EXPLORING THE POTENTIAL OF REWARD-BASED SYSTEMS FOR PRO-ENVIRONMENTAL BEHAVIOUR IN THE CONTEXT OF CLIMATE-NEUTRAL SMART CITIES

Preamble

The concept of carbon-neutral, climate-friendly smart cities is becoming increasingly important in the fight against climate change because it represents a comprehensive approach to addressing global challenges. As digital transformation advances and its ability to improve information sharing and communication increases, the development of a reward-based system that encourages environmentally friendly behavior is being considered. Such a system could provide real benefits to people and organizations, encourage sustainable behavior, and support the development of a sustainable culture. It should be emphasized, however, that a rewards-based system should not be viewed as a substitute for regulatory or policy changes aimed at reducing carbon emissions and promoting sustainable development. Rather, it should be seen as a complementary tool to enhance and expand these efforts. To ensure effectiveness, the design of reward schemes should be carefully considered for fairness and transparency. This report introduces the idea behind the reward for pro-environmental behavior and proposes an approach for integrating concepts such as digital transformation and the circular economy to facilitate the adoption and retention of pro-environmental behaviors. This is part of the research being conducted at the University of Stavanger as an approach to complement existing regulations to mitigate climate change and support the transition to a more resilient society.

Information on Greencoin Project

The Greencoin project is funded by the *PolNor IdeaLab program 'Cities for the Future: Services and Solutions'* program. The Greencoin project benefits from €1.9 million from Iceland, Liechtenstein and Norway under the EEA Funds, and co-financed by the Polish government through the National Center for Research and Development (NCBR). The project addresses the question of how to promote environmentally friendly behavior among urban citizens. The project proposes an interactive experiment in which citizens are rewarded for environmentally friendly behavior and, in parallel, develops a marketplace mechanism where citizens can use their reward points to purchase environmentally friendly goods and services. The goal of the system is to recognize green actions in society and to encourage communities to protect the environment by facilitating and promoting environmentally friendly behaviors. Several complementary research institutions and non-governmental organizations have participated in this project. Gdansk University of Technology, Warsaw School of Economics and Maria Grzegorzewska University as academic partners, and the non-governmental organization Stowarzyszenie Inicjatywa Miasto from Poland have joined forces with Oslo Metropolitan University and the University of Stavanger from Norway.

The Idea behind Greencoin Project

The Greencoin project idea emerged during the IdeaLab workshop in early 2020, which was organized by the NCBR and the Norwegian Research Council. The workshop brought together representatives from science, business, and non-governmental organizations from Poland and Norway to explore ways to improve future cities. While there was no shortage of sustainable technologies, there was a significant gap between their level of development and their presence in everyday life. Cities evolve slowly, and ecological values are not prioritized in the dominant economic model. As a result, there is a lack of incentives to drive positive change, and people who are determined to change their behavior for sustainability face organizational, financial, and technological barriers (Greencoin project, 2021).

Greencoin project assumptions are laid out in Figure 1. These are Ecology – to support pro-environmental behavior; Inclusiveness – the system is to be open and increase the accessibility to green solutions; Modernity – the system will be using digital coins using modern technologies; Universality – potential of applications across other geographical areas; Networking – the system brings together stakeholders involved in environmental and climate protection; Open Source – the software developed by the team will be open and freely available to the public (Greencoin project, 2021).

