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Opinion paper

Climate change and COP26: Are digital technologies and information management part of the problem or the solution? An editorial reflection and call to action☆

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ABSTRACT

The UN COP26 2021 conference on climate change offers the chance for world leaders to take action and make urgent and meaningful commitments to reducing emissions and limit global temperatures to 1.5 °C above pre-industrial levels by 2050. Whilst the political aspects and subsequent ramifications of these fundamental and critical decisions cannot be underestimated, there exists a technical perspective where digital and IS technology has a role to play in the monitoring of potential solutions, but also an integral element of climate change solutions. We explore these aspects in this editorial article, offering a comprehensive opinion based insight to a multitude of diverse viewpoints that look at the many challenges through a technology lens. It is widely recognized that technology in all its forms, is an important and integral element of the solution, but industry and wider society also view technology as being part of the problem. Increasingly, researchers are referencing the importance of responsible digitalization to eliminate the significant levels of e-waste. The reality is that technology is an integral component of the global efforts to get to net zero, however, its adoption requires pragmatic tradeoffs as we transition from current behaviors to a more climate friendly society.

1. Introduction

The 2021 United Nations (UN) Climate Change Conference (COP26) held in Glasgow UK, brings together many of the worlds' leaders to address the critical aspects of global warming. The conference aims to gain commitment for sustained progress towards the Paris Agreement and UN framework convention on climate change, by limiting increased global temperatures to 1.5 °C above pre-industrial levels (COP26, 2021). The Intergovernmental Panel on Climate Change (IPCC) identified in its 2018 report that global emissions would need to be at net zero by at least 2050 to retain a "high confidence" level of limiting temperature increases to sustainable levels (Masson-Delmotte et al., 2018). In her speech at the conference, US Treasury Secretary Janet Yellen stated that - "*rising to this challenge will require the wholesale transformation of our carbon-intensive economies*," and that "*addressing climate change is the greatest economic opportunity of our time.*" (COP26, 2021).

The transition toward net zero requires significant changes at a societal and industrial level and governments, as well as corporations, are increasingly turning to technological innovations to meet net zero emission targets (Miller, 2020). Digital technologies offer the potential to deliver sustained solutions to many of the seemingly intractable societal challenges relating to climate change (George, Merrill, & Schillebeeckx, 2021). The World Economic Forum (WEF) in its - *Harnessing Technology for the Global Goals* report, jointly authored with PwC, identifies the significant role that digital technology can play in improving resilience to global warming related, natural hazards, reducing emissions and enhancing the ability for humans to take the necessary steps to realize net zero. The WEF report identifies how digital technologies can help to automate and significantly improve the efficiency of industrial, manufacturing and agricultural processes and that Artificial Intelligence (AI) based systems could contribute to a reduction of 4% in global emissions by 2030 (World Economic Forum & PwC, 2021).

Although advancements in technologies are closely associated with offering solutions to global warming, the digital discourse also highlights the negative impacts of the widespread use of technology in the context of waste products, resource usage and CO2 emissions. The widely reported impact of vast bitcoin mining farms in various parts of the world and their appetite for significant energy consumption - 121.36 terawatts hours per year (CBECI, 2021) – illustrates the dichotomy of rapid technological advancement and potential barriers to net zero by 2050 (Mora et al., 2018). The debates surrounding the convergence of the digital and net zero imperatives are beginning to gain traction within the academic literature, where studies have started to focus on the role of digital technologies through a positive contribution lens, but also a reflective perspective, recognizing some of the negative aspects of the rapid adoption of technology (George et al., 2021; Merrill, Schillebeeckx, & Blakstad, 2019). What is clear is that, whilst the emerging diverse and disparate discourse has offered insight to many of the significant challenges and barriers to net zero from the digital perspective (George, Howard-Grenville, Joshi, & Tihanyi, 2016; Luo, Zhang, & Marquis, 2016), there exists a limited contribution from a wider and more informed multiple perspective context. This study contributes to the digital technology and climate change discourse, via the individual discussions on a multitude of interrelated sub-topics. Each invited expert has offered their own unique insight to the myriad of complexities and dependencies to attaining net zero by 2050.

The remaining sections of this article are organized as follows. Section 2 presents a brief review of existing literature in this space. Section 3 presents the experts' perspectives related to core themes surrounding information management (IM)/information technology (IT)/information systems (IS) and climate change. Section 4 - presents an overview of the key perspectives from the submitted full opinion articles. The main discussion section is presented in Section 5, where we assess the significant challenges and key contributions from the invited expert submissions. Section 6 concludes the paper by discussing implications for both research and practice.

2. Background literature review

The primary database used for the literature search was Scopus. Keywords such as "information systems" or "information technology" or "IT sector" were combined (AND operator) with keywords "environment", "sustainability", "sustainable" and "climate". The search taxonomy retrieved articles that had the combination of keywords in the article title, author keywords, or abstract. Via a process of filtering to eliminate non-relevant studies, a total of 372 articles remained. These articles were evaluated via their abstract to assess their suitability against the following two research questions.

- RQ1: Does the digital technology and IS/IT sector have a negative impact on the environment and how can it be reduced?
- RQ2: How can digital technology and IS/IT be utilized to mitigate the causes and impact of climate change?

After a further process of scanning of the title and abstract for the relevance of the article to the research questions, 88 articles remained. Additionally, ScienceDirect and Web of Science were also used, following similar approaches which resulted in 16 additional articles.

2.1. (RQ1) Does the digital technology and IS/IT sector have a negative impact on the environment and how can it be reduced?

Despite the contribution of the IS/IT industry toward the economic and social welfare of society, IS/IT has often been criticized for having a negative environmental impact. Concerns surrounding the adverse effects both hardware and software have on the environment date back to the Y2K era which led to the massive adoption of enterprise systems (Miyamoto, Harada, & Fujimoto, 2001). These negative impacts include high levels of energy consumption, greenhouse gas emissions and toxic disposal of IS/IT systems (Muregesan, 2008). The disposal of electronic waste (e-waste) while following recycling processes has been widely viewed as not being environmentally friendly, especially the impact of fossil fuels or respiratory inorganics (Barba-Gutiérrez, Adenso-Diaz, & Hopp, 2008). Refurbished ICTs are often used in developing countries where devices tend to have a short life-span and subsequently create environmental damage during disposal (Osibanjo & Nnorom, 2007). Studies have argued that electricity is a major cause of climate change, as many power stations throughout the world still rely on fossil fuels to generate electricity (Asongu, Agboola, Alola, & Bekun, 2020; Tamburini, Rossi, & Brunelli, 2015). Energy hungry technologies such as applications of blockchain in the form of bitcoin, has been widely criticized for producing over 22–29 million metric tonnes of carbon dioxide emission each year. These figures are comparable to the carbon dioxide production of entire countries such as Jordan and Sri Lanka (Marr, 2018; Stoll, Klaaßen, & Gallersdörfer, 2019). Technologies such as the Internet of Things (IoT), sensors and actuators have a shorter lifespan which leads to increased waste in the environment (Chakraborty & Gupta, 2016; Chakraborty, Gupta, & Sarkar, 2014; Nižetić, Šolić, González-de, & Patrono, 2020). Digital transformation initiatives such as smart cities have concerns surrounding ICT waste management, energy management and emission management which needs to be addressed for achieving long term sustainability and viability (Ismagilova, Hughes, Dwivedi, & Raman, 2019).

From an IS/IT perspective, IoT and Artificial Intelligence (AI) could potentially offer solutions for reducing the impact of technology projects (Salam, 2020). High ICT-driven initiatives need to plan for sustainability by thinking from the perspective of social welfare and e-waste impact (Kar, Ilavarasan, Gupta, Janssen, & Kothari, 2019). Wireless communication technologies need adaptations so that emissions can be further reduced. AI can operate with such technologies to enhance the usage of bandwidth and energy consumption to significantly reduce the carbon footprint of the telecom sector Ullah et al. (2020). Similarly, AI integrated with blockchain has been found to positively impact water management and climate control (Lin, Petway, Lien, & Settele, 2018). AI can manage and reduce energy consumption within smart cities (Şerban & Lytras, 2020). Studies have identified that blockchain applications can improve sustainable practices in supply chain management and agricultural practices (Kshetri, 2021). Similarly, within nano-technology applications, AI has provided benefits through better precision in agricultural water distribution delivering positive impacts on efficient use of natural resources. The communication of sustainability related messages within social media has greatly increased during the pandemic (Grover, Kar, & Ilavarasan, 2019; Grover, Kar, Gupta, & Modgil, 2021; Yadav, Kar, & Kashiramka, 2021). The literature has highlighted that during crisis periods IS research can provide "signposting" for sustainability actions through improved digital monitoring, tackling information flow and paranoia, and orchestrating data ecosystems for improved decision making (Pan & Zhang, 2020).

The focus towards renewable energy has increased dramatically. The IRENA (2021) report indicates that jobs in sustainability and cleaner energy are increasing exponentially year on year, especially in solar and wind energy. This shift towards greener energy consumption is common across industries producing and consuming technology products and services. There is evidence that if stakeholders are convinced about energy management, their engagement in Green IS/IT programs will increase (Nyberg, 2018).

The literature highlights the use of theories such as: Institutional Theory, Resource Based View, Technology Organization Environment framework, Theory of Planned Behavior and Motivational Theory as the dominant models used in the IS literature (Asadi & Dahlan, 2017). Lesser used theoretical lenses such as: Upper Echelon Theory, Self Determination Theory, Green Theory, Norm Activation Model, Elaboration Likelihood Model, Dynamic Capability Theory, Actor-Network Theory and Expectancy Theory. could be used to explore future research relating to environmental impacts of technology. (Tables 1 and 2).

2.2. (RQ2) How can digital technology and IS/IT be utilized to mitigate the causes and impact of climate change?

As early as 2008, Murugesan (2008) provided directions towards a greener IS/IT strategy. A holistic focus towards Greener IT entails reducing the energy consumption of computational devices. It also gives directions on reuse, refurbish and recycling of IS/IT products. Such a focus requires an organizational imperative as indicated by Butler (2011), whereby the study draws on institutional theory to explain the multitude of forces acting on organizations from the institutional, environment and organizational fields for environmental sustainability. Reduction of carbon based energy consumption directly leads to reduction of greenhouse gas emissions. The study by Simmonds and Bhattacherjee (2012) indicates that existing IT infrastructure, alignment of business strategy and relative advantages of green IT initiatives, have an overall positive impact on the adoption of IT initiatives within firms.

Recent IT/IS literature indicates that technology can be a solution for better environmental management and sustainability. For example, Wang X. (2015), Wang Y. (2015) highlights that IS/IT competence enables the integration of technology within the environmental management processes to improve performance. The same study demonstrated the positive impact of IT competence on IT-environmental management integration. The research by Jnr (2020) indicates that there is a significant relationship between integrated technologies and Green IS/IT innovation. The study by Ojo and Fauzi (2020) indicates that environmental awareness and leadership commitment positively impacts engagement in Green IS/IT practices. Further Marques et al. (2019) highlight that universities now consider emissions and Green IT principles to reduce the adverse impacts on the climate, while designing their curriculum. Audits in Green IT in enterprises help to enhance focus towards maintaining environmental orientation and better impacts on climate (Patón-Romero et al., 2021). These audits offer a view on the organization's position along the green IT capability maturity model from ISO/IEC 15504 to ISO/IEC 33000.

Within workplace infrastructure management, sensors and actuators are often being used for water management and energy consumption in smart buildings (toilet management, ventilation and air quality management) and smart devices (like air conditioners and lighting systems). These technologies have been observed to have brought in wide positive impacts on the climate within the existing literature (Zarindast, Sharma, & Wood, 2021). For example, blockchain applications are not always energy hungry, and often applications in different use cases such as SolarCoin and VerdePay may actually help in reducing carbon footprints (Howson, 2019). Applications of analytical models for information management enables more efficient energy management in smart cities (Gellert, Florea, Fiore, Palmieri, & Zanetti, 2019). Blockchain applications may enable a more efficient IoT ecosystem and thereby reduce energy consumption (Sharma et al., 2020). AI technologies such as deep learning together with big data analytics have been used for image mining for underwater environment management and air quality management (Kushwaha et al., 2021; Nair et al., 2021).

Driven by the pandemic, working from home has significantly increased, which has drastically reduced travel to workplaces, thereby reducing the carbon footprint from travel and maintaining office infrastructure. This change toward a work from home culture has been facilitated using video conferencing and collaboration systems enabled through ICTs (Chakraborty & Kar, 2021; Galanti et al., 2021; Richter, 2020). A recent review on AI and its possible impacts towards sustainability argue that AI will play a critical role beyond enabling better consumption of energy, water, and land usage, and it will facilitate environmental governance with greater effectiveness (Nishant et al., 2020).

Whilst the literature has exhibited an emerging focus on Green IS and sustainability within the information management literature, there is still tremendous scope for impactful research on many aspects of the use of technology to combat climate change.

3. Multiple perspectives from invited contributors

This section, in alignment with the approach set out in previous studies (Dwivedi et al. 2015, 2020, 2021a, 2021b, 2022), develops a set of unique expert contribution narratives that explore many of the key topics related to digital and IS technologies and climate change. This topic has numerous threads and interdependencies as many of the invited experts offer their own perspectives and viewpoints on the topic. The expert contributions are largely presented in an unedited form, as expressed by each of the contributors. The perceived unevenness of the logical flow inherent with this approach is countered by the capturing of the distinctive orientations of the expert perspectives related to the chosen topic (Dwivedi et al. 2015, 2020, 2021a, 2021b, 2022). The list of contributions is provided in Table 3 and extended in further detail within this section.

3.1. Behavior and attitudes

3.1.1. Contribution 1 – Climate change and information technology – Professor Robert M. Davison

3.1.1.1. Some issues. I think that IM/IT/IS has a profoundly negative impact on the environment in ways that are largely invisible. For instance, the devices that we use, particularly batteries, require the inclusion of rare earth elements, notably tantalum. This is mined from Coltan. Major deposits of coltan are found in DR Congo (Wikipedia, 2021) where open cast mines blight the landscape. In addition, hundreds of small scale independent miners look for their own spoils. The impact on the environment is considerable, and this includes the local wildlife that used to live in the area, notably the Eastern Mountain Gorilla. Militias are often employed to protect the mines and their all-too valuable minerals, but these militias may abuse the local people, wildlife and more (YouTube, 2017).

At a more visible level, the devices that we use require huge amounts of electricity, whether for the extraction and refinement process, the manufacturing process or the simple use of the end products. Where does the electricity come from? Well, that depends on where you live. You might be fortunate enough to live in a country that depends to a large extent on renewable energy resources (or at least gives you the option to source your electricity from such sources) – solar, hydro, wind, geothermal or wave for instance. But you might also live, as billions of people do, in a country that relies on coal or oil for energy production. Thus, to operate your devices, you are directly contributing to the coal economy and to further global warming via the CO2 that is emitted when coal is burned.

How can the negative effect be reduced? The answer is simple but painful: we need to keep our existing devices in use for much longer than we currently do. We need to avoid the temptation to update our devices as soon as the next version is available. Here devices include: phones, tablets, notebooks, cameras, electric cars and any other device with significant battery use. We can't eliminate the negative effects but we can reduce them.

3.1.1.2. Research agenda. I think that a valid research agenda has to include the concept of sustainability. Tan B. (2021) are currently editing a special issue of the ISJ on IS and Sustainable Development. They note that the 2015 UN Agenda for Sustainable Development includes 17 Sustainable Development Goals (SDGs) with 169 associated targets to be achieved by 2030 (United Nations Department of Economic & Social Affairs, 2015). These goals and targets constitute a research agenda in their own right, though not all are immediately applicable to IM/IS/IT. Meanwhile, Walsham (2012) argues that there is a need to undertake IS research that demonstrates how we can make the world a better place. To provide some other context, however, Clarke and Davison (2020) noted that almost no IS research, at least as published in the Association for Information Systems' basket of eight journals (EJIS, ISJ, ISR, JAIS, JIT, JMIS, JSIS, MISQ), included the environment as a key stakeholder or treated the environmental perspective as a matter of importance. Thus, the track record in IS is not particularly rosy. We have a long way to go.

3.1.1.3. Education. I teach Green IS issues to my MBA students: we identify and discuss issues concerning how green IS really is, including many of the issues raised in this editorial. We look at the topic from a policy perspective and consider what actions organizations can take to ensure that they genuinely adopt a green culture and implement green measures. This is particularly relevant to corporate social responsibility and the triple bottom line (Elkington, 1997).

3.1.2. Contribution 2 – digital platforms in combating climate change: user engagement tools and digital traces of climate footprints – Professor Ioanna Constantiou and Professor Morten Thanning Vendelø

In spite of the increasing awareness about the consequences of climate change, many individuals continue to fail in adjusting their behaviors and lifestyles in order to lessen their impact on the climate. While mottos like "think globally, act locally" urges people to consider the health of the entire planet and to take action in their own communities and cities, they do not seem to significantly contribute to combating climate change. Many individuals appear to experience difficulties in understanding how their behavioral patterns and choices affect the climate of the planet, although the most recent UN Climate Report shows that with no changes in greenhouse gas emissions the increase in the global temperatures will rise to 2.7 °C above pre-industrial levels by 2100 (United Nations Environment Programme, 2021). Hence, alternative means of influencing consumer behavior are required. Digital technologies can support individuals in developing connections between their behavioral patterns, and the ongoing changes in the global climate as well as identify and choose alternatives to these behavioral patterns (Schroder, Prockl, & Constantiou, 2021).

Digital platforms can support combating climate change by providing marketplaces where transactions can be made in more cost efficient and climate friendly ways, promote sustainable product innovation or inform consumers about their climate footprints. The abundance of data available to digital platforms can be used for activities that promote sustainable options and motivating climate friendly behaviors. For example, applications tracking user physical activity can quantify climate impacts and thereby nudge users to consider more sustainable options of public transportation (e.g., based on CO2 emissions of different means of transportation). Another area of interest is reduction of food waste. A number of digital platforms have recently emerged with related visions. Building on the logic of collaborative consumption and social entrepreneurship (Schroder et al., 2021), digital platforms such as Eat Grim provide a marketplace for selling vegetables and fruits that do not match industry standards based on appearance to consumers. Their aim is to change the consumers' perceptions of appearance related quality standards of what is edible and nudge their users to eat vegetables and fruits by focusing on other criteria such as freshness, or nutrition value of the vegetables and fruits. By redistributing these products to their consumers from restaurants or other retail shops, they reduce food waste. Another example is the digital platform Too Good To Go that connects customers to restaurants and stores, mainly bakeries, that have unsold food surplus. The surplus food is sold to consumers at discounted prices instead of being wasted. Finally, Plant Jammer is another platform that aims to reduce greenhouse gas emissions and fight climate change through sustainable cooking and plant-based food. Consumers reduce waste in their home by using ingredients that would normally be wasted due to lack of knowledge on how to combine through recipes in their daily meals.

These platforms provide multi sided marketplaces (Parker, Van Alstyne, & Choudary, 2016) governed by loose control mechanisms and apply pricing structures for cost compensation, hence display low intensity of competition (Constantiou, Marton, & Tuunainen, 2017). Based on the data they collect they can develop new mechanisms to engage users. Customer engagement, is a multidimensional tool, rooted in marketing and social psychology, and described as "the level of an individual customer's motivational, brand-related and context-dependent state of mind characterized by specific levels of cognitive, emotional and behavioral activity in direct brand interactions'' (Hollebeek, 2011, p. 790). These dimensions cover three key activities that can support consumer transition to more climate friendly behaviors. Techniques displaying a quantified climate footprint based on the individual behaviors that are tracked by platforms, could stimulate cognitive activities towards combating climate changes, for example considering the impact of specific food choices, e.g., daily consumption of meat. This can lead to behavioral changes when multisided platforms make more environmentally friendly options easily accessible and economically attractive as observed with platforms combating food waste. Finally, gamification or other nudging techniques that stimulate emotions, either positive or negative, can reinforce consumer engagement with different platforms combating climate

Table 1
Snapshot of adverse impact of ICTs on the environment.

SN	Select adverse impacts	Study
1	Carbon Dioxide emission related challenges increase with the use of ICTs (personal computers)	Miyamoto et al. (2001), Muregesan (2008)
2	Toxic disposal after use for old ICTs creates pollution in the land and water environment	Barba-Gutiérrez et al. (2008), Osibanjo and Nnorom (2007)
3	Electricity consumption increase by ICTs leads to the release of pollutants into the atmosphere.	Asongu et al. (2020), Tamburini et al. (2015)
4	Emerging ICTs requiring high processing power create higher pollution from high energy consumption	Howson, (2019), Stoll et al. (2019)
5	ICT components like microelectronics, sensors and actuators often have a short shelf life so land pollution challenges are faced while disposing them	Chakraborty and Gupta (2016), Nižetić et al. (2020)
6	Digital initiatives across firms and nations will have challenges towards managing disposal of ICTs, energy management and emission control while focusing towards sustainability	Ismagilova (2019), Singh and Sahu (2020)

Table 2
Snapshot of positive impact of ICTs on the environment.

SN	How can organizations using ICTs impact the environment positively?	Study
1	Green IT initiatives which involve changes in processed and routines impact adoption of IT in firms	Simmonds and Bhattacherjee (2012)
2	IT competency along enables integration of IT in environmental management in Green IT initiatives of firms	Wang X. (2015), Wang Y. (2015)
3	Leadership, along with environmental awareness lead to adoption of Green IT initiatives in firms	Ojo and Fauzi (2020)
4	Green IT audits enable movement towards ISO/IEC 33000 in terms of maturity models towards improved environment management	Patón-Romero, Baldassarre, Toval, Rodríguez, and Piattini (2021)
5	Universities may introduce Green IT in their curriculum for making larger impacts through sensitization of future employees towards Green IT initiatives	Marques, Bachega, and Tavares (2019)
6	Blockchain based smart contracts may enable trading in carbon credits and emission awareness across firms operating in a network	Howson (2019)
7	Blockchain may reduce energy consumption in IoT networks to enable greener IoT ecosystems	Sharma, Kumar, and Park (2020)
8	Collaboration ICTs and video conferencing systems reduce travel and indirectly save environmental pollution from vehicular emissions	Galanti, Guidetti, Mazzei, Zappalà, and Toscano (2021), Richter (2020)
9	Deep learning and big data analytics can be used for water and air quality management	Kushwaha, Kar, and Dwivedi (2021), Nair, Agrawal, Domnic, and Kumar (2021)
10	Influencers like CEOs and national heads can enable information sharing and subsequent adoption of sustainable initiatives among social media followers	Grover et al. (2019), Grover et al. (2021), Nyberg (2018), Yadav et al. (2021)
11	AI will improve environmental governance, safety and environmental risk reduction while focusing on information management for decision making	Nishant, Kennedy, and Corbett (2020)
12	Review of Green IS focuses on themes like energy-efficient computing, power management, data center design layout and location management, server virtualization, responsible disposal and recycling	Singh and Sahu (2020)

changes. The success of such mechanisms is reliant on increasing levels of user engagement with the platform where user behaviors can eventually be replaced with more climate friendly ones.

3.1.3. Contribution 3 – faith and climate change – Dr. Iyad Abumoghli

While the world's religious and spiritual traditions did not traditionally face climate change in the way society has come to know it since the mid-20th century, peoples throughout history have always lived through and had to deal with extreme and erratic weather events.

Comparable notions of climate change have been expressed in the world's different religions through their texts and teachings. There is no singular perspective or monolithic view of climate change within highly diverse faith and religious traditions. Within the same religion, adherents may hold different views and perspectives on climate change and humanity's relationship with nature. However, there are general perspectives developed in consultation with adherents of represented faith groups. Naturally, they are taken from those who accept the scientific consensus on climate change.

