identify the factor groupings that could be used to represent relationships among sets of many interrelated variables (Field, 2024, Purwono et al., 2023). Second, a multiple-factor analysis was executed using R version 4.4.1 and two libraries: "FactoMineR" and "factoextra." Two variables were defined for the analysis. Dimension 1 consisted of Role 1, comprising a learning practitioner, KM practitioner, and data analyst, and Role 2, comprising decision-making or decision-implementation. Dimension 2 consisted of green IT and KM factors derived from the literature review and incorporated into the questionnaire.

Tables 1 and 2 present the respondent profiles consisting of their operating roles and decision profiles. For the “Other” category, respondents indicated roles such as C-level roles and consulting roles.

Table 1. Operating roles of respondents
(Source: own analysis)

Operating role	Count	%
Data analyst	107	19.9
Knowledge management practitioner	225	41.7
Organizational learning practitioner	107	19.9
Other	100	18.6
Total	539	100.0

Table 2. Decision profiles of respondents
(Source: own analysis)

Decision profile	Count	%
Decision implementation	158	29.3
Decision-making	345	64.0
Other	36	6.7
Total	539	100.0

Knowledge management practitioners represented 41.7% (225) of the respondents, followed by data analysts and organizational learning practitioners at 19.9% (107), respectively. Sixty-four percent (345) of respondents indicated decision-making accountability, while 29.3% (158) indicated decision-implementation accountability.

4. DATA ANALYSIS AND FINDINGS

The Cronbach’s alpha reliability for the factors is 0.969, suggesting that the 11 green IT KM (GITKM) strategies have excellent internal reliability and are closely correlated (Tibeica et al., 2024, Izah et al., 2023). After the Varimax rotation presented in Table 3, Factor Grouping 1 (interpreted as *performance tracking and measurement*) accounts for 30.73% of the total variances between GITKM factors, Factor Grouping 2 (interpreted as *dark data management*) accounts for 25.40% of variances, and Factor Grouping 3 (interpreted as *knowledge exchange*) accounts for 21.37% of the total variances between GITKM factors. These three factor groupings account for 77.50% of the total variances among GITKM factors.

Table 3. Rotated component matrix of GITKM factors (Source: own analysis)

Rotated Component Matrix ^a	Component		
	1	2	3
We regularly conduct workshops and training sessions where employees share strategies to support our sustainability objectives.	0.777		
We have integrated digital decarbonization targets into our KM and operational policies.	0.763		
Employees are provided with guidelines on sustainable software development, including how to write energy-efficient code and minimize computational waste.	0.752		
Our KM system includes tools and protocols for analyzing energy consumption data across all IT systems, helping us identify areas for improvement in energy efficiency.	0.737		

Our organization has implemented a centralized database that tracks carbon emissions from all digital operations.	0.729		
Our organization is aware of the potential risks and challenges associated with managing dark data.		0.798	
We prioritize the secure and compliant handling of dark data to ensure it does not pose a threat to our organization.		0.752	
We have implemented effective strategies to identify and manage dark data within our data storage systems.		0.738	
Our organization effectively shares and exchanges tacit knowledge among employees to improve dark data management.			0.786
We effectively manage dark data at each level of the Knowledge Pyramid (Data to Information to Knowledge to Wisdom), ensuring a seamless flow from data to wisdom.			0.624
Our organization effectively transforms raw data into useful information within the context of dark data management.			0.615

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in six (6) iterations.

Factor Grouping 1, *performance tracking and measurement*, consists of five (5) GITKM factors, all reflecting high factor loadings (Williams et al., 2010). The factors with the strongest association are conducting employee workshops and training sessions, sharing strategies to support our sustainability objectives (0.777), integrating digital decarbonization targets into KM and operational policies (0.763), providing employee guidelines on sustainable software development (0.752), incorporating tools and protocols for analyzing energy consumption data across all IT systems (0.737), and implementing a carbon emissions tracking centralized database (0.729). A strong focus on measuring and tracking green IT initiatives could empower organizations to evaluate their environmental impact and ensure compliance with sustainability goals. By institutionalizing this practice as part of the organization's KM practice, organizations can identify areas for improvement, enhance operational efficiency, and foster a culture of environmental responsibility.

