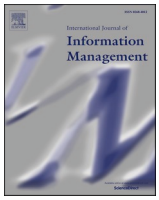
International Journal of Information Management 63 (2022) 102444

Contents lists available at ScienceDirect

International Journal of Information Management

journal homepage: www.elsevier.com/locate/ijinfomgt



Opinion paper on climate change

# Digital sustainability, climate change, and information systems solutions: Opportunities for future research

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ARTICLE INFO

*Keywords:*
Digital sustainability
Climate change
Climate resilience
Climate-conscious citizen
Science
ESG intelligence

ABSTRACT

Climate change is one of the most pressing global challenges facing society today, with potentially detrimental sustainability impacts on individuals, organisations, and societies. The impact of digital technologies on climate change is one of our key research priorities at the Digital Sustainability Knowledge Hub of the University of New South Wales, Australia. Building on digital sustainability research, we call for research contributions to mitigate and adapt to the effects of climate change, as it could cause far-reaching disruptions to communities and the economy here in Australia and worldwide. In this article, we provide an overview of Australia's perspectives and approaches to addressing climate change. Moreover, to encourage researchers to study and develop solutions, we propose future research directions focusing on climate resilience, climate-conscious citizen science, and organisations' Environmental, Social and Governance (ESG) strategies.

## 1. Introduction: a brief overview of climate change in Australia

In response to a recent United Nations (UN) climate action report, Secretary-General of the United Nations, António Guterres, posits 2021 is a "make or break year" to respond to the international climate crisis (United Nations, 2021b). At the 2015 United Nations (UN) global climate summit, Conference of the Parties' (COPs), in Paris, every country in attendance agreed to work together to limit global warming by a desired target of 1.5 degrees. To achieve this goal, experts agree the international community needs to halve emissions over the next decade and achieve net zero carbon emissions by the middle of this century (COP26, 2021). While the Australian federal government has allocated resources to address climate change, such as a $3.5 billion Climate Solutions Package (Australian Government, 2018) and the Emissions Reduction Fund (ERF) (Australian Government, 2021), it has not committed to the 2030 target to halve emissions. The federal government's target is to reduce emissions by 26–28% compared to the 2005 levels by 2030. Australia is currently on course to achieve a 30–35% reduction by 2030 and has pledged to achieve net zero emissions by 2050 (BBC, 2021a).

Australia has various opportunities to improve its response to climate change and several geographic conditions that underscore the importance of developing and implementing a concerted, nation-wide adaptation effort. A 2021 UN Sustainable Development Report ranks Australia last for climate action compared to the 193 United Nations member countries (Westfall, 2021). In 2021, the United Nations Educational, Scientific and Cultural Organization (UNESCO), recommended the Great Barrier Reef be listed as "in danger" due to climate change related threats (BBC, 2021b). The World Heritage Committee, composed of 21 country representatives, did not adopt the recommendation. Instead, the committee suggested Australia collaborate with the International Union for the Conservation of Nature (IUCN) and provide a progress report within six months (Lawrence, 2021). In addition to managing droughts and bushfires, the country is heavily invested in the coal industry. Australia has one of the highest levels of per capita greenhouse gas emissions in the world (Caswell, 2021).

While the federal government has not adopted the 2030 target, several Australian organisations and agencies have accepted the challenge. The Business Council of Australia has highlighted financial opportunities associated with the climate transition and encouraged

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https://doi.org/10.1016/j.ijinfomgt.2021.102444
Received 29 October 2021; Accepted 30 October 2021
Available online 6 November 2021

organisations to commit to a 50% emissions reduction target by 2030. More than half of the top 100 companies on the Australian Stock Exchange have made net zero pledges. New South Wales, the most populous state in Australia, recently committed to 50% emissions reductions by 2030 (Suckling, 2021). First Nations groups have recommended alternative approaches to controlling fire and managing the land (Australian Museum, 2021). According to Nalau and Melville-Rea (2021), the Australian federal government is developing a National Climate Resilience and Adaptation Strategy which will be released this year.

## 2. Digital sustainability and climate change: research opportunities

In addition to industry and government initiatives, there is an opportunity for the global research community to join the response to the climate crisis. Over the past decade, in the IS community, an increasing number of scholars have acknowledged the need to act swiftly on climate change, addressing issues surrounding environmental sustainability. In joining previous calls for action, we identify opportunities to develop knowledge and practice of digital sustainability as an overarching research programme.