The Buddhist perspective on climate change, for example, is presented as the ecological consequences of our own collective karma. Therefore, it is not just an ecological crisis, but a spiritual one too. Within the broad sphere of Christianity, Pope Francis' encyclical Laudato Si, provides a high-level perspective on Catholicism's views on climate change. He argues that climate change is a global problem and that humanity has a moral obligation to address it at all levels of society (UN News, 2015). Climate change can be explained through the Daoist concepts of Ying and Yang. The carbon balance between the earth and sky is off balance causing instability and disasters. Thus, climate change can be viewed as a manifestation of humanity's failure to maintain harmony with nature. The Hindu Declaration on Climate Change states that "today we call on all Hindus to expand our conception of dharma (duty). We must consider the effects of our actions not just on ourselves and those humans around us, but also on all beings. Addressing climate change from an Islamic perspective, is about assuming the role as trustee or steward (khalifa) of creation that God bestowed upon humanity. This trusteeship applies to all life forms and ecosystems, in their full diversity and richness, reflecting the glory of their creator. Today, the balance (mizan) of nature has been disturbed by human activity and choices which have resulted in overconsumption, overexploitation and overuse of resources, ultimately leading to environmental degradation and climate change. Climate change is already manifesting itself in highly localized contexts, directly impacting Indigenous ways of life. Therefore, climate change does not just represent an abstract scientific issue, but rather a very real and dangerous threat to livelihoods and culture.

Adherents from all the world's religions and faith traditions agree that climate change represents an immense threat that must be overcome, for the sake of humanity, the environment and all living beings we share Earth with. This common understanding has led to an increase in faith, intrafaith and interfaith efforts to address it. These serve as an acknowledgment of the overwhelming scientific evidence that climate change is indeed human-induced. Faith actors can play a crucial role here given that faith permeates into all areas of life and can inspire the behavioral changes necessary to address climate change.

As a testament to growing faith engagement, in the lead-up to COP21, held in Paris at the end of 2015, many Faith leaders and organizations called on governments to take climate change seriously and commit to addressing it. This formed part of a much broader global advocacy movement that helped lead to the creation of the Paris Agreement and the climate measures contained within it. In October 2021, in the lead up to COP26, more than 40 faith leaders met at the Vatican and submitted a Faith Appeal to the president of COP26 linking Faith to Science and calling upon nations to increase their ambitions and committing their organizations to take action to reduce their carbon footprint. This process has been only effective in engaging faith leaders over a period of seven months through information technology systems and online capabilities of applications.

Table 3
Individual contributions.

Contribution title	Author (s)
Section 3.1: **Behavior and attitudes**	
Contribution 1: Climate Change and Information Technology	Professor Robert M. Davison
Contribution 2: Digital platforms in combating climate change: User engagement tools and digital traces of climate footprints	Professor Ioanna Constantiou and Professor Morten Thanning Vendelø
Contribution 3: Faith and Climate Change	Dr Iyad Abumoghli
Contribution 4: The Pros and Cons of IM/IT/IS on Climate Change and Future Directions	Professor Bhimaraya Metri
Contribution 5: The Role of Online Communities in Supporting Digital Activism on Climate Change	Professor Niki Panteli
Section 3.2: **Education, awareness & changed working practices**	
Contribution 6: Climate Change and the Emergent role of IS: An agenda for IS against the background of COP26	Dr Rohit Nishant and Dr Thompson S H Teo
Contribution 7: Dematerialization is so material! The contrasting impacts of IT on the environment and climate change	Professor Yves Barlette
Contribution 8: Emerging Technologies to Mitigate Supply Chain Disruption Due to Climate Change	Professor Manoj Kumar Tiwari
Contribution 9: Facing the negative environmental digital impact: time to change values?	Professor Frantz Rowe
Contribution 10: From cradle to grave - impact of IT on climate change and the relevant research agenda	Professor Ramakrishnan Raman
Contribution 11: How has the IT sector negatively influenced the environment? Remedies, role of IT education and future research agenda	Professor Nripendra P. Rana
Contribution 12: Technology, Information Systems and Sustainability: A Public Interest Research Agenda	Professor Katina Michael and Dr Roba Abbas
Section 3.3: Impact on people and communities	
Contribution 13: Promoting IT Innovation to Improve the Global Environment-Towards Establishment of Global Co-creation & Co-evolution Models	Professor Mitsuru Kodama
Contribution 14: Smart City Initiatives to Maximize Information Value for Sustainability	Professor Brenda Scholtz
Contribution 15: Wider Issues in IS Research on Climate Change	Professor Rahul De'
Section 3.4: Responsible digitalization	
Contribution 16: Corporate Digital Responsibility: The Powerful Offspring of Sustainability and Digitization	Professor Michael Wade
Contribution 17: Digitalization and the Myth of Sustainability: Some Critical Reflections	Professor Suprateek Sarker
Contribution 18: Systems for sustainable growth	Professor Maung Sein and Dr Leona Chandra Kruse
Section 3.5: **Role of data, technology & IS governance**	
Contribution 19: Climate Change and Role of Information Technologies	Professor Babita Gupta
Contribution 20: Climate Crisis Response: Dynamic Information Governance for Social Sustainability	Professor Deborah Bunker
Contribution 21: Climate Change – IT - Data Science perspective	Ms Jeel Dharmeshkumar Shah
Contribution 22: The IS/IT in addressing the challenges of climate change	Dr Matti Mäntymäki
Contribution 23: The value of information management in the built environment to tackle climate change	Mr Henry Fenby-Taylor
Contribution 24: What can Information Technology and Systems Researchers and Educators do to Mitigate Climate Change?	Dr Wu He
Section 3.6: **Technology & IS research agenda**	
	Professor Samuli Pekkola

(*continued on next page*)

Table 3 (*continued*)

Contribution title	Author (s)
Contribution 25: Holistically Missing: Climate change and information systems research	
Contribution 26: Information Technology and Climate Change	Dr Rameshwar Dubey
Contribution 27: Blockchain and Climate Change	Dr Daniela Andreini
Contribution 28: Towards a relevant agenda for climate crisis issues within information research	Professor Johan Olaisen

UNEP's Faith for Earth Initiative was founded to accelerate and solidify precisely this spirit of interfaith collaboration, ensuring that faith actors had a voice at the highest level of environmental governance and greater access to the UN system. The interfaith initiative introduces the cultural, spiritual and ethical dimensions of sustainable development that faith actors bring into the implementation of the SDGs, particularly those related to the environment. Since its founding Faith for Earth has hosted and participated in multiple interreligious conferences, workshops, webinars and events, encouraging faith actors to come together and tackle common issues of climate change and environmental degradation.

Faith actors can play an important role by providing a moral voice to the climate change crisis. Combining spiritual ethics with climate knowledge and science can serve to drive behavioral change amongst adherents, more than either one can alone. Substantial and widespread changes in public attitudes are essential to tackle climate change. Given that faith permeates into all areas of life, authoritative faith voices can be strong drivers in motivating people for action. Indeed, given that many religions already advocate environmentally friendly behaviors as part of their core values such as living with fewer material luxuries, caring for creation or dietary restrictions, there are strong traditions to draw upon. Faith groups across the globe are bringing religious teachings into thousands of projects on the ground to protect people and nature from the effects of climate change and pollution. By leading by example, FBOs can inspire positive action in communities to begin the transformation to a carbon-neutral sustainable society from the bottom up.

Faith-based organizations have been using information technology to communicate with the world and pass their messages online, either directed to their congregations or to others through mainly social media and networks. Sharing publications, articles and courses has become easier for the faith communities. Climate change campaigns are among the most active ones among the faith communities.

3.1.4. Contribution 4 – the pros and cons of IM/IT/IS on climate change and future directions – Professor Bhimaraya Metri

3.1.4.1. How the IM/IT/IS sector is having a negative impact on the environment and how it can be reduced. The IS/ICT sector is a net source of global greenhouse gas emissions. The data centers used to power digital services now contribute approximately 2% of global GHG emissions – on par with the aviation sector (UNFCCC, 2016). The digital technology industry is one of the least sustainable and most environmentally damaging industrial sectors in the modern world (Junior, Majid, & Romli, 2018). If we are aiming to utilize technology as a mitigating factor for climate change we need to reform the way technology is used at different sectors, causing substantial damages:

3.1.4.2. Replacement rather than repair. A consistent shift in the consumption pattern which pushes replace over repair is causing huge overheads on the environment. Companies like Apple are systematically discouraging self-repairs or repair at affordable prices thus pushing for replacement.

3.1.4.3. Software upgrades pushing hardware replacements. Innovation and upgradation in the technologies sector are simultaneously pushing the hardware upgrades. These upgrades often leave the legacy hardware unusable leading to e-waste.

3.1.4.4. E-waste. Increasing digitalization is giving rise to the problem of e-waste. Much e-waste contains concentrated amounts of potentially harmful products, and this shows little sign of abating. In the absence of clear policy on e-waste flow management (Frazzoli, Orisakwe, Dragone, & Mantovani, 2010), the world produces about 50 million tonnes of e-waste, with only 20% of it being dealt with sustainably (UN report, & WEF report, 2019, 2019).

3.1.4.5. Technology driving electricity demand. The overall demand for electricity from the digital technology sector is growing rapidly (Jones, 2018). It is further predicted that ICT networks could use about 20% of the world's electricity by 2025. The World Economic Forum (WEF, 2021) report stated, "by 2020, Bitcoin mining could be consuming the same amount of electricity every year as is currently used by the entire world". Currently at the start of 2020, Bitcoin alone has a carbon footprint of 34.73 Mt CO2 (equivalent to the carbon footprint of Denmark), it consumes 73.12 TWh of electrical energy (comparable to the power consumption of Austria), and it produces 10.95 kt of e-waste (equivalent to that of Luxembourg).

Future projections relating to Smart Cities, 5 G and the Internet of Things give rise to additional concerns over energy demand Carroll and Heiser (2010). The negative outcomes of IT on the environment are further going to be increased with the advent of these new technologies. Even proliferation of Satellite Constellations could be a challenge (David, 2017).

3.1.4.6. How IM/IT/IS can be utilized to improve situation regarding climate change. Recent reports have highlighted that IT/IS can lead to a more efficient and sustainable energy consumption using smart grids, smart housing and smart logistics. Statistics suggest a possible fifteen percent reduction in the emission of green-house gases- close to the annual emissions of China.

There are many initiatives to reduce energy consumption and carbon emissions. Japan's $32 million Green IT Project promotes highly energy efficient ICTs in three areas. It aims to reduce energy consumption of network components and data centers by more than 30%. And Japan is experimenting with organic light-emitting diodes to cut the power consumption of displays by 50% (GZR, 2020).

Technology can also offer cost-effective market-driven solutions, using sensors, software and networks. Technologies can also help monitor and evaluate climatic conditions and change and may help mitigate natural disasters. We also need to have supported policies and regulations for green energy. Supporting demand for green technologies is only one step. Certain pacts undertaken by regulatory bodies such as the European commission and united nations, also pave the way to regularize sustainable technology development. One such pact is the European Green Digital Coalition between the European Commission and United Nations Environment Programme.

We have to ensure that new technology development is cognisant of impending climate changes. One of the ways to enable technology development that conforms to environment and sustainability goals is for governments to penalize technology developers that fail to adhere to global warming constraints. Leaders in the IT sector need to ensure that new technology developments and innovations are guided by the Sustainable Development Goals (SDGs) prescribed by the UN. Further, government and regulatory authorities may promote climate friendly IT innovations by prescribing the necessary guidelines and incentives for better e-waste management and lower energy demands.

3.1.4.7. A brief discussion on research agenda related to IM/IT/IS and climate change. Climate-change mitigating technology is a wide research area where researchers are attempting to gain more insights into the technology portfolio which can be utilized to mitigate the climate changes such as carbon emission, energy consumption and e-waste (McLaren & Markusson, 2020; Wang, Li, & Sueyoshi, 2018). Some of the other relevant research areas are.

- Reuse/ recycle and sustainable manufacturing
- Closed supply chain and e-waste removal
- Reducing waste and efficient consumption using technology
- Monitoring of natural disasters using technology.
- Zero power ICT solutions
- e-waste management
- Circular economy
- Green IT
- Energy Management for data centers and telecommunication networks
- Leveraging data science and Artificial Intelligence for predicting climatic changes and natural disasters

3.1.4.8. How IS/IT education should reflect this. There is a need for including the impact of IT/IS on climate change in the curriculum across all disciplines (Perkins et al., 2018). There is a severe lack of awareness around the topics of climate change and how it connects to digitalization and technology transformations. There is a very swift adoption of new courses such as industry 4.0, blockchain technologies and IoT across premier educational institutions. However, courses discussing the flip side of these technologies in the context of climate change and sustainability are scarce. In addition to this, courses that introduce climate change mitigation technologies can be a good addition to start a conversation around climate change issues.

3.1.5. Contribution 5 – the role of online communities in supporting digital activism on climate change – Professor Niki Panteli

COP26 gives us the opportunity to reflect on our role as IS researchers on how IS/IT can support climate change. I draw on my personal interest and knowledge of online communities and digital platforms, to posit that IS has an enabling and empowering role in the promotion of climate change. My position in this editorial was triggered by an article in which the Swedish teenager and activist Greta Thunberg wrote in the Guardian (Thunberg, 2021), where she criticized world leaders for being in denial over the climate crisis. Indeed, there seems to be a catastrophic myopia among world leaders on current and emerging environmental threats and the challenges that climate change is causing to our planet. Instead of government and officials leading these debates, transparency of the challenges that humanity faces has been achieved by school children, teenagers and young adults around the world. The role of IS has been invaluable in providing a platform for these young activists to be heard, to form a community, to grow a collective voice and ultimately to lead on debates and protests and increase awareness on the climate crisis. A notable example of an IS-enabled climate change movement is the “School Strike 4 Climate” which was initiated and led by Greta Thunberg. Boulianne, Lalancette, and Ilkiw (2020) studied one of the school strikes in 2019 which was linked to this specific social movement and found that the online media in particular Twitter were used to share diverse sets of information such as local events, tactics for protesting, and opinions of climate change and blame of governments and other institutions for inaction and compliance on issues related to climate change. According to the same study, online platforms are transforming political engagement whilst offering the younger generation the means to express their ideas and voice their concerns to a global audience.

Activism has been portrayed as a collective action (Landzelius, 2006), which can be orientated towards challenging the status-quo, and putting pressures on world leaders, corporations, communities, groups and individuals to make much needed changes. Digital activism can maintain activism traditional characteristics namely its collective nature and transformational purpose (George & Leidner, 2019), whilst its dynastic feature is that it relies on the use of online media and digital platforms with the purpose of reaching global audiences and mobilizing large-scale protests worldwide (Askanius & Uldam, 2011).

Online communities (OCs) offer the ground for breeding activism as they provide opportunities for individuals who regardless of their location voluntarily form a social aggregation through an online platform for sharing interests, knowledge and experiences (Rheingold, 1993). OCs can be used for providing a shelter for their members (Vaast & Levina, 2015) and a sense of place where members feel empowered to freely express themselves and get involved in stimulating discussions (Panteli, 2016). The growth and sustainability of these communities depends on members' involvement. Mutual understanding among members (Ma & Agarwal, 2007) as well as group attachment and identification (Panteli & Sivunen, 2019; Ren, Kraut, & Kiesler, 2007) have been found to be crucial for OC success.

In our research on digital activism, we studied the case of MedicineAfrica, an online health community (see Chamakiotis, Petrakaki, & Panteli, 2021), which had the aim to provide medical education and improve clinical practices in fragile, post-war countries. Findings showed that it is not so much the technological affordances of digital platforms—namely to inform, to network and to organize (Tim, Pan, Bahri, & Fauzi, 2018)—but it is primarily their potential to set up an online collective of like-minded individuals that allows this form of digital activism to succeed. Similarly, Cardoso, Boudreau, and Carvalho (2019) posited that though digital platforms can be used to organize collective action, the extent to which these are successful depends on the capacities and intents of their members, which the authors referred to in their study as resourcefulness and agency. It is not surprising therefore that IS researchers have shown an interest in OC members' behaviors and practices, and how OC users interact with and influence each other within this online setting.

Founded by passionate and enthusiastic individuals, OCs can be used to develop networks of support as a way for responding to emergencies (e.g. Nan & Lu, 2014); indeed climate change is not just a phenomenon that deserves to be understood, but an emergency that requires immediate action. With an understanding that OC knowledge flows travel beyond the community itself (Mozaffar & Panteli, 2021), there is a need to explore the direction and distance of the knowledge flows generated within OCs on climate change, and the impact that these are making on individuals, groups, organizations and governments worldwide.

Further, digital climate activism offers the opportunity to study cross-generational differences on the use of online platforms and within OCs. Cross-generational differences have been evident in the use of social media platforms (Panteli & Marder, 2017) and a study on these differences is particularly relevant and topical with the increasing number of young digital activists globally. Research therefore on the interactions within OCs founded and led by teenagers and young adults should fall part of the agenda for future IS research. This should shed further light on who is indeed leading the climate crisis!.

3.2. Education, awareness and changed working practices

3.2.1. Contribution 6 – Climate change and the emergent role of IS: an agenda for IS against the background of COP26[1] – Dr Rohit Nishant and Dr Thompson S.H. Teo

Climate change is an existential threat facing humanity today.[2] The recent global pandemic of COVID-19 has brought an important

[1] Acknowledgment: We would like to thank Annapoornima Subramanian (NUS) and Shirish Srivastava (HEC Paris) for their useful comments and suggestions.

realization that humanity needs to be prepared for impending challenges such as climate change. Leaders from different countries assembled at *the 2021 United Nations Climate Change Conference*, also known as COP26, between October 31, 2021- November 12, 2021. Political leaders as well as business leaders are expected to commit to ambitious goals and targets relating to emissions reduction. This COP26 comes after the recent working group report titled “Climate Change 2021: The Physical Science Basis” as a part of the Sixth Assessment Report (AR6) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC). The report has been described as the starkest warning of irreversible and inevitable climate change (Harvey, 2021). The report is a call to humanity to come together and face this challenge, and academia also needs to focus on climate change.

The role of IS has become more pronounced due to the increasing digitalization of our society, accelerated by COVID-19 pandemic. Exponential technologies such as AI and ML have the potential to combat climate change (George et al., 2021). However, the success of any technology is dependent on the people and processes surrounding the technology. IS, being at the intersection of people, process, and technology, is therefore well poised to play a key role in combating climate change. IS research has been focusing on socially relevant issues as well as examining green IS (Nishant, Teo, & Goh, 2017; Watson, Boudreau, & Chen, 2010). These researches have highlighted both the positive and negative aspects associated with IS. Nevertheless, recent conversations surrounding climate change offer new opportunities and avenues to IS research to contribute to this fight against climate change.

These conversations and development surrounding COP26 are on specific goals and targets, economic models and recognition of specific areas as critical in our fight against climate change. Companies and different nations are increasingly talking about “Net Zero” where the addition of greenhouse gases (GHGs) to the environment is nullified by equivalent reduction of GHGs from the environment. Companies such as Microsoft are showing their commitment to net zero by paying for the removal of carbon dioxide from the atmosphere. However, net zero also faces several challenges including measurement (Joppa et al., 2021) as net zero requires precise, consistent, and automated measurement. IS research can contribute to this endeavor by focusing on how IT used for automated measurement can help companies achieve the goal of net zero. It can focus on processes that increase the effectiveness of IT as well as the design of IS that facilitates automated measurement.

Another related development is the Science Based Targets initiative (SBTi), which helps companies to set emissions reduction targets in line with scientific assessment in order to meet the goals of the Paris Agreement (limit global warming to 2 degrees Celsius above pre-industrial level and focus on efforts to limit warming to 1.5 degree Celsius).[2] Over 1000 companies are working with SBTi.[3] IS research can focus on understanding the role that the intersection of people, processes and IT is playing in SBTi. It can also focus on developing an understanding of conditions under which IT is effective in helping companies implement SBTi as well as challenges in leveraging IT.

Another development is the increasing focus on the circular economy as a new economic model. The inherent objective is to minimize waste as much as possible relative to a linear economy, where products ultimately end up as waste. IS research has started to focus on the circular economy, but the focus has been primarily on the potential of IS to facilitate circular material flows (Zeiss, Ixmeier, Recker, & Kranz, 2021). As data increasingly flows through the digital economy, data flow has its own carbon footprint and the proliferation of data can lead to redundant data. IS research can focus on how the idea of circular economy affects data generation and data flow, and how IS research can help minimize the carbon footprint of IS artifacts. Data also forms an essential component of AI/ML. As our society increasingly uses AI/ML and other exponential technologies, their own carbon footprint cannot be ignored. IS research can help companies and societies to redesign processes such that these technologies can be used effectively without damaging the environment.

In terms of recognition of specific areas as important in the fight against climate change, there is also an increasing emphasis on biodiversity. In fact, the COVID-19 pandemic has brought out an important realization that deforestation and loss of biodiversity can trigger new pandemics (Tollefson, 2020). Climate change can also facilitate zoonotic spillover (Rodó, San-José, Kirchgatter, & López, 2021). IS research has generally not focused on issues relating to biodiversity. Nevertheless, projects such as Half-Earth Project Map, that maps biodiversity exemplifies how IT can play a key role in conserving biodiversity. IS research can focus on the design of IS artifacts that support biodiversity. It can also focus on IS use for biodiversity conservation by companies, government, and different agencies and explore the factors that contribute to the success of such initiatives.

Besides research, the IS community can contribute by making students aware of issues relating to climate change. Other disciplines such as management are increasingly focusing on climate change related issues.[4] The IS community has contributed to increasing awareness of issues related to climate change through courses on green IS and IS for sustainability. The current debates surrounding climate change provide an opportunity to reaffirm our commitment. Students are increasingly interested in courses on data analytics, AI, and ML. We can make students aware that data, AI, and ML also have a carbon footprint, and thus they should be used in an optimal manner such that their carbon footprint does not diminish the benefits realized from them.

In summary, we see that IS research and teaching can make a strong contribution to our fight against climate change through a focus on issues that have become topical due to COP26 and increasing digitalization of society.

3.2.2. Contribution 7 – dematerialization is so material! The contrasting impacts of IT on the environment and climate change – Professor Yves Barlette

3.2.2.1. How the IM/IT/IS sector contributes to a negative impact on the environment and how it can be reduced. IT and IS correspond to dematerialization, but only to some extent. If we create digital copies of documents and save paper (and trees), we still have to store the data we create. Moreover, data which was stored on our devices (smartphones and computers) or on DVD/Blu-Rays, USB sticks (e.g., movies and music) or just broadcasted (radios and TV), are now increasingly decentralized ‘in the cloud’, i.e., data centers. Data exchanges also involve emails, texts, and all that we exchange using social media. Even if emails seem “old-fashioned” today, some companies can send the same message including 10 MB of attached files to 1500 employees, generating 15,000 MB, which will never be deleted for most of us. If these are ‘dematerialized’ and almost ‘virtual’ documents, they require storage, and instead of removing old data, the size of our mailboxes keeps on increasing and is measured today in GB.

Hence, streaming and data exchanges have become the norm. Instead of waiting for broadcasting by TV channels and watching a movie, or by radio listening to a song, each of us can separately obtain the content on-demand and stream the same song over and over. The Korean series “Squid Game” from Netflix generated such a huge demand, that SK broadband sued Netflix over the resulting surge in network traffic (Campbell, 2021). The rollout of 5 G will multiply by 100 the traffic capacity offered by 4 G and will in turn increase the volumes of exchanged data. Although the climate impact of streaming and data exchanges may have been overrated, they nevertheless remain

[2] https://sciencebasedtargets.org/faqs#what-are-science-based-targets.

[3] https://sciencebasedtargets.org/companies-taking-action#table.

[4] How MBA Programs Are Changing Amid Multiple Crises | Time.

significant (Kamiya, 2020).

To solve these problems, education seems to be the main solution, however, a tax related to bandwidth consumption could be created for streaming and cloud-based companies. This would in turn increase cost for users. Options such as a tax for other kinds of companies or even a tax on the users themselves could be created, specific to bandwidth consumption and/or storage volume. Storage rationalization, also known as "Green storage", is also a possibility. Google is able to show its users their carbon footprint within the cloud (Lardinois, 2021). However, these data exchanges and distant storage of data require data centers and data transmission networks:

First, company IT infrastructures, data centers and data transmission networks, including computers and storage, that must be manufactured. The manufacturing of computers requires a large amount of fossil fuels, chemicals, and raw materials. The mining of raw materials for electronic products includes copper, lead, and gold and contributes to increased environmental problems. For example, gold mines are the leading source of mercury air pollution in the U.S. (Gerson, Wadle, & Parham, 2020). Mining also pollutes the water of surrounding communities. When the various devices are discarded, they are sent to landfills overseas in Africa, China, India, Vietnam and the Philippines. Computers contain heavy metals like lead and toxic chemicals that pollute the soil and contaminate groundwater when they are dumped into landfill. Some solutions to mitigate these issues include (1) increasing recycling, (2) stopping greenwashing that includes cessation of waste recycling to countries that cannot actually recycle and (3) mitigate planned obsolescence and increase the reparability of devices.