Factor Grouping 2, *dark data management*, comprises three (3) GITKM factors with strong associations and includes potential risks and challenges awareness associated with managing dark data (0.798), prioritizing secure and compliant handling of dark data (0.752), and implementing effective dark data management strategies (0.738). By recognizing the potential risks and challenges associated with managing dark data, which might lead to compliance issues and security vulnerabilities, organizations can incorporate effective KM strategies to identify, categorize, and manage dark data within data storage systems, thus ensuring its secure and compliant handling towards creating business value.

Factor Grouping 3, *knowledge exchange*, encompasses three (3) GITKM factors with strong associations, i.e., tacit knowledge sharing for dark data management improvement (0.786), strategies to manage and transform dark data into information and knowledge (0.624 and 0.615, respectively), and effectively sharing and exchanging tacit knowledge among employees to enhance dark data management. By creating mechanisms to enable effective knowledge sharing among employees, the seamless transformation of data, information, and knowledge can support insight generation, data-driven decision-making, and, ultimately, implementing innovative practices to support organizational sustainability goals.

The second analysis executed was an individual multiple-factor analysis, creating a factor map (shown in Figure 1) to determine the different stakeholders' opinions. The “habillage” parameter in the “factoextra” library was used to colour the individuals' observations. Dimension 1 explains 50.1% of the variance in the data, and Dimension 2 explains 14.6%, indicating that these two dimensions capture 64.7% of the total variance.

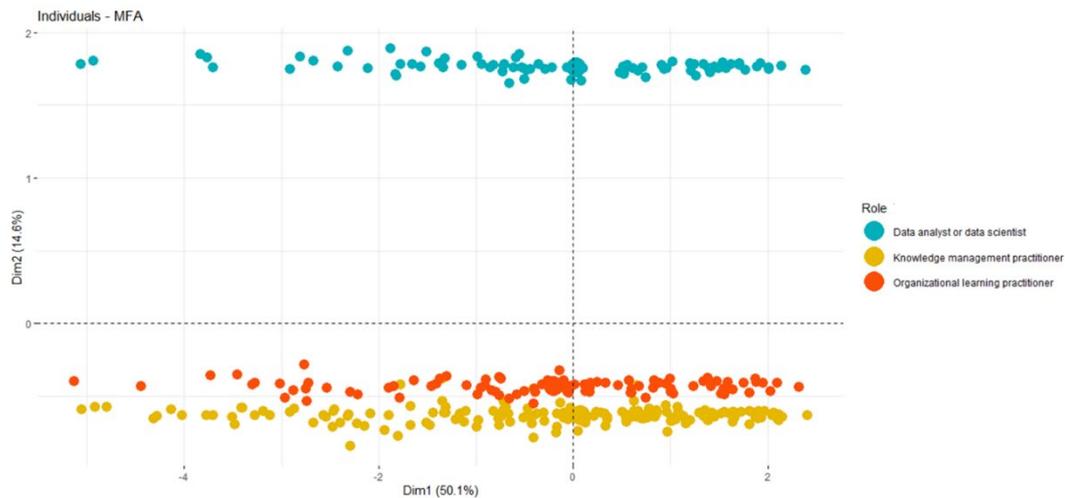


Figure 1. Individual multiple-factor analysis (MFA) (Source: own analysis)

The clusters, i.e., data analysts (blue cluster), knowledge management practitioners (yellow cluster), and organizational learning practitioners (orange cluster), indicate significant differences across the two dimensions, suggesting distinct characteristics for each group. The blue cluster is well-separated along Dimension 2, suggesting data analysts have unique attributes compared with other roles. The yellow and orange clusters are more densely clustered along Dimension 1, meaning knowledge management practitioners and organizational learning practitioners have more similarities in the characteristics associated with Dimension 1. The clear separation implies that data analysts could have different skill sets, tools, or methodologies compared to the other two roles—as understood in practice, within an organizational context and role allocation. The close clustering of knowledge management practitioners and organizational learning practitioners along Dimension 1 suggests that these roles share common ground in KM practices but have some distinct aspects, perhaps in methodologies or focus areas, as represented along Dimension 2.

