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Research article

Challenges in the adoption of sustainability information systems: A study on green IS in organizations

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ABSTRACT

Economic, social and ecological sustainability presents one of the greatest challenges of our society. As a result, there is growing pressure on a variety of organizations to implement sustainability programs, such as inclusion training related to social sustainability, cost management programs related to economic sustainability, and perhaps most importantly, green (information) systems related to environmental sustainability. Not only is multi-faceted sustainability most beneficial to organizations at large, but also there are several categorical thresholds that organizations must meet in order to be certified. For these reasons, companies are increasingly adopting information systems (IS) for sustainability in their operations. Specifically, programs designed to influence employee motivation, attitudes, beliefs, and behaviors are gaining attention. While there is a long tradition of research on technology adoption, such sustainability systems harbor several new phenomena, both with respect to individual and organizational adoption. Therefore, in this study, we explore the challenges of adopting sustainability systems in organizational contexts. Using activity theory and innovation diffusion theory, and with technology adoption theory as the backdrop of our investigation, we conduct a qualitative field study in four small- and medium- sized companies. Using both theory-guided deductive and inductive interpretation phases, we illuminate adoption challenges through combined intersections of adoption stages (knowledge, persuasion, decision, implementation, and confirmation) and activity domains (subject, instrument, object, community, rules). We then shed light on the severity and importance of these challenges through an expert validation study with green IS experts. In discussing the challenges in light of motivational and green IS design, we posit four dilemmas in green IS adoption that arise from tensions in the specific context of sustainability in organizations. Our findings expand existing knowledge in research on green IS, motivational IS design and sustainable behavior change interventions and yield several theoretical and practical avenues for future inquiry and endeavour.

1. Introduction

Achieving Sustainable Development Goals (SDGs) related to people, propriety, peace, and planet is considered the most important mission at individual, organizational, and societal levels (United Nations General Assembly, 2015). Accordingly, organizations are developing management strategies and seeking effective information systems (IS) and tools to address sustainability challenges related to the balance between people, economy, society, and environment in the digital age (Dwivedi et al., 2022; Papagiannidis & Marikyan, 2022). As economic growth has historically come at the expense of the environment, there is an increasing need to develop IS management theories in the area of environmental sustainability (Elliot, 2011; Melville, 2010). One of the main topics is *green IS* (El Idrissi & Corbett, 2016; vom Brocke et al., 2013).

The term green IS refers to the "design and implementation of IS that contribute to sustainable business processes" (Watson, Boudreau, Chen, & Huber, 2008, p. 2) and thus support or enable environmental sustainability initiatives (Jenkin et al., 2011). The main role of green IS is therefore to facilitate sense-making, decision-making and knowledge sharing and creation in order to achieve corporate sustainability objectives (Butler, 2011). Especially in small- and medium-sized

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enterprises (SMEs), which represent about 99% of all businesses in the European Union (European Commission, 2023), green IS can greatly contribute to companies' environmental sustainability (Baggia et al., 2019; Isensee et al., 2020). Accordingly, green IS research is concerned with the potential of IS to change organizational processes toward more sustainable practices (Dedrick, 2010; Loos et al., 2011). In particular, there has been an increasing focus on green IS as a pivotal tool to leverage change in employees' work practices and beliefs (Corbett, 2013; El Idrissi & Corbett, 2016). Previous work has shown that green IS, particularly when employing motivational affordances (Hassan et al., 2019), can support individual behavior change to advance sustainable development in organizations across multiple dimensions, such as resource consumption (SDG 12, Henkel and Kranz, 2018; Marikyan et al., 2019) or sustainable transportation (SDG 11, Lembcke et al., 2021), and promote education about sustainable behavior across dimensions (SGD 13).

In addition, green IS can catalyze transformative processes within organizations that lead to bottom-up changes in organizational culture and strategy toward sustainability. For example, green IS can support reflective disclosure and information democratization on sustainability issues among employees, thereby promoting organizational sensemaking (Henkel et al., 2017) and successful green IS can lead to the amplification and creation of sustainability values (Hedman & Henningsson, 2016).

However, the effectiveness and impact of green IS depends on its successful implementation and on its adoption and use by users (Dwivedi et al., 2022). The literature has predominantly examined the adoption of green IS in organizational settings from technical, administrative, governmental, and institutional standpoints (Singh & Sahu, 2020). Yet, there is also valuable research addressing the *individual* perspective of users, primarily employees, in the context of adopting and implementing green IS in workplaces. This research emphasizes that while companies can enforce the adoption of green IS among employees, *voluntary* adoption plays a crucial role in unleashing the full potential of these systems for inducing sustainable behavioral changes (Saeed & Abdinnour, 2013; Tsai et al., 2017). In this context, the consideration of individual cognitive processes in the adoption of green IS (Marikyan et al., 2019; Schmermbeck, 2019) and the exploration of psychological drivers and barriers resulting from employees' attitudes, knowledge, needs and interests (Herrenkind et al., 2019; Jenkin et al., 2011; Schmermbeck, 2019) are becoming increasingly important. Additionally, due to the impact of normative influences from colleagues (Dalvi-Esfahani et al., 2019; Herrenkind et al., 2019) and sociocultural forces (Jenkin et al., 2011) on the individual adoption of green IS, the role of the sociotechnical environment at work gains particular significance.

While initial studies have delved into these aspects, there is still considerable value in developing a comprehensive understanding of the challenges arising from individual employees' perceptions and motivations throughout the adoption process (Marikyan et al., 2019; Papagiannidis & Marikyan, 2022; Singh & Sahu, 2020). This involves considering not only the green IS itself but also individual attitudes, norms, and the sociotechnical environment within organizations (Dalvi-Esfahani & Rahman, 2016). Given the substantial presence of SMEs, it becomes particularly important, as attitudes and beliefs of individual employees towards digital sustainability tools are even more intertwined with the corporate culture towards sustainability than in larger companies (Isensee et al., 2020). Consequently, to advance existing knowledge and provide a foundational understanding for the successful implementation of green IS in different settings, this in-depth exploratory work aims to *provide meaningful insights and a deeper understanding of green IS adoption by exploring the challenges, difficulties, and dilemmas* of adopting and using an actual green IS from the employees' perspective. In doing so, this paper seeks to answer the following research question:

RQ: *What challenges do employees encounter when adopting green IS in organizational contexts?*

To answer this research question, this work draws on activity theory as a theory that sheds light the sociotechnical environment of a system (Engeström, 1987) and diffusion of innovations theory (DOI), which explains the decision- making process through which individuals adopt and use a technology (Rogers, 1983), as a theoretical framework to qualitatively examine the challenges and dilemmas that arise from green IS for sustainable behavior in organizational contexts from the employee perspective. Accordingly, we aim to understand *when* (in the individual technology adoption process) and *why* (due to which dimensions of the sociotechnical environment) *which* challenges arise. To this end, we conduct two studies. In a qualitative field study, in which employees from four different companies reflect in focus group interviews on the adoption process and the challenges they encounter during the adoption of a green IS, we gain rich qualitative insights into employees' perspectives. In a subsequent expert validation study, the importance and severity of these challenges are assessed from a more holistic perspective to underline the generalizability of the results of the qualitative field study. By triangulating the results of both studies, we identify and discuss *critical dilemmas* arising from the most significant challenges that need to be overcome for successful adoption and use of green IS. In what follows, we first present a literature review of relevant related work (Section 2) and our theoretical background (Section 3). We then explain our methodological choices and approach (Section 4), followed by a presentation of our results (Section 5). Subsequently, we discuss our findings in light of previous work and derive implications for theory and practice as well as avenues for future research (Section 6). Finally, we delineate our conclusions (Section 7).

2. Literature review

2.1. Green information systems

In the early 2010s, seminal articles in the field called for a focus on the central role of IS in transforming business and society toward a sustainable future (Elliot, 2011; Melville, 2010; Watson, Boudreau, & Chen, 2010). Since then, research interest in green IS has grown significantly. In contrast to the green IT stream, which examines how IT and IS can be designed and maintained to be environmentally friendly themselves (Dedrick, 2010), in a sense "greening OF IT" (Singh & Sahu, 2020), the green IS stream is concerned with the potential of IS to support enterprises' transition to sustainability at strategic and operational levels ("greening BY IT", Singh and Sahu, 2020). *Strategic* green IS include, for example, carbon management systems (Corbett, 2013), and IS for transforming offices into smart workplaces (Papagiannidis & Marikyan, 2020), implementing sustainable supply chain management (de Camargo Fiorini & Jabbour, 2017) or greening business processes (Roohy Gohar & Indulska, 2020). On the other hand, *operational* green IS that educate employees about sustainable choices and behaviors have gained increasing attention (El Idrissi & Corbett, 2016).

Previous work has shown that such operational green IS can successfully encourage employees to adopt sustainable behaviors (Singh & Sahu, 2020). For example, Casado-Mansilla et al. (2020) showed that persuasive feedback systems on current energy consumption promote awareness of energy use among employees. A study by Spence et al. (2018) found that use of the e-Genie tool, which includes dashboards on energy use and trend indicators, as well as hints and tips for energy-saving behaviors, significantly reduced building energy use and increased employee energy awareness. Often, green IS also use motivational and social design features to promote not only informational benefits for their users, but also to generate affective/motivational and social benefits (Hassan et al., 2019). Hillebrand and Johannsen (2021) designed an interactive climate chatbot with gamification elements (e.g., leaderboards and badges) and found that its use promoted a range of climate-friendly activities, such as eating a vegetarian diet, avoiding trash, and turning off electronic devices. Using the story of an evolving garden that becomes more beautiful when employees conserve energy, Oppong-Tawiah et al. (2020) demonstrated that narrative elements

combined with tips and suggestions can significantly reduce energy consumption. In addition, green IS have the potential to catalyze transformative processes within organizational culture. For example, Henkel et al. (2017) illustrated that through green IS that influence individual reconsideration of sustainability beliefs, reflective discourse and information democratization occur within organizations, stimulating organizational learning and ultimately influencing corporate strategy toward sustainability.

However, the success of green IS can not be taken as granted, their impact depends largely on adoption and use by employees in the organizational environment (Dwivedi et al., 2022). Employee evaluation has been highlighted as the most critical factor in the successful implementation of a green IS, as the decision to use or not use the green IS is ultimately made by employees (Schmermbeck, 2019). Simply forcing employees to use green IS for sustainable behavior can cause indifference (Saeed & Abdinnour, 2013) and diminish the potentials for corporate sustainability. Therefore, exploring factors that influence green IS adoption gains importance, especially since affective and social experiences that should be evoked by motivational green IS design cannot be coerced in voluntary settings (Wu & Lederer, 2009). Accordingly, an extensive stream of research has developed that addresses the adoption and use of green IS and particularly challenges that need to be overcome for successful green IS adoption in organizations (Papagiannidis & Marikyan, 2022; Singh & Sahu, 2020).

2.2. Challenges in the adoption and use of green information systems

Research on the adoption and use of green IS is an important area to understand how green IS can be implemented smoothly to reap their potential benefits and avoid adoption failures (Singh & Sahu, 2020). In this regard, previous studies have taken different perspectives and investigated three different facets of green IS adoption: *adoption factors* that need to be fulfilled for successful adoption, *adoption challenges* that emerge and need to be overcome, and the *adoption process* in which such challenges occur (see Table 2 for an overview).

First, regarding the *adoption factors*, a variety of previous work has explored critical factors that should be considered when introducing green IS in organizational contexts (e.g., Brooks et al., 2018; Sahu and Singh, 2016; Tooranloo and Ashjerdi, 2018), with a focus on *economical*, *organizational* and *regulatory* forces (Singh & Sahu, 2020). While there has been a focus on the organizational perspective (Singh & Sahu, 2020), e.g., analyzing the adoption of green IS from the perspective of institutional theory (Tooranloo & Ashjerdi, 2018), prior work focusing on *voluntary* green IS adoption by employees in particular has taken a more cognitive perspective. On the one hand, studies draw on rational choice theories for green IS acceptance and adoption, such as the theory of planned behavior of Ajzen (1991) (e.g., Herrenkind et al., 2019). On the other hand, scholars have particularly considered normative theories, such as the norm activation theory (Schwartz, 1977) or the belief-action-outcome framework (Melville, 2010), when investigating individual employee perspectives of green IS adoption in organizational contexts (Dalvi-Esfahani et al., 2019; Gholami et al., 2013). In this regard, it appears that especially in adoption of green IS that are voluntary to use by employees and aim to change awareness, attitudes or behavior of employees, factors related to the individual (the subject) and the social environment (the community) (Engeström, 1987) are important antecedents for green IS adoption. Existing research in this field explores individual cognitive processes and barriers, such as personal norms and attitudes towards green IS and the environment (Dalvi-Esfahani et al., 2019; Herrenkind et al., 2019) as well as the role of personal motivational and ethical drivers (Schmermbeck, 2019). Further, studies have investigated how descriptive and injunctive subjective norms (Herrenkind et al., 2019) and sociocultural forces (Jenkin et al., 2011) influence green IS adoption of individual employees.

Secondly, a particularly important issue in the adoption and use of green IS are *adoption barriers or challenges* that can be key impediments to the adoption of green IS in organizations (see Table 1). While some work interprets challenges as simple failure to meet adoption factors (Seidel et al., 2010), several studies have examined various challenges associated with green IS that offer deeper insights into *why* and *how* adoption fails. Similar to adoption factors, scholars have considered adoption challenges from an *organizational* perspective (see Table 2). For instance, companies face *regulatory* (Schmermbeck, Voss, Thünnesen, & Ahlemann, 2020; Volkoff, Bertels, & Papania, 2011) and *financial* (Schmermbeck et al., 2020) barriers to implement and use green IS. Especially SMEs as the largest group of companies, which usually have to cope with fewer resources and manpower, are confronted with additional resources, upfront costs and expertise needed to implement sustainability measures such as green IS (Álvarez Jaramillo et al., 2019). In addition, green IS might entail *technological* challenges (Volkoff, Bertels, & Papania, 2011). For example, organizations might struggle with the security and privacy regulations of green IS when setting up systems.

Furthermore, and most importantly for the adoption of operational green IS that aim to encourage employees' behavior change (El Idrissi & Corbett, 2016), companies also face *psychological* barriers to green IS adoption from an *individual* perspective. Those include missing knowledge on the goals and functionalities of the green IS (Jenkin et al., 2011) (i.e., how-to knowledge, which is critical for individuals to start adopting a new system (Rogers, 1983)), rules-related challenges (Engeström, 1987) such as ambiguity in responsibilities (Volkoff, Bertels, & Papania, 2011), and, a challenge that is particularly interesting in light of the cognitive adoption process (Rogers, 1983), intention-action gaps in using the green IS (Jenkin et al., 2011). While companies could force their employees to use green IS as a measure to overcome this challenge, research shows that *voluntary* adoption and use of IS is particularly important in changing behaviors (Saeed & Abdinnour, 2013; Tsai et al., 2017), and therefore companies are challenged to

Table 1
Overview of related studies on challenges for green IS adoption in organizations.

Authors	Topic	Research Method	Identified Challenges
Jenkin et al. (2011)	Motivating forces, strategies and gaps in green IT/IS practices in financial services organizations	Qualitative interviews	Knowledge gap Practice gap Opportunity gap Knowledge-action gap
Volkoff, Bertels, & Papania, 2011	The role of green IS in supporting strategic transition towards sustainability with a particular focus on compliance	Grounded theory: case study with semi-structured interviews	Ongoing changes and additions to existing regulations Ambiguity how to apply regulations Ability to transform regulations into tasks for execution Ambiguities or fluctuations in responsibility Unfamiliarity with the system Universal access to the system
Schmermbeck et al. (2020)	Positive and negative outcomes of green IS adoption	Quantitative survey with closed and open-ended questions	Lack of relevance for the organization Lack of resources Benefits unclear Unsuitability of products or services Lack of demand Other priorities Missing potential

Table 2
Overview of related studies on green IS adoption and use in organizational contexts (O = organizational perspective, I = individual employee perspective, NS = not specified).

Authors	Adoption factors	Adoption process	Challenges in adoption	Adoption context	Adoption type	Type of study	Type of green IS	Theory used
Seidel et al. (2010)	O,I			Corporation	NS	Observational	Strategic	None
Jenkin et al. (2011)	O,I		I	Corporation	Voluntary	Observational	NS	Green IT/S research framework
Volkoff, Bertels, & Papania, 2011			O,I	Corporation	Non-voluntary	Observational	Strategic	None
Gholami et al. (2013)	O,I			Corporation, SME	NS	Observational	Strategic, Operational	Belief-Action-Outcome framework
Sahu and Singh (2016)	O,I			Corporation	NS	Observational	Strategic, Operational	None
Brooks et al. (2018)	O,I	I		Corporation	NS	Observational	Strategic	Technology adoption framework
Tooranloo and Ashjerdi (2018)	O			Corporation	NS	Observational	NS	None
Carberry et al. (2019)	O			Corporation, SME	NS	Observational	Strategic	Institutional theory
Dalvi-Esfahani et al. (2019)	I			Corporation, SME	Voluntary	Observational	Operational	Norm activation theory
Herrenkind et al. (2019)	I			Corporation	Voluntary	Interventionist	Operational	Theory of planned behavior
Ijab (2019)	O	O		Corporation	NS	Observational	Strategic, Operational	None
Schmermbeck (2019)	O,I	O,I		NS	NS	Theoretical	NS	DOI
Schmermbeck et al. (2020)			O	Corporation, SME	NS	Observational	Strategic, Operational	Green IS adoption framework
Singh and Sahu (2020)	O,I			NS	NS	Theoretical	Strategic, Operational	Green IS value model
Current study		**I**	**I**	SME	Voluntary	Interventionist & Observational	Operational	Activity theory, DOI

persuade rather than coerce their employees to adopt a new technology. Employee acceptance and satisfaction with a new IS has been highlighted as one of the most crucial factors for IS success in SMEs, and managers are called on to support employees at all stages of IS adoption (Chouki et al., 2020). In the context of sustainable behavior, this challenge is particularly relevant as sustainability is usually an additional duty to employees' work tasks (Unsworth et al., 2013), where IS can interfere with work processes (Yoon et al., 2021). For SMEs, where individual attitudes and beliefs towards digital sustainability tools are even more intertwined with the corporate culture towards sustainability than in larger companies (Isensee et al., 2020), it is therefore highly relevant to understand the individual employee's perspective on the psychological challenges of adopting and using green IS.

Thirdly, research has shed light the *adoption process* of green IS in organizations. Considering the individual cognitive processes of green IS adoption among employees is crucial to understand *when* and *why* certain adoption challenges emerge (Marikyan et al., 2019). In this regard, related studies that have explored the adoption process of green IS have focused majorly on strategic IS (Table 2). For example, Ijab (2019) examined the process of implementing and using green IS from an organizational perspective and identified several implementation approaches that can subsequently lead to continued use of green IS in the company. Brooks et al. (2018) examined how organizational and green IS attributes influence employees' attitudes towards adoption and their subsequent participation in the use of strategic green IS, such as facility management systems to control energy consumption in buildings. Finally, Schmermbeck (2019) analyzed the processes of green IT/S adoption in organizations in a literature review guided by DOI and identified different societal, organizational, or individual drivers in the pre-adoption phase, followed by an adoption (use) and post-adoption (continued use) phase.