Second, IT devices, data centers and data transmission networks need power to operate thereby generating significant levels of heat. Several possibilities have been tested, for example underwater data centers and data centers located in northern countries. This does not reduce the heat generated but at least reduces the required energy for cooling. Even if the problem related to heat is not addressed, the use of carbon-free but polluting energies such as nuclear, must also be solved.

3.2.2.2. How IM/IT/IS can be utilized to improve situation regarding climate change. I see several aspects:

- IT/IS permits the use of more efficient products and designs that save raw materials and energy. For example, digital twins can help to better design improved products, e.g., car batteries (Merkle, Pöthig, & Schmid, 2021).
- Processes can be more efficient and supply chains can be improved, reducing energy used during manufacturing, reducing fuel requirements and food waste during transportation.
- Big data analytics offer possibilities for precision agriculture, reducing water waste, use of fertilizers, pesticides and other pollutants.
- Work-from-Home possibilities, reducing business trips, encouraging 'virtual' companies.
- Super calculators allow us to improve weather models and offer insights on what factors are the most important to regulate climate change.
- The solution to controlled thermonuclear fusion power, could solve the energetic component of IT/IS impact on climate change. Fusion is only possible when scientists are able to compute the shape of magnetic confinement devices of Tokamaks and Stellarators (Klinger, 2021) or to perform simulations.

3.2.2.3. Research agenda related to IM/IT/IS and climate change.

- Improving methodological innovations in greenhouse gas emissions calculations.
- Improving weather models to mitigate climate change and risks related to this change.
- Development of awareness campaigns dedicated to mitigating our personal and professional environmental impacts related to IT and IS.
- Increasing the conception and use of new big data analytics tools to mitigate the impacts of our society on climate change.
- Developing charters in companies including best practices (see below).
- Developing tools for smart buildings (lighting, heating, ventilation) and energy management (statistics, diagnostics).

3.2.2.4. How IS/IT education should reflect this. IS/IT education could act in several ways:

- Disseminate knowledge and create awareness-raising campaigns about the negative impacts of IT/IS on environment and how they can be reduced by adopting best practices including for example:
  - Automatic sleep mode and turning of the devices during nights and weekends.
  - Workers and home users should know that 'dematerialization' and 'virtualization' does not exist and that data is always 'materialized' somewhere.
- Future CIOs and members of IT staff should be offered during their education awareness-raising campaigns, including the same as above plus IT/IS-specific elements: for example, the fact of checking that all audiovisual devices are turned off every evening. The same for all the laser printers in a company, even if some monitoring is deactivated. Turning off the monitors of their computers, even if some systems must always run.

3.2.3. Contribution 8 – emerging technologies to mitigate supply chain disruption due to climate change – Professor Manoj Kumar Tiwari

Climate change has become one of the most important concerns in recent years at nearly all tiers of decision-making. Climate change is a set of worldwide phenomena caused mostly by the burning of fossil fuels that release greenhouse or heat-trapping gases into the atmosphere such as methane, carbon dioxide, chlorofluorocarbons, water vapor, and nitrous oxide. These factors have resulted in changing global weather patterns, with frequent occurrence of hurricanes, droughts and rising temperatures causing habitats to vanish, and altering ecosystems. Climate change has a worldwide impact. As a result of such calamities, homelessness is on the rise, putting vulnerable communities at risk of food insecurity, disease, and civil upheaval. Climate change, as a result of global warming, is a universally acknowledged reality that affects human, industry, business, and the environment in a variety of ways.

Supply chain and Logistics providers among all the industries being aware of the consequences of climate change are most conscious about the deterioration happening due to variation in weather patterns, storms, altered sea routes, and environmental changes will all have a significant impact on their operations, forcing them to alter conventional business models and trading routes. If logistics companies are on the front lines of climate change, they are also huge contributors to the crisis. Transportation industry accounts for nearly 25% of all CO2 emissions from fuel combustion around the world (IEA, 2019). While value addition to the product as it passes through the supply chain, each SC link causes environmental deterioration, especially climatic pollution, via GHG emission. In return, each channel in the supply chain faces opportunities and risks in the form of severe occurrences such as waterlogging or windstorms, higher temperature, soil erosion, rising sea levels, storms, impact on local weather conditions, increased storm frequency and intensity, drought, and so on. As a consequence, both climate change and supply chain activities are simultaneously impacted.

Mitigation (cutting emissions) and adaptation (preparedness for inescapable circumstances) are two aspects of dealing with climate change. Both of these challenges are multidimensional. To reduce greenhouse gas emissions, changes are required in power grids, buildings, transportation, land use and industry. Given a better knowledge of climate and catastrophic occurrences, adaptation necessitates disaster management and resiliency. Presently, Machine learning (ML) has gained popularity as a versatile tool for technological advancement. Artificial Intelligence (AI) and ML techniques can contribute to reduce emissions in several ways such as by speeding up the development of low-carbon technologies, better demand predictions, reducing system waste, remote sensing, improving energy efficiency, vehicle emission estimation from smartphone GPS traces, single building optimization, identifying behavioral patterns, and planning and operating low-carbon infrastructure.

The impact of information and communication technologies (ICTs) is becoming more essential as people become more aware of climate change and its obvious implications. It provides simple and faster problem resolution using simulations and a large variety of different options. Climate change concerns can be monitored, mitigated, and adapted with the use of ICTs. Some inventions of ICTs are Wireless Sensor Networks, Satellite Technology, GIS, Remote Sensing, Mobile Technology, and Web-based applications. Climate change mitigation and adaptation can be more efficient and successful with the use of ICTs, if integrated strategically; it contains knowledge centers, mobile phones, and interactive media. By educating and raising awareness at the community level, sharing theoretical and practical knowledge, and empowering people to have access to knowledge and relevant data, it can assist vulnerable populations in reducing the risk of climate change. Micro-sensor Wireless Network is among the most prominent technologies in the twenty-first century, with a wide range of applications. Commercial or human-centric applications, robotics, military applications, and environmental monitoring are all using the applications of wireless sensor networks. Sustainable Environmental Management Information System (IS) can maintain the decision-making process for supportable climate control and develops Earth-friendly design. Emergence of big data and AI/ML techniques allows climate solution research to design policy and its implementation at the building and household scale, street, urban areas, modified to specific circumstances but scalable to worldwide mitigation possibilities.

Furthermore, the wide application of ICTs also adds to the depletion of limited energy supplies and the increase in greenhouse gas emissions. It is one of the causes contributing to rising CO2 levels for producing ICT machinery and devices, energy usage, and electronic waste recycling. We are living in a phase of rapid transformation, where technological advancements are transforming the way of our living, at the same time directing us to face several challenges in the form of climate change and resource scarcity. Although these technologies contribute to greenhouse gas emissions to some extent, they aid in the reduction of considerably larger amounts released by all other industries. By establishing smarter cities, industrial processes, electrical grids, transportation systems, and energy savings benefits, ICT can cut CO2 emissions on a worldwide scale. ICT may be used to investigate and manage natural resources in a variety of ways, both locally and worldwide. As a result, information and communication technologies constitute a critical component in combating climate change and mitigating its effects. Some ICT tools used to mitigate climate change are:

- Computer-controlled devices are used in a variety of ways to reduce energy consumption in the home, at work, and in manufacturing;
- Telecommunications are critical in response to natural calamities caused by climate change;
- Sensor networks can be used to monitor vulnerable or dangerous environments.
- Satellite observations give critical information on climate and vegetation trends. Oceans and land can be monitored by sensors either on the ground or remotely through satellite. The state of the atmosphere can be examined for wind currents and greenhouse gas emissions that may indicate the impending arrival of a storm. Data on tsunamis and sea-level changes can be communicated via satellite via ocean buoys.
- Geographic information systems can understand and visualize data.
- Better study and modeling of complex environmental and climate systems are possible due to increased computing capability and innovative techniques.
- Distributed (grid) computing helps scholars to dig deeper into themes.

Natural catastrophes affect around 200 million people each year, according to United Nations figures. ICT plays a critical role in providing early warnings for natural disasters. It provides essential data on the effects of climate change that might lead to disasters, in addition to the usage of sensor networks to monitor hazards such as active volcanoes. Among these include increasing sea levels, depleting freshwater resources, deforestation, and ecosystem concerns. The Famine Early Warning System Network is one example of how ICT may help. Its goal is to reduce the possibility of food shortages by alerting people to early warning signals of famine. The system monitors and analyses data about climate and weather, as well as their impact on crops, utilizing information technology. The data is subsequently delivered to decision-makers in the form of monthly food security updates, predictions, and alarms, as well as assistance with emergency preparedness and long-term policy decisions. A variety of sensor systems created for weather monitoring (ocean buoys) and earthquake detection are used in tsunami warning systems (seismic sensors). Data is collected and delivered into real-time analysis and detection systems via satellite. Grid computing makes it possible to share data in order to do in-depth analysis. The Global Earth Observation System is available for all policymakers to get access to the data. There are free programs that allow us to zoom in on satellite photos that map the world. Geographic information systems (GIS) are one of the most powerful — and extensively used — tools for visualizing environmental data. Overall, using technology into climate change assessment, prevention, and adaptation can help save the ecosystem from damage and degradation.

3.2.4. Contribution 9 – facing the negative environmental digital impact: time to change values? Professor Frantz Rowe

To examine whether and how the IT sector can have a negative impact on the environment, following the evolution of our awareness of the issues, I will address first the aspect of the question which concerns how the use of IT products is affecting the environment, before turning to the issue of IT production itself.

The world has drastically changed since the end of the last century. In the 1980s, the first oil crisis was just behind. Society, including researchers with my transportation engineering and my economics background, saw enormous benefits in telecommunications to reduce transportation negative impacts on the environment such as pollution and CO2 emissions. Our first studies on the use of the telephone in households, that had been adopted lately in France in the 1970s, demonstrated some substitution effects on urban trips. However, the main lesson was that, at the scale of a large city, a) the net substitution effect was low since the telephone also induced some trips, and b) the main effect of telephone-transportation interactions was an accompanying or “management” effect (Claisse & Rowe, 1993). Unless we take and accept restrictive measures on our liberties to move, like the recent lockdowns, the effects of new communication tools such as video conferencing meetings, will not reduce transportation demand. This is notably due to an induction effect linked to the opportunities and more largely to a “digital rebound” effect (Coroama & Mattern, 2019), whether for business or social life, generated by interactions with communication technology. Hence my spontaneous answer to the question - how can (the) IT (sector) have a negative impact on the environment? - is that, unless we voluntarily reduce our activity and do less, the only significant gains from IT use will occur if we can reduce the negative impacts related to the efficiency of transportation systems. This means that we should design transportation systems so that their use is more environmentally efficient, i.e. they pollute less than others when used and have the best possible environmental footprint (for instance in terms of CO_2 emissions) when produced (Teubler, Kiefer, & Liedtke, 2018). Typically IS researchers can contribute to such “green” designs for “greener” use by examining how IT/IS can help support the use of such transportation systems and more generally support more environmentally efficient supply chains. We looked at this, studying how Carrefour had redesigned its supply chain, but gains were not spectacular (Antheaume, Thiel, de Corbière, Rowe, & Takeda, 2018; de Corbière, Takeda, Habib, Rowe, & Thiel, 2016). This revision of the supply chain is what we would call a " second order " revision. It involved using IT based solutions to improve the use of trucks and supply chain restructuring with an additional layer of consolidation centers. It did not involve “first order” transportation modes improvements such as the use of trains, or river-boats which generate fewer GHG emissions per t.km but may be more expensive, at least to start with. This is because what corporations seek is to be more efficient economically, while ideally showing that they are environmentally conscious. However, in the large retailing industry for instance, becoming environmentally efficient is not their main concern. Unless they are forced to do so, they will not really optimize CO2 emissions or other environmental indicators. A set of interviews on the impact of e-commerce on retailers supply chains shows that senior managers just want to be politically correct (de Corbière, Durand, & Rowe, 2010). However, we believe that the potential of information systems to reduce pollution is very large. Here again, we can distinguish between first order and second order changes. First order changes might be, for example: “combined truck-train transport, where for long distances trucks will travel on train carriages (as is done in Switzerland), or assisting with local manufacturing solutions, based on 3D printing, rather than subcontracting to a third party in another country. These first order changes also involve challenges which IT can help resolve. Second order changes might be, for example, to control cargo or to optimize vehicle routes regardless of the type of transportation mode considered. Regularly, containers are lost at sea and cargo and ships can be better controlled before their cargo falls overboard. Satellites, RFID technologies and web portals can be important to support these aims. There are many other avenues for improvements in that direction. But again, the issue is not just about what type of digital technology we should invest in to help traditional businesses reduce their environmental impact; what counts is to find appropriate production solutions and institutional mechanisms so that firms really aim at reducing harmful emissions in a significant manner and not always put profitability first.

Like the retail or transportation industry, the problem is that the IT sector itself is engaged in a worldwide competition where profitability and convenience innovations for the consumer are key. Typical of these innovations the smartphone is only 14 years old, but its appearance also has very negative implications simply because it needs to be produced and incorporates rare materials that are extracted in terrible conditions in some African and Asian countries. In short, the ecological imprint of IT may be negative because IT products also have drastically changed: by becoming “smart”, and more precisely due to the introduction of manipulable screens, our telephones have also become very destructive of scant resource (Ritthof, Rohn, & Liedtke, 2002). In parallel the speed at which we renew corresponding infrastructures such as 5 G and soon 6 G won’t help. Our dream of the world being cleaned from pollution by an immaterial economy was just a very naïve dream. Many other examples abound such as servers farms for the cloud and other data centers that demonstrate huge environmental costs. Worse than that with the internet of things, machine to machine communication, automated vehicles and bots in finance may make environmental pollution uncontrollable or at least many times superior to that created with human-controlled processes. For instance, researchers recently demonstrated that training an artificial intelligence could explode CO2 emission costs (Strubell, Ganesh, & McCallum, 2019). Not only are we exhausting resources, but there are huge geopolitical implications related to the sometimes unique locations of these resources on the planet and related to where chips or materials for certain of our digital equipment are produced (to the extent that children’s lives are destroyed as in Congo, see Lebrun, 2020). These geopolitical risks may in turn generate other ecological risks because we unfortunately know that wars are never clean.

Unless we take and accept measures to get sober in what we consume and what we produce, digitization alone may not be such a good solution for saving our environment. This goal implies making value choices (Rowe, 2018) and requires rethinking the design of our activities at multiple levels in an interdisciplinary and systemic manner (Nishant et al., 2020).

3.2.5. Contribution 10 – from cradle to grave – impact of IT on climate change and the relevant research agenda – Professor Ramakrishnan Raman

3.2.5.1. How the IM/IT/IS sector is having a negative impact on the environment and how it can be reduced. IT and its applications have made business processes efficient, but the rapid growth of technology and its applications has also negatively impacted the environment. Whilst green IT practices have advocated to minimize the negative impact of IT on the environment, there is still a huge scope for changes to be brought into manufacturing, logistics and operations, usage and disposal of information technology equipment, which can make every process sustainable and environmentally-friendly.

Manufacturing of Information technology products can be environmentally-friendly if the production adopts environmentally friendly processes. Process innovation is needed which can help in creating products which use fewer natural resources and also reduce pollution. Recycling and reuse of material and zero emission should be the goal of every IT manufacturing process. IT manufacturing can become environmentally friendly by using energy from renewable sources and also by focusing on energy efficiency. Innovation in business processes that can help in achieving zero pollution, remove greenhouse gas emissions and also eliminate waste. Focus on conserving natural resources can help in making manufacturing of Information technology products environmentally-friendly.

Logistics and supply chain processes used by the IT sector cause hazardous air emissions and greenhouse gas emissions. Logistics and operations can be environmentally-friendly if manufacturers shift to green suppliers and partners who provide green logistics and supply chain processes and also handle reverse logistics. If organizations focus on consolidated shipments and reduce packaging by redesigning products, it can immensely help in reducing the negative impact on the environment.

IT products have an impact on the environment even during the ‘use’ stage of their life cycle. The energy consumed by the product, the lifetime of the product, the heat dissipated and the digital frequency noise have a negative impact on the environment. Creating products that are more durable and reusable can help the environment. Less resource intensive gadgets which work with low power and solar power and IT gadgets will not only help protect the planet but also will help in the well-being of all.

Responsible and environmentally friendly disposal of IT products can help the environment. In several developing nations the practise of disposing IT waste in landfills is the most popular disposal method, which has a colossal negative impact on the environment. Stringent regulations applicable for every end consumer, which mandates safe disposal of e-waste to certified e-waste recyclers can help in reducing the negative impact of IT disposal on the environment.

3.2.5.2. How IM/IT/IS can be utilized to improve situation regarding climate change. Application of IT can immensely help in managing climate change. Use of IT while developing smart cities can help reduce annual global greenhouse gas emissions. For example, smart energy meters and smart electric systems help in managing climate change by optimal use of energy consumption. This in turn can also help in smart electric grid management which helps in reducing the losses. This is a simple example to showcase the use of smart IT systems which can help utility companies, end-users and society at large and also help also in managing climate change. Internet and Internet technologies are a force to reckon with for managing climate change. IT can infuse intelligence in transportation and logistics and make them smart. The Internet of Things (IoT) can make the supply chain smart and agile and hence can help in reducing the emission of greenhouse gases. Internet and Internet technologies can also help in monitoring the environment to reduce energy use in real time. IT can be used to harness and create green homes, green industries and hence can help in managing climate change.

3.2.5.3. A brief discussion on research agenda related to IM/IT/IS and climate change. Information Technology and Internet of Things (IoT) are vital in confronting climate change problems and help in managing the threats posed by climate change. IT and IoT are part of the solution as their applications are being used to cut greenhouse gas emissions and they help countries manage climate change. IT and IoT are needed for precipitous transfer of information concerning risks of climate change. In this context a few questions which need deeper research include - How can information needed for decision making be collected and disseminated in an efficient manner which can help to advance the integration of climate risks into plans and policies, which can be useful for those who need it most? How can a low-cost IoT infrastructure be created in the urban and rural areas of developing countries which can enable authentic and speedy dissemination of real time data related to greenhouse gas emissions? How can IT and IoT be used to enable countries to adapt to climate change?

3.2.5.4. How IS/IT education should reflect this. Education is vital in enabling people to understand the impact of climate change on life on this planet. Educating and creating awareness can help to change the attitude and behavior of people. Education alone can help in ensuring that people start adopting a sustainable lifestyle and also develop skills that can help in managing climate change. Education can not only inspire people to change their attitudes and behavior, but also helps them to make informed decisions which can have an impact on climate change. A deep-seated shift in pedagogy is needed for IT and IoT to enhance teaching and learning for sustainability. Teaching about climate change needs an interdisciplinary and cross disciplinary approach to synthesize diverse ideas. The information about climate change and its impact must be introduced within the school curriculum. IT must be used to create interactive activities on climate change which can help students to understand and learn in a better fashion. Projects related to sustainable development and climate change must be introduced at the high school level. IT tools which can help measure carbon emission must be taught along with practical application of the same. Teaching and learning which has hands-on experiences with technology must be emphasized. At the undergraduate and graduate level, educating and giving opportunities to students to work on environmentally sustainable projects to attain sustainability objectives using IT and IoT technologies can immensely help in bringing out of the box solutions to climate change problems.

3.2.6. Contribution 11 – How has the IT sector negatively influenced the environment? Remedies, role of IT education and future research agenda – Professor Nripendra P. Rana

3.2.6.1. How information management (IM)/information technology (IT)/ information systems (IS) sector have any negative impact on environment and how it can be reduced?. The IT sector is constituted of companies that produce software, hardware or semiconductor equipment or the companies that provide Internet or related services (Miller, 2021). Technological advancement has transformed the way we live our lives. Many would argue that the growth of the number of electronic devices such as laptops, desktops, high performance computing servers, and other most powerful data-intensive computing solutions (e.g., supercomputers) have brought us numerous benefits, there is no denying that the proper and continuous functioning of these technologies have come at a cost to the environment (Okafor, 2020). The heavy use of these devices present concerns when it comes to resource use, energy use, carbon footprint and waste. The negative impact of the IT sector on the environment could well be traced right from the manufacturing of these devices as a large proportion of materials come from finite natural resources and precious metals. Procuring raw materials and precious metals for manufacturing technological devices and electronic equipment comes with a high carbon cost usually powered by fossil fuels, deforestation, landscape degradation, water pollution and the release of vast quantities of carbon dioxide into the air (Mensah et al., 2015). For example, silicon, plastic, iron, aluminium, copper, lead, zinc, tin, nickel, barium are some of the most important materials used for manufacturing the technological equipment for which the mining of these poses serious threats to our environment (Williams, 2010). Similarly, manufacturing of these equipment requires massive energy to convert them into complex and sophisticated technological products. Subsequently, the transportation of these finished products also comes with a high carbon cost. Finally, massive servers and data warehouses that enable these technologies to work also consume a vast amount of energy and this threat does not stop there. These products also pose setback at the end of their lifespan and globally we throw away electronic waste (e-waste) of approximately $62.5 billion every year and only one-fifth of the electronic waste generated globally is currently formerly recycled, which undoubtedly an enormous threat to the environment (Amos, 2020; Okafor, 2020).

It is therefore very evident that the entire lifecycle of technological evolution to disposition adversely affects the environment and technological companies are largely responsible for this threat. This negative impact of the IT sector on the environment could be reduced to a certain extent by adopting the responsible practices of the circular economy, which signifies reusing some of the raw materials of the disposed equipment for a more sustainable approach to consumption. The governments and local authorities also have the larger responsibilities by legislating the circular economy model, promoting eco-friendly manufacturing and by adopting a responsible way of sustainable consumption. This could be achieved by implementing effective laws and regulations on e-waste (Geissdoerfer, Savaget, Bocken, & Hultink, 2017).

3.2.6.2. How can IM/IT/IS be utilized to improve climate change?. Technological developments – particularly the discovery of use of fossil fuels, have contributed to climate change. Rising temperatures are essentially blamed by scientists for human-generated gases (primarily CO_2), concentrations of which have been enhanced by almost 50% since the industrial revolution started. Innovations such as carbon capture, utilization and storage technologies are being used to reduce CO_2. During the time of the Coronavirus pandemic, many office jobs were being done from home resulting in reduced emissions of CO_2 from transport and office buildings (Sky News, 2021). The technological innovations to support remote working has been swiftly embraced as businesses endeavored to manage the effect of Covid-19. Greater use of data centers and cloud computing services by some of the leading technology giants including Amazon, Google and Microsoft are also an example of energy efficient services. With many of the latest technology efficient products such as smart LED light bulbs, smart outlet and power adapters, smart thermostat, etc. responsible for reducing energy consumption available in the market not only help households to save decent amounts of money in their annual bills but also reduce the CO_2 emissions (Oberhaus, 2019).

3.2.6.3. A brief discussion on research agenda related to IM/IT/IS and climate change?. Although the technology improvement with an environmental attribute reduces overall CO_2 has been discussed in the prior research, how the role of technology change in lowering carbon emission intensity needs to be further researched for the overall reduction of CO_2 (Li & Wang, 2017). While the low-carbon energy technologies contribute toward mitigating climate change (Schmidt & Sewerin, 2017), there is a need for further research on how social-psychological factors, lifestyles, behavioral patterns, etc. will help organizations and individuals to adopt such technologies that can reduce the CO_2 emission and serve toward the climate change. The future researchers could also look to explore the adoption of such technologies in different contexts for both well-aware and less aware consumers about using such technologies for the purpose of supporting climate change action. Future research can also explore individuals' pro-environmental behavior toward using such technologies.

3.2.6.4. How IS/IT education should reflect this?. Information technology education could be a key component of raising awareness of climate change mitigation and adaptation. One suggested solution could be the collaboration between the scientists and the students at the pre- and post-college levels to make them aware of how modern emerging technologies could help reduce hazardous emissions and reduce the threat of global warming. The pre-college school system is the right place to disseminate such scientific information on the key global climate change issues. School teachers should be provided with the necessary advanced level of educational and hands-on training from scientists from local research bodies on climate change and governments should take the necessary steps to make it a part of the curriculum. Climate change is not only the knowledge that should be taught to children right from an early age, but they should also be made aware of how to responsibly use technologies in a way that helps reduce carbon emissions becoming ambassadors for sustainable living.