Figure 2 depicts the standard deviation to understand the potential difference in opinion of specific GITKM factors and the role clusters. A standard deviation greater or equal to 1 indicates a relatively high variation, while a standard deviation of less than 1 can be considered low. A low standard deviation indicates that the data points tend to be very close to the mean. The standard deviation of most of the questions is above 1, which means the data points are distributed over a wide range of values, except for construct three evaluated by learning practitioners, namely “*Employees are provided with guidelines on sustainable software development, including how to write energy-efficient code and minimize computational waste.*”

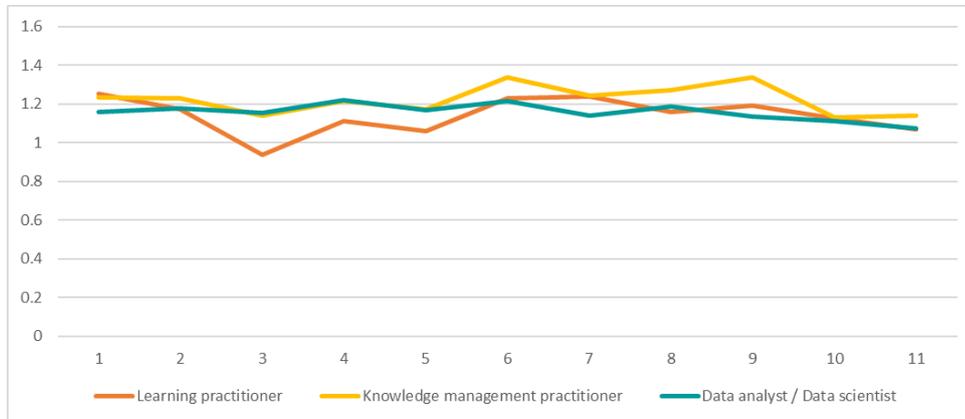


Figure 2. Standard deviation by role cluster (Source: own analysis)

When scrutinizing the differences between learning practitioners, KM practitioners, and data analysts, Construct 9 constitutes another observable gap, “*Our organization effectively shares and exchanges tacit knowledge among employees to improve dark data management.*” The divergence in these two constructs may be based on disciplinary perspectives, i.e., learning practitioners value the role of structured educational content, while the other roles may prioritize systemic or informal knowledge flows and technical interventions over formal guidelines. It is important to note that perceptions of sustainability initiatives vary across professional roles, highlighting the need for interdisciplinary alignment to ensure that GITKM factors are effectively valued, communicated, and implemented. This necessity inspired the development of a KM strategies and tactics work system, discussed in the next section, to ensure alignment and collaboration across role clusters.

5. KNOWLEDGE MANAGEMENT STRATEGIES FOR GREEN IT AND ORGANIZATIONAL SUSTAINABILITY

According to Alavi and Leidner (2001), at least four basic KM processes of creating, storing/retrieving, transferring, and applying knowledge must be considered in an organizational context. In addition, specifically related to dark data management and the outcome presented in Figure 1, the role of data science and deriving insight from unstructured and big data datasets must be an additional consideration.

To visualize and operationalize the findings, Figure 3 depicts the different organizational processes relevant to the three (3) role clusters (Figure 1) driven and guided by social, economic, and environmental organizational goals and objectives, which are also applied to measure and track performance. The workforce is supported in the organizational sustainability effort by awareness training and guidelines while executing the transformation of data to actionable insight and business value within a secure and compliant IT environment. Through continuous knowledge exchange, organizational agility, innovation, and decision-making are enhanced by allowing employees to access and build on shared insights, preventing redundancy and fostering a culture of collaboration. This KM strategy based on the GITKM factors not only supports

employee development and retention but also preserves institutional knowledge, thus making organizations more resilient and adaptable, especially in the context of their sustainable development goals.