Overall, the analysis of prior efforts to understand the adoption and use of green IS in organizations in general and the employee perspective in adoption of green IS in particular reveals that there are still vital gaps that merit further exploration:

(1) First, most research has focused on the factors of technology adoption and the drivers of technology acceptance (Table 2), which is a good basis for understanding the adoption of green IS in organizations, but does not adequately consider the *challenges* that emerge in the adoption of green IS throughout the adoption life cycle (Papagiannidis & Marikyan, 2022).
(2) Second, in those studies that explored adoption challenges and processes of green IS adoption, either an organizational perspective or a focus on strategic green IS is prevalent (Table 2). In this regard, it would be valuable to more comprehensively explore *individual* employees' perceptions and motivations in the adoption process (Marikyan et al., 2019; Singh & Sahu, 2020), especially in the context of *operational* green IS where *voluntary* adoption is pivotal for behavior change (Saeed & Abdinnour, 2013; Tsai et al., 2017).
(3) Finally, to the best of the authors' knowledge, there are no studies that *combine* consideration of individual cognitive processes of green IS adoption and use with a particular perspective on the challenges posed by the tension between the organizational context and the topic of sustainability (Table 2).

Drawing on both DOI (Rogers, 1983) as a theory to explore the technology adoption process and activity theory (Engeström, 1987) as a lens to consider the sociotechnical environment at work, this study therefore aims to advance the theoretical understanding of the adoption of green IS by employees in organizations with a particular focus on the challenges employees encounter in the voluntary adoption of operational green IS. Thereby, it builds on and extends previous work on the factors of green IS adoption, the barriers and challenges to adoption, and the process of green IS adoption (see Table 2).

3. Theoretical background

This work draws on activity theory (Engeström, 1987) and DOI (Rogers, 1983) as a theoretical framework to explore the challenges employees encounter when adopting green IS in an organizational

context. Both theories provide a unique lens from which to explore the barriers from the employee perspective in the adoption of green IS, with a particular focus on the individual cognitive process in voluntary (as opposed to coerced) adoption.

First, the sociotechnical perspective of activity theory links the technology to the organizational setting (Karanasios, 2018), which allows us to shed light on the challenges that emerge in the *sociotechnical environment* of green IS adoption (Allen, Brown, Karanasios, & Norman, 2013) rather than focusing only on the technology or the individual. This is particularly important as previous studies guided by normative theories have shown that the social environment in the workplace exerts a major influence on individuals' adoption of green IS (Dalvi-Esfahani et al., 2019; Gholami et al., 2013).

Second, the processual perspective of DOI allows to consider the adoption of green IS not as one final goal, but to shed light on the individual decision-making process of adopting green IS (from pre-adoption over adoption and post-adoption, Schmermbeck, 2019), which is particularly important when designing green IS to voluntary engage employees in sustainable behaviors (Marikyan et al., 2019). Thereby, DOI enables to discover the challenges within this process that can lead to discrepancies between attitudes, intentions and actual behavior, which are particularly critical in the context of sustainable behaviors (Kollmuss & Agyeman, 2002).

The combination of these two theories, illustrated in Fig. 1, thus enables to draw a comprehensive picture of the challenges in the adoption of green IS resulting from the interactions between the green IS, the organizational environment and the individual employee's psychological process of adopting the IS.

3.1. Diffusion of innovations theory

Because IS are technology-based innovations introduced to people in a social system, innovation research is a valuable tool for understanding the process of IS adoption as a process of social change (Allen, 2000). In particular, the *theory of diffusion of innovations (DOI)* (Rogers, 1983) has been widely used in IS research as a theoretical lens to study IS adoption and diffusion (Jha & Bose, 2016).

DOI posits that an individual's decision to adopt an innovation is a process consisting of five sequential stages (Rogers, 1983) (see Fig. 2). The DOI's five stages have parallels to Prochaska's transtheoretical model of behavior change (Prochaska et al., 1992) and McGuire's hierarchy of effects (McGuire, 1989), supporting the assumption that these stages do exist (Rogers, 2003).

Individuals begin in the *knowledge* stage, where they are first exposed to a new innovation and understand how it generally works at three levels: *Awareness-Knowledge* refers to the knowledge that the innovation exists, *How-to- Knowledge* describes the understanding of how to properly use the innovation, and *Principles-Knowlegde* consists of the knowledge of what operating principles the innovation is based on (Rogers, 1983).

Once individuals have acquired sufficient knowledge about the innovation, they enter the *persuasion* stage, in which they form positive or negative attitudes toward the innovation (Rogers, 1983). The persuasion stage differs from the knowledge stage primarily in that the knowledge stage is conceptualized as primarily cognitive, whereas the persuasion stage is affective and relates more to a feeling toward the innovation (Rogers, 2003).

However, once individuals have formed a positive or negative attitude toward the innovation, it is not directly transformed into a subsequent change in behavior (Rogers, 1983). Rather, a discrepancy between attitude and behavior often occurs, referred to as the attitude-intention-behavior gap (Sheeran & Abraham, 2003). This discrepancy is particularly pronounced in the case of environmentally friendly behavior (Kollmuss & Agyeman, 2002). Thus, the *decision* stage follows, in which individuals undertake activities that lead to an active decision for or against the innovation (Rogers, 1983).

In the subsequent *implementation* stage, individuals translate the results of the mental decision process of the first three stages into behavior, i.e., they begin to use the innovation (Rogers, 1983).

However, the implementation stage is not the end of the process. In the *confirmation* stage, which may continue indefinitely after the introduction of an innovation (Rogers, 2003), individuals continually seek confirmation of the decision they have already made and may reverse that decision if they are exposed to conflicting messages or experiences that cause dissonance (Rogers, 1983). In addition, disengagement may also result from substitution of the innovation for perceived better solutions or from dissatisfaction with its performance (Rogers, 1983).

DOI theory is particularly valuable to our research in understanding

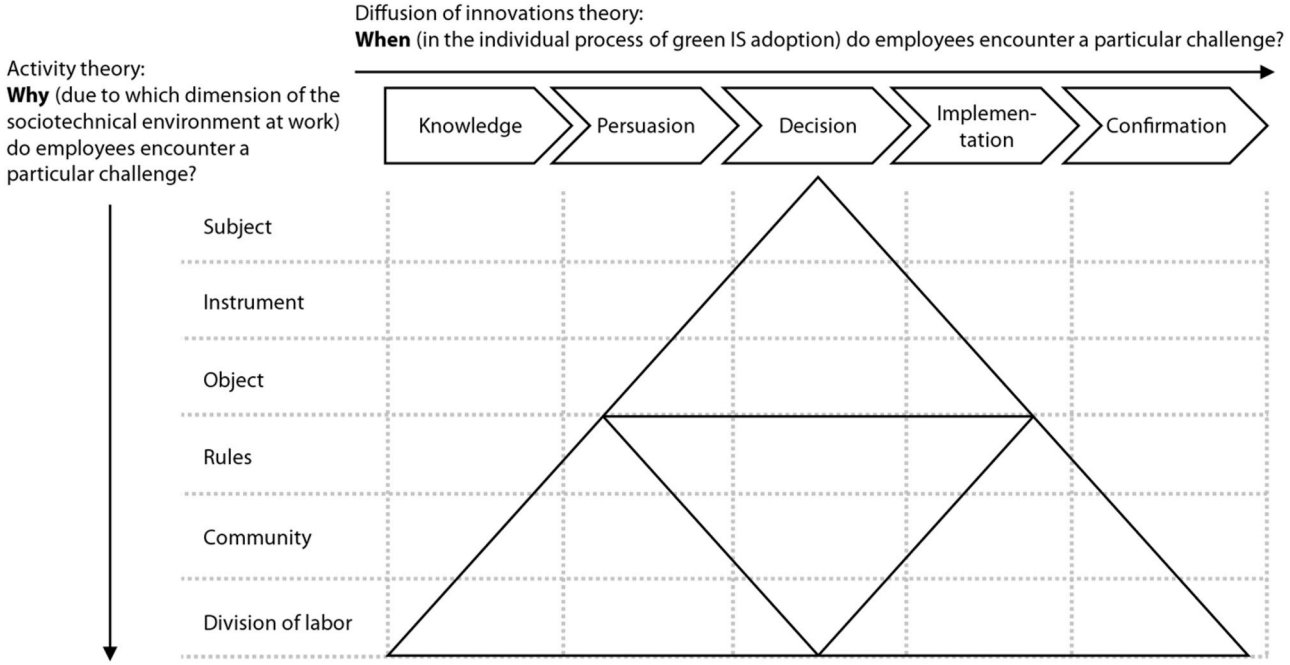

Fig. 1. Illustration of the theoretical framework based on DOI (Rogers, 1983) and activity theory (Engeström, 1987) that guides this study.

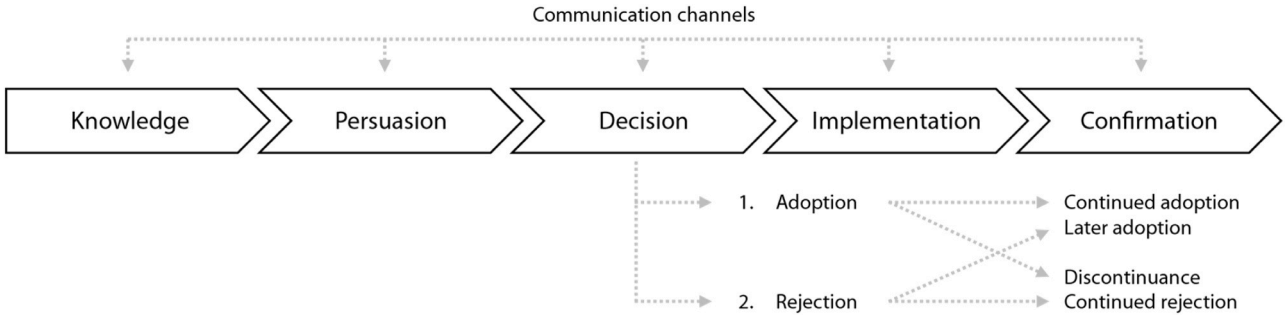

Fig. 2. A model of stages in the innovation-decision process.
Adapted from Rogers (1983, p.165).

when in the individual decision-making process a particular challenge to adopting green IS occurs. In line with urgent calls for innovation research in IS (Jha & Bose, 2016), we rely on DOI theory to cover multiple stages of the innovation adoption process that help us understand ***when*** in the individual adoption process challenges arising from the ecosystem in organizations influence the adoption of green IS for sustainability in the organizational context (Fig. 1).

3.2. Activity theory

In 1978, Vygotsky postulated that human behavior is not a mere response to a stimulus, as behaviorism assumed at the time, but the result of a mediated psychological act in which tools or signs mediate the relationship between a stimulus and a response (Vygotsky, 1978). Based on this work, which considered human behavior for the first time as an activity triad rather than a linear response, Engeström (1987) developed the activity triad model to describe the structure of human activity, his main contribution being to include social aspects in the activity system (Holt & Morris, 1993). The activity-theoretic system consists of a *subject* (the individual himself) acting toward an *object* (the goal toward which the activity is directed), mediated by *instruments* (tools and signs) and influenced by a social system of *rules*, *community*, and *division of labor* (see Fig. 3).

Specifically, community refers to an interdependent conglomeration of individuals who share, to some degree, a set of social meanings. Rules refer to incomplete guidelines for activities or actions provided by this community, while division of labor represents the task specialization of members within this community (Holt & Morris, 1993).

One of the most important contributions of an activity theory perspective in IS research is that it links technology (as instruments) and the organizational and social context, providing a sociotechnical perspective (Karanasios, 2018). In IS research (Karanasios et al., 2015) and especially in human-computer interaction research (Clemmensen et al., 2016), activity theory has proven to be a valuable lens for analyzing human behavior and interactions with IS.

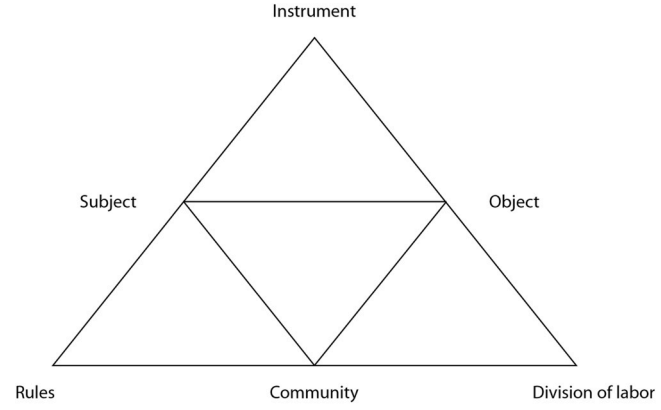

Fig. 3. The structure of human activity.
Adapted from Engeström (2015, p. 63).

In an application to our research, activity theory presents a useful angle to distinguish between challenges in adopting green IS that occur at the level of the subject (the individual employee), the object (sustainable behavior as a target behavior), the instrument (the green IS itself), and the community (the organizational environment of the employees including their peers as community members, organizational rules, and division of labor). Using activity theory as a perspective in IS adoption research allows us not to overemphasize technology, but instead to carefully consider the sociotechnical system in which the adoption occurs (Allen, Brown, Karanasios, & Norman, 2013) and explore ***why*** certain adoption challenges emerge (Fig. 1).

4. Methodology

Since our main research question is to investigate in depth what challenges are encountered in the process of adopting green IS, it is in line with the main purpose of *exploratory research* to investigate what happens in real phenomena (Makri & Neely, 2021). In particular, the goal of qualitative methods in exploratory research is to "understand [ing] issues or particular situations by investigating the perspectives and behavior of the people in these situations and the context within which they act" (Kaplan & Maxwell, 2005, p. 30). Accordingly, we opted for a *qualitative field study* approach, which is characterized in particular by the field context, i.e. the focus on individuals in the natural environment (Kaplan & Maxwell, 2005), and the qualitative methodology, which focuses on subjective perspectives and meanings, proximity to everyday behaviour and inductive analysis, but can still be guided by theory i.e. an orienting set of explanatory concepts (Ahrens & Chapman, 2006). As opposed to a positivist experiment that aims to test specific hypotheses and establish causal relationships through randomization and control, e.g., of the organizational context (Braa & Vidgen, 1999), we aimed to focus on a rich, holistic understanding of employees' experiences (Kaplan & Maxwell, 2005) and the real-world challenges and complexities that employees face when adopting and using green IS at work.

In contrast to most previous studies on green IS, which were mainly observational in nature, i.e. investigating how different organizations adopted and used different green IS (see Table 2), we decided to introduce a specific green IS that was similar across all companies. Thus, we combined the interventionist nature through which reactions to a particular IS (as an intervention) can be explored, typically found in action research, and observational methods that allow for rich interpretation and understanding, often found in observational case study research, in a *hybrid* approach (Braa & Vidgen, 1999). Thereby, we sought to investigate how the individual cognitive process of adoption and the sociotechnical environment – rather than the (unintended) specifics and circumstances of different green IS in diverse organizations (Braa & Vidgen, 1999) – influence the adoption and use of green IS. In

line with other qualitative field studies that have introduced specific IS in a natural setting for a certain period (Jacob, Faatz, Knueppe, & Teuteberg, 2022), we decided to limit the use of the green IS to a specific time period and then directly discuss with employees about their experiences to allow for an in-depth examination and reflection of employees' actual real-world experiences with the green IS, without any memory bias.

Accordingly, we studied four SMEs in Germany that implemented a green IS over a three-week period in April-May 2022 to promote sustainable employee behavior in the workplace. The green IS used was a smartphone app that was particularly suitable for the focus of our study due to three characteristics. First, it was an *operational* green IS that harnessed utilitarian features to guide employees toward sustainability actions they can take at work, where individual employees' perceptions and motivations are particularly relevant (El Idrissi & Corbett, 2016). Second, it also included hedonic and social features, such as collaborative or competitive goals and a dashboard with statistics, as well as gamification features for motivation, such as a leaderboard and a personal sustainability profile (Krath et al., 2023). This focus on motivational design targeted *voluntary* adoption by employees, which is vital to unleash the full potential of green IS in organizational settings (Saeed & Abdinnour, 2013; Tsai et al., 2017). And third, it employed the *smartphone* format, which we considered suitable on the basis of previous studies on green IS that have also opted for the mobile format as a good means of addressing individual employees (Casado-Mansilla et al., 2020; Hillebrand & Johannsen, 2021) and previous work that has highlighted the relevance of smartphone formats from the employees' perspective on green IS for sustainable behavior (Krath et al., 2022). Details of the green IS are provided in the Materials section.

To gain comprehensive insight into the challenges employees experienced in adopting the green IS and to benefit from the synergies achieved through group discussions (Bruseberg & McDonagh-Philp, 2002), we opted for *focus group interviews* with three to six employees who deployed the green IS during the study period as data collection method. Focus groups can particularly improve the quality of human-computer interaction and IS research because of their synergistic potential (Adams & Cox, 2008), as they often provide data that is rarely obtained through individual interviews and observation (Kamberelis & Dimitriadis, 2013).

Considering that generalization of findings from qualitative field studies tends to be limited by the specific circumstances and environment in which they are conducted (Conboy, Fitzgerald, & Mathiassen, 2012), such as the workplace culture, the people participating or the instruments used, we decided to complement the qualitative field study with an *expert validation*. To this end, we conducted *semi-structured expert interviews* with eight green IS experts who had extensive research and practice experience in designing and implementing green IS. Semi-structured interviews are particularly well suited to focus on pre-defined research questions while still gathering in-depth information about the opinions and experiences of individuals (DiCicco-Bloom & Crabtree, 2006), which was particularly important for our study as we wanted to not only identify the most important and severe challenges from the experts' perspective, but also explore the reasons *why* they consider these challenges to be particularly severe and what *recommendations* they would give to organizations to overcome these challenges when implementing green IS. Accordingly, we reflected with them on the significance and severity of the challenges identified in the qualitative field study in order to triangulate our findings and thereby improve the generalizability of our conclusions (Adams & Cox, 2008) as a basis for sound qualitative theory building (Conboy, Fitzgerald, & Mathiassen, 2012).