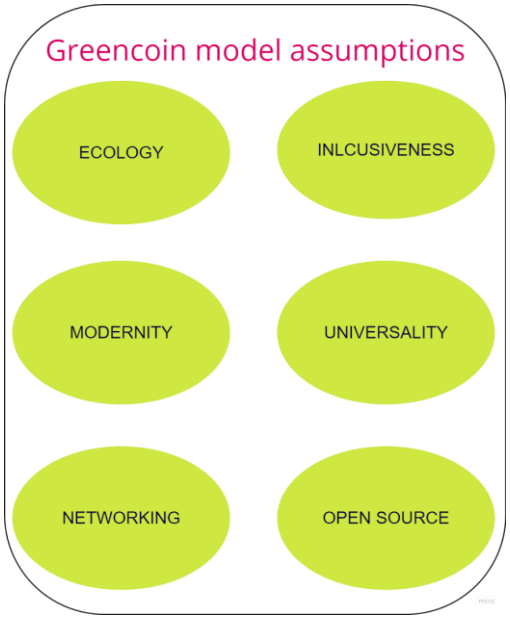

Figure 1. Greencoin functionalities

The team behind the Greencoin project diagnosed the problem as being the accessibility of green solutions and technologies for citizens, as well as the lack of incentives to change behavior. They proposed the following solution: *what if people who behave in an environmentally friendly way were given resources to spend on more green solutions, such as products, services, and*

technologies? This would create a self-perpetuating mechanism to support sustainable behavior, which is the core idea behind the Greencoin system (Greencoin project, 2021). The concept is represented in Figure 2.

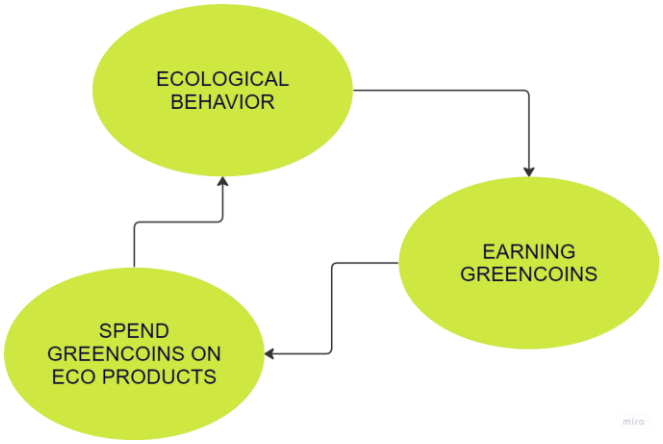

Figure 2. Greencoin concept

Global Challenges

Global production and consumption trends have been found to contribute significantly to a wide range of environmental issues including, but not limited to, air, water, and soil pollution, increased resource depletion, and adverse health impacts (Bleischwitz et al., 2018). Several planetary boundaries are now being exceeded due to human impacts on earth system processes, not only in terms of CO2 emissions and climate change, but also in terms of land-use change, biodiversity loss, and chemical pollution (Hickel et al., 2022; Sala et al., 2020). Steinmann et al. (2017) has found that resource use accounts for more than 90% of the global environmental damage, with everyday common products relying on resources extracted from multiple countries. This indicates that products have significant environmental impacts throughout their life cycle, from the extraction of raw materials to final disposal (Gasper et al., 2019; Sala et al., 2020). Pursuing the United Nations Sustainable Development Goals on Sustainable Consumption and Production (Gasper et al., 2019; UN, 2015) and advancing towards a more circular economy, the European Commission adopted measures on March 30, 2022, to ensure the creation and use of sustainable products (EC, 2022). Even so, it is argued that business interests have shifted the narrative from consumption volume to cleaner production, meaning that with sufficient innovation, consumption will cease to exert environmental pressure, and it can further expand without limit, such as the current business-as-usual (Gasper et al., 2019).

Research approach for innovation in Climate Neutral and Smart Cities

The researchers involved in this project align to the operational, tactical, and strategic phases that constitute mission-oriented research. All three levels contain tasks which contribute to the achievement of the research objectives established in the Work Package 3 which University of Stavanger leads, and within the accompanying work packages in which is partner.

At a strategic level, the researchers follow the leading goals of the academic organization. They provide general guidance for research activities to achieve mission-oriented goals. The goals are used by the researchers to grasp a clear sense of purpose and direction. At tactical level, the researchers are provided with the appropriate institutional framework on how to accomplish specific objectives within a specified time frame, including detailed schedules or instructions on how to complete tasks. At operational level, the researchers have the freedom to position themselves on the appropriate path which maximizes their work and outputs. The operations that researchers adopt integrate into broader activities, such as networking, collaboration, personal improvement, and in-depth research engagement.