3.2.7. Contribution 12 – technology, information systems and sustainability: a public interest research agenda – Professor Katina Michael and Dr Roba Abbas

3.2.7.1. The negative impact of technology and information systems on the environment. The coupling of natural and human systems is defined by highly integrated and complex system dynamics resulting from human-nature interactions (Liu et al., 2007). This has presented significant global challenges and wicked problems (Brown, Harris, & Russell, 2010; Buchanan, 1992) that require immediate attention in view of sustainability, particularly given the centrality of technology and information systems (IS) to these interactions. A multifaceted feature of the natural system that is integral to all forms of life is biodiversity, which can be considered at three levels: genetic diversity, species diversity and ecosystem diversity (Chapin III et al., 2000). Biodiversity is both implicitly and explicitly linked to health and wellbeing, in addition to sustainable development programs (Naeem, Chazdon, Duffy, & Worm, 2016; World Health Organization & Secretariat of the Convention on Biological Diversity, 2015). Human actions, notably decisions concerning technology and information systems, increasingly impact biodiversity. In line with the 26th UN Climate Change Conference of the Parties (COP26) Sustainability Governing Principles, there is a pressing need to engage in deliberate management of potential environmental impacts to encourage inclusivity, health and sustainability (UN Climate Change Conference UK 2021).

Adverse impacts on the natural world resulting from existing and emerging technologies and IS can be described as negative externalities (Dasgupta & Ehrlich, 2013; Perrow, 1991). The field of environmental economics, among other things, involves the study of externalities that generate tangible and intangible costs to the physical environment and its inhabitants (Cropper & Oates, 1992). It is often difficult to quantify these costs given the reach of an incident, and the extent of its irreversible impact. For example, significant oil spills cause major externalities that cannot readily be measured, such as the Deepwater Horizon oil spill, which was estimated to have spilled 4,900,000 barrels of crude oil into the Gulf of Mexico in 2010 (Beyer, Trannum, Bakke, Hodson, & Collier, 2016). There are two main types of negative externalities; the first refers to negative production externalities that can cause, for example, air or water pollution through manufacturing plants powered by technology and other forms of engineering; and the second denotes negative consumption externalities that can cause for instance, traffic congestion and noise pollution that are generated by systems (Biglan, 2009). Externalities caused by technologies and IS may be unanticipated, unintended, and even paradoxical (Pringle, Michael, & Michael, 2016).

Unanticipated externalities refer to those incidents and system failures that were not factored into scenario planning and risk management processes during systems design and development, such as the Fukushima Daiichi nuclear disaster whereby a substantial wave surged over defences and flooded reactors causing major radiation leakage (von Hippel, 2011). Unintended consequences of technologies and IS are those that were discounted as potential outcomes of a respective system, but nonetheless transpired (Ash, Berg, & Coiera, 2004). An example is the use of irrigation systems for crops, which subsequently contributes to soil erosion and increased soil salinity (Khan, Tariq, Yuanlai, & Blackwell, 2006). Conversely, paradoxical externalities emerge from attempts to use technologies and IS for advantage and benefit, but where the result is a negative outcome on another aspect of the environment. An example is the introduction of Internet of Things (IoT) devices to monitor energy systems to lower consumption that requires the devices to be powered and over time to be replaced, causing often toxic and non-biodegradable e-waste that is disposed of in landfills (Mukhopadhyay & Suryadevara, 2014).

A common element underpinning these types of negative externalities is the impact on public resources that are shared by communities (Pigou, 1920). These include the ocean and its fisheries and clean drinking water, amongst others, leaving individuals and communities vulnerable, potentially compromising their health and wellbeing. Furthermore, these undesirable impacts extend to the natural system and environment. These impacts can be linked to technologies and IS that do not suitably consider socio-ecological and socio-technical considerations, and that fail to recognize the value of design, testing and validation, with sustainability and people in mind (Chen, Boudreau, & Watson, 2008; Trist, 1981).

The mitigation of the undesirable consequences of existing and emerging technologies and IS necessitates intervention in the form of sustainability transitions (Loorbach, Frantzeskaki, & Avelino, 2017; Smith, Stirling, & Berkhout, 2005), moving beyond the existing multi-level perspective (Geels, 2004, 2011) toward transdisciplinarity. At the heart of these transitions is the establishment and socio-technical (re)design of higher education frameworks resulting in new forms of knowledge production, allowing for the design and redesign of human-centered socio-technical systems for sustainability, and consequently for human benefit (Geels, 2010; Verbong & Geels, 2010). The proposed socio-technical intervention would require commitment to a series of stages or flows, as depicted in Fig. 1, which we define as the Socio-Technical Sustainability Design Cycle. These include: (i) establishing a detailed understanding and conceptualization of the tightly coupled natural and human systems in context and in view of interactions and feedback loops; (ii) implementing the appropriate sustainability transition through a process of socio-technical (re)design; (iii) measuring the effect of the design over time in view of the degree to which negative externalities are reduced or mitigated; (iv) assessing the impact on human health and wellbeing, in addition to environmental sustainability; and (v) iterating to ensure continual evaluation of the tightly coupled system given its evolving nature. It should be noted that despite this proposed cycle, there will be cases in which paradoxical externalities occur, which is an inherent and unavoidable characteristic of tightly coupled systems. This occurs for two reasons: (i) events in nature are not always predictable no matter how "controlled" the socio-technical transitions are through, for example, regulation and policy mandates (Smith et al., 2005), and (ii) interventions themselves are a form of "technology" that are subject to independent and autonomous forces that are "uncontrollable" (Winner, 1978).

3.2.7.2. Sustainability transitions through transdisciplinarity. The proposed model suggests that our global challenges and significant problems require a transdisciplinary lens, beyond a multi-level perspective, in which design interventions are required in the form of sustainability transitions. Within this model, the information systems discipline has a significant and mediating role given its socio-technical orientation and appreciation of the open systems paradigm (Scott & Davis, 2015; von Bertalanffy, 1950; Watson et al., 2010). For instance, step (ii) in Fig. 1 would markedly involve a redefinition of technological and information system design and development processes (Schoormann, Stadtländer, & Knackstedt, 2021), characterized by the emergence of a supportive human-centered, transdisciplinary educational framework (Crow & Dabars, 2015) oriented toward a public interest technology (PIT) research agenda (Abbas, Hamdoun et al., 2021; McGuinness & Schank, 2021; Michael & Abbas, 2020).

Transdisciplinarity, in the context of the proposed sustainability transitions, typifies trans-institutional, trans-sectoral and trans-national frameworks bringing together at a minimum industry, government and academia toward the production of knowledge (Crow & Dabars, 2017, p. 474; Hadorn, 2008). This involves recognition that while all problems are local and community focused, their impacts are increasingly global, given the age of entanglement we now live in (Hillis, 2016 as cited in Crow & Dabars, 2020, p. 381), and the tight coupling of natural and human systems, as described above. In considering sustainability transitions more specifically, the proposed Socio-Technical Sustainability Design Cycle would promote Public Interest Technology (PIT) research, empowering citizens and communities (Pitt, Michael, & Abbas, 2021). It would additionally emphasize the importance of directing attention to highly integrative basic and responsive (HIBAR) research (Crow & Dabars, 2020, p. 376), which is still lacking internationally, despite the creation of globally oriented goals such as the United Nations Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) (World Health Organization, 2015). In transitioning to HIBAR research and practice that requires PIT processes and innovations, we are seeking to recognize negative externalities and to continually strive to reduce them by introducing alternative socio-technical design options in each selection environment (Nelson & Winter, 1977, pp. 61–70).

3.2.7.3. A public interest technology research agenda for sustainability. A preliminary phase in operationalising the proposed design cycle and implementing sustainability transitions is the strategic realignment of IS, and/or the higher education system to proceed toward the production of knowledge and socio-technical innovations that are purpose driven and in the public interest (Abbas & Michael, 2021), facilitating an integrated and responsive approach to addressing our global challenges and key problems (Melville, 2010). Capturing first principles from foundational theories and frameworks across disciplines, including IS, and merging them to form a transdisciplinary lens will allow for the creation of models and simulations that afford a high-level view or conceptualization of existing major forces and counterforces (Frodeman, 2014; Scholz, 2020). Achieving such a capability commands stakeholder engagement in the provision of data to an emergent knowledge system, encapsulating multi-level perspectives (local-national-global) within socio-cultural, business, techno-economic and institutionally-relevant policy contexts (Köhler et al., 2019). We suggest that the role of emerging technologies and IS, as they relate to this knowledge system, be embedded within a PIT framework (see Abbas, Pitt, & Michael, 2021, Fig. 1), represented as a complex, open socio-technical ecosystem that is informed by the landscape of technological and IS developments. The framework also acknowledges the corresponding application areas and the link to financing models, stakeholder engagement (balancing lived experience and professional expertise), transdisciplinary theorizations/conceptualizations and operationalisation to achieve the goal of sustainability toward human health and wellbeing (Abbas et al., 2021).

3.2.7.4. The role of IS/IT education. The subsequent and corresponding phase in operationalising the proposed Socio-Technical Sustainability Design Cycle relates to the elimination of disciplinary silos in higher education institutions, that have existed since scientific endeavor was acknowledged as the foundation of the Age of Enlightenment. Through the deliberate reconfiguration or redesign of university structures, new transdisciplinary agendas can be positioned to respond to global challenges (Crow & Dabars, 2015, ch. 5; Gholami, Watson, Hasan, Molla, & Bjorn-Andersen, 2016). In order to ensure our long-term sustainability as a species and a planet, university design must undergo a rapid rethink, becoming more adaptive and agile but also closely aligning to public and planetary challenges (Crow & Dabars, 2020). The transition to transdisciplinarity, even interdisciplinarity, remains fraught with risk principally with respect to forming meaningful ties between Computing, Informatics, Business (including Information Systems) and Engineering schools in addition to other non-STEM domains of knowledge. A harmonization is required not only within the STEM disciplines, but going beyond traditional collaborative fields to incorporate action-oriented endeavors through the creation of Schools dedicated to Sustainability or Life Sciences (Tejedor, Segalàs, & Rosas-Casals, 2018). Here the traditional research university is challenged to apply itself to real-world problems. However, irrespective of the inevitable difficulties, the COVID-19 pandemic has demonstrated the importance of solidarity toward collective action, harnessing the knowledge produced from both professional expertise/practice and the lived experience. The IS discipline is in a prime position to offer information and knowledge management expertise to support transdisciplinarity, and it is our obligation to actively implement sustainability transitions and responsible systems design (Monson, 2021),IS research (Pan & Zhang, 2020) and innovation (Stilgoe, Owen, & Macnaghten, 2013) in the interest of sustainable futures (Hadorn, Bradley, Pohl, Rist, & Wiesmann, 2006; Hess & Ostrom, 2007).

3.3. Impact on people and communities

3.3.1. Contribution 13 – promoting IT innovation to improve the global environment: towards establishment of global co-creation & co-evolution models – Professor Mitsuru Kodama

3.3.1.1. IT innovation through convergence. The leading core technologies in the cutting-edge technology fields of IT, energy, automobiles, electronics, semiconductors, biotechnology, pharmaceuticals and materials science, etc. have become dispersed among individuals, companies and organizations across the globe. The integration of these superior core technologies is a source of innovation of new products and services. (e.g., Kodama, 2007).

Across various fields in society, IT innovation is changing working practices, lifestyles, the way products are made and resources are used in production activities. IT technology is being incorporated into a variety of advanced devices and contributing directly and indirectly to the reduction of CO2 emissions. IT innovation is driving energy-efficient manufacturing by promoting energy-saving investments and measures. Such IT innovation will bring about "convergence" - the fusion and integration of different technologies and services and the building of business models across different industries.

Meanwhile, with the adoption of the Paris Agreement, a new international framework for the reduction of greenhouse gas emissions and other measures from 2020, all participating countries, including those that are developed, emerging and developing, are strongly urged to take measures to combat global warming. Specifically, Cyber-Physical Systems (CPS) and the Internet of Things (IoT) have been trending globally in recent years while collaboration and fusion of the IT industry with various other industrial fields is transforming various businesses, social activities and the lives of people. Backing the evolution of these innovative technologies is the convergence of IT and electronics technologies, including sensing and location information technologies, energy management systems (HEMS, BEMS, FEMS, etc.), energy-saving devices and data utilization.

Furthermore, smart communities such as smart towns and smart cities, into which many countries are currently pouring efforts, are attracting attention as next-generation social systems that connect homes, buildings, and transportation systems with IT networks to make effective local use of energy. IT solutions including energy management systems such as HEMS, BEMS and FEMS to optimize operation smart meters, renewable energy and EVs, etc., and CEMS to integrate the management of those as well as transportation systems such as ITS are becoming indispensable in smart communities. The development of these innovative technologies will greatly contribute to the reduction of CO2 emissions and enable a dramatic increase in energy reduction benefits. Furthermore, XR technology, which has a promising future, will contribute directly and indirectly to global environmental issues by minimizing the physical resources generated, utilized, and consumed in various processes in social, economic, and management activities.

Therefore, IT industries in every country need to contribute to global society by further strengthening technological and business partnerships with various industries, supply chains and venture businesses to promote new technologies and businesses through convergence strategies that will open up the future while understanding environmental contributions such as global warming countermeasures.

To date, the advances of IT have shortened the time and space in business processes and supply chains across a whole range of industries, accelerated decision-making and raised business efficiency, and have given birth to new business models that transcend and converge dissimilar industries (Kodama, 2020, 2021). IT innovation promotes industry-wide co-creation & co-evolution to improve the global environment and increases the possibility of forming dynamic "global ecosystems" as new value chains (see Fig. 2).

Through such convergence, what actions should companies, public bodies, government organizations, and a country as a whole take in terms of strategy building and organizational reform to create new business models that integrate different technologies and create IT innovations across industries? What kind of national leadership and management is required to achieve this? These are just a few of the many practical issues facing many stakeholders around the world, including those in academic research.

3.3.1.2. Research agenda related to IM/IT/IS. While individual industries, companies, and governmental organizations in each country have their own strategies, the key concept of organizational behavior to adapt to (or create) the convergence worldview is new "strategic knowledge integration" at the global level. Organizational platforms that support such global strategic knowledge integration are global IT

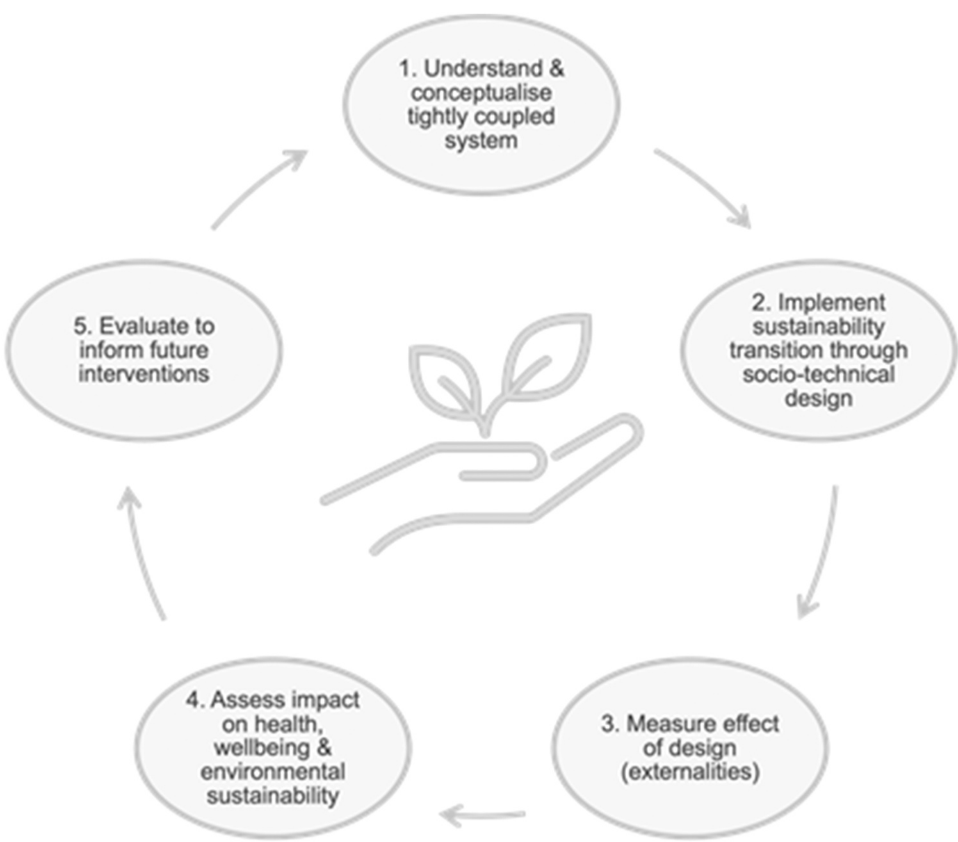

Fig. 1. Socio-technical sustainability design cycle.

community formations. Global IT communities are important organizational platforms for evolving the core knowledge in one's own country while at the same time actively exploring and integrating the best knowledge from around the world with the core knowledge of one's own country (see Fig. 2).

To drive global strategic knowledge integration, the most crucial issue is not only to integrate the diverse knowledge of different organizations within a company, but also to form global IT communities with superior stakeholders including customers around the world and integrate the best knowledge in the external environment, an ecosystem consisting of globally dispersed knowledge, with the knowledge in the organizations within a company. The key word to accelerate such global knowledge integration inside and outside an organization is "IT collaboration".

In forming global IT communities across the world, "collaborative dynamic capabilities" (Kodama, 2018) to appropriately generate, evaluate, and use common knowledge (i.e., lexicon, meaning, and interests) (Carlile, 2004) regarding environmental contributions such as global warming countermeasures among diverse stakeholders, are a trigger to realize IT collaboration.

In addition, the "IT-leadership" of national leaders is crucial to accelerate new strategic knowledge integration through IT collaboration through the formation of global IT communities across a wide range of countries. For this purpose, "holistic leadership" (Kodama, 2017) through the holistic thinking and actions of world leaders will be a particularly important factor of management.

However, existing studies in the IM/IT/IS fields have shed little light on the details of the theoretical concepts and practical processes of global IT community formation. Furthermore, there is very little accumulated research on IT collaboration. The holistic IT-leadership of leaders will play a role in forming and developing the organizational platforms of global IT communities. Hence, the cultivation of such leaders will become a pressing issue going forward.

3.3.2. Contribution 14 – smart city initiatives to maximize information value for sustainability – Professor Brenda Scholtz

The growing population, particularly in urban areas, has put pressure on researchers and society to address challenges surrounding the global lack of scarce resources and the negative impact on the environment (Khatoun & Zeadally, 2016; Kumar, Singh, Gupta, & Madaan, 2020). The technological footprint of companies and individuals has exacerbated this problem since technologies are mainly reliant on fossil fuel, thus the more technology used, the more carbon dioxide is released into the atmosphere, creating global warming. Technology manufacturers and implementers therefore need to consider adopting practices of environmentally sustainable computing. This phenomenon can be viewed as sustainability in technology or Green IT, where the priority must be to reduce the negative impact of an organization's technological footprint. On the other hand some argue that providing individuals and organizations with access to information and technology can assist people with living more conveniently and easily; for example reducing travel and our carbon footprint. This phenomenon can be referred to as sustainability by technology, whereby we need to reduce the negative impact of companies and their value chains by enabling sustainability use cases or initiatives.

The interplay of sustainability in technology and by technology must therefore be addressed by all stakeholders in industry and academia. One solution to achieving this interplay is to utilize the capabilities of information management (IM) and the related field of information systems (IS), which are reliant on the acquisition of information, the custodianship and distribution of that information to those who need it, and its ultimate disposal through archiving or deletion thereof. However, valuable information can only be provided to users if access to data is available. The Economist has described data as "the oil of the digital era". However, others, such as the Centre on Regulation in Europe, argue that this "often-used analogy between data and oil is misleading." Their argument is that data, unlike oil, is not scarce and therefore it cannot be likened to oil (MacCarthy, 2018).

One thing that everyone agrees on, is that the digital economy cannot live without data and that it remains an immeasurably valuable and unexplored asset. More than 90% of the world's data has been created in the last two years – more than 2.5 quintillion bytes of data per day. We are experiencing an information explosion. Herbert Simon, the Nobel prize-winning psychologist and economist, stated way back in 1971 that *"In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."* (Bélanger, Van Slyke, & Crossler, 2018).

The potential value of data, information flow and technology to address the effective management of scarce resources has been the driver of the Smart City concept (Ismagilova et al., 2019). According to Albino, Berardi, and Dangelico (2015)*: "A Smart City is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analyzed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource-efficient and sustainable. The information exchange is based on a Smart Governance operating framework designed to make cities sustainable"*.

The promotion of a Smart Environment is one of the core dimensions of a Smart City (Van der Hoogen, Scholtz, & Calitz, 2020). The success factors that are linked to this dimension are the attractiveness of natural conditions, environmental protection policies, having a sustainability strategy for resource management, and making sure that a city is 'future proof'. A sustainability strategy should enable an integrated view of socio-economic, political and environmental visions; thus focusing on the 17 Sustainable Development Goals (SDGs) of the United Nations. Future-proof refers to the ability of something that allows it to continue to be of value into the distant future such that the item does not become obsolete. Another core dimension for a Smart City is that of Smart Policy, meaning that any Smart City initiative should align with the strategy of the city, the country (government laws), intergovernmental agreements and of course global policies (Garg, Schmitt, & Stiller, 2017; Yadav, Hasan, Ojo, & Curry, 2017). Policies here include environmental policies and those related to information governance and therefore IM. The privacy of personal data and information is causing much concern and therefore acts and regulations are important in the context of a Smart City. In South Africa the Protection of Personal Information Act (POPIA) was implemented in 2013 to protect the information and privacy of people, but was only enforced on 1 July 2020 (POPIA, 2020). The General Data Protection Regulation (GDPR) is the European equivalent to the POPIA for South Africa (GDPR, 2018). In addition to these acts, companies are also pushed to have their own information governance and management policies and guidelines.

Another dimension that is closely linked to climate change issues is that of Smart Mobility. This dimension focuses on factors that involve sustainable, innovative and safe transport systems that are accessible locally, nationally and internationally (Calderón, López, & Marín, 2017; Yadav et al., 2017). IoT is an integral part of Smart Mobility and is regarded as an enabling technology of big data (Bibri, 2019). However, big data is only valuable once quality data is produced, which is required for intelligent decision making to contribute to sustainable smart cities. The Smart City definition illustrates the importance of information exchange within a Smart City and therefore the importance of the provision of open data and the creation of open data hubs.

Smart Technology and ICT-infrastructure is considered a support dimension of a Smart City since it is integral to all the other dimensions. It refers to the different types of smart technologies that are used in a Smart City and since these technologies produce and utilize data, it also involves relating all the data in smarter ways. Some of the opportunities for smart cities are that the data is in a digital format through IoT, Artificial Intelligence (AI) and machine learning technologies, making real-time collection, processing and sharing easier and therefore, decision making and solution development is becoming faster and more advanced (Allam & Dhunny, 2019). Providing access to quality data through the related strategy of information governance is becoming more and more critical. Information governance is the overall strategy for information and provides a balance between the risks of the information with the value that this information can provide. Data quality forms part of governance, since it is focused on the integrity and value of the information itself. When the factors of a Smart City concept are integrated, such as ICT, urban infrastructure, open data with data governance, and stakeholder participation, equitable and sustainable solutions can be developed to face city challenges (Yadav et al., 2017).

Stakeholder participation is emphasized in the Smart People dimension of a Smart City and it is here that the importance of skills, qualifications and education is addressed. The lack of skills lies in the areas of IT/IS and Computer Science graduates in general, but in particular with regard to Data Science, AI and machine learning competencies. Higher education has started addressing the need for these competencies in the recent IS2020 curricula guidelines (IS2020, 2020). Competencies related to sustainability and environmental issues are also included in the IS2020 guidelines as social and ethical considerations. In Germany and South Africa modules related to Green IT, and environmental information systems have been introduced in recent years. So whilst some progress has been made, much more effort and investigations need to take place to introduce more competencies regarding sustainable technologies, data management, data analytics and data science into IS/IT and CS degree programs.