Details of the data collection and analysis process and participants of

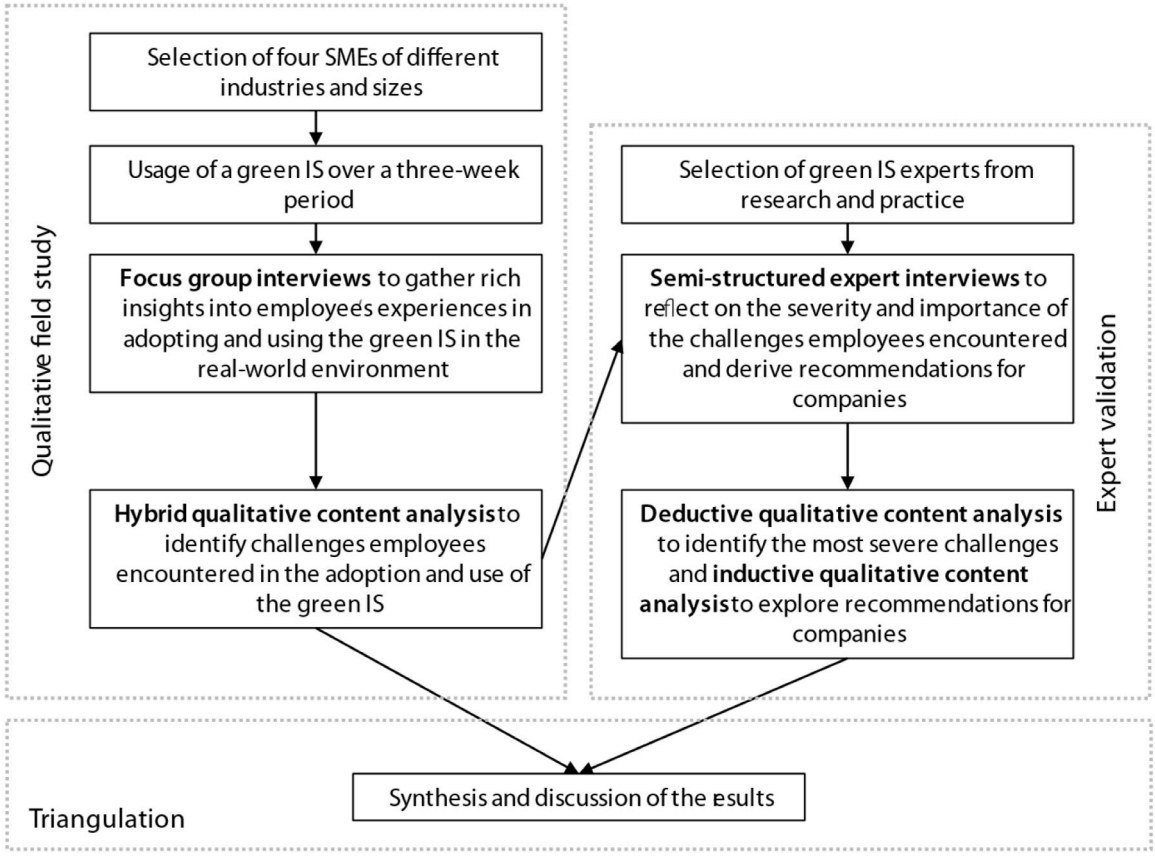

Fig. 4. Illustration of the research methodology and the combination of two studies to gain triangulated insights into the challenges employees encounter in adopting green IS in organizations.

both studies are provided in the respective sections. Fig. 4 illustrates how the results of both studies in an integrated research process lead to an in-depth understanding of the challenges employees encounter when introducing and using green IS in the workplace.

4.1. Data collection

Company selection. To ensure a basic homogeneity of the participating companies, we focused on *SMEs in Germany*, i.e., following the German definition of SMEs by the Institut für Mittelstandsforschung (IfM) Bonn, companies that have 499 employees or less (IfM Bonn, 2016). Second, we selected companies from *different industries* to ensure consideration of the diversity of business practices in SMEs that may affect workplace routines and the associated challenges for employees in adopting and using green IS. To account for the social dynamics that are an important factor in the human activity system (Engeström, 1987) and that may vary by company size, we included companies of *different sizes*. Finally, we focused particularly on *employees working in offices* (as opposed to manufacturing or skilled trades), since the green IS we introduced focuses particularly on sustainability actions that can be taken in office spaces in terms of instructional characteristics. Table 3 shows the participating companies. Company A is an industrial technology provider with approximately 250 employees from various sectors, with a focus on engineering and software development. Their product relates to circular economy and recycling, and according to their own presentation, environmental sustainability is already embedded in their culture. Company B is an industrial software provider with approximately 400 employees who are mainly software developers due to their core B2B software product. Company B is making various sustainability efforts, such as offsetting its emissions, using green power, and switching to electric vehicles, but its employees have not been as involved in its sustainability strategy. Company C is a glass manufacturer with approximately 150 employees. The majority of these employees work in the production halls and often come from abroad or have little education. In administration, about 30 employees work in research and development, procurement, sales, marketing and process optimization. The company attaches great importance to the recycling and reuse of its glass products and environmentally compatible production, but is particularly interested in new approaches to creatively involve its employees and motivate them to adopt sustainable behavior. Finally, Company D is a web design agency with 30 employees, mainly software developers and UX designers. Environmental sustainability has gained importance for them as a key criterion of responsible and sustainable digitalization. However, the company is not yet engaged in efforts for sustainability.

Focus group recruiting. For a fruitful focus group discussion, it is important that the group size is small enough so that each participant can contribute and large enough so that participants do not feel intimidated, so common recommendations revolve around a minimum of three and a maximum of eight participants (Adams & Cox, 2008). Accordingly, we opted for focus groups of 5–6 employees in each of the companies, selected by company representatives to reflect the diversity of gender, age, and job positions in each company. Thus, the representatives of each company selected the participants themselves and approached them through the company's own channels, either in written form or in direct communication. The company representatives, who were based in either the sustainability (Company A) or human resources (Company B-D) functions, had no authority to issue directives to the approached employees, so they were not pressured to participate due to power dependency. Potential participants were given a description of the aims and method of the study *before* making a decision, i.e. that the study aimed to explore how a green IS would support them to behave more sustainably in their daily work and that there would be focus group interviews on their experiences of using it after a three-week period. However, the participants were not informed in advance that this discussion would center around the challenges they encountered during adoption so as not to influence the natural adoption process. The contacted employees then voluntarily agreed to participate. Prior to using the green IS, we conducted preliminary interviews about their motivations for sustainable behavior.

Table 3
Overview of the participating companies.

Designation	Type	No. of employees	Engagement in corporate sustainability
Company A	Industrial technology provider	±250	Core activities related to the circular economy, anchored in the corporate culture
Company B	Industrial software provider	±400	CO2 compensation, green power and electric vehicles
Company C	Glass manufacturer	±150	Climate-friendly production and focus on recycling
Company D	Web design agency	±30	Awareness of sustainability, but no action so far

Introduction of the green IS. The process for introducing the green IS to the focus groups was mostly similar across the companies. In all four companies, due to the prevalence of Covid-19 regulations, the use phase was initiated by a virtual meeting where focus group participants were briefed on the basic features of the green IS and asked to install it on their mobile phones by the researchers. Employees had the opportunity to ask questions during this initial meeting, but there was no additional written guidance on how to use the green IS. In Company C, focus group participants directly discussed certain guiding rules for the use of the green IS during the usage period, such as whether or not it should be used in the home office, while there was no such discussion in the other companies. In addition, in Company C and D, the company representatives who recruited the focus group participants attended the meeting and added information about the motivation and relevance of using the green IS from the employer's perspective, while there was no such normative input in Company A and B.

Implementation of the green IS. Based on initial discussions with the participating companies about the duration of the field study, which should be sufficient to observe employees' reactions to the green IS, we opted for a three- week usage period. So as not to interfere with the natural adoption process in the companies, we did not manipulate or control the implementation process. The employees were free to decide if and when they wanted to use the green IS in their daily work. In this context, it is important to mention that in Company A, some employees were able to use the smartphones provided by the company, while in Companies B, C and D all employees had to use their personal mobile phones. The way the focus groups carried out their work was also different in the companies. In Company A, all focus group participants worked completely remotely and never met in person. The focus group members of Company C and D, on the other hand, mainly worked in the office and met in person several days per week, but under the prevailing regulations due to Covid-19. Company B pursued a mixed approach to remote working, with some employees regularly visiting the office and others working exclusively from home. Altogether, the employees used the green IS throughout the three-week usage period, with some interaction peaks in the first week and naturally less interaction on weekends (see Figure 10 in the Appendix).

Focus group interviews. After three weeks of using the green IS, we invited focus group participants to participate in a focus group interview (taking place in May 2022) in which 3–6 employees attended (Company A: 3/5, Company B: 5/6, Company C: 4/5, Company D: 6/6), what we considered appropriate in light of existing recommendations for focus group size (Adams & Cox, 2008). Due to differences in Covid-19 regulations across the companies, three focus group interviews (Companies B, C, and D) were conducted on-site, and one focus group interview (Company A) was conducted online via Microsoft Teams. All interviews were recorded using multiple devices in the room or audio recording software. The focus group interviews lasted 66 min (Company C),

94 min (Company A), 95 min (Company D), and 97 min (Company B), respectively, excluding the introduction and conclusion, which were not recorded, and were carried out in German. Author 1 moderated the focus group interviews based on a predefined guideline. First, as an easy introductory question, employees were asked how often they used the green IS during the three weeks. After an initial sharing of the positive experiences while using the green IS (in terms of the features that were most motivating and how the green IS supported sustainable behaviors), the conversation moved to the challenges that were encountered while using the green IS. Specifically, participants were first asked to write down obstacles they faced on post-its for themselves, followed by an in-depth discussion of their experiences based on their own and their colleagues' post-its. In this context, they also discussed explicitly when in the adaptation and use process of the green IS these difficulties arose. To conclude with a solution-oriented approach, the last part of the focus group interviews asked employees to reflect on what would need to change for them personally in terms of their work environment, their individual circumstances, or the design of the green IS in order for them to overcome the challenges discussed.

After the focus group interviews were conducted, the recordings were manually transcribed and translated into English, and the transcripts served as the basis for the data analysis.

Expert recruiting. In order to find suitable experts for our validation study on the challenges from the employees' perspective, we searched scientific databases (e.g., Scopus) for authors of pioneering work on green IS in organizations as well as scientific networks (e.g., ResearchGate) for academics with a research focus on green IS. In addition, we identified green IS solutions on the market and searched for the developers of these solutions. We then contacted potential experts via email with general information about our study (i.e., that we aimed to discuss the challenges of implementing voluntary green IS in organizations based on the results of a previous field study) and asked them if they would be willing to contribute their expert perspective. Out of 26 experts contacted, eight agreed to participate in the expert validation.

Expert interviews. The expert interviews were conducted after having entirely finished the data analysis of the focus group interviews. As the experts were based in different geographical locations, the interviews were conducted remotely. Before starting the data collection, we informed each participant about the details of data collection and processing and obtained their informed consent. Author 1 and author 3 conducted the expert interviews using a predefined guideline, starting with brief information about the previous field study and a prescreening of demographic questions. In the following, we applied a sequential procedure in which the experts were first asked to mark what they considered to be the most important or most severe challenges out of the 55 challenges that the employees mentioned in the qualitative field study on a digital whiteboard. Afterwards, in the semi-structured interviews, we requested them to explain why they had marked them. Finally, we asked for recommendations from the experts for companies facing these challenges. All interviews were conducted in English, recorded using audio recording software and lasted between 27 min and 52 min. Author 3 then transcribed the interviews using locally installed artificial intelligence software, supplemented by manual revision, as a basis for data analysis.

4.2. Participants

Focus group participants. The participants in the focus group interviews were diverse in terms of gender, age, position, and job description in their companies. Six participants considered themselves female and twelve participants considered themselves male. Ages ranged from 19 to 42 years old. In addition to demographic data, all participants indicated that sustainability is an important and pressing issue for them, but they cited different motivations for sustainable behavior. Most employees named individual or egoistic motivations, such as a good feeling and their children's future, while others mentioned social pressure and changing awareness in society as main motivations. Only four participants stated intrinsic concern for the biosphere and the environment as the main driver for sustainability. Regarding the adoption and use of the green IS during the study, most participants indicated that they used the green IS daily or multiple times a week, while only three participants used it rarely or very irregularly. There was no participant who did not adopt and use the green IS at all. However, seven participants also indicated that their usage decreased significantly over time, and they stopped using it after one or two weeks. Table 4 shows an overview of the participants in the focus group interviews.

Green IS experts. The experts who participated in the expert validation were mostly researchers, with some of them also having extensive practical experience in designing and implementing green IS in organizations. Two of them identified themselves as female and six as male, with an age range of 31 to 55 years. Each expert had at least five years of experience in green IS research or practice. In terms of their research or practice focus, the experts differed slightly; some focused on climate change engagement or green IS in private and organizational contexts in general, while others dealt with a specific area of environmental behavior, such as energy conservation. Table 5 shows an overview of all experts who participated in the expert validation study.

4.3. Materials

The mobile green IS that we used as an intervention in our selected companies explicitly targeted employee behavior in their daily work. The green IS intended to guide employees on what sustainability actions, especially related to environmental sustainability, they can take in their workplace and provide them with a sense of accomplishment in contributing to corporate sustainability. Thereby, their self-efficacy regarding sustainable behavior should be strengthened, which according to the theory of planned behavior (Ajzen, 1985) is a crucial determinant for sustainable behavior in the workplace (Katz, Rauvola, Rudolph, & Zacher, 2022). Since hedonic experiences in sustainable behavior can support behavioral intentions beyond the rational choice approach of the theory of planned behavior (Bamberg & Möser, 2007; Lindenberg & Steg, 2013), the green IS we used intended to generate not only informational benefits but, in line with recent developments in green IS research (Hassan et al., 2019), also positive affective and social experiences in sustainable behavior.

In line with the general aspects of user experience in motivational IS (Hamari & Koivisto, 2015), i.e. utilitarian, hedonic and social design features, we describe below the characteristics of the green IS used.

Utilitarian aspects of user experience refer to design features that support the perceived usefulness of the green IS from the employee's perspective, i.e., the perception that it promotes or supports sustainable employee behavior (Davis, 1989), and the perceived ease of use, i.e., the perception of the effort required to use the green IS (Davis, 1989; Hamari & Koivisto, 2015). The app had three main utilitarian features to help employees engage in sustainable behaviors with minimal effort (Fig. 5). First, employees could *(a) set their own sustainability goals* by selecting from preconfigured goal suggestions, such as "Save 20 liters of water in a week." Second, the green IS provided employees with *(b) customized recommendations for sustainability actions* they could take to achieve their goals, e.g., "Turn off the tap when you wash your hands," with *(c) specific information* on how much water they could save by doing so. Third, employees received *(d) personalized reminders and tips* about their goals during the workday.

Hedonic aspects of the user experience describe features that aim to promote the experience of enjoyment and fun when using the green IS (Hamari & Koivisto, 2015). The green IS contained four main hedonic design features to promote positive affective experiences related to sustainable behavior for employees (Fig. 6). First, when employees successfully completed a sustainability action, they received a *(a) juicy animation of an avatar* as a form of emotional reinforcement of the

Table 4
Overview of focus group participants.

No.	Gender	Age	Role	Job description	Motivation for sustainable behavior	Use of the green IS	Company
P1	Man	37	Follower	Health-safety-environment coordinator	Feeling that you are doing something good	Multiple times per week, but decreasing	Company A
P2	Woman	32	Follower	Software development	Contributing to a healthy environment in the future	Very irregularly	Company A
P3	Man	30	Follower	Marketing	Not caring for the environment has a negative impact on ourselves	Rarely	Company A
P4	Man	39	Manager	Customer support	Leaving future generations a planet worth living on	Daily, but decreasing	Company B
P5	Woman	38	Follower	Staff position executive board	Leaving a healthy world for her own children	Daily, but decreasing	Company B
P6	Woman	33	Manager	Commercial office work	A lot can be achieved if everyone joins in	Daily, but decreasing	Company B
P7	Man	37	Manager	Executive board sales & organization	Not destroying the future for his own children	Daily, but decreasing	Company B
P8	Man	30	Follower	Software development	Good feeling with sustainable behavior	Multiple times per week, but decreasing	Company B
P9	Man	42	Manager	Marketing and and business development	The planet has suffered damage long enough and it is up to us to change something	Daily	Company C
P10	Woman	19	Follower	Apprentice industrial clerk	Gratitude and responsible use of the luxuries we are given	Multiple times per week	Company C
P11	Man	41	Manager	Research and development	Current overconsumption of natural resources	Daily, but decreasing	Company C
P12	Man	35	Manager	Procurement	Competitiveness of the company	Multiple times per week	Company C
P13	Woman	32	Follower	Marketing and sales	Calls for people to pay attention to sustainability	Daily	Company D
P14	Man	39	Manager	Agile coach	We hear and read that the planet goes to the dogs	Rarely	Company D
P15	Woman	30	Follower	Product owner	Social pressure and personal interest due to the effects of the climate crisis	Daily	Company D
P16	Man	24	Follower	Software development	Preventing waste of resources	Daily	Company D
P17	Man	32	Manager	Service and support, software development	There is only one planet and there is no more time to waste	Multiple times per week	Company D
P18	Man	43	Follower	Sales	Perspective for human civilization	Multiple times per week	Company D

previous action. Second, employees earned *points for sustainability actions* and advanced in a *level system*. Combined with these features, employees were able to view a *(b) personal sustainability profile* where they could see the goals they had achieved and the number of points they had earned in the various dimensions of sustainable behavior. And fourth, a *(c) dashboard with statistics on metrics saved* (in the dimensions of CO2, water, energy and waste) allowed employees to see the impact of their behavior and how much they could achieve with little effort.

Finally, social aspects refer to characteristics that promote social influence, i.e., perceptions of how colleagues use the green IS or how they expect oneself to use it (Ajzen, 1991), and relatedness between colleagues (Hamari & Koivisto, 2015). In our green IS, there were three main social design features to support positive social experiences in sustainable behaviors (Fig. 7). First, as part of a collaborative approach, employees could set themselves *(a) team goals* and invite each other to achieve them through a joint effort. Second, employees could challenge their colleagues in *(b) competitions*, such as "Who will be the first to perform 10 eco-friendly nutrition actions in the workplace?" And finally, the app used a *(c) leaderboard* where employees could compare their sustainability performance with the performance of their colleagues based on their accumulated points.

4.4. Data analysis

Focus group interviews. On the basis of the transcribed focus group interviews, we chose the qualitative coding approach (Kaplan & Maxwell, 2005) and opted for a *hybrid qualitative content analysis* following the methodological suggestions of Mayring (2014) using MAXQDA as qualitative data analysis tool. First, deductive coding is particularly aimed at subdividing and analysing values of predefined theoretical structuring dimensions (Mayring, 2019), which we considered suitable to structure challenges in the adoption of green IS at the workplace in accordance with our theoretical lenses of activity theory (Engeström, 1987) and DOI (Rogers, 1983). The deductive coding process involved (1) defining the categories to be coded (in our case, the five stages of the innovation adoption process (Rogers, 1983) and the six dimensions of the human activity system (Engeström, 1987)), (2) developing category definitions and anchor examples for the respective categories for coding, (3) relating concrete text passages to the categories (with each text passage related to the categories on two dimensions, the temporal dimension (DOI theory) and the activity dimension (activity theory), (4) revisiting coding rules after 25% of the material, and (5) coding the remaining transcripts. Important to note is that we used latent as opposed to semantic analysis for coding (Braun & Clarke, 2006), which means that we included the context of the discussion and the underlying assumptions of the semantic data (Braun & Clarke, 2006) in order to determine e.g. whether a text passage related to the decision to use the system or the experiences during use. Table 11 in the Appendix displays our coding guideline for the theoretical categories.

Second, for structuring of the content, we used inductive coding to reduce the material per identified main category, an approach similar to thematic analysis to summarize the main themes per category and gain richer insights into the deductively coded categories (Mayring, 2014). The inductive coding process involved (1) determining the level of selection and abstraction of themes to be coded in each main category, (2) linking deductively coded text passages either to existing themes or forming a new theme, (3) revisiting categories after 25% of the material, and (4) coding the remaining material without changing existing categories and adding new categories as needed.