Digital sustainability represents the opportunities and challenges facing the convergence of digital and sustainability imperatives (George, Merrill, & Schillebeeckx, 2021; Pan & Zhang, 2020). Accordingly, digital sustainability activities can advance environmental sustainability goals by creatively deploying technologies that create, use, or transmit electronic source data (George et al., 2021). This idea of digital sustainability, which has digital technologies at its core, raises a pertinent question: *How can digital technologies be leveraged to build practical solutions that tackle climate change challenges?*

Existing IS research on climate change can be broadly organised into two interrelated streams. The first stream of research, aligning with several recent calls to investigate the role of IS in societal challenges (Majchrzak, Markus, & Wareham, 2016), addresses significant societal needs emerging directly or indirectly from climate change. For example, Suseno and Abbott (2021) explore how woman entrepreneurs leverage digital social innovation to initiate business ventures that tackle climate issues. The second, relatively more established, stream of research investigates the roles of IS in environmental sustainability – an imperative in the global sustainable development roadmap that is deeply connected to climate change. IS research on environmental sustainability can be further divided into two perspectives: Green IT – i.e., reducing the direct environmental impacts of IS use (Dedrick, 2010) – and Green IS – i.e., using IS to promote eco-sustainability in businesses and society (Melville, 2010). Green IT research primarily focuses on environmental sustainability issues at an organisational level – for example, Nishant, Teo, and Goh (2017) examine shareholders' reactions to companies' Green IT announcements. Green IS research, on the other hand, considers a wider range of issues pertaining to environmental sustainability across the micro, meso, and macro levels (Seidel et al., 2017; Tim, Pan, Bahri, & Fauzi, 2018) – for example, Kurkalova and Carter (2017) explore the benefits of decision support systems in promoting sustainable farming practices. Nevertheless, considering the increasing number of climate catastrophes, from recurring periods of extreme heat to rising precipitation events happening across the globe, IS research has not paid sufficient attention to challenges relating to climate change. Hence, we propose three key themes for future climate change research in the IS discipline: climate resilience, climate-conscious citizen science and climate-intelligent IS solutions.

### 2.1. Theme 1: climate resilience

**Climate Resilience (CR)** refers to the capacity to make effective use of IS to anticipate, absorb, and adapt to climate-related shocks and disturbances. Several climate catastrophes in recent years – from hurricanes and bushfires to droughts and floods – have shown that our collective capacity in responding to and recovering from major exogenous events has never been more critical. Amid this sequence of cascading events, the role of IS in shaping individuals, organisations', and communities' capacity for resilience has been brought to the forefront. We see resilience as a much-needed perspective to unpack the black box of digitally enabled climate initiatives and illuminate the roles of IS in shaping our capacities in not only responding to, but also rebuilding from and continuously adapting to longer-term consequences of climate catastrophes – many of which are now becoming inevitable. For example, extreme crop drought events are taking a toll on our food production system, putting many regions at risk of climate change famine (United Nations, 2021a). A recent case study by Chaudhuri and Kendall (2021) explores how Weather IS can be used by farmers to withstand, recover from, and adapt to climate change challenges through establishing new collaborative practices.

There are several important questions under the theme of CR which the IS community is well-positioned to address. First, IS has a proud track record of driving impactful research agendas, from the digital divide (Walsham, Robey, & Sahay, 2007) and social innovation (Majchrzak et al., 2016; Qureshi, Pan, & Zheng, 2021) to, more recently, sustainability imperatives (Pan & Zhang, 2020; Zeiss, Ixmeier, Recker, & Kranz, 2021) and digital resilience (Boh, Constantinides, Padmanabhan, & Viswanathan, 2020; Tim, Cui, & Sheng, 2021). Considering the integral roles of IS in tackling the challenges of climate change and our emerging thought leadership in digital resilience (Boh et al., 2020; Rai, 2020), we propose that it is now time to mobilise IS research on CR. Moving forward, IS research could address phenomena involving one or more of the interrelated *capacities of resilience* (i.e., anticipating, absorbing, and adapting), particularly in conceptualising the enabling and constraining roles of IS in shaping such capacities amid climate-related disturbances.

Second, we direct research attention to how climate impacts disproportionately affect historically marginalised communities and exacerbate existing *inequalities* (Chaudhuri & Kendall, 2021). The World Bank estimates that around 216 million people, mostly from developing countries, will be forced to flee the impacts of acute climate events by 2050, unless radical actions are taken (Clement et al., 2021). The IS community has accumulated rich expertise from relevant research areas, such as ICT for development (ICT4D) (Chipidza & Leidner, 2019) and digital inclusion (Andrade & Doolin, 2016), which are highly relevant to this theme. We urge the IS community to play an active role in investigating how IS could be leveraged to support CR initiatives that promote inclusive and equitable developments, such as the uplift of digital readiness among digitally disadvantaged groups and empowerment of civil movements that advance climate justice. The success of these initiatives would be fundamental for the development of climate-resilient communities – communities that are vital, cohesive, and more empowered to create continuous adaptations to climate-positive, sustainable practices.