Much research has been done on the topics of smart cities, Green IT and ICT for sustainability. However, reported empirical studies on IS for meeting the SDGs are still considerably low, particularly with regard to sustainable management of water and sanitation (SDG 6); access to affordable, reliable, sustainable and modern energy for all (SDG 7); and conserve and sustainably use the oceans, seas and sustainable behavior (SDG 14). In Africa and other developing countries these three SDGs are far from being met, where access to clean water and energy are major problems for the vast majority of the population. There is also a lack of valuable information and empirical research regarding emerging smart cities, especially in developing countries (Backhouse, 2015; Estevez, Lopes, & Janowski, 2016). This lack of information prevents stakeholders from making informed decisions, such as how to manage the city resources more efficiently or how to attract potential investors.

3.3.3. Contribution 15 – wider issues in IS research on climate change – Professor Rahul De'

In The Great Derangement: Climate Change and the Unthinkable, noted writer Amitav Ghosh (2018) points to the absence of writing on the destruction of nature and habitats through the devastation wrought by Imperialism and the rise of industrial capitalism. He calls this absence in the canon of English literature the 'great derangement' where thinkers and intellectuals are oblivious to the plainly visible damage done to the planet. This neglect of climate change continued in writings in history and politics. Ghosh calls for an awakening to recognize and

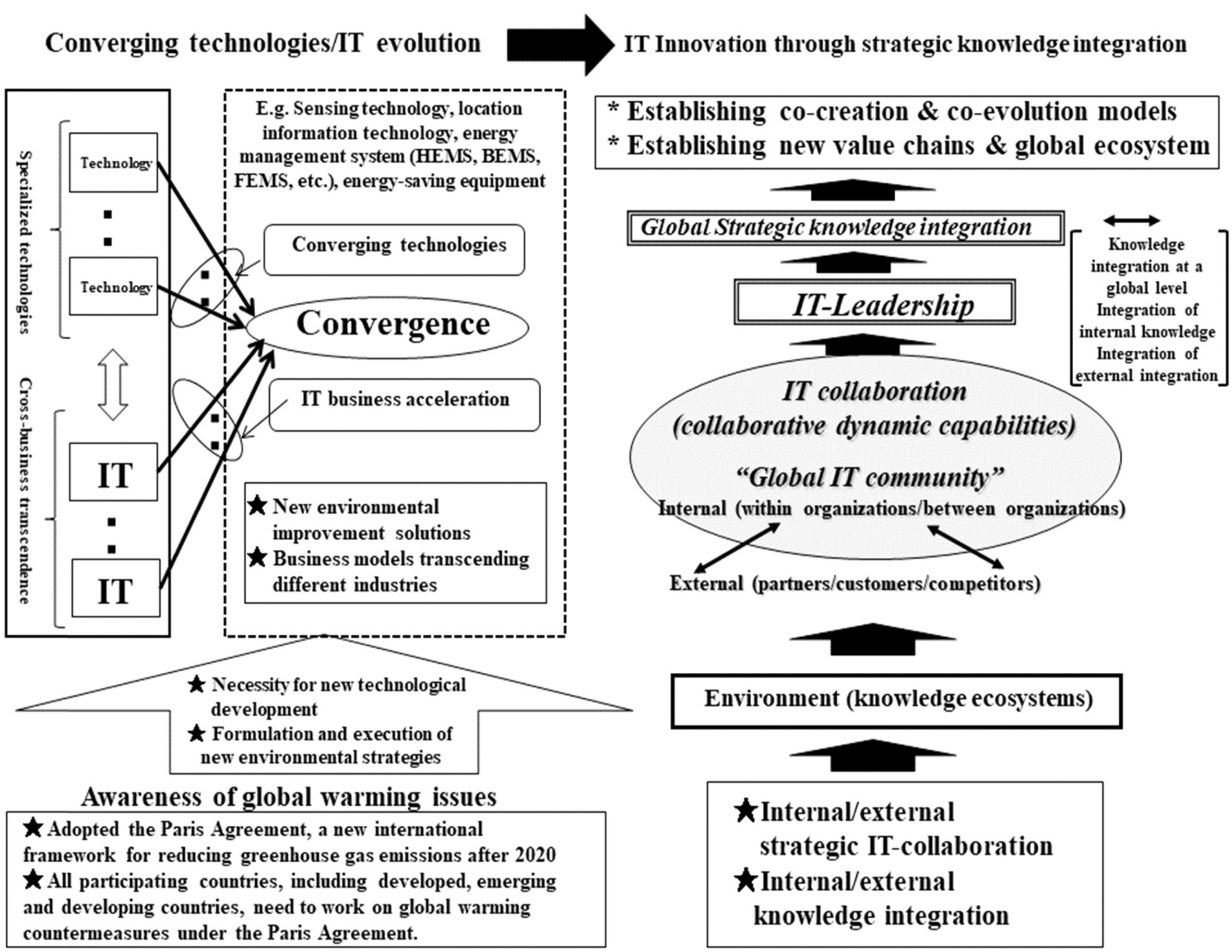

Fig. 2. Global IT innovation through IT- leadership.

give voice to the scale of the 'unthinkable' impact of this phenomenon.

Ghosh's call resonates in IS research, where this phenomenon is recognized as a 'critical challenge' for researchers and practitioners (Gholami et al., 2016; Eliot and Webster, 2017). The call is for more extensive research on climate change and its impact on the world, where 'grand challenges' require a wider understanding of the phenomena and a scoping that includes ideas and concepts outside of current disciplinary concerns (Winter & Butler, 2011). Following this reasoning, three possible issues are presented in this brief essay that can address the scale of climate change concerns, and, which also resonate with prior IS research. These ideas have to do with engaging with issues of the postcolonial condition; a focus on the impact of climate change on ordinary people; and its impact on women.

3.3.3.1. Focus on postcolonial condition. Prior research in IS has examined the postcolonial condition prevailing in former colonies of large imperial nations of the West, which includes most of the developing and less-developed world (Lin, Kuo, & Myers, 2015; Ravishankar, Pan, & Myers, 2013). This condition essentially refers to the power asymmetry between former rulers and the ruled, and defines the cultural and political practices of both, even though there is no present-day colonial presence. The postcolonial condition is perpetuated largely through multinational corporations and global agencies.

Global actors, such as large multinational corporations and multilateral agencies (like the World Bank and the International Monetary Fund), have a massive and disproportionate effect on world affairs. Their beliefs, policies, and practices affect millions of people directly and indirectly, as they influence governments and the actions that governments take. These institutions have a strong influence on the uptake of information technology in many nations, through efforts such as electronic governance, ICT for development, and spread of technologies to reduce the digital divide (De, Pal, Sethi, Reddy, & Chitre, 2018). They also have a strong influence on industrialization, deforestation, energy consumption patterns, and the overall adoption of modern technologies. Prior research has shown that many "development" projects ultimately harm subaltern people, who are the poor and marginal groups, rather than benefit them (Ferguson, 1994), and scholars often doubt the very benefits of development in such situations and contexts (Escobar, 2011).

Green IS research that is concerned with recording and analyzing the impact of climate change (Melville, 2010) must also document the postcolonial conditions and the impact of multilateral agencies. When agencies fund, say, construction of roads or dams or massive irrigation projects, the impact on the environment must be documented and the particulars of local politics, struggles, and contestation must be recorded. Crowd-sourcing technologies may be used to both record the different perspectives of people, and also to arrive at a possible consensus (Malone & Klein, 2007).

3.3.3.2. Focus on people. Though there is considerable work on Green IT and Green IS from the perspective of organizations and how they can manage their consumption and production patterns (Dedrick, 2010; Khuntia, Saldanha, Mithas, & Sambamurthy, 2018; Melville, 2010), the emphasis must also include the manner in which ordinary people in urban and rural areas, in remote mountainous regions, on isolated islands, and in forests are affected, and how they are using IT to both learn about and counter the effects of climate change (Watson et al., 2021). The focus can be on local and indigenous approaches to adapting to climate change, and how digital technologies can support those, with information and feedback.

One problem that can be addressed through both design science and action research is that of measuring the changes that are slowly and inevitably happening, and how people are adapting to them. These changes are in local climate conditions, in soil composition, in levels of water tables and aquifers, and in the extent and survival of local flora and fauna. These changes may be viewed from multiple perspectives of resource depletion for businesses or from that of people's livelihood, and the impact on local sustainability (Clarke & Davison, 2020).

3.3.3.3. Focus on gender. Theorizing about climate change around issues of mitigation and impact cannot be "gender blind" (Pearse, 2017). In rural areas, the brunt of droughts, flooding, soil degradation, river erosion, salinization, and loss of food crops, is felt largely by women (Alston, 2015). With these drastic and adverse changes in agricultural conditions, there follows shortages in food, nutrition deficiency for both women and children, loss of livelihood, and increase in debt (Chandra, McNamara, Dargusch, Caspe, & Dalabajan, 2017). Though both men and women suffer the consequences of extreme climate events, it is women who are worse off as national policies do not fully account for them, and relief measures are not easily accessible to them. When climate change events force populations to migrate, women are worse off as they lose their local social networks, are subject to abuse, and are unable to secure livelihoods on foreign soil. The gender imbalances are exacerbated and become entrenched (Alston, 2015).

Prior research in IS has established the imbalanced access that women have to both ICT devices and facilities in developing regions (Rashid, 2016). As they are most prone to adverse effects of climate change, research has to both reveal these deprivation issues, and find ways to address them.

3.3.3.4. Conclusion. IS research has an opportunity to sidestep the great derangement in literary culture by both exposing the causes and consequences of climate change, and finding ways and means to address them. Some work has already started on understanding concerns of postcolonial dominance, identifying issues of ordinary people, and understanding the particular challenges faced by women. Future research will likely build on this.

3.4. Responsible digitalization

3.4.1. Contribution 16 – corporate digital responsibility: the powerful offspring of sustainability and digitization – Professor Michael Wade

3.4.1.1. Two dominant trends. Two of the most significant global business trends over the past several years have been *sustainability* and *digitization*. Sustainability revolves around the natural world, most notably humanity's impact on our planet. Digitization, by contrast, focuses on the virtual world. Without obvious common roots, these two megatrends have largely developed independently of one another (Naujok, Fleming, & Srivatsav, 2018). I recently had a conversation with the Chief Sustainability Officer of a consumer goods company and when I asked him about digital and sustainability, he looked back at me blankly.

However, this is likely to change. If we expand the definition of sustainability to include responsible and ethical practices of all kinds, not just those that impact the planet, we see plenty of intersection points. Examples include cyber-security, data privacy protection of employees and customers, digital diversity and inclusion, ethical algorithms including AI, technology component recycling, right to repair, ethical gig economy practices, and there are many others. Unfortunately, our research suggests that most organizations today are unprepared to effectively respond to these challenges. If they do so at all, it is in a fragmented manner. This opens up new and interesting avenues for research.

3.4.1.2. A new field of corporate digital responsibility. It is time to bring these disparate and fragmented elements together under a single umbrella so that they can be addressed in a consistent and complementary manner. We refer to this new consolidated focus as Corporate Digital Responsibility (CDR) (Lobschat et al., 2021). CDR can be regarded as a subset of Corporate Social Responsibility (CSR), an already established entity in many organizations.

Corporate digital responsibility is defined as *a set of practices and behaviors that help an organization use data and digital technologies in a way that is socially, economically, and environmentally responsible (Wade, 2020).*

3.4.1.3. Each CDR sub-categories contains a number of areas. Social Corporate Digital Responsibility revolves around an organization's relationship to people and society. The important topic of data privacy protection of customers, employees, and other stakeholders is included here. It also incorporates aspects of digital diversity and inclusion, such as bridging an increasing divide between digital haves and have nots across geographies, industries, social classes, and age. There are also societal impacts of inaccurate A.I. decision-making algorithms that can lead to unfair or discriminatory practices, as has been noted among many recommendation engines (Noriega, 2020). Other technologies can also have harmful effects on society. Facebook, among others, banned so-called deep fake videos that realistically apply false or misleading statements to real people.

Economic Corporate Digital Responsibility relates to the responsible management of the economic impacts of digital technologies. Much has been said about the replacement of human jobs by robots and other digital technologies, and this is certainly a relevant part of economic CDR. Yet, it also relates to the creation of new jobs in a digital world that are enriching, purposeful, and interesting. There is emerging evidence to suggest that the so-called gig economy creates jobs that are often uninteresting, repetitive, and underpaid (Tan Z.M., 2021). There are also questions regarding the sharing of the economic benefits of digitization with society through taxation of digital work, and fair compensation of data monetization to the original owners.

Finally, *Environmental Corporate Digital Responsibility* concerns the link between digital technologies and the physical environment. There are many issues here, including the responsible recycling or disposal of old computer equipment. The extension of obsolescence cycles by one year, for example, can have an enormous impact on the environment.[5] There are also issues regarding the limiting of power consumption, including reducing the use of electricity to support bitcoin mining.

3.4.1.4. A call for a multi-disciplinary focus on CDR. Many organizational processes, practices, and projects exist to address digital aspects of social, economic, and environmental responsibility. Yet, they are rarely coordinated or optimized. Some, like cybersecurity, tend to be the responsibility of IT departments, others, like workforce automation, may fall under the purview of operations, and yet other elements may sit with HR, legal, engineering, R&D, or particular lines of business. Without effective coordination, organizations leave themselves open to risks, and may miss out on rewards.

Research too, is required to better understand the dynamics of CDR from both theoretical and empirical perspectives. This research will need to be multi-disciplinary since CDR covers aspects of many different fields, including IS (the coordination of technology and people), IT (the ethical design of technologies themselves), operations (the development of systems and practices to embed CDR in organizational processes), organizational design (how to set up structures to effectively govern CDR activities), strategy (how to align CDR with other organizational objectives), and OB (how to train people to act in responsible ways).

In summary, as the sustainability and digitization trends continue to grow, Corporate Digital Responsibility will become increasingly relevant for organizational performance, both to mitigate risks as well as find new sources of advantage. As researchers, we need to get ahead of this trend not only to better understand it, but to influence its development through the creation and dissemination of tools, frameworks and best practices to practicing managers.

3.4.2. Contribution 17 – digitalization and the myth of sustainability: some critical reflections – Professor Suprateek Sarker

Digitalization is all around us, and we are all well aware of the value digitalization brings to help improve many facets of human existence. Indeed, when we think about digitalization, most of us see the positive impacts digitalization has had, and can potentially have, on the environment. After all, in digitizing business processes, we drastically reduce, even eliminate the consumption of paper, which saves trees, and in turn contributes to better environmental outcomes. We also think of how, through metering, we are able to encourage consumers to consume less electricity, which again contributes to better environmental outcomes (e.g., Wunderlich, Veit, & Sarker, 2019). Perhaps a more high-profile example that we can all relate to pertains to the new generation of automobiles, that have been described as "computers on wheels" (Wade, 2016). Digitalization vehicles can help to optimize fuel and/or battery usage, and hence result in less pollution of the environment. Furthermore, metaphors like 'cloud' imply something floating and delicate" and green, and add to our sense that digitalization is at the heart of our battle to save the environment (Crawford, 2021, p. 41) and can have a significant role in addressing climate change. Yet, many argue that the above represents a grossly biased picture, and is a consequence of the largely pro-digitalization, "digital utopia" narrative which includes the myth[6] of digitalization's contribution to sustainability, that is promoted by tech companies, sections of the business press, and those fascinated by the wonders of digitalization.

Crawford (2021), among others, provides a critical commentary on the "mineralogical layer" (p. 32) underlying digital technologies and AI that made me acutely aware of the environmental effects associated with digitalization. She notes that "seventeen rare earth elements," that are part of virtually every digital device/technology surrounding us, have to be extracted from mines. Mining of such minerals is not only associated with slavery, conflicts, and human exploitation very often, but also results in dangerous waste. Specifically, she quotes David Abraham who writes ". 99.8% of earth removed in rare earth mining is discarded as waste… that are dumped back into the hills and streams" and this leads to "pollutants like ammonium…" (pp. 36–37). Particularly alarming is the estimate by the Chinese Society of Rare Earths that refining one ton of these elements "produces 75,000 liters of acidic water and one ton of radioactive residue" (p. 37). The amount of consumption of water and electricity by data centers and other components of the digital infrastructure is also shocking, but is largely hidden from view or consciousness of the average consumer or decision-maker, who is led to believe that digitalization is "clean" and a key part of the solution for the environmental crisis (pp. 42–45).

Along similar lines, Wade (2016) suggests that in addition to batteries and their deleterious environmental impacts, "rare metals are sprinkled throughout vehicles, mostly in the magnets that are in everything from the headlights to the on-board electronics. But those rare metals come from somewhere—often, from environmentally destructive mines… and processed in less-than-green ways."

The point of highlighting the above issues is *not* that digitalization needs to stop. The point is to *make people aware that there are environmental trade-offs that we are implicitly making when we use digital technologies.* Indeed, by many accounts, the clean paperless image has been carefully cultivated, and it distorts the assessment of environmental impacts in one direction, in favor of further digitalization.

As IS researchers who embrace the sociotechnical view (e.g., Sarker, Chatterjee, Xiao, & Elbanna, 2019), we are aware that the need for efficiency, effectiveness, and economic value *needs to be* balanced with a

[5] Maria Noriega, https://www.csomagazine.com/technology/managing-equipment-waste-knowing-when-say-goodbye.

[6] Please refer to Sarker and Nicholson (2005) for a quick review of "myths" and the roles they play.

consideration of humanistic outcomes. Given the critical role that the environment, especially in the form of climate change, is seen to play in shaping human wellbeing (even threaten survival), we need to consider environmental outcomes as an undeniable aspect of humanistic outcomes of digitalization.

While outlining a research program is not feasible in a short editorial segment, there are a few points I would like to make, that may have implications for research and teaching:

As researchers and teachers, we need *to develop and communicate a balanced picture of digitalization*, and not unreflectively perpetuate the "digital utopia" narrative.

We must reflect on the culture that our societies have developed, of technology infusion in human processes as a natural course of development of organizations, economies, and societies. We need to develop frameworks and metrics that will help managers and technology consumers assess the economic value and convenience with respect to the true costs. Just as we have metrics to capture the economic value of digital technology implementation, we need to develop and incorporate the use of environment-related criteria and metrics as part of the proposal and justification process for any significant digitization initiative. At a very basic level, we need to ask why we need digital technology infusion in a certain aspect of life, and whether it is warranted when a holistic assessment is done. And, we need to develop conceptual and analytic tools to be able to carry out such assessments, even if such analysis is initially far from perfect.

Obviously, the environmental damage resulting from the harnessing of digital technologies is a systemic issue involving many different stakeholders, and IS scholars cannot solve the problems themselves, *but we need to actively consider how we may be part of the solution*. We need to become aware of the issues, make the environmental costs transparent in our communication with stakeholders, conduct revelatory studies of the hidden environmental costs of certain technologies that are extolled, create models that incorporate benefits and costs including environmental costs, and, most importantly, make our students aware of the one-sidedness of the pro-digitalization narrative. We need to incorporate environmental impact analysis of digitalization initiatives as part of the IS curriculum, and foster an environmental consciousness among the students with respect to digitalization. Undoubtedly, a lot of research will be needed to enable decision makers to link environmental costs to a particular decision pertaining to digitalization.

Many of us talk about responsible AI – here, my objective is to encourage *responsible digitalization*, and the responsibility is regarding environmental impacts of digitalization. As we set out on this path, I reiterate that our goal will not be to single-mindedly promote or oppose digitalization, but to "right-size" the extent of digital infusion in any initiative, after careful consideration of benefits and costs, where costs will not only consider the immediate tangible financial implications but also environmental costs over time that humanity will be left to bear.

3.4.3. Contribution 18 – systems for sustainable growth – Professor Maung Sein and Dr Leona Chandra Kruse

"Stark realities, critical choices [...] Years, or even decades, of progress have been halted or reversed." These alarming statements began this year's Sustainable Development Goals (SDGs) report, underlining the gloomy consequences of COVID 19 related crises. The prospect, however, is not all doom and gloom. Digital transformation has been accelerated in various governmental and business sectors, and we need to continue harnessing the potentials of information systems to address key societal, economic, and ecological issues. Supported by well-designed information systems, researchers, economic actors, policymakers, and civil society can join forces to rebuild a more resilient and sustainable future.

Perhaps no issue is more crucial now than the threat of climate change. This is not just an isolated threat: it directly challenges our conceptualization of sustainable growth and sustainability itself. We view sustainability as a synergy across people, planet, and profit, following the SDGs. We place a particular emphasis on a holistic view of information systems (IS) for sustainability which entails the study of designing, engineering, using, and disposing of information systems in order to minimize their environmental impact as well as to promote sustainability-related practices. This holistic view embraces different initiatives across various computing and informatics disciplines in the spirit of transdisciplinarity and multilateralism.

In the following, we will delve into the role of IS in this crucial discourse on the threat of climate change. We will first set the scene by providing our perspective on IS and sustainability. We will then propose specific approaches that the IS research community can take to address the issues we raise. We will conclude our editorial segment by discussing issues related to evaluating the initiatives and frameworks aimed at meeting sustainability challenges.

3.4.3.1. Setting the scene. The thirteenth SDG persuades us to "take urgent action to combat climate change and its impacts," and this year's report continues to urge us on how "rising greenhouse gas emissions require shifting economies towards carbon neutrality" (United Nations (UN), 2021, p. 20). For us, this urging means exploring new and alternative approaches to minimize the environmental impact of information systems, in addition to our ongoing measures. We observe several ongoing transdisciplinary movements to this end. One of them, computing within limits, aims to reshape computing research by acknowledging a need for limits (LIMITS, 2021). This movement is guided by three core ideas: aiming for a steady-state economy and acknowledging the limit of growth, considering models of scarcity in order to promote resilience, and reducing energy and material consumption while avoiding the rebound effect (Nardi et al., 2018). Rethinking the status quo in our design and computing assumptions can help us shape the way forward.

Minimizing the environmental impact of information systems, however, concerns not only the design and use period. We need to anticipate what happens in the post-use period, that is, minimizing and managing e-waste. This is echoed by the twelfth SDG: "ensure sustainable consumption and production patterns." However, this year's report shows that "electronic waste continues to proliferate and is not disposed of responsibly [.] Each person generates about 7.3 kg or e-waste, but only 1.7 kg was recycled" (United Nations (UN), 2021, p. 19).

3.4.3.2. Design science research for sustainability. What can the IS community do to meet the enormous challenges posed by the threat of climate change in particular and to sustainability in general? The simple answer is that research needs to make this a key area to address. Understanding the phenomenon, explaining the mechanisms of climate change and predicting its consequences are agendas that continuously engage researchers from across the disciplines. We propose that the IS community can significantly contribute to these ongoing initiatives through designing artifacts (systems, prototypes, methods or frameworks).

While designing systems in a way to best accomplish a particular purpose (combating climate change in our case here), lies at the very core of what we do in our discipline, our call here is to take a design science research (DSR) approach in our research. DSR aims at creating new prescriptive knowledge through building methods and artifacts to improve the world in some way, however incremental. The DSR paradigm is fundamentally a problem solving paradigm. It is not atheoretical tinkering – artifacts are developed based on theoretical and conceptual foundations, drawing upon the knowledge base for explanation research – and in the process creates theoretical and conceptual knowledge that are of prescriptive nature such as design principles that are transferable to other contexts. While care is taken to ensure rigor, the very fact that the artifacts developed through DSR are to solve problems faced by the society makes it relevant by definition.

3.4.3.3. Sustainability as value for design. DSR is perfectly placed to meet the threats to sustainability. Among the papers and prototypes presented in the 2021 edition of the premier conference of the DSR community (Design Science Research in IS Technology – DESRIST), one is an excellent illustration of what the IS community can do. Hillebrand and Johannsen (2021) developed a chatbot called KlimaKarl "to Promote Employees' Climate-Friendly Behavior in an Office Setting". The App can be classified under "persuasive technology" that has been used successfully in the health sector to promote healthy living (e.g. weight management) through behavior change. Obviously such systems cannot force behavior change but can definitely informate users. A system of this genre can prove to be useful in the particular case of wind powered energy in Norway. While there is a broad support for developing green energy, many localities vehemently oppose constructing windmills in their areas. Systems can be effective in helping citizens see a balanced view and hopefully reduce opposition to windmills.

DSR, like any research approach, is not value free (Iivari, 2010) and consequently, "the values of DSR should be made as explicit as possible" (p. 44). The burden of explicating the value of the designer and his/her goal in designing the artifact is essential to help the user understand the possible deleterious outcome or the unintended dark side of the technology. This is a particular sensitive issue with the use of persuasive technology in a debated issue such as sustainability.