In order to test reliability of our results, we performed an intracoder agreement check for 25% of the material both in regards to the main

Table 5
Overview of green IS experts participating in the expert validation study.

No.	Gender	Age	Years of experience with green IS	Origin of experience	Green IS research or practice focus
E1	Man	31	5	Research & Practice	Green IS for climate change and environmental behavior engagement, gamified IS
E2	Woman	44	24	Research & Practice	Green IS for sustainable consumption, CSR programs, employee education, community engagement
E3	Man	45	7	Research	Human centered design of green IS for pro-environmental behavior, energy conservation
E4	Man	35	11	Research & Practice	Green IS for energy use optimization in companies
E5	Man	42	15	Research	Individual (awareness), group (collaboration) and organizational (strategies) impact of green IS
E6	Woman	39	13	Research	Green IS in private and organizational contexts, impact and acceptance of green IS
E7	Man	55	7	Research	Green IS for workforce development, training, ethical implications of technology
E8	Man	44	5	Research	Green IS for user involvement in sustainable behavior in public and residential buildings, gamified IS

category and the identified subthemes (Mayring, 2014) five months after the original coding. Intracoder agreement checks are a measure of test-retest reliability that provide an estimate of relative coding consistency (Chen & Krauss, 2004). We performed intracoder agreement checking using the built-in method of MAXQDA to calculate the agreement rate and Cohen's kappa coefficient (κ), which accounts for agreement by chance (Neuendorf, 2017), between two encoded transcripts, the original encoded transcript and a copy of the transcript encoded five months later. The intracoder agreement rate was 78.57% (κ = 0.88) for the deductive category coding and 81.82% for inductive theme coding (κ = 0.94), indicating re-test reliability of our results (Neuendorf, 2017). To further ensure the reliability of the theoretical classification and avoid researcher bias, an intercoder agreement check was conducted. While the hybrid coding was performed by the first author, the third author deductively classified the identified themes, without prior knowledge on how they were related to the categories, into the theoretical dimensions of activity theory and DOI based on the coding guideline (Table 11) with the anchor examples. The agreement rate between the theoretical classification of the first and third author was 63.64% (κ = 0.61), indicating a good agreement (Neuendorf, 2017). Any conflicts in the classification were discussed and jointly resolved by both authors.

Expert interviews. As we conducted semi-structured interviews with the experts and were interested not only in. *which* challenges they highlighted as important (during the structured phase on the digital whiteboard), but also *why* they considered these challenges significant and what recommendations could support companies overcome them, we opted for a qualitative coding approach (Kaplan & Maxwell, 2005), similar to the focus group interviews.

Since the identified challenges were predefined in the expert evaluation and the experts' selection of challenges resulted in a quantitatively evaluable prioritization, which we could compare between the experts (Denzin & Lincoln, 2018), we decided to apply a combination of deductive coding of the challenges marked on each expert's digital whiteboard and a deductive qualitative content analysis (Mayring, 2014) to derive novel insights on the highlighted challenges and their reasons for selection in the transcripts. The deductive content analysis conducted by author 1 started with (1) defining the categories to be coded (the 55 challenges mentioned by the employees in the qualitative field study), (2) assigning concrete text passages to the categories, (3) checking the coding after 25% of the material and (4) coding the remaining material.

Secondly, without prior assumptions about the category structure, we used an inductive qualitative content analysis approach (Mayring,

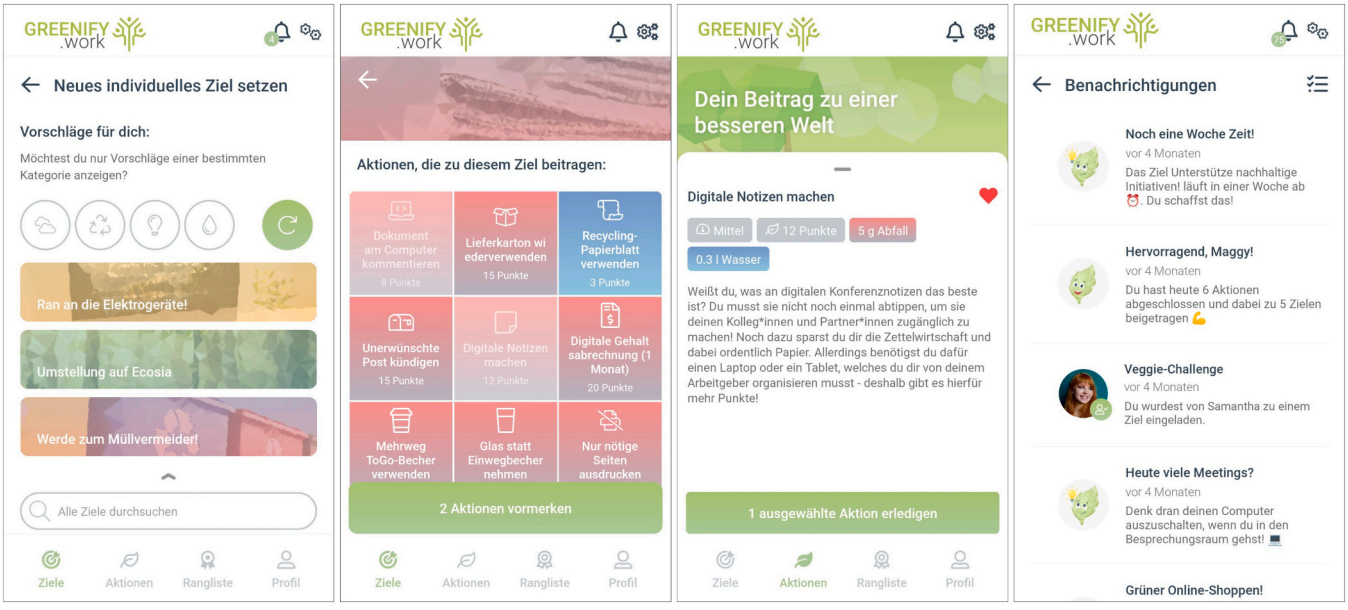

Fig. 5. Utilitarian design features in the green IS: (a) goal setting, (b) customized recommendations of sustainability actions with (c) detailed information on the actions, (d) personalized reminders and tips.

Fig. 6. Hedonic design features in the green IS: (a) juicy avatar animation, (b) points and level system in a personal sustainability profile, (c) dashboard with statistics on metrics saved.

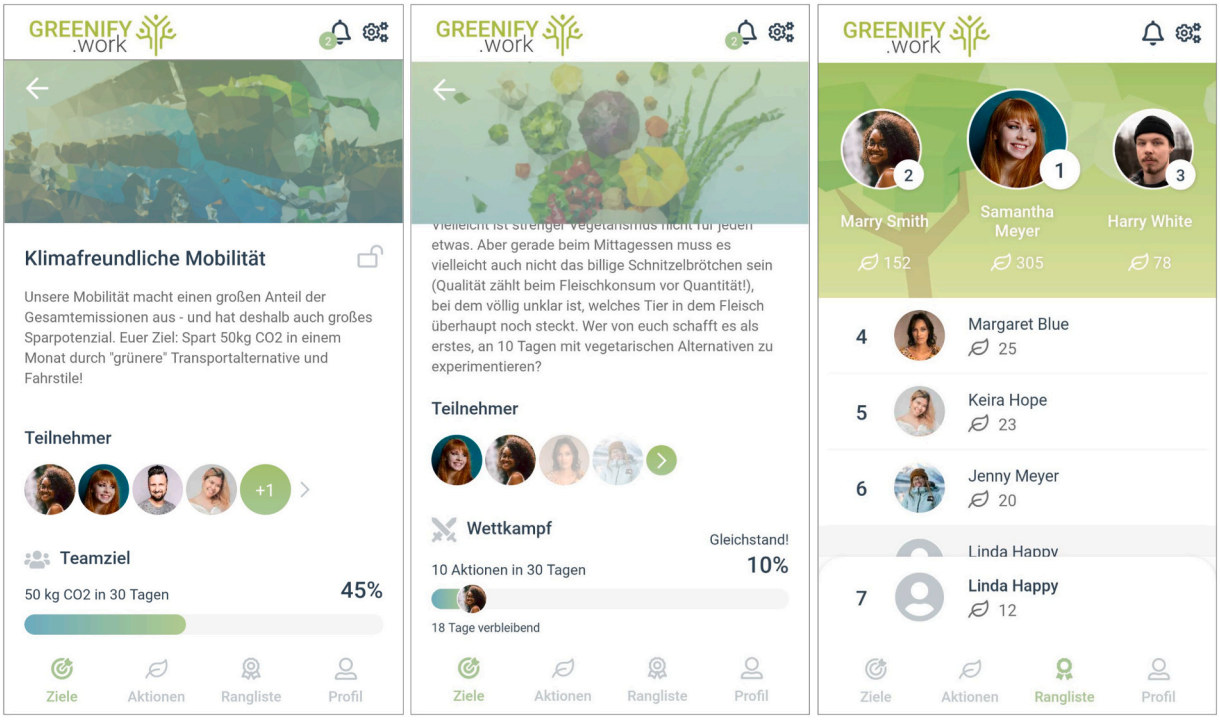

Fig. 7. Social design features in the green IS: (a) team goals, (b) competitions, (c) leaderboard for peer comparison.

2014) to code and classify the expert recommendations for companies. For the inductive coding of the recommendations conducted by the first author, we first (1) defined a selection criterion and level of abstraction for the categories (Table 12), then (2) worked through the transcripts line by line and either formed new categories or related text passages to existing categories, (3) revised the categories according to 25% of the material and merged categories where necessary, (4) coded the remaining material and finally (5) formed main categories, i.e., we grouped the categories into overarching themes of the recommendations.

To ensure the reliability of our coding, we conducted an intercoder agreement check. To this end, author 3 first coded 25% of the material based on the categories provided by author 1 and then deductively related all identified categories to the overarching themes. The intercoder agreement for the inductive coding was 87.14% ($\kappa = 0.67$) and the agreement for the main categories was 65.71% ($\kappa = 0.59$), indicating good and moderate agreement, respectively (Neuendorf, 2017). All coding and classification conflicts were discussed in a joint session and resolved by both authors.

5. Results

5.1. Qualitative field study

In the qualitative field study, we identified 55 different challenges that employees in the four companies noted with regard to the adoption and use of the green IS, both in terms of the temporal dimension (DOI theory) and the activity dimension (activity theory), with the important exception of the dimension of division of labor, which relates to task specialization among members of a company (Engeström, 1987). Interestingly, we found that in the knowledge and decision stages, challenges were mainly related to the subject, the instrument, and the rules, while in the persuasion stage, the role of the object and the community were more important. Most of the challenges we observed were related to the implementation and confirmation stages of innovation adoption, where all activity dimensions present different challenges to be tackled. In the following, we will present the identified challenges in detail, organized by the stages of the innovation adoption process (Rogers, 1983). Table 6 and Table 7 provide an overview of the detected challenges, with those challenges noted by at least four of the participants in at least two different companies marked as particularly important.

5.1.1. Challenges in the knowledge stage

Challenges that arose in the knowledge stage of the adoption and use of the green IS, i.e., related to awareness that the green IS exists and how it works, were mostly related to the **instrument**, i.e., the green IS itself. In particular, employees referred to language barriers (P11), lack of explanation of functions through some kind of onboarding (P17), or intransparency in how certain functionalities work (P2) as barriers related to *how-to knowledge* and *principles knowledge*.

> "Here topic briefing onboarding at the beginning [.] then when I had the app again, [I didn't know] what was phase anymore because [P15] had explained it to me only once briefly" (P17).

In addition, one participant highlighted the importance of understanding compliance with organizational privacy **rules** as a critical challenge (P7), and another referenced the challenge that **subjects** may lack technical knowledge about how to install and use any app or IS, which prevents them from even considering using it (P17). In contrast, challenges related to *awareness-knowledge* or to the object or community were not mentioned by the employees.

5.1.2. Challenges in the persuasion stage

While few participants referred to challenges in the knowledge stage, several employees from all companies encountered challenges in the persuasion stage. In the persuasion stage, individuals form positive or negative attitudes towards the green IS (Rogers, 1983). Here, employees referred to challenges mainly related to the **object**, i.e., the issue of sustainability in organizational contexts (Engeström, 1987), and the **community**.

In terms of the **object**, particularly participants from Company A and B, in which no normative introduction to the green IS was given by a company representative on the relevance from the company's perspective, emphasized that sustainable behavior in the workplace was not a personal need (P1, P2, P3, P4, P5, P7). Specifically, they cited that *"you don't get anything out of it"* (P7) and that *"not to sound too mean, but it's really just about increasing sustainability in the workplace"* (P2). In addition, employees indicated that they did not see any personal consequences (P2, P5, P7, P17) or that the consequences were at least unclear (P7) if they chose not to use the green IS.

> "It is, we must say this very clearly, about the company. You don't do it for yourself, so to speak. So if a company says, okay, download this app on your private phone and now make sure you save water for me, then I can also say 'I don't give a fuck'" (P17).

In this context, P7 also stressed that from a management perspective, the cost-benefit ratio for the company to implement the green IS and act

Table 6
Results of the qualitative field study categorized by the stage of innovation adoption (Rogers, 1983) and the elements of the activity system (Engeström, 1987) – Knowledge, Persuasion and Decision stage. Challenges noted by at least four of the participants in at least two different companies are highlighted as particularly important in bold.

	Knowledge	Persuasion	Decision
Subject	C1: Lack of required technical knowledge (P17)	**C6: Attitude against smartphone use (P1, P2, P4, P5, P8)** C7: Attitude against habit changes (P12) C8: Perception as part of work (P2, P3)	C16: Deferral of use to the future (P8, P12)
Instrument	C2: Language barriers (P11) C3: Lack of onboarding (P17) C4: Intransparencies in functionality (P2)	C9: Rivalry of other software (P6, P7)	C17: Lack of system visibility (P1, P6, P7)
Object		**C10: Lack of personal need (P1, P2, P3, P4, P5, P7)** **C11: Lack of personal consequences (P2, P5, P7, P17)** C12: Ambiguity of personal consequences (P7) C13: Cost-benefit ratio for company unclear (P7)	
Community		**C14: Lack of social pressure (P2, P3, P9, P10, P13, P15)** C15: Lack of role models (P3, P9, P12)	
Rules	C5: Appropriateness of data protection (P7)		**C18: Organizational regulations that impede adoption (P2, P7, P9, P10)**

Table 7
Results of the qualitative field study categorized by the stage of innovation adoption (Rogers, 1983) and the elements of the activity system (Engeström, 1987) – Implementation and Confirmation stage. Challenges noted by at least four of the participants in at least two different companies are highlighted as particularly important in bold.

	Implementation	Confirmation
Subject	**C19: Forgotten in everyday work (P5, P9, P10, P11, P13, P15, P16, P17, P18)** C20: Ignorance of triggers and reminders (P7, P8) C21: Perception as unmotivating (P18) C22: Experience of failure (P18)	**C42: Lack of long-term motivation (P5, P7, P8, P12)** C43: Decrease in novelty (P7, P11) C44: Unfulfilled expectations (P15)
Instrument	**C23: Effort too high (P1, P3, P4, P6, P7, P8, P9, P11, P14, P15, P16, P17)** **C24 Obstacles in usability (P4, P8, P11, P17, P18)** **C25: Lack of trigger to continue use (P2, P4, P7, P16, P17)** **C26: Intrusive features (P7, P9, P11, P17)** C27: Aesthetics do not meet personal taste (P2, P15, P17) C28: Lack of company-specific individualization (P2, P9, P12) C29: Lack of informational content (P2, P12) C30: Lack of structure (P3, P15) C31: Complicated design (P7) C32: Bugs in functionality (P2) C33: Lack of interaction features (P15)	**C45: Lack of connection to work environment (P2, P4, P5, P7, P9)** C46: Lack of individualization (P8, P13) C47: Inappropriate difficulty (P17)
Object	C34: Unfulfillability of tasks (P2, P15, P18) C35: Difficulty of reconstruction (P8, P18)	**C48: Lack of transparency of achievements (P3, P5, P8, P15)** C49: Cost-benefit ratio insufficient (P7, P8, P11) C50: Lack of relevance of achievements (P5, P8) C51: Decreasing topic relevance (P10)
Community	C36: Lack of interpersonal communication (P2, P15)	**C52: Critical mass of users (P1, P2, P3, P4, P6)** C53: Decreasing use by colleagues (P6, P7) C54: Lack of celebration of team achievements (P4, P9)
Rules	**C37: Conflict with work tasks (P1, P2, P3, P4, P5, P7, P16, P17)** **C38: Lack of clear rules (P4, P13, P15, P17, P18)** C39: Perception of imbalance and unfairness (P13, P15, P18) C40: Lack of control and fraud protection (P2, P11) C41: Excessive rules (P7)	C55: Appropriateness of incentives (P11)

for sustainability was not clear and that it would be important to *"using calculation examples to show companies directly why it makes sense to do it that way. [.] The part costs in sum afterwards say 1.000 €, to take a value. This equipment costs 1000 € and you write directly behind it, so the motivation is however probably around X higher. Means your savings in CO2 that you don't have to buy as certificates, electricity that you don't have to pay, gas that you don't pay, water, are 5000 €. Then it's much easier for the company to say, yeah sure, let's do it right away."* (P7).

From these statements, it becomes clear that the adoption of green IS faces significant challenges due to the organizational context.

Second, given this lack of individual relevance, employees across companies also stated that the lack of social pressure (P2, P3, P9, P10, P13, P15) and role models (P9, P12) were important critical **community-related** challenges to their attitudes toward the green IS. In particular, they noted that use *"has to be lived. It has to be mandated, because otherwise it's useless"* (P12) and that companies might even consider making an *"obligation for them [employees] to use the app"* (P3) in order to exert social pressure on employees.

Finally, related to the **subject** dimension, several employees commented that their personal attitudes toward smartphone use (P1, P2, P4, P5, P8) played a critical role in their decision to use the green IS.

> "The problem is the personal attitude towards the use of apps or something like that. And if I'm not interested, then I don't do it [.]. It doesn't matter what the manager says. That's the problem. The problem or the thing, that's the personal interest." (P1).

Also, the presence of and rivalry with other software and IS used at work (P6, P7) particularly prevalent in Company B, and the perception of the green IS as a part of the work especially noted by two employees in Company A added to the already existing duties, hindered a positive attitude formation towards it.

> "I think my brain saw the app as something I have to do in addition to what I already do every day during the eight or nine hours I'm here at work. And that caused me some kind of stress" (P3).

5.1.3. Challenges in the decision stage

Challenges that occur in the decision stage are particularly revealing because they can account for the gap between attitude, intention, and action that is often observed in sustainable behavior (Kollmuss & Agyeman, 2002).

In relation to the **instrument**, three employees noted that even if they had a positive attitude towards using the green IS, they did not start using it because the system was not visible (P1, P6, P7), specifically due to the fact that the green IS was an app that was displayed on the last screen by default on smartphones.

> "I think that was the problem, so maybe I should have kind of dragged it to the front from the beginning, because the apps that I see then in the front, I tend to think, oh, there I should be clicking something" (P6).