The next research opportunity involves *climate-resilient digital infrastructure*. IS research should investigate the resilience of digital infrastructure against impacts of climate variability. Resilience as a system property is critical to ensure business continuity and reliable service provisioning (Heeks & Ospina, 2019), particularly in the face of disruptions. The global supply chain disaster accompanying the COVID-19 pandemic is a recent case in point highlighting the importance of systems resilience in light of major exogenous shocks. Nevertheless, existing research to date contributes limited conceptualisations of resilient attributes (Hanelt, Busse, & Kolbe, 2017) and limited understandings on design considerations and principles that can support flexible, adaptive approaches to infrastructure. Resilient infrastructure also serves a critical role in strengthening climate-smart decisions and strategy making, but currently there is limited understanding on the affordances of such infrastructure in promoting agility and adaptability of organisations to ongoing and upcoming climate disturbances. Future research can

address these limitations.

### 2.2. Theme 2: climate-conscious citizen science

**Climate-conscious citizen science** refers to the use of citizen science (CS), i.e., the direct involvement of the public in scientific research, to study and mitigate climate change related impacts. Researchers have traditionally employed CS approaches to overcome human resource limitations in the scientific process (Sauermann et al., 2020). CS is a type of crowdsourcing practice, where everyday citizens engage in data collection pursuits, with the crucial difference that participation is often voluntary and relies heavily on participants' intrinsic motivation (Lukyanenko, Parsons, Wiersma, & Maddah, 2019). In recent years, the availability of digital technologies that afford widespread participation and efficient collection of data at scale has spawned numerous digital citizen science projects worldwide (Bonney et al., 2014; Shulla, Leal Filho, Sommer, Lange Salvia, & Borgemeister, 2020). A citizen science approach is particularly useful to study and mitigate climate-change related impacts as such endeavours typically require close monitoring and collection of multiple parameters over extended periods of time – a task enormous in scale and complexity.

The conversation in citizen science is moving beyond the dominant "productivity view", where citizens are viewed as increasing scientific knowledge production, to accommodating a "democratisation view", where citizens are viewed as active participants, shaping project objectives and outcomes (Sauermann et al., 2020). This renewed direction raises hope that CS can potentially democratise science and elevate the role of everyday citizens from that of data collectors to one of change agents through individual and collective *climate-conscious action* (Fransen, 2021; Groulx, Brisbois, Lemieux, Winegardner, & Fishback, 2017). A digital CS approach not only enables rudimentary measurement and monitoring of climate-impacted phenomena, but affords citizens and communities to organise, prioritise and participate in "collective production" (see Majchrzak & Malhotra, 2020) of climate-conscious action (de Sherbinin et al., 2021; Groulx, Fishback, & Winegardner, 2019) via digital platforms. We, therefore, call for greater attention from policy-makers, city councils, universities, and other public sector agencies to build *climate-conscious citizen science* capabilities in collaboration with local communities. We take the view that local communities can play a salient role in shaping policy choices that influence how we prepare and respond to climate-change-related impacts by sharing traditional knowledge, providing access to new sources of information, and reducing bias in the research process (Fransen, 2021).

IS research can significantly inform the development of climate conscious citizen science capabilities and we call for further research in two related areas namely, improving the *information quality* and *motivation and engagement* on CS platforms. We first bring to attention the pertinent issue of *information quality* in citizen science (Lukyanenko, Parsons, & Wiersma, 2016). Projects that aim to document impacts of climate change often collect data on multiple, changing parameters, over long durations of time, which introduces a layer of complexity to maintaining information quality. Therefore, future research can focus on understanding the information quality needs from a CS perspective as existing models of information quality developed in the for-profit organisational context may not be fit for purpose (Lukyanenko et al., 2019). There are numerous questions for future research to explore: What are the dimensions of information quality salient in CS projects? What are the trade-offs on information quality in CS projects and how can they be managed? How do experts and citizen scientists reconcile diverging perspectives on information quality? How can we control for information quality in the design of CS platforms?