3.4.3.4. Green practices within DSR. Finally, environment-friendly practices such as green computing and green coding can be incorporated in the design of artifacts, whether as a DSR project or routine design. These practices help to minimize the environmental impact of the resulting information systems. The IS research community is also a user of IT. We need to be mindful of the potential e-waste of our research endeavor and ingrain e-waste management in our daily behavior. Some of the points in this editorial indeed represent critical choices which must be made in the face of the stark climate realities.

3.5. Role of data, technology and IS governance

3.5.1. Contribution 19 – climate change and role of information technologies – Professor Babita Gupta

3.5.1.1. Information technologies and climate change. Information technologies require energy at every stage of its life-cycle and contribute to the carbon footprint. However, IT is also helping reduce net carbon emissions in various industry sectors. Technology-enhanced working using the video conferencing and cloud-based collaboration that has accelerated during the COVID-19 pandemic is proving to be a double-edged sword (Frontier technologies, 2020). While these technologies helped the environment by significantly reducing the impacts of travel and commuting, they also increased carbon emissions since the backend infrastructure, such as massive data centers, is enormously energy-intensive. Current estimates of information and communication technology (ICT) impact range from 1.4% to 3.9% of global CO2 emissions, highlighting the need for accurate data on ICT's impact on the environment (Cunliff, 2020; Murugesan, 2021; Robertson, 2021).

Several information technologies are poised to play a critical role in monitoring, managing, and mitigating climate change-related phenomena and increasing environmental resiliency. For example, artificial intelligence and robotics are being utilized for automated detection and monitoring of environmental hazards, remote sensing to track deforestation activities and marine life, monitoring biodiversity, traffic flow optimization, estimating real-time precipitations, and managing flood risks and emergency planning. Increasing occurrences of extreme weather events are affecting food production and distribution globally. Advancements in information technology utilizing multi-source spatial and temporal data, robotics, drones, Internet-of-Things (IoT), etc., are being explored in the agriculture and transport industry. For example, precision agriculture technology is an environmentally sustainable strategy for optimizing water input, weed control, disease eradication, pest reduction, and yield enhancement to avert water and food insecurity and optimize the food production chain.

Data centers are the backbone for managing big data, cloud computing, AI, blockchain, and IoT. They also have massive power consumption needs contributing to climate change. Researchers and innovators are exploring novel technologies such as liquid cooling that improve heat-dissipation efficiency and reduce their impact on the environment to reduce the carbon footprint of data centers and other IT infrastructure.

3.5.1.2. Role of higher education in building environmental resiliency. Higher education institutions can provide knowledge and resources to the learners and create awareness, inspiring the next generation to navigate the complexities of climate change. Education and training can encourage learners to think about technological and behavioral changes to reduce and mitigate environmental impact within their local sphere of influence and macro level. Institutions offering information systems and related programs are beginning to incorporate pedagogical practices in their curriculum that engage students to reflect on organizations' sustainable and responsible technology adoption and use practices. Educational institutions can create partnerships with community stakeholders to accelerate carbon-neutral business practices and build environmental resiliency. Several universities are forming coalitions committed to climate action, such as the University Climate Change Coalition, to leverage scientific knowledge and expertise for climate change solutions. In addition, universities are offering programs that emphasize environmental justice and equity, such as responsible business MBA and hospitality and sustainable management.

3.5.1.3. Research agenda and climate change. The estimates for carbon dioxide levels in the year 2021 are at 417 parts per million. Bringing it down to the safer threshold of 350 parts per million would require the removal of about 2000 gigatons of CO2 from the atmosphere over the next century (Fork & Koningstein, 2021; Frontier technologies, 2020). This reversal of climate change would require everyone's effort, including researchers in the IT, information systems, and related areas, to develop a robust and practical research agenda:

Methodologies to assess the sustainability of ICT Infrastructure.

- Develop an actionable set of metrics that can measure the reliable and precise impact of an information technology infrastructure, an IT project, or a portion of the cloud in terms of its carbon budget and footprint
- Develop reporting mechanisms, models, and infrastructure that would make it easy for companies to evaluate their as well as their supply chain partners' emissions and environmental impact.

Sustainable, greener technologies.

- Strategies grounded in organization behavior and culture that persuade companies to shift from fossil-fuel-based electricity to using cleaner, renewable energy solutions in their IT projects, technology infrastructure, and data centers
- Creating mechanisms for designing sustainable technologies compliant to be carbon-neutral in the ICT industry by 2050
- Models for integrating disparate data and prediction models and forecast systems for weather, traffic, demand, patterns of consumption, and real-time inventory that companies can use to optimize their supply chain and reduce waste and carbon footprint
- Best practices to make the entire life cycle of IT greener, including energy-efficient hardware and software that has reusable code and is optimized for the green hardware.

Resource recovery and reducing e-waste.

- Research on e-waste management and strategies for e-waste prevention, smart recycling, and resource recovery, without shifting the e-waste burden to still-developing economies.

Use of behavioral theories to engage stakeholders in climate change solutions.

- Research on the role of social media and models grounded in behavioral theories that can prevent or at least reduce the impact of misinformation on public perception of climate change
- Strategies to empower consumers so that the collective consumer sentiment about climate change imperative can incentivize companies to pursue carbon net-zero more actively as a goal
- Research on digital and social media best practices to increase consumer awareness of the impact of their purchasing choices and decisions on environmental sustainability and design strategies that nudge consumers to adopt behavior that reduces their carbon footprint.

Role of governance in climate change innovations.

- Research on the role of governments in enabling effective guidelines, policies, legislation, incentives, R&D collaborations, and regulations about emission standards versus companies setting voluntary targets for achieving carbon neutrality within the critical time frame.
- Research on the role of policy governance within the organizations when implementing IT projects and the evaluating impact on the environment.
- Research on the role of social media and other digital tools to influence leaders in government and businesses to embrace sustainable consumption and production.

3.5.2. Contribution 20 – climate crisis response: climate crisis response: complex information governance for social sustainability – Professor Deborah Bunker

"*Climate change is destroying our path to sustainability. Ours is a world of looming challenges and increasingly limited resources. Sustainable development offers the best chance to adjust our course.*" – Ban Ki-moon (2012).

We are amid an existential climate crisis which has been building since the onset of the industrial revolution (Jonsson, 2012). Information systems (IS) scholars continue to debate our contributions to tackle climate change and sustainability. In response to the global climate crisis, we are being called upon to “develop suitable theoretical frameworks to underpin the investigation of complex phenomena and complex problems” on a societal level (Hasan, Smith, & Finnegan, 2017, p. 298).

In response to any crisis, however, we know that to develop and deploy resources effectively, an IS must produce an accurate, reliable, and trustworthy assessment of the situation *at scale* (Bunker, 2020). The key to achieving this 'situational awareness' is the development and implementation of an accepted approach to complex information governance for response to societal problems and crises (Bunker, 2020; Nüttgens, Gadatsch, Kautz, Schirmer, & Blinn, 2011; Smith & Stirling, 2008). How the value, authenticity; accuracy; reliability; and legality of information is determined, controlled, and assured through acceptable governance mechanisms, is at the heart of how information is represented and used to develop situational awareness and support sustainability goals for climate action ". the ways in which these representations are articulated into knowledge that structure our overall understandings" (Smith & Stirling, 2008 - p. 2). Complex information governance has, however, been shown to be difficult to assure as seen in the financial market failures of 2001 and 2008 and more generally in the response to the current COVID-19 pandemic.

Information governance is defined as "a collection of competences or practices for the creation, capture, valuation, storage, usage, control, access, archival, and the deletion of information and related resources over its life cycle" (Mikalef, Bourab, Lekakos, & Krogstie, 2020). IS research on information governance, however, has mainly focussed on big data analytics and organizational innovation for formal IS. Far less is known about information governance in complex scenarios where formal IS and informal social IS might combine to jointly produce situational awareness on which to frame a response.

Yet we know of many cases where trusted situational awareness, dynamic organizational collaboration and multi-stakeholder decision support have been produced by combining formal and informal IS. These include adoption and use of:

- a cloud-based, freely available IS used by environmental non-government organizations (ENGO), for eco-collaboration activities in a structurally dynamic manner based on the NGO national context i.e., Thai, Lebanese, Australian (Aoun, Vatanasakdakul, & Bunker, 2011).
- a combined open social media platform and proprietary job scheduling system to communicate with and organize a student volunteer army during the Christchurch Earthquakes (Bunker, Ehnis, Seltsikas, & Levine, 2013); and
- an open social media platform for dynamic communication, coordination, and collaboration activities during Hurricane Harvey (2017) by emergency management agencies, media organizations, journalists, private individuals, celebrities, politicians, and influencers who took on the roles of information starters, information amplifiers and information transmitters (Mirbabaie, Bunker, Stieglitz, Marx, & Ehnis, 2020).

These cases highlight an emerging need for development of effective complex information governance approaches for IS, using dynamic organizing principles. Lee, Zhu, and Jeffery (2019) researched information governance and data management for these types of platform 'ecosystems'. While they focussed on data governance and practices, they did not directly address the complexity of information governance where trusted situational awareness/consensus is developed at a societal level from a combination of formal and informal IS.

In order to conceptualize and understand complex information governance for development of trusted situational awareness and response at scale, *transitions* may hold the key i.e. dynamic co-evolutionary processes that evolve from the "interplay of many unlike, particular processes" (Kemp, Parto, & Gibson, 2005, p. 23). Transitions present us with an opportunity to develop approaches for complex information governance as they are "aimed and guided in an iterative, forward-looking, adaptive manner, using *markets*, *institutions* and *hierarchy* (the three basic forms of coordination)" (Kemp et al., 2005, p. 23). These three forms of coordination are critical 'global levers' for climate action so consensus regarding information governance at a transitional level is crucial for achievement of situational awareness, development of sustainability response/goals and resulting action. The key components or mechanisms of complex governance for social sustainability include: *policy integration, common objectives, criteria, trade-off rules and indictors, information and incentives for practical implementation and programs for system innovation* (Kemp et al., 2005).

“The most significant challenge is to ensure that multi-player governance regimes embody capacity for sustainability-oriented co-ordination, direction and re-direction” (Kemp et al., 2005, p. 18). This can be achieved through the nature and dynamics of *autopoiesis* or self-producing/constructing physical systems (Bunker et al., 2013; Mingers, 2002, 2004). These systems are: self-producing; contingently maintained (so that they don’t breakdown); structurally open but organizationally closed; structurally determined; able to be structurally coupled to other systems by mutual specification and/or co-evolution; and able to embrace embodied cognition and self-reference/recursion to enable self-construction/production (Mingers, 2002, p. 280). Transitional processes combined with the nature and dynamics of autopoietic systems, provide IS scholars with a theoretical basis for complex information governance development.

The use of both formal organizational IS and informal personal/social IS in disaster management and crisis response, has been rapidly co-evolving at scale over the last decade (Ehnis & Bunker, 2020). While IS scholars have mainly focussed on information governance approaches for formal organizational IS, the self-producing/constructing attributes of hybrid IS which combine elements of the formal and informal have been largely ignored. The negative aspects of social systems and platforms and their combination/integration with formally managed and governed IS, have presented society with many problems (Elbanna, Dwivedi, Bunker, & Wastell, 2020). There is, however, potential for their management and use to effect positive outcomes for social sustainability and the response to the global climate crisis, if approaches to complex information governance are developed and implemented by IS scholars and practitioners.

Currently there is a global focus on the importance of science, technology, engineering, and mathematics (STEM) education, but more recently there have been calls for a reframing of STEM from techno-science, towards a science of reconnection with nature (Smith & Watson, 2020). IS courses and training can therefore, make a valuable contribution to the development of complex information governance for social sustainability at scale by developing and delivering units of study that focus on: 1) complex information governance and leadership for social sustainability - frameworks, concepts, descriptions, rules and communications approaches based on transitions and autopoietic systems; 2) how to work in large and diverse teams - understanding, implementing and accommodating approaches to complex information governance; 3) and understanding the information governance of global supply networks and logistics for sustainable development goals.

3.5.3. Contribution 21 – climate change – IT – Data Science perspective – Ms Jeel Dharmeshkumar Shah

The world's climatic conditions seem to deteriorate every day, and the evidence from the research(Shaftel, 2021) held at NASA further bolsters this claim. The researchers at NASA further believe that the unprecedented warming trends today are the effect of human actions. Since most of these actions involve the development or use of technology, it certainly plays a significant role in climate change. The world today seems to be in a state of quandary. Whether to restrict the use of technology or invest in further research in the same field is a concern. However, in this case, I believe that the cause is the solution- just like the snake venom that is fatal for humans but is also proven to be medicinal and used to save lives. When the problem is so complicated, the solution must also be four-fold; we must take the System-of-Systems (SoS) approach. We must be able to analyze the dependencies of various systems - such as human, environmental, physical and information systems- which the SoS framework can enable. This could be a holistic approach to finding possible solutions to this complicated issue as it provides a good understanding from all viewpoints. Data Science is a required field for this discussion as it can analyze all forms of data and help automate crucial decisions.

'Green Technology' is expected to transform our society. The Climate Group, in their report, estimates that smart technologies such as smart homes/buildings, smart transport and logistics, intelligent agriculture management systems and smart electricity grids are a few of the various ways that can help reduce greenhouse emissions. It is Data Science that makes these technologies' Smart' or 'Intelligent'. While Big Data provides a platform for processing large chunks of heterogeneous data, Data Analytics and AI help analyze this data and identify trends (with the help of machine learning to identify main features and make predictions). This intelligence is then used in business to make informed and calculated decisions. Cloud computing can further be used to accelerate the process, and IoT could help apply these efficiently in a practical scenario. Analyzing the foot-fall data of various public transport systems, for example, could help identify efficient routes, and this 'Smart Transport System' would then optimize its fuel consumption and aid in reducing carbon footprints. Another such example would be a 'smart air conditioning system' that collects, compares and analyses weather and usage data to develop plans that optimize economic and environmental savings—solutions such as these help tackle issues regarding the sustainability of the climate. Various techniques followed by the Data Scientist aid this kind of analysis.

Classification is one such technique that draws meaningful information and differentiates the data based on similarities found in its attributes. Artificial Neural Networks (ANN) can also be utilized in many practical scenarios for cause and effect analysis. One such example is the study carried out in the United States that used this technique to identify the factors affected due to differences in hydro-climatology of two different streams. This study successfully inferred how the differences affected the average runoff, flow stability(from baseline) and frequency of floods in the two areas (Poff, Tokar, & Johnson, 1996). Further improvements in the climate model were also made in 2003 (Knutti, Stocker, Joos, & Plattner, 2003) to increase its efficiency with larger datasets. Calculations from this model revealed that almost half the members surpassed the surface heating range that the IPCC estimated earlier. In such challenging scenarios, neural networks can help extensively. It is all used to explore the general trend in climate change and its mechanisms to identify the hidden correlation/attributes in the data that is otherwise not decipherable.

The use of Solar energy has become increasingly popular today as it is a renewable source of energy. One of the major drawbacks of this form of energy is that its availability widely depends on meteorological conditions. The efficiency and performance of a solar power plant would depend on these changing conditions. Jang, Bae, Park, and Sung (2016) has discussed how we can leverage images captured by the satellite to train a SVM (Support Vector Machine) model and predict the motion of clouds. This could be a brilliant way to determine when the plant would be most productive and when it would require backup. In this way, data analytics could help manage climate changes for uninterrupted and effective energy production.

Climate change also significantly affects coral reefs that are important for the ecosystem as they provide food and shelter for their inhabitants. Thermal stress due to the warming of the ocean could cause infectious diseases, while frequent intense storms could lead to the destruction of the reefs. A rise in sea levels could lead to sedimentation, whose runoff can destroy the corals, while fluctuations in precipitation lead to an increase in runoff that could make the water murky and restrict the light. One such study (Franco, Hepburn, Smith, Nimrod, & Tucker, 2016) conducted in 2016 used the Bayesian Network approach to evaluate how climate change disturbances affected the coral reefs. The study revealed interesting results identifying the factor that contributed the most to the carbonate budgetary state of the reef and concluded that the change in the state of the reef was mainly due to the decrease in water quality (Franco et al., 2016).

Data Science offers a plethora of such techniques that can be applied in the majority of challenging scenarios. It can help in the acquisition of environmental data as well as monitoring and analyzing it. This can help take immediate actions in case of an emergency or check if an industry is compliant with the pollution control requirements. Remote sensing and continuous data monitoring improve data availability that is the foundation for Data analysis. Risk analysis is another critical feature that can be used in combination with IoT enabled devices to send real-time alerts in case of high-risk prediction. These alerts and controls maintain safety by keeping a check on potential hazards. Results drawn from such analysis could also aid in finding sustainable alternatives.

These advantages are very beneficial for governance, and the government has collaborated with the IT industry in developing and launching schemes that help alleviate the environmental conditions. The 'National Clean Air Programme (NCAP)' was established in 2020 by the central government that is predicted to reduce 20–30% of particulate matter concentration in 4 years by 2024 (NCAP, 2020). Another such flagship scheme introduced by the government is the 'Namami Gange Programme' that aims to reduce water pollution, conserve effectively and revive river Ganga (Namami Gange Programme, 2020).

With the enormous number of benefits and applications, Data Science, in my opinion, has not yet reached its full potential. This is because 'Data' forms the foundation of Data Science, and without accurate and complete data, ambitious goals can be challenging to achieve. A recent paper published on the 10th of October 2021 (Callaghan et al., 2021) successfully collected enough evidence to conclude- based on mapping of 10000 attributes- that almost 80% of the land area globally is affected by climate changes caused by human actions. This is an excellent insight although the researchers also identified the 'attribution gap'. Though the paper could draw important information about global climate models, it failed to understand the impact of climate on low-income countries. This was because they were unable to collect enough data from these regions. Shruti Nath, a researcher at Climate Analytics, said, "*Developing countries are at the forefront of climate impacts, but we can see in our study there are real blind spots when it comes to climate impact data. Most of the areas where we are not able to connect the dots attribution-wise are in Africa. This has real implications for adaptation planning and access to funding in these places*" (Mercator, 2021).

Although curation of data and its quality remains a problem, my belief in the potential of this field stays unaltered. Though there are many hurdles on the way, Data Scientists are working hard in fighting these challenges and coming up with new and improved solutions every day.

3.5.4. Contribution 22 – the IS/IT in addressing the challenges of climate change – Dr Matti Mäntymäki

3.5.4.1. Need of increased attention to the sustainability implications of IS/IT. Digital services, platforms, and infrastructures consume significant amounts of electricity globally. On the other hand, digital infrastructures consume electricity. From this vantage point, for example Bitcoin can hardly be considered an environmentally sustainable technology. Moreover, the upgrade from HD to 4–8 K quality in video has an effect on the energy consumption of the devices such as smartphones and tables used to watch the videos. Considering the global smartphone penetration, energy consumption of smartphones is a significant sustainability issue. All in all, this calls for increased attention to the sustainability implications of IS/IT development and operations. This in turn requires that sustainability impact of digital services, platforms, and infrastructures be measured and monitored in a reliable and transparent fashion.

3.5.4.2. Reducing digital waste through IS/IT design. As the volumes of data being created, transmitted, and stored have skyrocketed also the volumes of 'digital waste', i.e. unused digital content, have surged. To provide some perspective of this phenomenon, CO2 emissions of YouTube in 2019 was evaluated to equal a city size of Glasgow.[7]

A well-known example of how IS/IT design could reduce CO_2 emissions is not to show video for users who are only listening to audio. This idea of digital waste reduction videos could be taken a step further by default by asking the user if he/she wants to see the video in addition to the audio content.

In addition, energy efficiency can be considered in website design. Typically, today's websites are dynamic. While this design approach offers benefits in terms of user experience, it basically requires that the server hosting the website creates the website for the user. A static website that is stored on the server and updated on a 12-hour or 24-hour interval is considerably more power efficient.

3.5.4.3. Research-based decision-making to accelerate adoption of 'green initiatives'. Resulting from the increased innovation around Greentech, there will be various new technological solutions to address the challenges of climate change. The effectiveness and impact of technological tools is dependent on their successful implementation as well as adoption and use by the users. The academic IS community has worked on technology adoption for decades and the individual-level technology adoption has evolved to be one of the most mature areas of academic IS research (Venkatesh, Davis, & Morris, 2007). Hence, the IS community is well-equipped to contribute to the deployment of various technological solutions targeted to fight climate change.

3.5.4.4. Sharing economy and circular economy as a means towards more resource-effective societies. The sharing economy is one way for existing resources to be used more efficiently (Sutherland & Jarrahi, 2018). Sharing economy at scale is typically executed through digital platforms. Digital platforms such as Uber are famous for leveraging data, advanced analytics, and artificial intelligence to predict and balance supply and demand.

Another mechanism toward a more resource-efficient society is the circular economy. It is evident that executing a circular economy requires implementation of digital infrastructures where the physical and digital elements go hand-in-hand (see Lee, 2008; Rajkumar, Lee, Sha, & Stankovic, 2010).

3.5.5. Contribution 23 – the value of information management in the built environment to tackle climate change – Mr Henry Fenby-Taylor

The built environment is made up of sectors that have an outsize responsibility when it comes to the future of our planet. It provides us with our economic infrastructure – power lines, roads, railways, utilities, as well as our social infrastructure of homes, schools, hospitals and so on. Yet it also contributes around 40% of the UK's total carbon footprint, according to the UK Green Building Council.

There is a real sense of urgency that this needs to change. Industry leaders are increasingly in consensus that they need to prioritize how they mitigate and adapt to climate change, as well as reduce emissions.

3.5.5.1. Unlocking the value of data. Critical to tackling climate change in the built environment will be the use of Information Management. It is currently a vast, largely untapped resource that will be pivotal in transforming the decision making process. At its core, Information Management is about making efficient use of resources – it's about transforming information about the lifecycle of built assets into actionable intelligence.

Effective information management gathers information across the lifecycle of assets from design to creation to operation. At each of these stages, data is collected that informs better decision making, enabling reductions in waste, time and cost, more efficient use of resources, improved design and safety and increased infrastructure resilience – all essential for reducing carbon emissions from our built environment and serving those it was intended for.

Although we have the technology to collect large amounts of data it needs to be structured, managed and shared in an effective way to make it valuable. The Centre for Digital Built Britain (CDBB), through the National Digital Twin programme (NDTp) is creating the Information Management Framework which is a collection of open, technical and non-technical standards, guidance and common resources to enable secure and resilient sharing of data across sector and organizational boundaries.

There are already some excellent examples of successful green Information Management in practice. The Energy and Carbon Reporting

[7] https://www.wired.co.uk/article/youtube-digital-waste-interaction-design.

Framework developed by the CDBB, WMEBoom and the Construction Innovation Hub defines when operational energy and emissions need to be analyzed and reported during the lifecycle of built assets. This tool is providing organizations like NHS Scotland and their supply chain the ability to effectively identify and therefore control the energy and carbon impact of their built assets. It also supports the Construction Leadership Council's CO2nstructZero programme which sets out how the construction sector can meet the Net Zero challenge.

3.5.5.2. Sharing data to improve climate resilience. The sharing of data is an important part of the process. At the NDTp, the Climate Resilience Demonstrator (CReDo) provides a practical example of how connected data and greater access to the right information across organizational and sectoral boundaries can improve climate adaptation and resilience.

Collaborating on CReDo are Anglian Water, BT and UK Power Networks who will use their asset and operations data as well as weather data on a secure, shared basis to inform an increased level of infrastructure resilience.

CReDo will integrate data between energy, water and telecoms networks to improve climate resilience decision-making across infrastructure systems.

3.5.5.3. Fit for the future. Although it is clear we should be pushing towards a green information economy, there remain hurdles - we need a workforce with the appropriate skills who can make it happen. Our work at the CDBB has a socio-technical focus and part of this is balancing the technology with the people aspect.

That is why we commissioned a Skills and Competency Framework report, a joint collaboration between Mott MacDonald, Lane4 team and the Construction Innovation Hub, that sets out the key roles and skills needed. It is a very practical framework that allows organizations and individuals to assess their own needs and consider how to address them.

3.5.5.4. A shift in culture. Data is no longer a commodity to be hoarded, but a resource to be shared. If industry and government are serious about tackling climate change there needs to be collaboration and there needs to be interoperability between information management systems, so that we use all the data we have in a relevant, impactful way.