Also, on the **subject** dimension, some employees mentioned that they kept postponing use to the future and attributed this to external circumstances (P8, P12).

> "But then you just don't do it somehow and think to yourself, yeah, come on, the moment is bad or something and then it's already forgotten right away when you've arrived at the thought that you'll do it later or something." (P8)

In three of the four companies, there were also organizational **rules** that hindered adoption for some employees. For example, rules in Company A and C restricted the use of personal smartphones during work hours (P2, P9), which prevented employees without company phones from using the green IS (P2), or restricted giving apprentices an organizational email address for authentication (P10). In addition, P7 noted that organizational rules may contradict the use of certain functions or the realization of certain instructions of the green IS: *"That's an exciting question, for example, turning off the lights. I would say we are not allowed to do that. [.] Because the workplace specifications for workplaces dictate a certain amount of light. And if we turn that off, then we sit too dark"* (P7).

5.1.4. Challenges in the implementation stage

Once employees started using the green IS, they encountered a variety of challenges related to all dimensions of the activity system (Engeström, 1987).

Initially, a majorly important challenge across all companies related to the **subject**. Employees stated that they forgot about the green IS in everyday work (P5, P9, P10, P11, P13, P15, P16, P17, P18) and some of

them also ignored triggers or reminders from the IS (P7, P8).

> "I just didn't think about it at some point, I used it for the first 2,3,4 days and at some point I just didn't think about using it at all." (P17)

One particular challenge that could explain why employees forgot about the green IS in their daily work is related to the prevailing **rules** in the workplace. Nearly half of the participants indicated that they often saw sustainable behavior and IS use as conflicting with their work tasks (P1, P2, P3, P4, P5, P7, P16, P17). For example, focusing on using the green IS for sustainable behavior can distract from the current task: *"And then I would have to change the focus and look, okay, now I have to select this, this, okay, and then do the action. That's what pulls you out. That's just the way it is with us, when it comes to development. If you're out of it for ten minutes, it takes you half an hour to get back into it"* (P16). In some cases, this could even lead to employees deciding whether they should focus on their work tasks or on sustainable behavior (P1).

> "Sounds nice, but I have so many things to do. What, what it's important for, for you, I can say to my manager. The manager will say, okay, then you have to do your work, not to use the app for example" (P1).

In addition, several employees referred to challenges with the rules for using green IS (P4, P13, P15, P17, P18), which even led to a perception of unfairness (P13, P15, P18) in Company D, while none of the participants from Company C who had discussed about guiding rules in the introductory meeting noted these challenges. In particular, participants mentioned ambiguities regarding the use of the green IS in home or remote office environments (P4, P13), especially when they decided to work remotely for other reasons rather than sustainability: *"When am I actually allowed to mark the home office day when I do it? So I just said, hey, cool, I'm actually always here in the office, but now I've had Corona for 14 days, I had to stay at home, so I could now directly get ten times the 40 points. And then, no, you're not allowed to do that, I think, yeah, why not, I've saved on CO2. I didn't drive to work. Yes, and you weren't allowed to. So I think there's still a bit of a need for a set of rules, I have the impression"* (P4).

Notably, the lack of protection against fraud was cited by two workers as a challenge that contributed to perceptions of injustice: *"And I have always wondered if that is also just based on trust or, you know"* (P2). Moreover, a less noted challenge related to the organizational **community** mentioned by two employees, which may also contribute to forgetting about the green IS in everyday work, was the lack of interpersonal communication between colleagues (P2, P15).

> "We didn't really do that very much, because one or the other was on the road a lot or was at home, so we didn't talk much about it. So hey, I did this today or I did that. Yes, that would probably have helped a little bit" (P15).

Concerning the **object**, some employees mentioned that they encountered the challenge that some tasks for sustainable behavior seemed unachievable to them, which they found demotivating: *"Well, for example, I am not a cyclist, I don't have a bicycle. Accordingly, this option is completely eliminated for me, for example, climate-friendly mobility"* (P15). Since sustainable behavior can be realized on many levels and is reflected in many actions, employees were sometimes faced with the challenge of reconstructing their behavior to track it in the green IS: *"And then you look at the favorites or the actions and somehow try to reconstruct, what did I do today?"* (P8).

Finally, it must be acknowledged that important challenges related to the **instrument** emphasized by several participants across companies, particularly usability (P4, P8, P11, P17, P18), but also aesthetics (P2, P15, P17), structure (P3, P15), design (P7), and functionality bugs (P2) are probably mainly due to the specific design of the green IS used in this study and are likely to occur in any IS implementation, and therefore do not present any particular challenges of a green IS for sustainability in organizations. However, employees also discussed challenges related to the instrument that may be noteworthy for the context of this study. One majorly important point was that employees perceived the effort required to use the green IS as too high (P1, P3, P4, P6, P7, P8, P9, P11, P14, P15, P16, P17). Often, employees could not justify why they felt the effort was too high, but some noted that it was related to *"not having the smartphone with them all the time"* (P16) to interact with the green IS, or that it annoyed them to have to track their activities:

> "It sounds a bit stupid, but the effort to enter something or whatever is somehow still too high for me in everyday life, even if it's so intuitive and quick like an app or something." (P8).

Also, they felt that the green IS was missing triggers (P2, P4, P7, P16, P17): *"And if I'm not triggered, then it's quickly forgotten"* (P4), but at the same time mentioned that it was sometimes too intrusive (P7, P9, P11, P17). Also, employees in Companies A and C, i.e., companies involved in the development of industrial technologies for the circular economy or in manufacturing with an existing focus on environmentally friendly production missed a lack of company-specific individualization in terms of how employees should behave sustainably in order to feel a real connection to green IS: *"If you think of it as an app that should be used within [anonymized], you should also include some, let's say, [anonymized] specific knowledge"* (P2). In addition, some employees felt that the green IS did not provide them with enough informative content related to specific topics (P2) or *"suggestions on what to do"* (P12), even though they felt that this information was a key reason for the value added by the green IS.

5.1.5. Challenges in the confirmation stage

Finally, challenges that occur during the confirmation stage are particularly important because they can determine how employees perceive their satisfaction or dissatisfaction with the green IS and reevaluate their decision to adopt it (Rogers, 1983). In our study, we found significant subject, instrument, object, and community challenges that resulted in employees discontinuing use after some time.

Regarding the **subject**, employees particularly from Company B and C indicated that they lacked long-term motivation to use the green IS (P5, P7, P8, P12). Specifically, employees indicated that they lacked *"incentives"* (P12), *"connection to a long-term goal"* (P7), or concrete rewards to consider continued use of the green IS.

"It would have to be 'Let's save energy' - I don't know, 5000 kilowatt hours, I'll use that as an example. 'Then at the summer party we'll have an extra barbecue or something' [P5: Yeah, something like that]" (P7).

However, in relation to this issue, P11 also mentioned that in terms of **rules** it was very important that any incentives were appropriate to the organizational context: *"The prize should be something like a fruit basket, I think that's good. Anything else would be kind of inappropriate again"* (P11).

In addition, two employees mentioned that there was a novelty effect in using the green IS that initially made them want to use it, but that diminished over time: *"It's nice when you've seen it all once and then a second time. And then you want the time, I actually didn't want to spend the time there all the time anymore"* (P11). It is particularly noteworthy that P15, who indicated that sustainable living was already very important to her, also felt that her expectations of the green IS were not met, which made her dissatisfied: *"For me, the motivation was actually to live more sustainably and not to skim off what I'm actually doing. That's why it was a bit funny. I was in first place relatively quickly because I eat vegetarian food every day and turn off the toilet light every time I go out there and always turn off all the hallway lights anyway. That's not really the challenge, and the challenge was what was actually interesting about it"* (P15).

In terms of the **instrument**, employees saw a lack of connection to the work environment (P2, P4, P5, P7, P9) as an important challenge in the reevaluation of green IS use and suggested that green IS should be supplemented with offline nudges such as *"post-its"* (P5) or *"posters"* (P5) to improve this connection to the everyday work environment. They also missed ways to individualize their interaction with the green IS: "*That*

you have a little more flexibility in actions or even other actions that you might have thought of" (P13).

Related to the **object**, i.e., sustainability, a key challenge to continuous engagement in sustainable behavior by the green IS was that employees did not experience their behavior and achievements as transparent (P3, P5, P8, P15) and relevant (P5, P8), and that at the end, the individual cost-benefit ratio of using the IS for sustainable behavior seemed insufficient for them (P7, P8, P11). In particular, they missed *"being proud of what you've accomplished"* (P8) or seeing relevance in *"how much [they] have accomplished with the company so far"* (P3).

> "It would be cool if that was said a little bit more actively because you've saved so much water, we now have this and this or something" (P15).

Of particular interest is that the youngest participant also observed a decreasing relevance of sustainability as a topic over time, making continuous engagement more difficult: *"But I would say that the trend, I think sustainability is a huge trend, [.] And I think that's also a trend where you say, yeah every trend, after a while it has that here again, that it goes down"* (P10).

Finally, particularly employees that worked in Companies A and B, i.e., the larger companies, cited key **community** challenges that prevented continued use of green IS for them. Among other things, a critical mass of users needs to be reached so that the overall commitment to sustainability in the workplace is perceived as valuable (P2, P3, P4, P6).

> "But I think if more people participated, then, yeah, you would be more likely to stick with it" (P6).

P3, in particular, expressed how frustrating it was to use the green IS but to feel like he was alone in his commitment: *"But if I feel like I'm the only one or that we're really few, then you say, okay, that's kind of like, I'm not running with the others. We're not all rowing in the same direction. I'm the only one rowing in that direction and the others just aren't as active"* (P3). Two employees in Company B also mentioned that they found it significantly demotivating when they observed diminishing use by their colleagues (P6, P7): *"And for me personally, the motivation has decreased because we have used less and also set fewer goals together or created challenges. That group dynamic [.] as soon as the group stops or the tendency decreases, in terms of usage, it almost completely drops off"* (P7).

5.2. Expert validation study

5.2.1. Expert evaluation of the challenges identified in the qualitative field study

In the expert validation study, it became evident that experts brought varied perspectives to assess the importance and severity of the challenges raised by the employees. Out of 55 challenges, 54 were considered important by at least one expert. Despite differing perspectives and experiences, some challenges were recognized as critical by several experts. While the majority of those aligned with challenges deemed important by at least four employees in two different companies, experts also emphasized challenges as severe that were encountered by only a few participants in focus group interviews. The results of the expert validation are illustrated in Table 8 and Table 9, with challenges named by at least three experts highlighted in bold.

In the **knowledge** stage (although not particularly perceived by employees), experts emphasized that a lack of adequate onboarding (E1, E2, E3) and opacity in the functionality (E3, E5, E6) of the green IS can pose major challenges that hinder the adoption process before it actually begins. In particular, they cited that the system *"has to be absolutely crystal clear before you even kick it off"* (E2) because employees may give up if they do not comprehend how the green IS is intended to work: *"If people don't understand how this thing is supposed to work [.] most people would give up, I suppose, here and say 'yeah, come on. If this isn't running smoothly, yeah, go to hell'."* (E6).

Next, in the **persuasion** stage, and in accordance with the employees, the experts highlighted challenges related to the subject (employees' individual attitudes and perceptions), the object (sustainable behavior as a goal) and the community in the workplace as especially important. Several experts pointed out that the general opposition to smartphone use, even if it may only be *"affecting very few people"* (E6) and *"can differ according to thing like age"* (E7), can be a major challenge for those affected when introducing smartphone-based green IS, similar to the resistance against habit change for sustainability (E1, E3, E8). Particularly insightful was E3's statement that such attitudes can be significantly influenced by the cultural environment and pose a greater challenge in some countries than in others: *"So what we found in my study was that, for example, the people in Switzerland had the more negative attitude, compared to the people in southern countries like Spain or Greece or Italy."* (E3).

In addition, the experts emphasized significantly more than the employees that the perception of the green IS being part of work (E1, E2, E3, E5, E7), i.e., *"added to their workload"* (E1) or *"[taking] time [from] them to be meeting the other priorities that they have"* (E7), can present a severe challenge for building attitudes towards using in the persuasion stage. Due to the perception that it is a part of work, people would also not be willing to *"volunteer outside of work hours"* (E2).

However, as part of work, a very important challenge highlighted by both experts and employees is that employees lack a personal need to behave sustainably (E1, E2, E3, E6, E8). Sustainability is *"not directly tied to [the] goal function"* (E6) and employees feel less affected than at home because *"[they] don't pay for electricity, [they] don't pay for the water, [they] don't pay for anything"* (E8). Therefore, a normative influence in the workplace might be needed to inspire motivation for sustainable behavior: *"Pro-environmental behavior is not really a need at work. If you're*

Table 8
Challenges highlighted as important and severe in the expert validation study – Knowledge, Persuasion and Decision stage. Challenges noted by at least three experts are named and highlighted in bold.

	Knowledge	Persuasion	Decision
Subject	C1 (E3, E6)	**C6: Attitude against smartphone use (E2, E3, E6, E7)** **C7: Attitude against habit changes (E1, E3, E8)** **C8: Perception as part of work (E1, E2, E3, E5, E7)**	C16 (E2)
Instrument	C2 (E3) **C3: Lack of onboarding (E1, E2, E3)** **C4: Intransparencies in functionality (E3, E5, E6)**	C9 (E5, E8)	C17 (E6)
Object		**C10: Lack of personal need (E1, E2, E3, E6, E8)** C11 (E3, E6) C12 (E3, E5) C13 (E3)	
Community		**C14: Lack of social pressure (E3, E6, E8)** **C15: Lack role models (E1, E2, E3)**	
Rules	C5 (E4)		**C18: Organizational rules that impede adoption (E3, E5, E7)**

Table 9
Challenges highlighted as important and severe in the expert validation study – Implementation and Confirmation stage. Challenges noted by at least three experts are named and highlighted in bold.

	Implementation	Confirmation
Subject	**C19: Forgotten in everyday work (E1, E4, E6, E8)** **C20: Ignorance of triggers and reminders (E1, E3, E4, E8)** **C21: Perception as unmotivating (E1, E3, E4, E6, E7)** C22 (E2, E3)	**C42: Lack of long-term motivation (E3, E4, E6, E8)** **C43: Decrease in novelty (E2, E5, E6, E8)** C44 (E1, E3)
Instrument	**C23: Effort too high (E3, E4, E7)** C24 (E2, E3) **C25: Lack of trigger to continue use (E1, E3, E5, E6, E8)** **C26: Intrusive features (E2, E3, E7)** C27 (E6) C29 (E1, E3) C30 (E3) C31 (E3, E6) **C32: Bugs in functionality (E2, E3, E4, E8)** C33 (E3, E5)	**C45: Lack of connection to work environment (E1, E2, E3)** C46 (E8) C47 (E3, E6)
Object	**C34: Unfulfillability of tasks (E1, E3, E5, E6)** C35 (E3)	C48 (E3, E6) **C49: Cost-benefit ratio insufficient (E3, E6, E8)** C50 (E3, E6) C51 (E6)
Community	**C36: Lack of interpersonal communication (E1, E3, E8)**	**C52: Critical mass of users (E3, E5, E6, E8)** C53 (E3, E8) **C54: Lack of celebration of team achievements (E1, E6, E8)**
Rules	**C37: Conflict with work tasks (E3, E5, E6)** C38 (E3) C39 (E3) C40 (E3) C41 (E3, E6)	**C55: Appropriateness of incentives (E1, E2, E3, E6, E8)**

at home, it's a need, because you need to save money for yourself and your family. But if you're at work, what, you know, every publication says is that, actually, it's not a personal need. It's something that you need to be motivated differently due to, you know, the environment or whatever else." (E3).

In this context, the experts also stressed the point raised by employees that the adoption of green IS could suffer greatly if there were no social pressure (E3, E6, E8) or role models (E1, E2, E3). E6 explained that *"social norms tend to be underestimated [and] even though people might not necessarily acknowledge them, or acknowledge to be influenced by them [.] there is enough literature showing that in reality we are, and if everybody of my colleagues are using it and talking about it in the cafeteria, then obviously I will also feel I should use it"* (E6). Also, management emphasizing *"that this isn't something that is being dumped on workers [and] the company does [.] care about"* (E1) is essential due to the inherent hierarchy in workplaces (E3).

> "In order to start any campaign, you have to have the buy-in of the leadership, period. There is no growth further as long as the big ranks are not into it, and being the first ones to act and showing that they are doing it. So, anything else doesn't matter, you just need to have the buy-in of the highest echelon in the ladder. Otherwise, forget it." (E2).

In the **decision** stage of adoption, the experts particularly underscored the challenge of organizational rules that could hinder adoption (E3, E5, E7), such as *"not using a mobile phone at a time"* (E5) or regulations of work councils (E7), which must be particularly considered when introducing green IS so that they do not conflict with the use of green IS in the workplace.

In a similar vein, experts highlighted that conflict with work tasks (E3, E5, E6), which was also experienced by a large number of employees in the qualitative field study can be a critical challenge in the **implementation** stage. Particularly if *"someone's duties were contrary to what you were asking them to do"* (E3) or if more important work priorities collide with the use of the green IS, this can hinder the use of the green IS in daily work: *"If I have so much on my plate, you know, in terms of urgent stuff, and tasks from my employer, then these kind of things probably are not top priority anymore. And if I feel I'm already struggling to deal with my daily, you know, work, hands-on, then probably, yeah, this is the first thing that people will stop doing"* (E6).

In addition, the experts emphasized a number of challenges in the implementation stage that related to the design of the green IS itself and the corresponding response on the subject site. On the one hand, the green IS can easily be forgotten in everyday work (E1, E4, E6, E8) if *"there are no spaces that are demarcated for interacting with the system"* (E1) and *"everyday life [.] drive[s] people away from this type of application that you need to be in constant contact [with]"* (E8), or if the effort required to use the green IS is too high (E3, E4, E7). Thus, the experts considered a lack of triggers (E1, E3, E5, E6, E8) as a critical instrument-related challenge: *"If there are no triggers to continuous use, reminders or so, I might just forget about it after a while, because there's other things triggering my attention."* (E6). On the other hand, experts highlighted more strongly than the employees that such triggers could also be ignored (E1, E3, E4, E8), especially after some time (E8), and that employees might even *"disactivate the app"* (E4). From the experts' point of view, the design of intrusive features (E2, E3, E7), such as too many notifications (E2) or triggers at the wrong time (E3), could pose a particular risk in this regard: *"Intrusive features is a destructive issue. Because actually, [.] people said that, okay, you're asking me at nine o'clock in the morning to report on my energy usage, or to close the windows and open the air conditioning. I'm trying to do something else right now, to check my emails and whatever."* (E3). Moreover, although the employees in the field study did not particularly encounter this problem, the experts emphasized that the perception of the green IS as unmotivating can strongly hinder its use (E1, E3, E4, E6, E7), such as that the green IS may lack stimulation for growth and *"meaningful progress"* (E1) or *"reinforcement"* (E6). In this context, E7 from his perspective as a work ethics researcher also raised the point that features originally conceived as motivating, such as competition, may evoke concerns about the use of such data: *"That it would be used as a kind of form of data valence, or surveillance"* (E7).