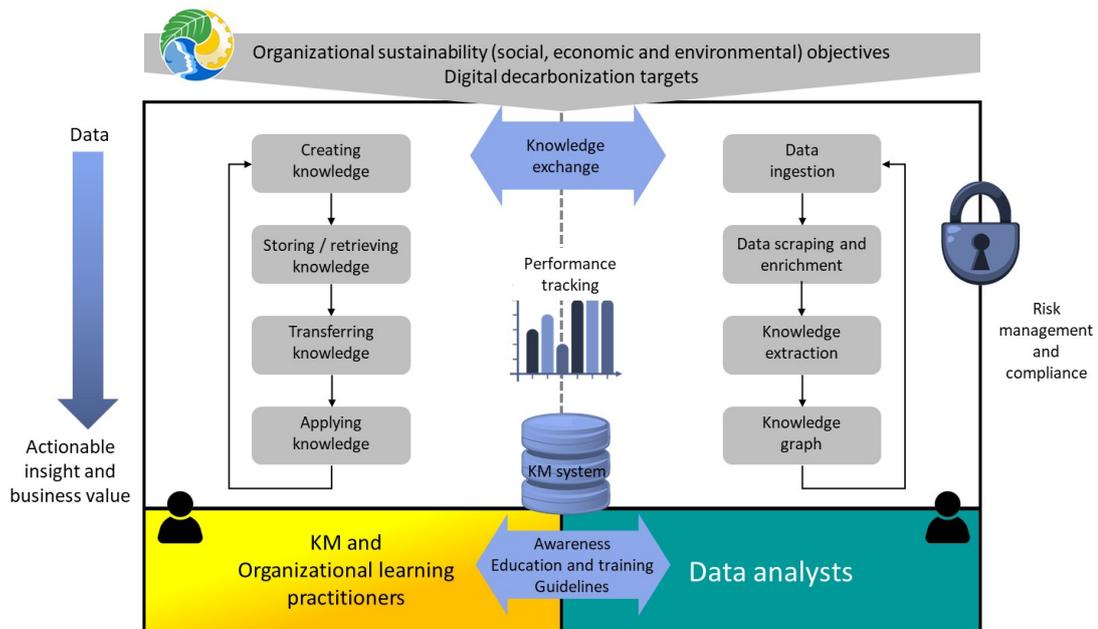


Figure 3. KM strategies and tactics work system (based on the GITKM factors and MFA analysis)

In terms of their qualitative comments, the respondents emphasized that the responsible and efficient use of knowledge and data within organizations is essential for achieving sustainability, highlighting the fundamental role of data in KM strategies and processes. This effort can only be successful based on data governance, and the respondents highlighted data accuracy, data analysis, data science, data cleaning, and data pre-processing as important. Apart from creating awareness and training, the respondents accentuated the need for departmental collaboration to ensure knowledge management and digital decarbonization efforts are integrated across the organization. This holistic approach can lead to more sustainable practices and better utilization of organizational knowledge. The respondents highlighted that leadership plays a critical role in prioritizing digital decarbonization and dark data management; they further stated that leaders should communicate the importance of these initiatives, aligning them with the organization's broader sustainability goals. Such communication can include setting clear targets for reducing the digital waste and carbon emissions associated with data storage and processing. Several respondents highlighted the importance of goal setting, tracking, and measuring against organizational sustainability goals, but even more so, evaluating the impact of digital operations. Finally, several respondents highlighted that by leveraging artificial intelligence (AI) capabilities to access vast amounts of data and thus use a lot of processing power to process the data, adequate strategies to address dark data and digital decarbonization risks must be considered.

6. CONCLUSION

This study aimed to consider key KM strategies and tactics supporting green IT initiatives to advance organizational sustainability. This objective was achieved by collecting 539 responses through an online questionnaire and analyzing the responses using factor analysis and an individual multiple-factor analysis. The study identified three KM strategies: performance tracking and measurement, dark data management, and knowledge exchange. A key finding highlighted the difference in approach and consideration between knowledge management and organizational learning practitioners, compared to data analysts. The findings were visualized and presented in a conceptual work system.

The implementation of the identified KM strategies and tactics towards organizational sustainability could be investigated in future research, thereby contributing to a more detailed implementation of the conceptualized work system. In addition, there is potential to investigate and analyze the contributions of different role players and functional roles, e.g., decision-makers instead of decision-implementers.

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