CS initiatives rely heavily on the intrinsic *motivation* of participants for ongoing contribution. Documenting climate change related phenomenon requires the engagement of citizens over several years to collect multiple easy-and-difficult to measure parameters. Keeping citizen scientists productively engaged and motivated on the platform is therefore an important concern for CS project designers (Lukyanenko et al., 2019). Digital citizen science platforms have tried to gamify the data collection process and introduced socialisation features to encourage relationship building within the community with varying degrees of success. There are again numerous questions for future research to explore: How can we engage and motivate citizen scientists to take climate-conscious action? How can platforms motivate and engage citizen scientists with varying skills, education, interest levels to contribute to CS projects? What are the peculiarities of digitally measuring and monitoring climate change related phenomenon? and How can platforms account for these contextual conditions in their design choices to motivate large scale participation of citizens? The current issues with motivation may also be reflective of the productivity view of CS, where citizen science projects and platforms are driven largely by scientists, which may not adequately account for a citizen perspective (Bonney, 2021). We therefore call for more diversity of *research approaches* to studying and conducting citizen science. We particularly encourage future studies to co-design citizen science projects with the direct involvement of local communities adopting human-centred approaches to address the issue of motivation and engagement. Last but not the least, we also encourage IS researchers to employ CS approaches to study IS phenomenon that has a bearing on climate change (Levy & Germonprez, 2017; Weinhardt, Kloker, Hinz, & van der Aalst, 2020).

### 2.3. Theme 3: climate-intelligent IS solutions and ESG intelligence

**Climate-intelligent IS Solutions and ESG Intelligence** leverages the transformative power of IS to mitigate adverse environmental impacts (Melville, 2010; vom Brocke, Watson, Dwyer, Elliot, & Melville, 2013). IS researchers can use these solutions to create practical impact and enhance engaged scholarship (Pan & Pee, 2020). The key lies in solving environmental sustainability problems instead of merely studying them as phenomena. With a solution-based focus, we encourage IS researchers to apply their sustainability knowledge, technical and data analytics skills that go beyond making theoretical contributions and solving problems that matter (Gholami, Watson, Hasan, Molla, & Bjorn-Andersen, 2016).

With an outcome-based focus, given the relative lack of a strong tradition in creating practical solutions in our research community, future research on the methods and approaches to developing actionable and valuable solutions for stakeholders become critical (Gholami et al., 2016). Solution-building researchers can draw from the firm foundation of design science, action design research, and action research principles (Baskerville & Wood-Harper, 1996; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) the community has built in recent years involving "in vivo real-time approaches" (Malhotra, Melville, & Watson, 2013, p. 1266).

In the context of *climate resilience*, the promises of solution-oriented research in generating immediate differences in practice are becoming much more relevant, particularly in shifting how urgent climate disasters will unfold and in mitigating their negative impacts. Correspondingly, we call for more impact-driven, research-with-practice (Rai, 2019) efforts to address pressing climate challenges so that we can bring about change when it will make the most difference. We also encourage future research to investigate building technical artefacts that help *climate-conscious citizens* in achieving end objectives, such as for example, platforms for (a) aggregating citizen-collected data, (b) enabling citizens to organise and engage in collective production of climate-conscious action, and (c) understanding gaps in climate-conscious citizen science project efforts.

Finally, there are opportunities to develop *sustainability intelligence* solutions to help visualise, track, and benchmark an organisation's Environmental Social and Governance (ESG) strategies (Ketter, Padmanabhan, Pant, & Raghu, 2020). To become sustainability intelligent, organisations will need access to advanced data analytics to manage the

vast amounts of sustainability initiative-related data, utilise strategy visualisation techniques, and design easy-to-access dashboards to be future-ready (Pee, Pan, Wang, & Wu, 2021). Data-driven systems that are powered by AI-based algorithms can equip organisations with strategy visualisation capabilities to track sustainability efforts, design sustainability initiatives and optimise performance (Pan, Li, Pee, & Sandeep, 2021). Organisations could also integrate analytics systems into their existing operations to bring environmental sustainability to the forefront of digital innovation and organisational transformation (Zhang, Pan, Yu, & Liu, 2019).

## 3. Conclusion

Given that the climate crisis has emerged as the dominant concern for humanity, IS researchers have a moral obligation to collaborate with organisations and the community to respond urgently. In particular, the rapid emergence of innovative technologies with huge transformative potential, like artificial intelligence (AI), machine learning (ML), analytics, and the Internet of things (IoT), offer immense possibilities for tackling sustainable development goals (Pan & Zhang, 2020).

Climate change and other broader sustainability challenges pose a critical threat to our ability to flourish on the planet. This article briefly discusses Australia's perspective on climate change before proposing opportunities for future research. Specifically, we discuss opportunities afforded by the three proposed themes: 'Climate Resilience', 'Climate-conscious Citizen Science', and 'Climate-intelligent IS Solutions and ESG Intelligence'.

We hope this article inspires the IS community to create knowledge and best practices for digital sustainability. Furthermore, this article suggests research directions in which digital sustainability research can provide practical solutions to tackle the urgent climate crisis humanity faces. We urge the IS community to play an active role by investing more effort to conduct solution-oriented studies that show how one can leverage the transformative power of IS to mitigate adverse environmental impacts (vom Brocke et al., 2013).

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