Furthermore, even though the employees in the field study did not particularly encounter these challenges, the experts highlighted two key challenges that can prevent employees from actually using the green IS when they want to. First, bugs in functionality must be avoided at all costs (E2, E3, E4, E8): *"Okay, this is what I talk about to my students as well, when I teach them human-computer interaction, never release an application with bugs to the wide audience. Never. You just lose them. So even the slightest bug, we did, after extensive testing and everything, [.] we did end up with a small bug in one of the cases. And we lost a significant amount of people because of that, because they were, you know, put off by it"* (E3). Secondly, not being able to fulfill the sustainability tasks required by the green IS could be detrimental to adoption (E1, E3, E5, E6). In this context, the experts emphasized that while it could be on the employees' side to view a task as *"impossible"* (E6), the structure of the workplace can also be a factor that contributes to whether sustainable behavior is facilitated or hindered: *"It might be that you want to do something that you think is significant, but the structure in the context doesn't allow you to do it, because the company is just unsustainable by itself. So, you want to do things that would be significant, [.] but there are lots of systems that already work in a way that you cannot just do anything about them"* (E1).

Finally, the experts underscored that a lack of interpersonal communication can be a major challenge for the purposeful use of the green IS in the implementation stage (E1, E3, E8), especially in shared workspaces where employees need to talk to each other and commit that

"all [people] in the same office should do the same thing, [.] because if someone closes the window and gets the point, and another guy gets up and opens the window, [it] makes no sense" (E3).

In the **confirmation** stage, where employees re-evaluate the use of the green IS, the experts pointed out the lack of long-term motivation as a critical challenge (E3, E4, E6, E8) and that *"maintaining engagement"* (E4) is one of the biggest barriers to green IS in general.

"It's in general a very steep slope, for apps in general, like, many of them are being used once and that's it. And I think in sustainability that's even more the case. I mean, there's a bunch of studies that looked into interaction of people with web portals for sustainability stuff and so on and usually people visit zero or one time. And only a very small subgroup of people is really motivated enough to come back again. I think that's probably what I would classify as one of the biggest issues and hurdles." (E6).

In this context, several experts indicated that a lack of connection between the green IS and the daily work environment (E1, E2, E3) and especially a decrease in novelty (E2, E5, E6, E8) could be related challenges that hinder continued use: *"[It] kind of loses novelty and it's not novel anymore, and they just quit using it"* (E8).

From a rational choice perspective, the experts emphasized even more strongly than the employees in the field study that an insufficient cost-benefit ratio of sustainable behavior is a major challenge for continued use (E3, E6, E8) and stressed the need for actual *"incentives"* (E3) or *"economic benefits"* (E8) or at least some kind of recognition: *"If I see I have to make lots of efforts and at the same time I get little benefits, neither financial nor any sort of, I don't know, other recognition or, you know, I feel better after it, yeah, if I just invest without seeing any [.] impact achievement, whatever, then that's probably not very motivating to use it in the long run"* (E6). In terms of recognition, active recognition and celebration of team achievements was underlined as important by several experts (E1, E6, E8). But even more, experts highlighted that a critical mass of users is inevitable to ensure relatedness and normative influence with respect to continued use (E3, E5, E6, E8), especially in cases where *"people have to participate voluntarily"* (E5). *"Related to social laws, if I have the feeling that I'm the only one using this thing, and everybody else in the company is not, you know, then probably there's people that also stop using it."* (E6).

As a final but very important challenge, the experts placed much more emphasis on the appropriateness of incentives (E1, E2, E3, E6, E8) than the employees in the field study. On the one hand, the incentives should be attractive (*"pay enough or don't pay at all"* (E6)) and may get *"gradually better or higher"* (E3) over time. But on the other hand, the incentives should also be appropriate in relation to the overall goal of sustainability and not compromise employees' efforts: *"Sometimes we try to reward people for doing sustainable things with things that end up being unsustainable themselves. So, for example, many of the apps that we analyzed they reward your behavior with encouraging more consumption, for example, or if a person wants to be rewarded with extra money or a trip to somewhere. This is just defeating the purpose"* (E1).

5.2.2. Expert recommendations for companies to address challenges in the adoption and use of green IS

In response to the challenges, the experts provided a series of recommendations for organizations on how to address the most critical challenges employees face when adopting and using green IS. Overall, these can be summarized into eight main categories: creating awareness about the existence of the green IS, activating social norms for green IS use, ensuring the green IS aligns with internal structures and company culture, designing the green IS to fit employees' and working mode, considering ethics in green IS, maintaining relevance of the green IS with variation, including social dynamics for continued green IS use and adding tangible benefits for continued green IS use. Table 10 summarizes the main categories and the according recommendations of the experts from the interviews.

Firstly, the experts made recommendations on how to **create awareness of the existence of the green IS** in the first place, particularly in response to the lack of onboarding as a critical challenge in the knowledge stage of adoption. In this context, companies could use prompts outside the system, such as posters or stickers placed in the workplace to attract attention (E2). Additionally, E8 suggested that companies should organize onboarding sessions with *"contact [persons] explaining what the app will be about [.] how it would work and everything"* (E8).

Subsequently, several experts suggested that the lack of personal need for employees, which is a major challenge in the organizational environment, can be addressed through various measures that **activate social norms for the use of the green IS**. For example, companies

Table 10
Expert recommendations for companies to address challenges in the adoption and use of green IS.

Main category	Recommendations
Create awareness about the existence of the green IS	R1: Organize onboarding sessions (E8) R2: Use posters to attract attention (E2)
Activate social norms for green IS use	R3: Establish sustainability leaders (E1, E3, E8) R4: Communicate joint impact and create a sustainability culture (E1, E3, E5) R5: Communicate relevance for the company (E1, E7) R6: Define common goals (E8) R7: Be careful to maintain integrity (E2) R8: Be careful to not undermine agency with social pressure (E5)
Ensure the green IS aligns with internal structures	R9: Consider structural changes and rules to enable use (E1, E5) R10: Make sure management supports the system (E2) R11: Consider group structure and shared devices (E3)
Design the green IS to fit employees' expectations and working modes	R12: Take into account the local culture (E4, E5, E7) R13: Include employees in co-design (E1, E3, E7) R14: Personalize the system (E1, E3, E4) R15: Investigate employees' needs and expectations (E2, E3) R16: Incorporate employees' feedback (E2, E7) R17: Tailor the system to the characteristics of the work environment (E3, E4) R18: Conduct usability pretesting (E3, E6) R19: Dynamically adapt the system to the daily workplace habits (E8) R20: Transform existing systems rather than develop new ones (E1) R21: Synergize with other applications (E8) R22: Add possibility to defer notifications (E3)
Consider ethics in green IS design	R23: Follow guidelines on trust and ethics (E7) R24: Establish rules that enable a fair use and punish fraud (E3)
Maintain relevance of the green IS through variety	R25: Generate continuous new content (E1, E3, E8) R26: Provide informational content with real value (E1, E4) R27: Organize special events (E1, E2)
Include social dynamics for continued green IS use	R28: Stimulate competition (E2, E4, E8) R29: Include inter-team competition (E8) R30: Be careful to not undermine collective efforts with competition (E7) R31: Communication outside of the system (E6)
Add tangible benefits for continued green IS use	R32: Provide tangible rewards for sustainable behavior (E2, E8) R33: Tailor incentives to employees' wishes (E1, E2) R34: Incentivize instant behavior (E8) R35: Extend the green IS focus to include behavior outside of work (E1, E2)

should establish *"sustainability leaders"* (E3) or *"ambassadors"* (E8) as role models who educate and influence their colleagues to use the green IS (E1, E3, E8). In addition, company representatives should focus on communicating what the *"impact of many people doing the same things can become"* (E1), thereby creating a *"community"* (E3) around sustainability that can be accompanied by common goals (E8). As well as appealing to the value and relevance of employee behavior change to sustainability, the experts suggested that companies should focus on emphasizing the relevance from a corporate perspective: *"I think [it] is very important to communicating commitment and importance on the part of the company. So if they want workers to do something, it has to be very clear that the company thinks this is important, that this is good for everyone, that everyone is doing it, not just the people who are at the base of the company"* (E1). However, two experts also pointed out in this context that such normative messages should be treated with caution. When communicating the importance of the topic, companies should ensure that integrity is maintained, i.e. that there *"is the consistency of what the company stands for"* (E2). In addition, E5 emphasized that it is important to *"appeal to people's individual sustainability behaviors [.] rather than trying to put some sort of social pressure [.] Because there are some people who actually don't believe in sustainability, they feel like, you know, this whole conversation is just a figment of, you know, climate change activists, imagination, right. So when people are already predisposed against that, trying to impose social pressure can be very counterproductive."* (E5).

When it comes to severe challenges related to organizational rules that hinder adoption or conflicts with work tasks, the experts gave several recommendations to **ensure that the green IS aligns with internal structures**. On the one hand, companies should always check whether the planned green IS is compatible with the existing structures and rules in the workplace (E1, E5), because otherwise *"it can happen that they try to implement a system where workers are trying to do the best they can, but the structure really doesn't afford what they are trying to do. So maybe instead, they should have focused on really reconfiguring the whole way of how they operate"* (E1). In this regard, company representatives who want to implement a green IS should also make sure that management supports the system (E2), and on a more operational level, ensure that the green IS works with the existing group structures and shared equipment (E3).

In addition, the experts offered a number of suggestions on how the **green IS can be designed to fit employees' expectations and working modes**. First and foremost, corporate actors wishing to introduce a green IS should take into account the local cultural background (E4, E5, E6, E7), which could influence, for example, the orientation towards collectivism or individualism (E5, E7) and the attractiveness of competition (E5). Secondly, the experts emphasized the importance of involving employees in the design of the green IS (E1, E3, E7), e.g. through *"participatory design"* (E1). If they are not involved in the design process itself, the experts emphasized that at least their needs and expectations should be investigated (E2, E3), that their feedback during use should be taken into account (E2, E7) and that proper usability pretesting should be conducted to avoid any usability obstacles and errors during the use of green IS (E3, E6). Thirdly, the experts emphasized tailored and adaptive design of green IS as a possible avenue to meet individual needs and ways of working and thereby avoid conflicts with work tasks. In this respect, the green IS should be customized to the preferences of individual employees (E1, E3, E4), for example by allowing them to set *"how often they want to be reminded of things"* (E3) or by offering them *"tailor-made actions"* (E4). On the other hand, the green IS should be tailored to the characteristics of the work environment (E3, E4) and, in the best case, dynamically adapt to daily work habits: *"When you receive a nudge in the exact time of doing something that you should. For instance, turning off air conditioning when you leave for lunch. This works very well. I don't know the numbers by heart but I think that 75% of the workers, if they receive a nudge in the exact time that they for instance, are leaving the office exactly five minutes earlier or so, they will turn off lights and they will turn off air conditioning, for instance, and even computer"* (E8).

Finally, the experts suggested thinking about how the green IS could be designed to synergize with other, existing applications (E8) and whether it would be possible to redesign existing systems to incorporate sustainability aspects rather than developing new, standalone applications (E1).

In addition, two experts stressed the need to **consider ethics in green IS design**, particularly following guidelines on trust and ethics for technology in the workplace to protect employees from surveillance (E7), and establishing rules that allow for fair use and punish fraud or unfaithful use of the green IS (E3).

Regarding the challenges related to the continued use of the green IS, the experts made several suggestions on three levels. First, in response to decreasing novelty, the experts suggested **maintaining the relevance of the green IS through variety**, e.g. by developing and incorporating new topics or features into the green IS (E1, E3, E8), by providing valuable informational content that is interesting (E1, E4) and *"feels insightful"* (E1), and by organizing special events (E1, E2) around the green IS: *"Maybe it's good to have one or two highlights throughout the year [.] So it could be once a quarter, it could be twice a year, but it should be something that keeps the expectation and the excitement going"* (E2).

Secondly, in response to the challenges related to the community, such as the critical mass of users and the lack of celebration of team achievements, the experts suggested a focus on **social dynamics for continued green IS use**. In this context, the green IS could, for example, stimulate competition as a social dynamic (E2, E4, E8), possibly also between teams (E8). At the same time, companies should be careful not to undermine collective efforts through competitive mechanisms (E7), because *"it put[s] workers in opposition to each other"* (E7). Moreover, E6 suggested the company to constantly communicate about the green IS outside of the system itself to fuel interpersonal exchange about it, e.g. by *"includ[ing] it in the corporate newsletter"* (E6).

Finally, with regard to the lack of long-term motivation to use the green IS in combination with an insufficient cost-benefit ratio for sustainable behavior in the workplace, the experts emphasized the role of **tangible benefits for the continued use of green IS**. In particular, companies should consider providing tangible rewards for sustainable behavior, such as *"points that can be exchanged for goodies"* (E2) or *"prizes, like one extra day off, premium parking sport in front of the building"* (E8). In this vein, the experts also recommended tailoring incentives to employees' wishes and suggestions to make them palatable (E1, E2), and incentivizing instant behavior as opposed to behavior in the future (E8). Moreover, the focus of the green IS could be expanded to include behavior outside of work to reinforce the sense that usage is beneficial not only to the company, but also to the individual employee as a person (E1, E2).

6. Discussion

Research has called for a greater focus on employee perceptions and individual perspectives on the adoption and use of green IS in organizational settings (Marikyan et al., 2019; Singh & Sahu, 2020), considering the specifics of the sustainability context during the adoption process (Papagiannidis & Marikyan, 2022). Our research delves into hitherto unexplored aspects of challenges associated with the adoption and use of green IS from the perspective of employees, considering both the individual cognitive processes of adoption and the tensions that arise in the sociotechnical environment at work. Through a qualitative field study, we identified 55 distinct challenges encountered by employees during the adoption of green IS. Our subsequent expert validation study shed additional light on the severity and relative importance of these challenges from a broader perspective and provided valuable recommendations for overcoming them. Notably, experts largely underscored challenges similar to those mentioned by the employees, introducing unique insights into why these challenges hold particular significance within the organizational setting.

Our findings highlight that both employees and experts emphasize

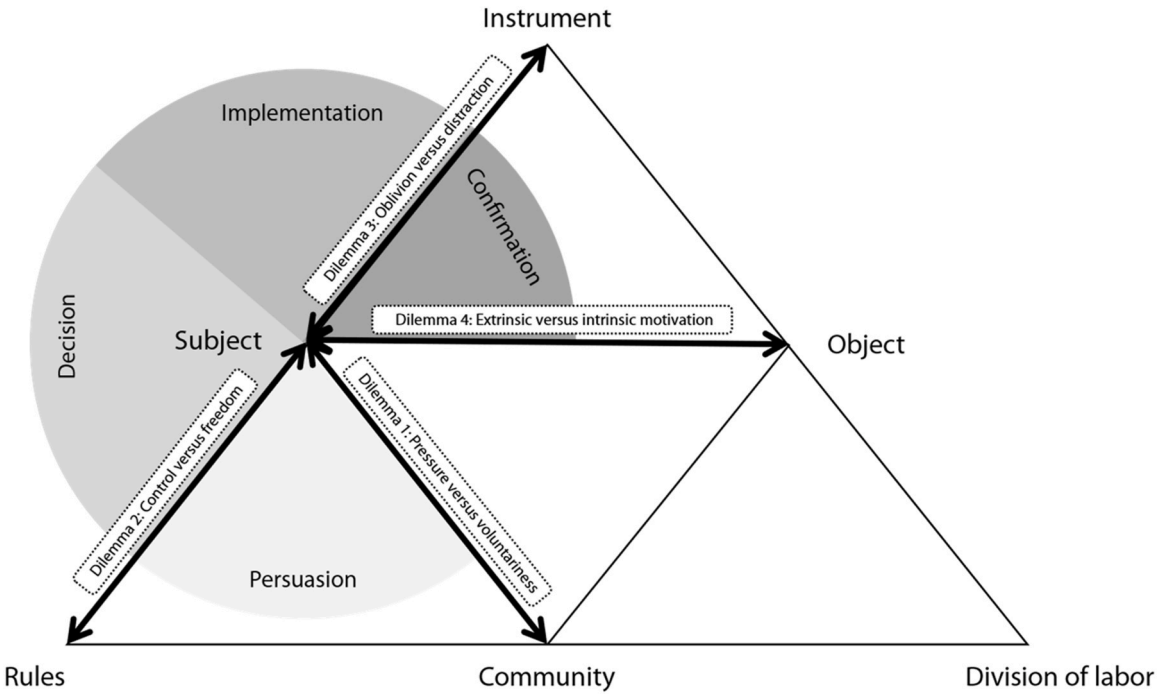

Fig. 8. Theoretical model of dilemmas in the adoption and use of green IS in organizational contexts in light of motivational design.

different themes at various stages of adoption. During the knowledge stage, the absence of onboarding processes and how-to knowledge about the green IS emerge as the most critical challenges. In the persuasion stage, the foremost obstacle is a lack of personal need, influenced by the perception of the green IS as part of work and a deficiency in normative influence. In the decision stage, consideration of rules and regulations that hinder adoption becomes paramount. Moving into the implementation stage, challenges revolve around the functionalities of the green IS and conflicts that arise in integrating it into daily work. Finally, in the confirmation stage, the most significant challenges include a lack of motivation for continued use, a decline in novelty, an insufficient individual cost-benefit ratio, a lack of a critical mass of users, and inappropriate incentives.

To draw implications of these findings at the superordinate level, specifically how to address these challenges in green IS research and practice, there is merit in discussing these challenges and the recommendations experts provided for companies to overcome them in light of previous research on the design and effects of green IS. Previous work has put forth the importance of motivational design in supporting the utilitarian outcomes of IS through positive affective and social experiences (Hassan et al., 2019; Koivisto & Hamari, 2019; Koo et al., 2015). Especially studies in the field of green IS that focus on voluntary adoption of operational green IS tend to use a variety of motivational affordances such as gamification elements (Hillebrand & Johannsen, 2021), narratives (Oppong-Tawiah et al., 2020), and nudges (Spence et al., 2018) to increase intrinsic motivation for sustainable behavior.

In critically juxtaposing our challenges and expert recommendations with knowledge on motivational IS and green IS design, it becomes evident that overcoming these challenges is not straightforward. Rather, we see that various green IS design and implementation approaches to address these challenges seem to be contradictory. Thus, we postulate that these challenges cause dilemmas in the design and implementation of green IS in organizations that spur higher-level, transversal discussions about green IS design and implementation. These dilemmas result from critical tensions between the subject and the community, the rules, the instrument and the object, which occur at different stages of the individual adoption process of green IS. Fig. 8 illustrates the theoretical model of dilemmas in the adoption and use of green IS in organizational contexts in light of motivational design. We do not attempt to resolve these dilemmas in this work, but rather to identify and derive theoretical propositions as starting points for further theoretical discussion and empirical work.