3.5.6. Contribution 24 – What can information technology and systems researchers and educators do to mitigate climate change? – Dr Wu He

To respond to climate change, a significant threat to the United States and the world, the U.S. National Academies of Sciences, Engineering and Medicine has convened a committee of experts and published a report in 2021 to highlight the need for transforming the world's energy system to one with net-zero emissions of carbon dioxide (CO2) by 2050 (NASEM, 2021). The report emphasizes the need to invest in new technology, expand innovation toolkits, and reduce the cost of existing technology in a socially just way. My Views on the above four questions:

3.5.6.1. Energy Use and Technology. The information management, information technology, and information systems sectors highly depend on computers, sensors, and a wide variety of physical and electronic devices. However, the production and use of computers, sensors, storage devices, and other electronic devices require a tremendous amount of energy, contributing to greenhouse gas emissions and causing harm to the environment. For example, data centers consist of a large number of servers and computing resources interconnected by high-speed networks, which need to work nonstop 24×7. Data centers have to rely on cooling systems to ensure all those machines do not overheat. Such cooling systems consume a lot of energy. The United States Data Center Energy Usage Report (Shehabi et al., 2016) indicates that data centers in the U.S. alone likely consumed approximately 73 billion kWh in 2020. Energy efficiency strategies and technologies, including AI and data analytics, could help monitor data centers' energy usage and significantly improve energy conservation to reduce cost and carbon emissions. Google has reported using AI to reduce energy consumption in its data centers by as much as 40% (Evans & Gao, 2016).

3.5.6.2. Potential of information technology on mitigation of climate change. Information technology has great potential to increase the energy efficiency of buildings, transportation systems, manufacturing, supply chains, power grids, infrastructure, and agriculture, enabling sustainable solutions for energy consumption and usage. Low-cost internet of things (IoT) sensors and devices (e.g., smart thermostats, smart humidifiers, smart air purifier, smart air conditioner, smart fans, smart blinds, and so on) have been used to reduce energy consumption and achieve long term cost savings by tailoring climate-control according to real-time needs and lifestyle of people and their schedule (either in the building or away). Teleconferencing, telemedicine, e-commerce, and e-learning technologies are playing a role in reducing unnecessary travel and thus reducing total emissions into the environment. These sensor-based technologies can continuously collect massive amounts of environmental data to measure emissions and other relevant parameters and adjust based on optimal standards or human preferences and needs. Big data analysis and visualization can be leveraged to unlock insights that will help individuals, organizations and communities track electricity consumption patterns, identify energy leaks, improve energy use efficiency, and find creative ways to conserve energy and adapt to climate change faster and better.

3.5.6.3. Suggested research agenda on climate change. Several potential research ideas on climate change for information management, information systems, and technology researchers are listed below:

- Conducting empirical research to collect first-hand evidence and develop evidence-based guidelines and suggestions to help practitioners design and implement Green IT(green information technology) and Green IS (green information systems) initiatives within their organization. Green IS (green information systems) refers to the use of information systems to achieve environmental objectives. In contrast, Green IT (green information technology) refers to the practice of environmentally sustainable computing and emphasizes reducing the environmental impacts of IT production and use (Dedrick, 2010). Green IT/IS can help reduce the negative consequences of technology production on the environment and contribute to sustainable solutions, including environmentally sustainable business processes, practices, and end products in organizations and communities (Boudreau, Chen, & Huber, 2008).
- Studying the adoption of energy-saving IT in locations like home, businesses and communities, and assessing the impacts of information technology innovations on human behavior, mitigation of climate change, and relevant policymaking.
- Conducting design-based research on designing and developing AI-based techniques, modeling and simulation, decision support tools, games, visualization, and other technologies or approaches that help the general public visualize and understand possible impacts of climate change.
- Studying the use of games, mobile apps, augmented reality/virtual reality/mixed reality and other technology innovations in promoting environmentally sustainable behavior that contributes to climate change mitigation. Such studies could help understand the role of human behavior in achieving climate change mitigation strategies, reveal insights why people choose to engage in specific environmentally sustainable behavior or not, develop innovative approaches, policies, best practices, and solutions to climate change (Douglas & Brauer, 2021).

3.5.6.4. IT/IS education on climate change. This generation and future generations need to understand the impacts of climate change on our daily lives and society. IT/IS education could play a critical role in helping individuals and communities in the understanding of the science behind climate change and what steps are needed to alleviate greenhouse gas emissions and global warming caused by climate change and human activity. IS/IT educators could use project-based or problem-based learning approaches to engage students to explore specific climate change issues and community-related climate datasets (e.g., heat, cold, rain, drought, snow, wind, river, lake, ocean, water quality, air quality, and coastal flooding) and to assess the impact of potential solutions by leverage existing software, tools and techniques such as data analysis and visualization, modeling and simulation, augmented reality/virtual reality/mixed reality, and AI techniques. When students are asked to use technology tools to explore specific climate change issues and datasets of interest or relevance to their local communities, they are more likely to become interested and engage in active learning for systems thinking, complex problem-solving, creativity, and evidence-informed decision-making. In the meantime, they will become familiar with these software, tools, and techniques through learning by using them to analyze data and solve problems in a meaningful way. Students will have a chance to develop interdisciplinary skills to interpret complex data analysis and visualization results into informed decisions and sound policies. The ability and skills to interpret data and communicate results to support the decision-making process are important for IT/IS students to become effective decision makers or problem-solvers in their careers. IS/IT educators are recommended to come up with concrete learning activities, to develop technology-related case studies, tutorials, projects, and exercises on the topic of climate change, and to encourage their students to work on collaborative or hands-on projects using open-source resources, including various datasets and open-source software and tools available on the Internet, such as CODAP, R, Python, and more. There exists significant levels of climate change, open-source projects on GitHub, which is an excellent way for IT/IS students to learn, practice, and contribute.

3.6. Technology and IS research agenda

3.6.1. Contribution 25 – holistically missing: climate change and information systems research – Professor Samuli Pekkola

3.6.1.1. Introduction and related activities. In Finland, the Ministry of Transport and Communications recently published a climate and environmental strategy for the information and communication technology sector (Ojala & Oksanen, 2021). The strategy defines ICT related objectives and measures for carbon-neutral Finland, paying attention to ICT infrastructures and their energy efficiency, making recommendations on energy aspects in software and service procurement, considering material flows and recycling of the devices, suggesting energy consumption statistics on data centers, and increasing awareness of energy specific issues of software and hardware.

These areas and objectives, and their measures are evidently impactful on climate change. They increase awareness and provide general goals. Unfortunately, the strategy pays no attention to how *the use of ICT* impacts on climate and environment. The use aspect is touched, for example, in the European Commission's ICT for Sustainable Growth (2021) program, where, similarly to Estonia (2018), UK (Howes, 2020), and Norway (2016), the point of foci is on sustainable economics, not on sustainable ecology, environment, green ICT, or climate change – whatever term is adopted. This means that, in practice, environmental issues and ICT are approached either sporadically with a narrow view and disconnected contexts, or indirectly in the context of economic growth and prosperity.

Similarly, IT/IS literature sees environmental issues as something that the ICT managers should consider in their work. For example, Esfahani, Rahman, and Zakaria (2015) and Singh and Sahu (2020) summarized the green IS studies focusing on the benefits, adoption, design and implementation, or initiation of green IS projects. Loeser (2013) takes a more concrete approach and lists a variety of different contexts for green IS initiatives. Wang X. (2015), Wang Y. (2015)'s meritorious literature review parallels these and poses a set of research questions, all aiming to understand the green IS initiatives. In general, it seems that IS literature focuses the adoption of ideas of climate change into the IS activities and context. Comprehensive understanding about how to apply and use IT/IS to improve the situation regarding climate change seem to be scarce.

3.6.1.2. Towards a holistic understanding of IS and climate change. The absence of comprehensive approaches is surprising especially after the lessons from COVID-19. For example, the amount of traveling decreased up to 90% in California due to stay-at-home orders (Schilling 2020). At the same time, air quality improved significantly (Eregowda, Chatterjee, & Pawar, 2021). People have learned new ways of working, learning, and living, without a need to travel to work, school, or anywhere. Although these settings of distant working, online learning, and online shopping, traveling, and leisure have been studied (c.f. Dwivedi et al., 2020; Pan & Zhang, 2020), the approach is again contextual: how to use IS in online meetings or education, how to provide or acquire goods, food, or services online, and how to manage and govern the IT (Herath & Herath, 2020).

Contextual approach becomes problematic with the interconnectivity of systems and the systems of systems. For example during the COVID-19 pandemic, online learning tools have turned out to be quite efficient in conveying learning contexts to distant learners, although some learning-related difficulties have been identified (Chen & Roldan, 2021; Xie, Siau, & Nah, 2020). Yet the difficulties may go beyond the learning contexts. Online activities have been reported to increase loneliness, disconnectivity with fellow students and teachers, distraction, mental problems, and increased workload (Maqableh & Alia, 2021; Pan & Zhang, 2020). These negative issues may have unpredictably long-lasting effects on learners: for instance, do they know the topics, have they made friends, and have they learned to interact in face-to-face situations? The quality of an online learning environment may have an impact on the rest of the learner' life.

Similarly, targeting green IS/IT activities locally may, or may not, be beneficial from the viewpoint of climate change. They may have unintended consequences similarly to online learning: activities seemingly beneficial in the short term may possibly be harmful in the long run. This notion leads to following research topics:

- What are the long-term effects of green ICT investments? To climate and environment? To people: employees, learners, travelers, and their ways of doing, working, and living? To institutions? To firms and other organizations? To other parts of the system?
- When do the benefits of green ICT investments exceed its investment costs? The example of an electric car illustrates this: building an electric car is more environmentally harmful than building a petrol car, but the tide turns when the car is used enough. What is this turning point for a green IT/IS investment?

And most importantly:

- How can ICT be used to improve the situation regarding climate change? Interestingly, we are studying how the ideas and isms of climate change and green ICT are adopted, but not how ICT should be used to reduce climate change. This has been touched by sustainable economic endeavors, but aren't there any other values in addition to economic issues?

3.6.2. Contribution 26 – information technology and climate change – Professor Rameshwar Dubey

Irresponsible human activities are well reflected in the form of rising sea levels, forest fires, extinction of some rare species, the meteoric rise in floods in many parts of the world, and fast-shrinking levels of safe drinking water. These are clear indications that human influence on climate systems is clear and growing (Wright & Nyberg, 2017). Whyte (2020) argues that it is now too late to avoid dangerous climate change. The negative effects of climate change have attracted significant attention from the world's top leaders, industry, media, and policymakers (Banerjee, 2001; Kolk & Pinkse, 2008; Mees, Uittenbroek, Hegger, & Driessen, 2019). Some scholars argue that "climate change threatens irreversible and dangerous impacts," that may have serious negative effects on people and ecosystems (Whyte, 2020), and to address the pressing global threat, there exists a unanimous call for an immediate reduction in carbon emission levels (Park, Byun, Deo, & Lee, 2015). Although the COVID-19 crisis has caused severe discomfort and impacted human lives in significant ways, studies have identified signs of some positive and visible regional effects on the planet (Khan, Shah, & Shah, 2021). This could be easily explained by a change in behaviors during lockdown that has reduced human activities such as transportation, irresponsible consumption, production, and industrial activities. In the last two years, there is some evidence of an improvement in the quality of air, water and the environment looks greener and cleaner than it used to be (Everard et al., 2021). This change has been possible due to the role of emerging technologies, (Dwivedi et al., 2020; Pan & Zhang, 2020). Many scholars have found positive effects from emerging technologies on environmental sustainability: big data and predictive analytics capability (Dubey et al., 2019), blockchain technology (Saberi, Kouhizadeh, Sarkis, & Shen, 2019), AI (Nishant et al., 2020), and cloud computing enabled supply chain design (Shee, Miah, Fairfield, & Pujawan, 2018). However, the COVID-19 crisis has further accelerated the debate on "how information technology capabilities or information management scholars" can help tackle climate change (He, Zhang, & Li, 2021).

Despite the general optimism in the role of environmentally friendly technologies or emerging technologies in tackling climate challenges, some developed and developing economies, industry and global corporations still remain skeptical about the role of information technology in tackling the climate change crisis (Teräväinen et al., 2014). Wright and Nyberg (2017) argue that the organizations in pursuit of their economic gains have in the past lobbied against carbon emissions initiatives and further delayed constructive action. Despite the rich body of literature on the corporation's initiative towards mitigating the carbon emissions problem (Banerjee, 2001; Wright & Nyberg, 2017), organizational/ management/ information technology scholars have an important role to play particularly in addressing the climate change crisis.

There is a need for theory-driven research that provides an in-depth understanding of both the causes and possible solutions to tackle climate change. We note some clear research gaps in the academic literature and posit the following research questions that may help bridge the gaps in our understanding and the expected role of the information technology /emerging technologies in tackling the climate change crisis:

a. *How AI-enabled predictive analytics techniques may help identify some of the economic activities in some parts of the world which are contributing to carbon emissions?*
b. *How the use of distributed ledger technology (DLT) and AI can help identify the role of some corporations involved in unethical practices that led to contamination of water bodies and deforestation?*
c. *How the use of AI enables predictive analytics to detect issues during logistics and transportation within developing economies thereby contributing to a reduction in carbon emissions?*
d. *How AI-enabled technologies can help build swift trust and collaboration among the stakeholders engaged in tackling the climate change crises?*

3.6.3. Contribution 27 – blockchain and climate change – Dr Daniela Andreini

Of all technologies in place in the market, the one I know best is the blockchain. This technology has environmental, social and economic impacts, and in these few words, I would like to focus on the ecological aspects.

3.6.3.1. How IM/IT/IS sector has any negative impact on the environment and how it can be reduced. Like any other technology, blockchain creates a digital ecosystem composed of multiple hardware devices, program files, and different actors' data files. Another critical component of the ecosystem is interacting and exchanging cryptocurrencies, files, information, etc. The sustainability of the blockchain is controversial; for instance, O'Dwyer and Malone (2014) stated that the energy consumption of the Bitcoin mining network is comparable with the Ireland electricity consumption. In the same way, we can think about the energy and infrastructural consumption of all the IM/IT/IS systems that cause enormous energy and infrastructural consumption and thus a tremendous environmental impact.

3.6.3.2. How IM/IT/IS can be utilized to improve situation regarding climate change. At the same time, other authors demonstrated that the artificial intelligence and IT ecosystem could find more efficient ways to create and exchange information and virtual services. For instance, for what concerns bitcoins, Dimitriou and Karame (2013) demonstrated that in mining bitcoins, if a miner can create a block more efficiently and speedily than another one, the system will substitute the less efficient miner with the most productive and profitable one. This mechanism drives the entire system towards a more effective way to use and consume energy and infrastructures. Thus, the IM/IT/IS systems can be the sources and the solution of energy consumption and dispersion.

3.6.3.3. A brief discussion on research agenda related to IM/IT/IS and climate change. The cost and climate impact of blockchain are strictly related to its diffusion. For instance, in this historical moment, the substitution of traditional currencies with bitcoins in our monetary system would be too expensive in energy consumption, and thus it could not be sustainable. Therefore, in finance, for instance, more research is needed to understand how the two monetary systems can coexist efficiently. The same thing can be extended to other IM/IT/IS systems: virtualized and physical transactions should coexist to balance environmental, social, and economic systems.

3.6.3.4. How IS/IT education should reflect this. Experimentation in education is relevant, and more educational systems should turn into laboratories, where institutions should offer problem-solving driven teaching methods.

3.6.4. Contribution 28 – towards a relevant agenda for environmental issues within KM/IM/IS/IT – Professor Johan Olaisen

The climate crisis is the largest threat to civilization we have ever faced. The Intergovernmental Panel on Climate Change (IPCC) report in 2018 made the science very clear. There are significant climate impacts all around the world even if we limit warming to the recommended 1.5 C. The report also showed there are significant increases in impacts and damages between 1.5 and 2.0 C. These results were fully supported by the IPCC science report (2021). We are building our living standards upon coal, gas, and oil, and few of us want to change our lives, and new global generations are coming that want our living standards. Every corporation wants to be green and practice sustainability even if the reality of the image is most often an illusion or just a fashion (Jevnaker & Olaisen, 2021a, 2021b).

What is the research situation within knowledge management (KM), information management (IM), information technology (IT) and information system (IS) research? We investigated all academic papers

2016–2020 (N = 481) delivered at the European Conference for Knowledge Management (ECKM). We found that less than 5% of the papers investigated climate issues and concluded that the KM/IM/IT/IS potentially harms environmental-climate issues owing to neglect (Jevnaker & Olaisen, 2021a, 2021b).

All research consists of problem, knowledge, and methodology sentences. We get traditional pragmatic business-as-usual research when there is an over-focus upon methodology and knowledge sentences and a low focus upon problems. We must start to ask the research questions about environmental and sustainability issues.

Through verification and falsification (Popper, 1974), research is expected to come up with theories, paradigms, perspectives (Kuhn, 1962) that explains and explores practices that we may evaluate, giving us either empirical research or critical research (what is acceptable/not acceptable) or constructed research (what is adequate and what is not adequate). Most research is empirical, and to get more focus upon environmental issues, we must get more constructed and critical research setting up the green and sustainable agenda. We must ask the essential questions about if the academic papers involve acceptable or not acceptable climate solutions or if the papers are adequate or not adequate for relevant climate issues. Fig. 3 presents the model of the climate crisis issues within information research.

Research deals with four paradigms: the empirical, the materialistic (political), clarified subjectivity, and action papers. Jevnaker and Olaisen (2021a, 2021b) found that nearly all papers might be classified as empirical and as a form of clarified subjectivity papers in harmony with accepted problems, methodology, and knowledge. We must invite papers in conflict with accepted problems, methodology, and knowledge. These papers will be representing the materialistic political and action paradigms. We must ask how research papers, often in conflict, contribute to climate issues. To get green and sustainable papers, we must get more problem-focused research on climate issues, more critical and constructed papers, more exploring papers built upon sensitizing concepts and less upon definitive concepts, and more political and action-based papers. Most of all, we need editors and conference chairs dedicated to climate issues asking for adequate and critical papers on this topic that might be political, action-based, and problems often based in conflict with existing issues, knowledge, and methodology. A political economy paradigm for the climate crisis in information research is a complement to presently prevailing concepts. KM/IM/IS/IT research and papers might be utilized to be a knowledge café, outlet, and center for environmental issues and perspectives. We might develop an environmental paradigm for relevant KM/IM/IS/IT research. We might define another future for societies and organizations. We might be giving the picture of a pluralistic sustainable future and even a utopia (More, 1973). We already have the experience through AI and robotics forming the fourth industrial revolution and solving the environmental issues is the fifth industrial revolution based upon the perspectives from KM/IM/IS/IT research. The paradigms within information research focusing upon the climate crisis area as described in Fig. 4:

The objective and agenda of IS/I/IT/KM research strategy for sustainability are to help to promote knowledge, information, systems, and technology that will:

- Resolve national and global challenges relating to sustainability in corporations and societies
- Facilitate industrial development that enhances sustainability and increases green competitiveness
- Promote the innovativeness and creativity for sustainable solutions
- Such objectives will include areas like:
- Reduced climate change and effective adaptation measures
- Preservation of ecosystems services and lower environmental impacts
- Sustainable cities, corporations, regions, and transport systems
- The circular knowledge economy

The IPCC reports (2018, 2021) have mentioned five areas: Food and ecology, Sustainable cities, Energy and material, Health and wellbeing, Transportation. IT/IS/IM/KM are mentioned as essential for all these areas, and there is a need for developing the areas into issues for journals and conferences. The identified focus for research within information research is in Scandinavia sustainable private and public cases where the green and sustainable practices are documented. These cases should be developed into model cases for KM/IM/IS/IT. The cases should be used as action research cases promoting a sustainable practise (Jevnaker & Olaisen, 2021a, 2021b). The Scandinavian impact model might look like Fig. 5:

An important issue is how KM/IM/S/IT in higher education should reflect the environmental issues. Education that ensures future competencies upon sustainability, reuse, and environmental issues is essential. Environmental, green, and sustainable practices are an essential part of green education. Green KM/IT/IM/IS practice in action will be significant to get the students to participate in the transformational changes. The students must understand how different practices influence the environment. I have developed an executive program at BI (Oslo) "Sustainable leadership-in-action," where sustainable practices are discussed and reflected upon through collaboration with Norwegian businesses and the participants' experiences and where the students project paper is an empirical paper reflecting and learning from green practices with a synopsis as a reflection upon how they have implemented sustainable practices in their organizations. Ideally, should environmental issues be a part of all programs. KM/IM/IS/IT are innovative and creative tools for the solutions to environmental issues. Let COP26 also be the starting line for new objectives, areas, and education within KM/IM/IS/IT. We have every tool we need within information research to help to reduce and tackle the climate crisis. Let us all contribute!.

4. A brief overview of full opinion articles related to this theme

This section outlines an appraisal of the selected full opinion articles related to this theme included within volume 63 of IJIM. Each study covers one or more themes related to the overall climate change and emissions reduction agenda, together with the views of the authors on the key specific technology and IS related topics. The following table (Table 4) lists the full selection of the full opinion articles.

The opinion article by Ågerfalk et al. (2022), explores the Scandinavian perspectives on three current research projects where digital transformation is posited as offering a positive force in the fight against climate change and its impact on the world. The research viewed the climate change challenges from a stakeholder-centric perspective, emphasizing the criticality of closely involving people to engender the necessary change required in the design of digital technologies and the requirement for green IS researchers to engage in a collaborative context.

It is vital that emerging technology focussed solutions, designed to combat climate change, take account of the necessary ethical dimensions and values from the onset to negate the potential scenario of technological innovations exacerbating the climate change problem. These aspects are analyzed by Brooks et al. (2022) where the opinion article highlights the importance of technologies delivering the required socio-economic impact through climate engineering solutions. Via a review of the relevant literature, the research reveals the disjointed nature of ethical dimensions in many cases, lagging behind emerging technological innovations. The study advocates a rebalancing of emphasis where ethical dimensions are an integral element of the climate engineering process.

The opinion article by Laukkanen et al. (2022) argues for the usefulness of virtual technologies for changing human consumption behavior toward more sustainable consumption behaviors. The article argues that such technologies could provide greater opportunities to influence consumer decisions than the present digital environment. The article details a discussion on technology-assisted sensory marketing, cognitive and emotive aspects of virtual reality, and outlines applications of virtual reality technologies to encourage sustainable consumption.

The opinion article led by Papadopoulos and Balta (2022), highlights the low levels of existing studies that focus on the role of Big Data Analytics (BDA) and impact of climate change, positing the potential opportunities for more sustainable operations and supply chains. The study assesses the challenges faced by operations and supply chains, asserting the contribution from BDA in providing a valuable role in the development of solutions to the myriad of climate related problems.

Environmental sustainability from a technology acceptance perspective, is discussed in Papagiannidis and Marikyan (2022), where the opinion article highlights the dichotomy of technology negatively impacting the environment, whilst helping to manage and save precious natural resources. The research offers insights to the technology acceptance process from the sustainability perspective, arguing for a change in approach from researchers to be more cognisant of the impact of systems on the environment, thereby engendering environmentally compliant behaviors.

Researchers have highlighted the valuable role of smart and climate intelligent cities in the transition from current high emission urban infrastructure. The opinion article by Pee and Pan (2022) calls for resilient urbanization to weather the impending climate shocks that are likely to materialize as a direct result of global warming. The research posits the role of IS research and its potential contribution to energy and resource optimization and the role of IS in the contribution to mitigating many of the current climate change related challenges.

The opinion article by Pan et al. (2022) offers an Australia focussed perspective to approaching the climate change crisis highlighting the role of innovative technologies with huge transformative potential such as AI, analytics and IoT to tackle global warming whilst adhering to sustainable development goals. The researchers posit a research agenda that focuses on: climate resilience, climate-conscious citizen science, and substantive ESG strategies that can positively impact global warming.

The key challenges related to redesigning the necessary human processes to eliminate environmentally harmful activities, while maintaining humans' fundamental value proposition are discussed in the opinion article by Trkman and Černe (2022). The opinion article discusses a future world where humans transition from digitalization to a human digitalization, recognizing the critical role of government and research institutions for this change. The researchers highlight the role that technology can have in identifying, planning, enabling and executing the required changes in human behavior, as well as measuring and communicating their impact.