Dilemma 1: Pressure versus voluntariness. Green IS that aim to motivate and encourage sustainable employee behavior commonly use motivational features such as feedback and progression (Casado-Mansilla et al., 2020; Spence et al., 2018), as well as gamification (Hillebrand & Johannsen, 2021; Oppong-Tawiah et al., 2020) to enhance the hedonic experience of sustainable behavior. Because user experiences cannot be coerced, motivational design of IS is particularly relevant in contexts where the use of IS is considered voluntary (Wu & Lederer, 2009). However, our results suggest that during the *persuasion stage* of green IS adoption, i.e., when employees develop attitudes and intentions to adopt green IS, normative information on the relevance and intended impact from the organization (R4, R5), normative influence through role models (C15), e.g., by establishing sustainability leaders (R3), and social pressure or even obligation from the community (C14) can be vital to influence feelings of personal need (C10) and personal consequences (C11) to behave sustainably that employees might otherwise miss in the organizational setting, especially if they perceive the green IS as part of work (C8). Previous research supports that the activation of social norms can influence individuals' rational decision-making processes toward sustainable behavior (do Canto et al., 2023; Lindenberg & Steg, 2013). These findings raise the question of whether motivational design is sufficient to promote the adoption of green IS in organizations. However, it should be noted that social pressure can also be counterproductive for employees who have a negative attitude towards using technology (C6) and changing habits (C7) and can undermine individual agency (R8). There thus appears to be a tension between the focus on individual agency and voluntary adoption by the employee (the subject) and concentration on creating social pressure from management, leaders and colleagues (the community), e.g., by adding normative prompts for participation or linking adoption of green IS to benefits or disadvantages for all employees. Evidence from IS research in general is inconclusive as to whether

voluntariness is not a critical factor for IS adoption (Jeyaraj, 2021) or whether such social pressure mechanisms that limit voluntariness of participation can critically backfire (Tsai et al., 2017) because forced behavior can cause individuals to become indifferent to it (Saeed & Abdinnour, 2013). This would pose a risk especially for SMEs, which depend on employee acceptance and participation for the success of IS (Chouki et al., 2020). Thus, further research is needed on the dilemma of voluntariness versus social pressure and coercion and its implications for the design and use of green IS in organizational contexts and specifically in SME settings. Accordingly, we put forward the following theoretical proposition:

Proposition 1. *Green IS design and implementation must carefully balance employees' need for individual agency to unleash the benefits of motivational design for intrinsic motivation to engage in sustainable behaviors with normative approaches to activate social norms to use the green IS.*

Dilemma 2: Control versus freedom. Our results show that once employees have formed a positive attitude toward the system, contradicting organizational regulations that impede adoption (C18) and a conflict with work tasks (C27) present critical challenges for employees to turn their intention into action in the *decision* and *implementation* stage of green IS adoption and thereby bridge the attitude-intention-behavior gap prevalent in sustainable behavior (Kollmuss & Agyeman, 2002). These findings suggest that an integrated rule system with rules that provide defaults and guidelines on where, when, and how to use green IS in the organizational setting and congruent corporate structures and regulations (R9) can facilitate the onset of use and reduce the cognitive effort required for employees to use green IS in the decision and implementation stages of individual green IS adoption. However, this rule-based and structured design is at odds with free and unstructured experiences (Caillois, 2001; Deterding, 2015; Hamari & Koivisto, 2015), and excessive rules can pose a similar obstacle to green IS adoption (C41). Overly structuring and constraining the system experience may come at the expense of creative action and thinking, and ultimately compromise the intended outcomes of motivational design affordances in green IS in organizational contexts (Koivisto & Hamari, 2019). While it is of course essential to ensure that the green IS aligns with internal structures, such as group structures (R11), and that management supports the system (R10), our findings still highlight the inherent tension between prioritizing employees' individual freedom (the subject) in deciding how and when to use the green IS, and emphasizing a strict set of rules and company regulations to control the use of the green IS in daily work (the rules). Exploring the balance that provides guidance to employees and enables them to use green IS in their daily work without compromising the overall system experience therefore warrants further research attention. Correspondingly, we put forward the following theoretical proposition:

Proposition 2. *Green IS design and implementation should be accompanied by organizational structures and regulations that enable access to and use of green IS to avoid a intention-behavior gaps among employees, while simultaneously ensuring that the system experience is not constrained at the expense of creative action and thinking.*

Relatedly, control and protection against cheating to effectively combat fraud and unfairness in green IS (C39, C40), especially when they include competitive features, may come at the expense of privacy and imply constant surveillance, leading to ethical discussions about motivational design in green IS (Lilley & Wilson, 2013). Studies show that requiring self-disclosure can impair the motivational impact of green IS (Shevchuk & Oinas-Kukkonen, 2019) and that privacy concerns can greatly hinder the adoption of green IS (Mulcahy et al., 2019), which is why guidelines on trust and ethics for technology in the workplace should be followed (R23). However, other work suggests that mutual surveillance between familiar people in green IS can reinforce sustainable behavior, at least in collectivist cultures (Kimura & Nakajima, 2011), highlighting the importance of considering local culture (R12). Therefore, further research should be conducted on how to resolve the dilemma between ensuring fairness in social design mechanisms by controlling employees' use (the rules) and addressing cultural and individual concerns about surveillance (the subject) that may inhibit the use of green IS in organizational contexts.

Proposition 3. *Green IS design and implementation needs to carefully weigh the potential benefits of motivational design features, in particular social design features, and accompanying privacy and surveillance concerns of employees.*

Dilemma 3: Oblivion versus distraction. In the *implementation* stage, designers of green IS face the dilemma that employees forget about using the green IS at work (C19), especially due to lack of triggers (C25), and on the other hand consider the green IS to be intrusive, when implementing features such as notifications (C26), leading to its ignorance (C20). Previous studies postulate that immediate feedback (Castelli et al., 2015; Hillebrand & Johannsen, 2021; Khosrowpour et al., 2018; Loock et al., 2011) and recurring triggers (Casado-Mansilla et al., 2020; Langrial et al., 2014) both inside and outside the IS are valuable motivational prompts to increase interaction with the IS and thus counteract forgetting in the workday, an observation that is partially reflected in our results. However, our findings question whether more interaction with the green IS is better in organizational contexts and illustrate the tension between prioritizing uninterrupted focus on work tasks on behalf of the employee (the subject) at the expense of attention to the green IS, and placing constant interaction, feedback, and notifications with the green IS (the instrument) at the center at the cost of distraction. Previous research supports that motivational design and features can also be perceived as intrusive (Mani & Chouk, 2017) and distracting from work (Yoon et al., 2021), the latter critically interfering with expectations of job duties placed on employees in organizational settings. SMEs are particularly at risk of interferences between IS and work tasks, as they often lack strategic IS planning to carefully consider needs, objectives, and interdependencies with the new system (Chouki et al., 2020). In a sense, motivational design of green IS in the organizational environment seems to be a balancing act of either being perceived as intrusive or being forgotten. Consequently, further research is needed to study different green IS designs, in particular by exploring employees' needs and expectations (R15), involving them in co-design (R13), constantly considering their feedback (R16) and adapting the green IS to both the individual and the specific workplace environment (R14, R17) to find the sweet spot. Therefore, we raise the following theoretical proposition:

Proposition 4. *Green IS design and implementation must acknowledge the inherent priority of focusing on work tasks in the organizational environment while at the same time counteracting oblivion.*

Dilemma 4: Extrinsic versus intrinsic motivation. Both research on sustainable behavior (Iweka et al., 2019) and motivational design (Deci et al., 1999) have pointed out the pitfall that extrinsic incentives can undermine intrinsic motivation for sustainable behavior once the incentives are no longer present, or even lead to counter-effects (Delmas et al., 2013). However, the critical challenge of a lack of long-term motivation (C42) due to a decline in novelty (C43), an insufficient cost-benefit ratio (C49) and the lack of a critical mass of users (C52) suggests that continuous variety (R25, R27), social dynamics (R28) and tangible benefits (R32) are essential to maintain continued use of green IS and engagement in sustainable behaviors in the *confirmation* stage of individual adoption of green IS. In particular, our findings raise the question of whether the motivational design of green IS is sufficient to promote intrinsic motivation in the absence of personal needs and the benefits of sustainability as an overarching objective. There appears to be a tension between prioritizing the individual benefits perceived by employees of using green IS (the subject) and ensuring broad participation by offering incentives on the one hand, and the overarching goal of promoting intrinsic and voluntary interest in sustainable behavior

(the object) through motivational green IS design on the other. In contrast to potential motivational pitfalls, studies have also observed positive effects of extrinsic motivation on sustainable behavior (Lossin et al., 2016) and adoption of green IS (Koo et al., 2015), particularly in organizational settings (Handgraaf et al., 2013). On the basis of this discussion of extrinsic and intrinsic motivation for green IS design, we postulate that there may be a trade-off in reaching the critical mass of users to exert normative influence on all employees and improve individual cost-benefit ratio through extrinsic incentives, at the expense of intrinsic motivation for those employees who are already interested or voluntarily want to learn more about sustainability. We call for further research to explore the role of extrinsic and intrinsic motivation in the particular context of sustainability in organizations and how green IS design can be realized to find a beneficial consensus. Accordingly, we put forward the following theoretical proposition:

Proposition 5. *Green IS design and implementation must take into account employees' individual cost-benefit decisions to use green IS, while at the same time avoiding any undermining of intrinsic motivation for sustainable behavior.*

From the discussion of our results, we see that the challenges employees encounter in the adoption and use of green IS in organizational settings, particularly when it comes to operational green IS and voluntary adoption, involve four critical dilemmas for green IS design that result from tensions between the subject and the community, rules, the instrument and the object at different stages of the individual adoption process of green IS. Thus, our findings underscore that simply considering a set of factors for the adoption of green IS and opting for motivational affordances in green IS design does *not* automatically lead to their adoption, use, continued use, and positive sustainability outcomes. Instead, the challenges and dilemmas with the according theoretical propositions we identified provide valuable contributions to further theoretical research and suggest that the practical design of green IS should consider these challenges and contradictions thoughtfully to ensure successful implementation of green IS in organizations.

6.1. Implications for theory

The results of our work contribute to expanding existing knowledge in the fields of (1) adoption and use of green IS, (2) design of green IS and general motivational design of IS in an organizational context, and (3) sustainable behavior interventions in organizations at a general level.

(1) First, in identifying challenges and dilemmas arising from the tension between the employee as individual actor in green IS adoption, the topic of sustainability and the organizational context, our findings extend the prevalent research focus on organizational, economic, and regulatory factors of technology adoption in research on green IS adoption (Papagiannidis & Marikyan, 2022; Singh & Sahu, 2020) and underscore the value of considering individual perspectives on green IS adoption, taking into account individual cognitive processes (Marikyan et al., 2019; Singh & Sahu, 2020). Through an in-depth qualitative study of employees' perceptions at different stages of technology adoption, we add new insights into the conflicts that arise in the adoption process and thereby extend previous knowledge that attitudes toward green IS (formed in the persuasion stage) influence behavioral intention to use green IS (formed in the decision stage, e.g., Herrenkind et al., 2019; Jenkin et al., 2011) and explain actual use (in the implementation stage) of green IS (e.g., Herrenkind et al., 2019; Wunderlich et al., 2012). Particularly, we shed new light on *how* certain individual adoption factors, such as attitudes, are formed through interactions of the subject with the community, object and rules at the workplace and *how* they consequently lead — or, in the case of the critical dilemmas we identified, may also not lead — to behavioral intention, adoption and continued use of green IS. Thus, our approach of conceptualizing green IS adoption based on DOI theory and activity theory to develop a new understanding of green IS adoption challenges has proven to be a valuable means of advancing green IS theory by drawing on insights from innovation and behavioral research. We therefore invite green IS studies to explore how theories and knowledge from related or even completely distinct fields can reshape our perspective and thereby enhance our understanding of green IS adoption. Our theoretically grounded model of the four dilemmas in the adoption and use of green IS in organizational contexts provides a valuable new starting point for further exploration of the tensions between sustainability and the organizational environment. Because the subject is at the center of the tensions in the adoption process, future research should examine the role of these dilemmas, taking into account the subject's personality (McCrae & John, 1992), goal orientations (Pintrich, 2000), and other dispositions that may influence the employee's perception of these tensions. In addition, we invite further research that uses our findings as a basis to examine how different contexts (beyond the SME context) influence these dilemmas and to extend our model to include other dilemmas that may occur in different contexts. For example, in private households, there may be additional tensions for individuals arising from the division of labor among family members that influence the ways in which green IS may or may not be adopted and used for sustainable behaviors at home, and in larger companies, there may be other tensions arising from differences in corporate culture and more divided communities, as well as a greater number of pre-existing rules that merit further exploration.

(2) Second, our findings contribute to discussions about the design of green IS in particular and the general motivational design of IS in organizational contexts. As our dilemmas show, there are critical tensions around whether green IS design should be guided by strict rules as opposed to allowing creative play (Koivisto & Hamari, 2019) and the extent to which control and fraud protection are worth limiting individual privacy (Kimura & Nakajima, 2011; Mulcahy et al., 2019; Shevchuk & Oinas-Kukkonen, 2019). Moreover, green IS design faces the challenge of balancing the provision of essential triggers for interaction (Casado-Mansilla et al., 2020; Langrial et al., 2014) with distraction from work (Yoon et al., 2021). These tensions are not unique to green IS design, but rather represent dilemmas that arise for motivational IS design in organizational contexts in general whenever an issue such as sustainability, compliance, IT security, or health is added to employees' daily work tasks. In line with the call for more design-oriented IS research (Ågerfalk et al., 2022; Lehnhoff et al., 2021), we invite future research to build on these dilemmas and explore how different motivational designs can help solve these dilemmas in organizational contexts.

(3) Third, our findings hold implications for research on sustainable employee behavior interventions beyond green IS. Through identification of our dilemmas, we shed light on the reasons why the intention-behavior gap commonly occurs in sustainable behavior and also in sustainability interventions. On the one hand, we raise the question of whether voluntary sustainability interventions in an organizational context must inevitably be accompanied by normative influence or even pressure. While previous work on the role of voluntariness in IS adoption is inconclusive whether voluntariness is essential for the success of IS when it comes to individual employee adoption (Saeed & Abdinnour, 2013; Tsai et al., 2017) or not (Jeyaraj, 2021), there is still great potential for research examining the particular importance of voluntariness in behavior change interventions in the sustainability context in general – a topic that urgently

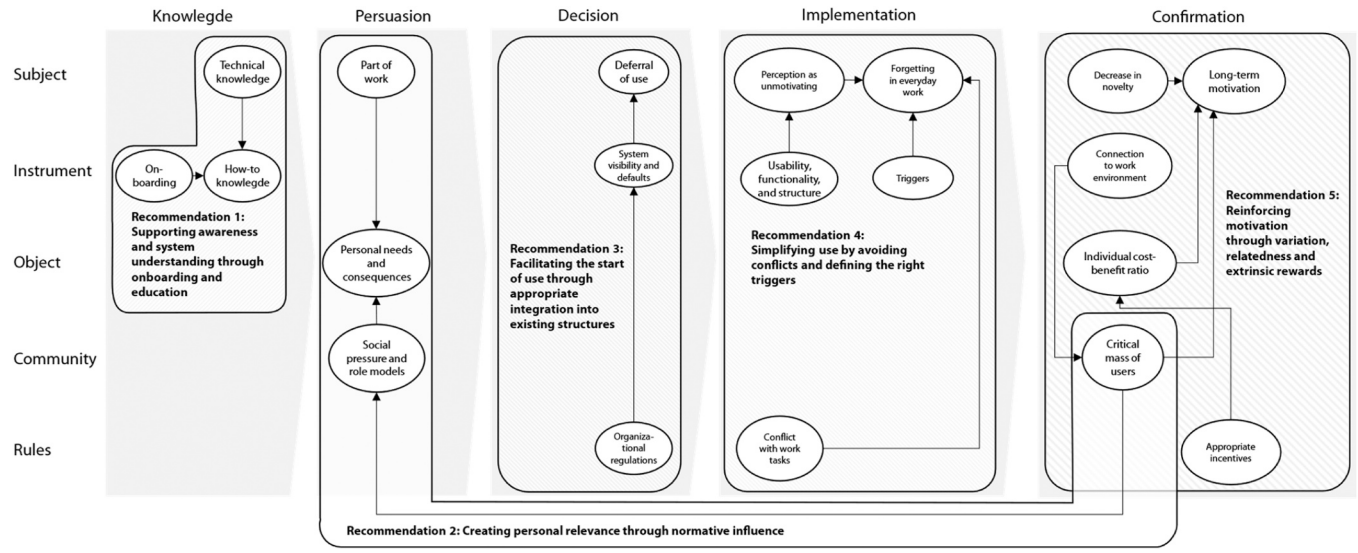

Fig. 9. Five overarching recommendations to support practitioners in addressing the identified challenges in green IS design and implementation while carefully considering dilemmas that arise from tensions between the individual and the sociotechnical environment.

deserves further attention. In particular, our findings encourage further investigation into how social pressures or hierarchical obligations influence the experiences and outcomes of interventions for sustainable behavior in organizations. In addition, our results contribute to the discussion on the role of extrinsic and intrinsic motivation in sustainable behavior change interventions. While research has argued both against (Deci et al., 1999; Delmas et al., 2013; Iweka et al., 2019) and in favor (Handgraaf et al., 2013; Koo et al., 2015; Lossin et al., 2016) of extrinsic incentives in behavior change interventions, our results suggest that despite the potential motivational pitfalls of extrinsic rewards for already interested and intrinsically motivated employees, intrinsic motivational designs are not sufficient to promote continuous engagement in sustainability efforts for others. Instead, we emphasize the relevance of extrinsic incentives and normative influence to attract the relevant critical mass of users who lack individual relevance and need to engage in sustainable behaviors in the organizational environment. We urge that further and more experimental research is needed to examine how extrinsic and intrinsic motivations unfold in the participation and effects of sustainable behavior change interventions in organizational contexts.

6.2. *Implications for practice*

Our exploration of the challenges and dilemmas of designing and implementing green IS in organizations not only opens up valuable avenues for future theoretical endeavors, but also provides practical implications for the design and implementation of green IS for practitioners both in SMEs and in companies in general.

Carefully considering the interactions between the different challenges of the activity system dimensions over time and the recommendations provided by the experts in the expert validation study, we illustrate five overarching recommendations to support companies in targeting the identified challenges in the design and implementation of green IS in different stages of green IS adoption while thoroughly taking into account the dilemmas that result from tensions between the individual and the sociotechnical environment (see Fig. 9 for an overview).

Recommendation 1: Supporting awareness and system understanding through onboarding and education. Although few of the challenges cited by employees related to the knowledge stage of innovation adoption, experts noted that challenges related to how-to knowledge (e.g., how to use the functionalities of the green IS) caused by a lack of onboarding and missing individual technical knowledge can hinder further adoption of green IS. The overarching recommendation in the knowledge stage is therefore to educate employees about the operating principles of the green IS, taking into account their individual technical knowledge backgrounds. For example, interactive onboarding sessions in which managers introduce the green IS to their employees through a virtual or in-person meeting where employees can take the opportunity to ask questions about the features of the green IS and discuss any privacy concerns can present a suitable means of guiding employees through the knowledge stage. Particularly in SMEs, where a lack of resources and time may limit technical support for employees, we recommend developing guidance on how to install and use the green IS, or opting for integrated green IS onboarding that explains how the green IS works. In addition, constant communication outside the system, e.g. with information posters, can support the onboarding process by helping to raise awareness of the existence of the green IS.

Recommendation 2: Creating personal relevance through normative influence. The workplace context poses a particular challenge when it comes to the personal need and consequences of sustainable behavior in the persuasion stage where employees form a positive or negative attitude towards adopting and using the green IS - employees receive no direct personal benefit (such as lower costs from saving energy at home) and therefore often miss motivation to behave sustainably for the sake of supporting their employer. Further, the fact that some of them perceive the green IS as part of the job, and thus as an add-on to the duties they already have, seems to make it even less personally relevant. However, in our study, employees and experts emphasized the role of the community, especially social pressure and normative influence from role models in the company. In particular, the absence of hierarchical pressure and perceived relevance and importance from the employer to use green IS appears to reduce relevance, whereas "living sustainability" as part of the team culture, e.g. through establishing sustainability leaders, might activate social norms that can influence the intention to adopt the green IS not provided by the topic alone. The overarching recommendation for designers of green IS aimed at changing employee behavior in the persuasion stage is therefore to create personal relevance for individual employees through normative influence mechanisms and role models within the community so that employees feel a social relevance for using the green IS even without a direct personal need or benefit.

However, as stated in the theoretical discussion, practitioners should

carefully consider the *dilemma between pressure and voluntariness* when attempting to create normative influence mechanisms to ensure that employees' individual agency is not constrained to the point that they become indifferent to green IS and begin to use it unfaithfully in the face of perceived obligation. For example, an appropriate approach to creating personal relevance through normative influence might be to accompany the adoption and use of green IS with normative prompts for relevance of individual adoption for the company and the joint effect of sustainable behavior change to create positive impacts at the team, corporate, and societal levels. Especially in SMEs with strong relationships between colleagues, sustainability leaders could play a central role in promoting the relevance of sustainable behavior in the company and fostering a corporate culture that emphasizes the importance of sustainable behavior. For normative prompts to be credible, it is important to communicate to employees that they are not being asked to shoulder the burden alone, but that the green IS is part of the company's overall effort to become more sustainable in all aspects of its operations and strategic decisions, underlining integrity. For instance, companies may redirect the financial benefits generated by sustainable employee behavior into measures to improve employee health and well-being, or to invest in energy-efficient workplace equipment, so that employees derive personal benefits from using the green IS, which in turn increases normative pressure for all colleagues to participate.

Recommendation 3: Facilitating the start of use through appropriate integration into existing structures. The biggest challenges mentioned by employees in the decision stage relate to the deferral of use, which relates to the intention-action gap prevalent in sustainable behavior: Our interviews indicate that employees have formed a positive attitude towards using the green IS, but did not put their intention into practice. Organizational rules and structures that impede adoption (such as a restriction on smartphone use during working hours or barriers in the registration and user authentication), were particularly highlighted by employees and experts alike as reasons that prevent the adoption of the green IS and invoke delays in green IS use. Therefore, we postulate that a major challenge in the decision stage is to find design approaches that combat such postponement and facilitate the start of use by appropriately integrating the green IS into existing structures - both in terms of visibility (where to integrate the green IS into the existing digital ecosystem in the workplace) and in terms of rules (considering registration, authentication and usage processes upfront and defining a format that every employee can easily use).

Our findings indicate that in this stage practitioners should consider the *dilemma between freedom and control* when establishing organizational rules and regulations about how and where to use the green IS so as not to constrain the system experience, while at the same time carefully consider that the design of the green IS does not violate employee privacy. For example, in accordance with guidelines on trust and ethics for technology in workplaces, employees should be educated about how their actions within the green IS can be tracked and analyzed by the company. Similarly, while it may be beneficial to embed the green IS within an existing IS used in the workplace rather than opting for a standalone application, companies should be careful to separate data related to sustainable behaviors from data related to job performance. In either case, it is recommended that behavioral analytics in the green IS be fully anonymized and aggregated so that employees do not feel surveilled when using the green IS, which is particularly relevant in SMEs and smaller teams where the identity of anonymized data sets can still be quickly inferred.

Recommendation 4: Simplifying use by avoiding conflicts and defining the right triggers. Employees and experts identified five main and interrelated challenges during the implementation stage. The challenges of perceiving the green IS as unmotivating and conflicts with work-related tasks can contribute to forgetting the green IS in daily work routines as the main obstacle in the implementation stage. Our findings indicate that barriers related to the instrument itself in terms of usability, functionality, and structure mainly lead to the perception of the green IS as effortful and unmotivating. Also, employees inherently prioritize their work tasks over the green IS, so after the first few days they forget about the green IS in their daily work routine. Missing sufficient triggers for employees to use the green IS probably contribute even further to its oblivion. Thus, we see that the design of the green IS can create a critical conflict between work and sustainability in the organizational context. The central recommendation in the implementation stage is therefore primarily to simplify use of the green IS as part of daily work routines by considering and avoiding potential conflicts in advance, so that employees do not perceive sustainable behavior as competing with their work tasks.

While the most straightforward idea to avoid forgetting to use green IS during a workday might be to remind employees of the green IS as often as possible, practitioners should carefully consider the *dilemma between oblivion and distraction* when designing triggers and notifications. To reduce the sense of conflict between sustainable behavior and work tasks, green IS should not include intrusive features that interrupt the work experience and reinforce employees' sense that sustainability is an additional duty for them, but rather it is recommended to thoroughly define effective triggers for sustainable behavior. For example, green IS designers should consider the characteristics of the workplace environment, understand relevant workflows within their organization, and particularly consult employees working in these workflows and co-design appropriate and dynamically adapted triggers, e.g., when an employee switches between tasks, returns from coffee break, or leaves for lunch. In the case of organizations such as SMEs that purchase or implement existing green IS rather than develop custom solutions, the procurement process should include criteria on how to configure and customize functionalities and notifications so that they fit the specific work routines and requirements of their own staff and interfere with the existing processes as little as possible without being forgotten. Green IS that offer opportunities to personalize triggers and reminders to the specific needs and contexts of individual employees hold particular promise for reducing disruptions to daily work. In addition, a concept that is highly interwoven with the company culture, such as "offline" feedback mechanisms and triggers that raise awareness of the importance of continuous sustainable behavior outside the boundaries of green IS, represents a valuable design opportunity. Finally, when selecting or designing green IS, practitioners should not underestimate the importance of the usability and seamless functionality of the green IS and should conduct careful usability testing to ensure that the effort required to use the system does not hinder its adoption and use. To this end, automating behavior tracking and analysis with aggregated feedback mechanisms has the potential to significantly reduce perceived effort and thus support the continued use of green IS.

Recommendation 5: Reinforcing motivation through variation, relatedness and extrinsic rewards. Employees and experts cited a lack of long-term motivation and an insufficient cost-benefit ratio to use the green IS as the biggest challenges in the confirmation stage. On the one hand, our results indicate that this might refer to the lack of appropriate extrinsic rewards or other extrinsic benefits for continued use of the green IS, which demonstrates the importance of extrinsic motivation in the work environment. On the other hand, a decrease in novelty might also negatively affect evaluation towards continued use. Finally, the lack of a critical mass of users seems to prevent the experience of a community commitment to sustainability, which might additionally support discontinuance. Exacerbating the above can be that the green IS is not sufficiently connected to the offline work environment, which may lead to declining use by colleagues. Since not all employees are at the same stage of technology adoption at the same time, the circumstance that only a minority of colleagues are using the green IS for sustainability in the workplace reduces normative influence and lacks role models for additional users that are still in the persuasion stage of green IS adoption. The key recommendation in the confirmation stage is therefore to reinforce continued use by either adding suitable extrinsic rewards with

increasing value or by satisfying employees' needs for constant excitement and relatedness in sustainable behavior at work by always offering new and valuable content and functionalities as well as special events and opportunities to cooperate and socialize with other users.

At this stage, the *dilemma between extrinsic and intrinsic motivation* becomes crucial for practitioners deciding whether and how to engage continued use with rewards and incentives. In general, several recommendations mentioned in the context of continued use suggest that fostering intrinsic motivation through variation and social connection should come first, before considering money or incentives as rewards that could potentially undermine intrinsic motivation. For example, companies could regularly highlight the joint achievements of their employees and illustrate the impact of their actions in a tangible and understandable way (e.g., not just stating the amount of kWh saved, but also how the savings will help enable investment in future sustainability measures by the company that will facilitate sustainable operations in the long term). In order to foster common initiatives to continuously use green IS and to ensure that a critical mass of users is reached, especially in larger companies, it is advisable to make team efforts outside the green IS transparent, e.g. by displaying how many team members have already contributed to support the companies' sustainability goals today on a monitor in the coffee kitchen and by setting milestones that employees can achieve together as a team challenge. Companies might consider supplementing the appeal of such milestones and team achievements with extrinsic rewards. In this case, however, decision-makers should reflect on the appropriateness of incentives and opt for rewards that do not jeopardize the overall goal of sustainability (e.g., vouchers that encourage further consumption) and better benefit the entire workforce or be shared among contributors, not just among individual top employees or the top 10, as otherwise employees who are far from the top might be demotivated.

6.3. Limitations and future research

This study followed guidances for conducting rigorous qualitative studies from Braa & Vidgen, 1999, Adams and Cox (2008), Kaplan and Maxwell (2005), Mayring (2014) and DiCicco-Bloom & Crabtree, 2006 to ensure reliability and validity of the results. Through a qualitative field study, we collected data over a three-week period from different SMEs implementing a green IS, and afterwards triangulated our findings by conducting an expert validation study. However, as with any research study, there are still shortcomings in our methodological choices that should be further explored in the future.

First, all companies that participated in our study used the same green IS as the basis for analyzing user perceptions and experiences. In particular, following previous work, we have used a smartphone-based green IS, but other formats such as tablet- or browser-based green IS (Spence et al., 2018) would be conceivable and may bring other challenges or benefits in the organizational setting. Further, our solution implemented only motivational design features and no financial or other tangible rewards. Therefore, we suggest considering other green IS in future studies to ensure the dependability of our qualitative research. Specifically, we invite future research to experiment with different green IS that are more or less intrusive and accompanied by extrinsic incentives in order to expand knowledge about how to solve the dilemmas of oblivion versus distraction as well as extrinsic versus intrinsic motivation through the design of green IS.

In a similar vein, we explicitly focused on SMEs, as they represent the vast majority of companies in the European Union (European Commission, 2023) and are therefore critical actors in society's transition to sustainable development, with great potential to use green IS as enablers for corporate sustainability (Baggia et al., 2019; Isensee et al., 2020). However, some of the challenges we identified may be circumstantial to the SME environment, particularly those related to rules and community in the workplace, and may vary in larger companies. We therefore invite future research to examine the challenges of adopting and using green IS in larger companies to contrast our findings with other corporate environments. In particular, it would be intriguing to investigate how different rule systems in companies of different sizes affect employees' expectations of freedom when using green IS, thereby providing new insights into the dilemma of control versus freedom in the design of green IS. In addition, it may be interesting to examine how social connections among employees and differences in corporate culture in companies of varying sizes affect normative influence mechanisms, thereby generating new insights into the dilemma of pressure versus voluntariness in green IS design.

Since the study was conducted during Covid-19, our sample was limited to a single country. Differences in national cultural dimensions such as power distance, uncertainty avoidance, individualism-collectivism, masculinity-femininity, and short- or long-term orientation (Hofstede, 2011) could lead to different results that are worth exploring in future studies. Even though Germany is a representative country in Europe and Western culture, there are still many subcultural factors that may differentially influence users' perceptions and beliefs about sustainability and green behavior, as well as their experiences in using green IS. Therefore, we suggest that research on challenges that hinder the adoption of green IS should be continued in different subcultural backgrounds and contexts.

In addition, future studies might consider more diverse samples. It could be useful, for example, to discuss the challenges and difficulties of using green IS depending on demographic or dispositional differences between samples. For instance, the relevance of different challenges hindering the adoption and use of green IS might differ between different age groups, while in the current study only two of the users studied belonged to Generation Z.

Finally, we would like to point out that although the focus group participants were selected and recruited by company representatives to reflect the diversity of the company, their participation in the research project and use of the green IS was nonetheless voluntary and therefore possibly subject to a degree of self-selection bias. Whilst we asked employees about their motivations for sustainable behavior, in further studies focusing on voluntary use of green IS, it would also be interesting to investigate employees' expectations towards green IS and how expectation confirmation or dissonance affects the adoption and use of green IS. In addition, while this is often difficult in research projects, we would like to suggest that in future studies it may be useful to include participants through random sampling within a company with mandatory participation to include employees who may not have an initial interest in the topic of the research project in order to explore how green IS adoption and use processes differ under obligatory rather than voluntary conditions. Particularly, the consideration of employees' degree of agency in green IS adoption could be valuable to add more insight into the dilemma of pressure versus voluntariness in green IS design.

7. Conclusions

In response to urgent calls to shift the focus of research on green IS from examining adoption factors from organizational and economic perspectives to considering individual perspectives in the adoption process, our study focused on examining individual challenges encountered in the process of adopting and using green IS in organizational contexts. Against the theoretical background of DOI and activity theory, we identified 55 different challenges that hinder successful adoption from the employees' perspective through a qualitative field study. The subsequent expert evaluation illuminated the significance and importance of these challenges and highlighted that different themes related to the sociotechnical environment dominate the various stages of green IS adoption. The theoretical discussion of our findings reveals that there are four critical dilemmas in green IS design and implementation that arise from the tension between sustainability and the organizational context. To support practitioners in facing these

dilemmas, we developed five recommendations how companies could address the dilemmas when designing and implementing green IS. Our findings extend previous knowledge on green IS adoption by revealing conflicts that arise in the individual adoption process and shed new light on how individual adoption factors are formed in the sociotechnical environment and how they lead or not lead to adoption and continued use of green IS in organizations. Thereby, our results stimulate discussion about the role of voluntarism, privacy, intrusiveness, and extrinsic motivation in the design of motivational IS and sustainable behavior change interventions in the organizational context.

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CRediT authorship contribution statement

Kirchner-Krath Jeanine: Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – original draft. **Morschheuser Benedikt:** Conceptualization, Methodology, Validation, Writing – review & editing. **Sicevic Nevena:** Investigation, Validation. **Xi Nannan:** Funding acquisition, Resources, Writing – original draft, Writing – review & editing. **von Korflesch Harald F. O.:** Conceptualization, Resources, Supervision. **Hamari Juho:** Funding acquisition, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

None.

Appendix A

A. Coding guidelines.

Table 11
Coding guideline for the categories derived from DOI theory (Rogers, 1983) and activity theory (Engeström, 1987) as a basis for the deductive coding of challenges mentioned by employees in the qualitative field study.

Category	Definition for coding	Anchor example
Categories derived from activity theory		
Subject	Challenges related to employees as individuals in terms of their perceptions, attitudes, and behaviors	"I'm not, let's say app person or I don't have Instagram or whatever where I need to share what I'm doing all the time." (P2)
Instrument	Challenges related to the design, structure, or functionality of the green IS	"I personally found the description text a bit long, which was most likely because it was just mostly a blog text. I think you could reduce that visually, you can make bullet points or something, then it reads faster and easier. I found that, that's why I'm very quickly tired to even read these texts sometimes." (P15)
Object	Challenges related to the topic of sustainability and sustainable behavior in the context of the work environment	"Of course, it's also like that, you don't have a real need for it. So I have an app, no idea for shopping, where I can organize the shopping list cool. I always use it when I have the need to go shopping. But here." (P4)
Community	Challenges related to social dynamics between colleagues	"If the department head doesn't model that, it won't work with the rest." (P12)
Rules	Challenges in terms of guidelines for action between colleagues both in the green IS and in the organizational environment	"Sounds nice, but I have so many things to do. What, what it's important for, for you, I can say to my manager. The manager will say, okay, then you have to do your work, not to use the app for example." (P1)
Division of labor	Challenges related to task specialization among colleagues	- no anchor example found -
Categories derived from DOI theory		
Knowledge	Challenges related to awareness of the green IS, understanding of its use, and knowledge of its operating principles	"So that you come into the app and don't directly understand what you're supposed to do there." (P17)
Persuasion	Challenges related to attitude formation for the use of the green IS	"I think nobody would look ahead because of this app and say that you are now eating a vegetarian lunch. Of course, it's a matter of attitude, because once you've washed the apple in the bowl, it's certainly in your head at some point and you do it automatically. But it is not necessarily an indication for the future." (P12)
Decision	Challenges associated with starting to use the green IS after building positive attitudes, which may account for a gap between attitudes and behaviors	"But then you just don't do it somehow and think to yourself, yeah, come on, the moment is bad or something and then it's already forgotten right away when you've arrived at the thought that you'll do it later or something." (P8)
Implementation	Challenges related to the use of the green IS	"Gamification didn't resonate with me at all. I felt zero challenge." (P18)
Confirmation	Challenges associated with reevaluating the use of green IS in terms of dissatisfaction with its performance, unmet expectations, potential dissonance, and other reasons for disengagement	"And the question I ask myself is for the employee afterwards, at the end of the day, what's the long-term motivation? I can imagine that this has the gamification effect that it's supposed to have. Quite blatantly at the beginning team KPs against who knows what. That's all great, but it wears off after (.) I guess 1 to 2 weeks this effect is gone, it's gone." (P7)

Table 12
Category selection criterion and level of abstraction for the inductive coding of recommendations to overcome challenges in green IS adoption mentioned by the experts in the expert validation study.

Category selection criterion	Level of abstraction	Exemplary category	Exemplary text passage
Suggestions, advice or best practices that are good or suitable for overcoming the challenges in adopting green IS in the organizational environment (Cambridge University Press, 2023)	Concrete and generalizable instructions for stakeholders in a company, not testimonials about a specific project or experience	Establish sustainability leaders	"It's very important to recruit people that already have a good standing of the workplace, they are very good influencers. So, you find who these people are at each workplace, and you can kind of recruit them and make them for example, sustainability leader or the person that will influence all the others, so if you find these people, they are key people to getting a critical mass." (E3)

B. Interaction with the green IS over the three-week period

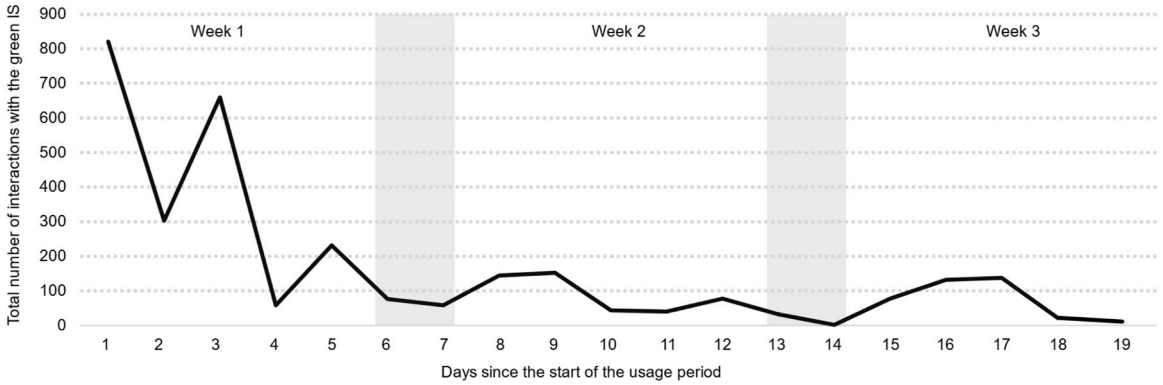

Fig. 10. Illustration of the green IS usage over the three-week period.

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