5. Discussion and recommendations

This section elaborates on the expert contributions presented in Section 3, to reveal the key emphasis and emerging themes relating to digital technology, IS and climate change. We highlight the implications for government and society, and develop a number of key recommendations for policy, practice and education.

5.1. Expert Contribution Analysis

A systematic analysis of the contributed articles was undertaken to offer a deeper insight to the key topics and underlying analytics. The analysis reviewed: a) the frequency of specific keywords mentioned in the articles, b) specific text features such as keywords, phrases and c) scores of polarity and sentiment analysis. Fig. 6 presents a word cloud view of the frequently occurring text from the submitted individual contributions. The analysis results highlight that the words: *impact*, *sustainability*, *green*, *environment* and *smart* are some of the significant and influential keywords emerging from the analysis of the contributed expert inputs.

Fig. 7 presents the polarity analysis of the contributed expert inputs. Most of the contributed expert inputs exhibit neutral polarity on the use of digital technologies and information management for climate change. If the neutral polarity is ignored, and the positive and negative polarity is compared, the majority of authors present a generally positive outlook for the use of digital technology and IS for combating climate change. This highlights the general consensus from the invited contributors, on the important role that technology can play in the global effort to reduce emissions to net zero by 2050.

5.2. Emerging Issues and recommended actions

Whilst the views on the extent of the role of digital technology and IS in combating climate change vary amongst the contributors, there is general consensus that technology is an integral component of the overall solution, whilst at the same time - a fundamental aspect of the problem (Muregesan, 2008; Osibanjo & Nnorom, 2007). There exists a realization amongst many of the contributors that a more sustainable implementation of technology in all its forms, needs to be at the forefront of solutions to get to net zero, the mistakes of old cannot be repeated once more.

A number of the submitted articles reference the negative impact of human behavior and people's attitudes in their day to day use of technology, positing the necessity for a transformative change in the way technology is developed, used and recycled. The expert input by *Professor Davison* illustrates these points specifically, highlighting the study by Clarke and Davison (2020), where the study asserts that very few studies within the IS research discourse, viewed the major challenges from the environmental perspective or included the environment as a key stakeholder. *Professors Constantiou and Vendelø* develop a narrative that highlights the potential use of technological solutions to facilitate the necessary change in human behaviors, citing how technology could be used to: identifying climate impact of transportation options, reduction in food waste via collaborative consumption and education on sustainable cooking. Behavioral influences from the community perspective in the context of faith and youth activism, are discussed in the expert inputs by *Dr Abumoghli* and *Professor Panteli* respectively, highlighting the important role of technology in building active communities that challenge the status quo. The expert input from *Professor Metri* cites the study by Junior et al. (2018) to highlight the woeful record of environmental sustainability from the technology industry, where the article posits the necessity of embedding the UN SDGs within technology design considerations and the potential of penalties for organizations that fail to change behaviors.

The educational awareness and requirements for changed working

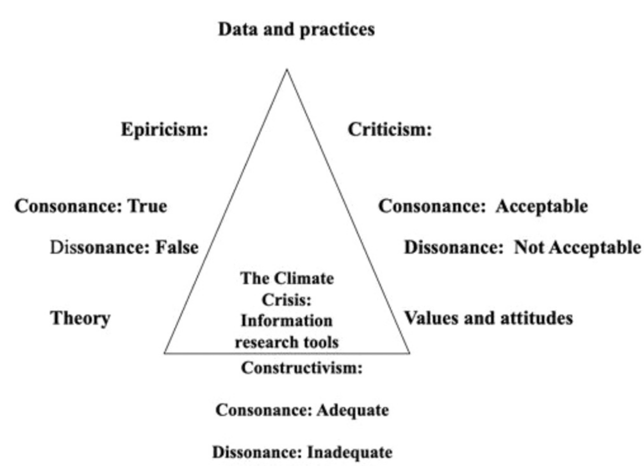

Fig. 3. Towards an agenda for handling the climate crisis in information research.

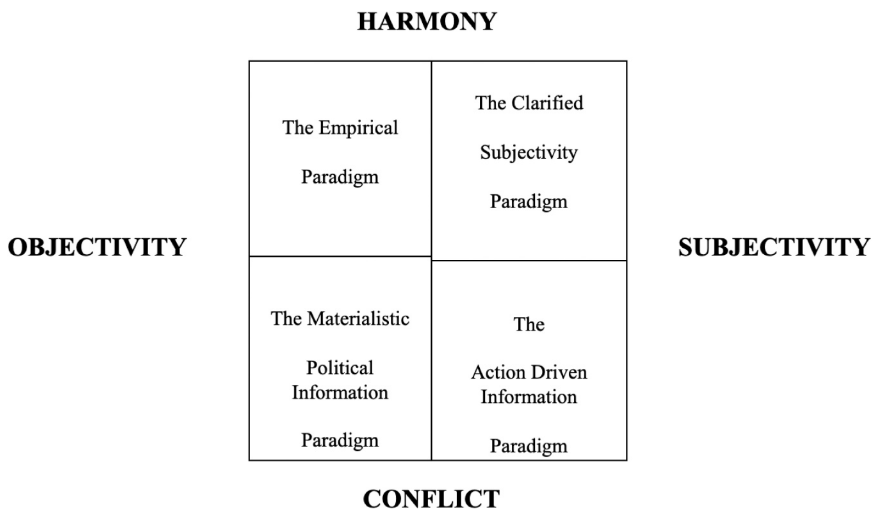

Fig. 4. Information research paradigms for use in the climate crisis.

practices, are discussed within a number of submitted articles, where these aspects are viewed from the technological perspective and impact on progress to net zero. The expert inputs from *Professor Barlette* and *Drs Nishant and Teo* identify the need for the IS community to educate more effectively to instil a greater awareness of the impact from technology adoption and the delicate balance between benefits toward net zero and contributing to the problem. The impact of climate change can be effectively monitored via the use of technology leading to a greater awareness amongst people to change their behaviors. These points are discussed in the expert input from *Professor Tiwari* where the article asserts the benefits of education at a community level, to empower people to gain access to knowledge and relevant data and assist vulnerable populations in the fight against climate change. The manufacture of technology based products relies on the use of precious and finite natural resources, at significant cost to the environment (Okafor, 2020). The expert inputs by *Professors Rowe*, *Raman and Rana* illustrate some of the negative impacts on the environment from the use of technology and the necessity for organizations to change their working practices to be more cognisant of the impact from the choices we make, the effect on the planet and support for the transition to environmentally friendly products. *Professor Rana* further emphasizes the need for education not just on climate change but also on how to use technology in a responsible way to help reduce carbon emissions and become ambassadors for sustainable living. The expert inputs by *Professor Michael and Dr Abbas* discuss the importance of a transition from current IS design practices to a more sustainability focussed approach and framework (Crow & Dabars, 2015), presenting a socio-technical sustainable design cycle for responsible systems design.

A number of the expert contributions discussed perspectives relating to the impact of people and communities, where key aspects of technology can be used to ensure humans live and work with a “lighter touch” to conserve precious resources and attain net zero via the innovative use of IS infrastructure (Elbanna at a., 2020). The expert input by *Professor Kodama* references the increasing focus on smart communities in the form of smart cities where next generation social systems connect homes, buildings and transport, within an environmentally supportive infrastructure, highlighting the criticality of an emphasis based on IT collaboration to deliver meaningful change. The smart city contribution to reduced emissions is discussed by *Professor Scholtz*, where the contribution highlights the smart environment dimensions of smart cities (Van der Hoogen et al., 2020), and the necessity for addressing the necessary skills and educational requirements to ensure people can interact with smart infrastructure, thereby attaining the intended benefits and sustainable outcomes. The expert input from *Professor De’* discussed the issues surrounding Green IS initiatives (Dedrick, 2010;

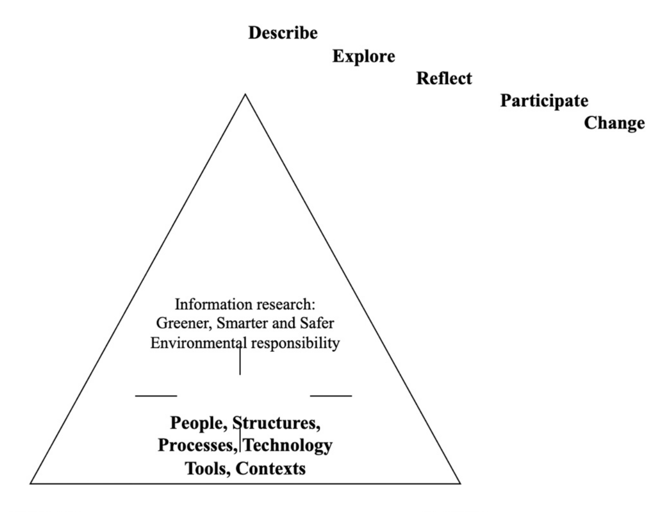

Fig. 5. The Scandinavian impact model of information research.

Table 4
List of full submitted articles on climate change, IS and technology.

Authors	Title
Ågerfalk, Axelsson, and Bergquist (2022)	Addressing climate change through stakeholder-centric Information Systems research: A Scandinavian approach for the masses
Brooks, Cannizzaro, Umbrello, Bernstein, and Richardson (2022)	Ethics of Climate Engineering: Don’t forget technology has an ethical aspect too.
Laukkanen, Xi, Hallikainen, Ruusunen, and Hamari (2022)	Virtual technologies in supporting sustainable consumption: From a single-sensory stimulus to a multi-sensory experience
Papadopoulos and Balta (2022)	Climate Change, Big Data, Big Data Analytics, sustainability, challenges
Papagiannidis and Marikyan (2022)	Environmental Sustainability: A technology acceptance perspective
Pee and Pan (2022)	Climate-Intelligent Cities and Resilient Urbanization: Challenges and Opportunities for Information Research
Pan, Carter, Tim, and Sandeep (2022)	Digital Sustainability, Climate Change, and Information Systems Solutions: Opportunities for Future Research
Trkman and Černe (2022)	Humanizing digital life – Reducing emissions while enhancing value- adding human processes.

Fig. 6. Word cloud analysis from top scoring words within invited expert inputs.

Khuntia et al., 2018; Melville, 2010), and how digital technologies can counter the effects of climate change. The article highlights the need for a greater emphasis on gender rebalancing to counter the poor access to technology from women in developing nations and the disproportionate effect that environmental change has on women.

Studies have posited the need for a greater focus on responsible digitization and corporate digital responsibility (Crawford, 2021; Lobschat et al., 2021). These aspects are discussed in the expert inputs from *Professor Wade* and also *Professor Sarker* where both articulate the need for organizations and consumers to take a more holistic view on the use of technology across the full lifecycle, highlighting the need for a more balanced, realistic and wider debate on environmental tradeoffs. The article by *Professor Sein and Dr Chandra Kruse* advocates a Design Science Research (DSR) approach from the IS community when developing sustainability and global warming solutions. This approach aims to create new knowledge through building methods and artifacts that are aligned with improving societal problems via the greater adoption of green practices.

The literature has posited the role of technology in the monitoring and governance of climate change progression, via the extensive use of IS systems and remote sensing devices to provide the necessary data to scientists and decision makers at a global level (Bunker, 2020; Nüttgens et al., 2011). The expert input by *Dr Mäntymäk*i highlights the need for a greater awareness of the sustainability impact of digital services, platforms, and infrastructure and that these systems be measured and monitored in a reliable and transparent fashion to mitigate the surge in unused digital content - so called digital waste. The expert inputs from *Professor Gupta, Professor Bunker and from Mr Fenby-Taylor* elaborate on these crucial aspects where they posit the benefits of improved data innovation practice, transitional approaches to complex information governance and effective information management to engender a culture shift in the use of data in all its forms, more collaboratively, thereby delivering impactful change. The expert input by *Ms Shah* highlights the critical role of data science processes to inform decision makers, monitoring of potential environmental hazards and accurate modeling of global warming scenarios. In the contribution from *Dr He,* he discussed the role of data analysis and climate change, where the role of sensor-based technologies was highlighted in the collection of huge amounts of environmental data to measure emissions and develop insights to conserve and improve energy use.

A number of the submitted expert inputs discussed topics associated with IS and digital technology research, commenting on the current position and potential agendas for the future. The expert input from *Professor Pekkola* criticised the narrow approach taken by organizations and public bodies where environmental issues and ICT are approached from disparate perspectives in the context of economic growth and prosperity. The article from *Professor Dubey* posits the need for theory-driven research utilizing AI based approaches to provide a better understanding of the causes of climate change and potential solutions. The impact of blockchain technology and the environment was discussed in the submission from *Dr Andreini,* where the article asserts the need for a research agenda better aligned to understanding how the traditional and cryptocurrencies can coexist more effectively. The article from *Professor Olaisen* critiqued the current IS literature, finding that a very small percentage of studies actually investigated climate issues, asserting the need for researchers to start to ask the necessary research questions, on key aspects of the environmental and sustainability issues.

5.3. Recommendations for research

The expert contributions detail a number of research recommendations on many aspects of technology and digital products. One of the key emerging themes from the contributions is the call to explicitly include the environment as a key stakeholder. This is referenced in the expert inputs by *Professors Davison and Sarker* and implicitly supported in many other contributions, where a more honest and informed perspective is required, advocating a research agenda that focuses on impacts as well as benefits from a responsible IS perspective. Many of the contributions highlight the need for further research on the role of IS in improving systems and processes in the transportation, agriculture and manufacturing industries to improve energy efficiency, reduce waste and deliver accurate data to make better, more informed decisions.

A number of contributions detail the critical role of IS and digital technologies in the provision of key data that can inform decision makers on the progress of global warming initiatives. Some of the topics discussed within the expert input by *Professor Raman* articulate many of the perspectives on this topic, highlighting the need for more research to improve the collection and dissemination of data on climate risk and use of sensor based IoT technologies within developing countries to alert authorities on emission levels. The expert input from *Professor Rana* supports a greater level of research focus on the socio-psychological behavioral factors surrounding the adoption of digital technologies, that can help inform researchers on how people adapt to new interactions and systems that reduce emissions.

The theme of multidisciplinary perspectives on IS and sustainability for research agenda, is discussed by a number of experts including the need for greater focus on global IT collaboration. Viewing these perspectives from a transdisciplinary lens is advocated in the contribution from *Professor Michael and Dr Abbas*, where they posit the benefits of creating models and simulations within an overall sustainability framework that can encapsulate multi-level perspectives on the provision of data and technology interaction.

A number of articles have referenced the role of smart technologies, smart cities and smart mobility, within the overall transition to a more sustainable digital infrastructure where people can interact with IS more

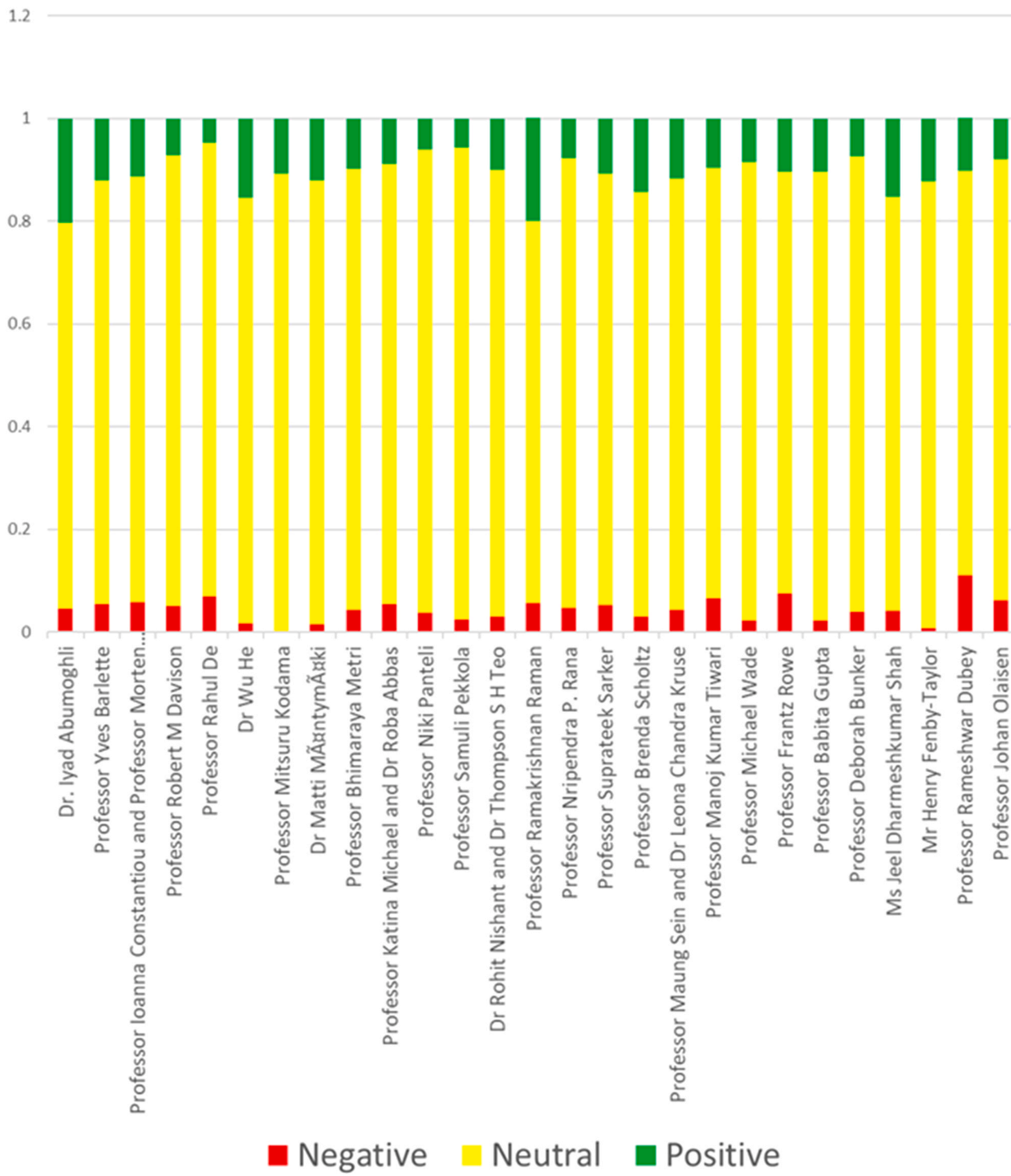

Fig. 7. Polarity analysis of the contributed expert inputs.

effectively throughout their daily lives. However, as highlighted by *Professor Scholtz*, the focus on aligning smart initiatives to the UN SDGs seems to be an underdeveloped research area that could inform further research on key topics of sustainable water management, sanitation and access to sustainable energy sources. This sentiment is further explored in a number of articles, but particularly the call for greater multidisciplinary perspectives on CDR as highlighted by *Professor Wade*, asserting the need for a better understanding of the dynamics of CDR from theoretical and empirical perspectives.

The problem of e-waste is discussed within a number of articles and further research in this area is explicitly called for. The article from *Professor Gupta* discusses a number of these key points that are detailed within many expert inputs, calling for greater research on improved strategies for dealing with this problem that negates the need for shifting the problem to emerging economies.

The pivotal role of data and data science has been referenced in many submissions but particularly in the from *Ms Shah* where the article discusses the criticality of accurate data and empirical studies to inform key decision makers. Further research and insight is needed, through evidence-based initiatives to ensure the effects of global warming are effectively communicated to governments and organizations to ensure timely decisions are made and relevant resources are made available in the critical areas.

5.4. Recommendations for education

The need for a greater educational awareness amongst IS researchers and users, seems to be a common thread within the submitted articles. A number of articles advocate a more holistic emphasis and informed debate on the environmental impact of technology, as well as its benefits in helping to mitigate further global warming and attainment of net zero by 2050. Many of the experts advocate a more balanced perspective within the IS and technology curriculum, to ensure students better understand the impact of behaviors. A number of articles also posit the need for better education on technologies that directly mitigate climate change, highlighting that this core topic seems to lack focus within many institutions.

Technology has a critical role to play in the changing of human attitudes and behaviors toward sustainability. IS can educate and inform people about the carbon footprint to explore new innovative ways to perform everyday activities but in a more sustainable way. The article by *Professors Constantiou and Vendelø* illustrates how digital platforms can engender collaborative consumption and social entrepreneurship, educating people to redistribute unwanted products and reduce waste as well as influence consumers via sustainable cooking and plant based food. A number of experts have detailed the role of IS in the context of educating people through online communities. The contribution from *Professor Panteli* emphasizes this aspect, positing the role of young people and their digital activism in influencing a change in behaviors, whilst *Dr Nishant and Professor Teo* discuss the need for IS educators to increase awareness on green IS and the sustainability aspects of technology. It is clear from the submitted articles that education is a key component of the transition to net zero and ensuring that all stakeholders (industry and individuals) have the necessary knowledge to engender changes in behavior, is a key component of the transition.

5.5. Recommendations for practice and policy

The UN COP26 conference gained commitment for a number of key initiatives that could have a significant impact on global warming. The key commitments included: at least 100 countries (including Brazil) agreeing to end deforestation by 2030; Led by the US and EU - 80 countries pledged to cut methane emissions by 30% by 2030; Although commitment could not be gained from China, the US, India and Australia - 23 nations made new commitments to phase out coal power, including five of the top 20 users: Indonesia, South Korea, Poland, Vietnam, Chile and Ukraine; India committed to attaining net zero by 2070 (COP26, 2021).

Governments have a critical role in combating global warming from the legislative and policy perspective, but to ensure the targets set for 2050 have a realistic chance of being achieved, we need change at a societal level. The IS and technology industry has a critical role to play in the monitoring of progress toward net zero, but also a pivotal role in the development of innovative solutions to better manage emissions and offer people alternatives to current carbon based practices. Many of the contributions have highlighted the crucial role of organizations adopting a green philosophy and demonstrating a firm commitment to CSR and CDR policies and working practices. A number of the experts have discussed the realities of technology contributing to the global warming problem due to the high levels of waste and inability for manufacturers to adopt a greater sustainability focus on manufacturing materials, processes and poor emphasis toward product repair, not replace - so called e-waste. The expert input by *Professor Metri* cites the 2019 UN and WEF reports that 50 million tonnes of e-waste was produced in that year, with only 20% being dealt with sustainably and the rest ending up as landfill. Many articles discuss these aspects, highlighting that the IS industry has much to do in this area. Organizations have their part to play to align with the goals and commitments from COP26, but successful outcomes rely on support from government and institutions to create the necessary environment and policy infrastructure, thereby enabling the technology industry to make the right long term decisions for the environment and society.

6. Conclusions

The UN climate change conference – COP26 held in Glasgow UK, is seen as one of the last chances for governments and key decision makers to make the firm commitments needed to ensure global temperatures do not exceed 1.5 °C above pre-industrial levels by 2050. The use of technology and IS is an integral component of many of the proposed mitigation measures, as governments and societies around the world take the necessary steps in transitioning to net zero.

This multi-contribution editorial study offers a technology focussed and IS perspective on the climate crisis where many of the multi-faceted complexities facing governments, organizations and decision makers are discussed. In alignment with the approach set out in previous studies (Dwivedi et al., 2015, 2020, 2021a, 2021b, 2022), each of the invited experts offers their own unique viewpoints to explore many of the key topics related to climate change, IS and digital technologies. The major technology and IS focussed themes that have emerged from the invited experts include: the impact of technology on behaviors and attitudes; Education, awareness and changed working practices; Impact on people and communities; Responsible digitalization; Role of data, technology and IS governance; Technology and IS research agenda.

We present this opinion paper as a timely perspective on this critical topic where we have discussed the multifaceted role of digital technology and IS in combating climate change. The expert contributions highlight the urgent need for education initiatives that offer a more holistic and balanced perspective on the opportunities for technology based solutions but also communicate the realities of the negative impact from e-waste and the shifting of the problem to poorer emerging nations. The developed countries throughout the world have a responsibility to develop solutions for problems of their own making and a greater focus on responsible digitalization has to be the right direction to engender sustained change. We advocate a greater awareness from individual consumers as well as manufacturers, on the "lived in" realities of environmental tradeoffs and key value choices (Rowe, 2018), as we continue to utilize technology as an integral component of our daily lives. Decision makers need to be cognisant of these key choices, as greater use is made of technology in all its forms to deliver net zero by 2050.

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