Networking and collaboration, such as attending conferences, workshops and seminars are a great opportunity to meet other researchers and professionals in the field, present their work, and interact. Online networking (on LinkedIn, ResearchGate, Academia, etc.) can bring added value in connecting with other researchers and professionals in the field. Personal improvement, such as joining professional organizations, provides opportunities for networking and collaboration and gives access to a wide range of learning instruments. Seeking mentorship provides guidance, support, and feedback on research and career goals. Developing and improving hard and soft skills will ease the capability of researchers in deploying their research and enhance their visibility. Research engagement incorporates the accompanying activities mentioned above and leads to the resulting outputs that build up the performance indicators.

Proposed research approach

The research framework is structured around the interaction of *pro-environmental behaviour* (PEB), *digital transformation* (DT), and *circular economy* (CE) as illustrated in Figure 3. This framework is thought to serve as an accelerator for deploying products and solutions for climate neutral smart cities.

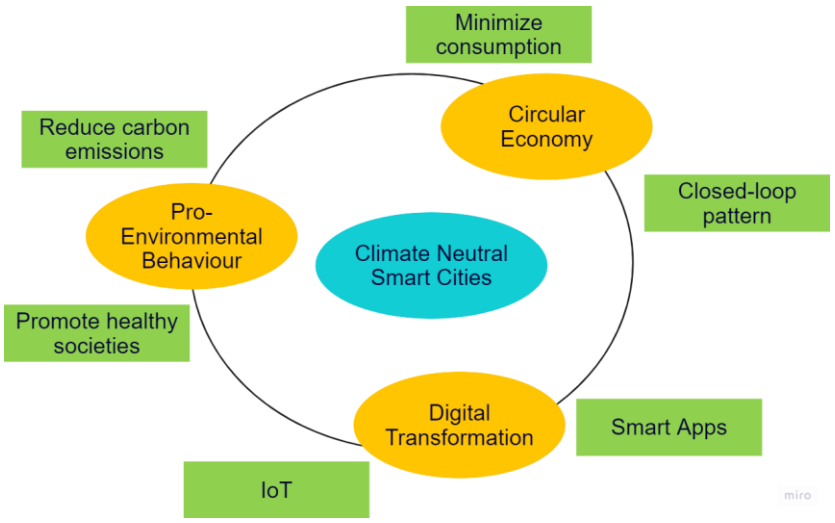

Figure 3. Conceptual framework

Adopting environmentally sustainable behavior often requires individuals to make additional efforts such as modifying their daily routines for recycling, public transportation, or energy saving at home. People are motivated by various influences, as explained by Rogers in the theory of innovation diffusion (Rogers, 1962). Innovations are typically adopted in a temporary sequence by several adopter groups, with innovators and early adopters embracing the innovation first, followed by the subsequent adopter groups. Early adopters enthusiastically promote innovations, but most innovations fail to cross the separation between early and late adopters (Moore, 1991). To facilitate widespread adoption of PEB, innovations must show concrete, tangible values, and ease of use. One key element in the context of innovations lies within the potential of DT in developing and integrating coherent policy response across all areas (OECD, 2019). DT refers to the process of using digital technologies to create new or modify existing economic and societal activities (OECD, 2019). Digital transformation has recently emerged as an significant phenomenon, encompassing the profound changes taking place in society and industries due to the use of digital technologies (Vial, 2019). Even if digitalization has historically increased environmental impacts at local and planetary scales (Creutzig et al., 2022), CE provides a practical framework for implementing sustainable practices by promoting the efficient use of resources and minimizing waste. CE helps translate PEB into actionable strategies that reduce environmental impact. In this context, the CE benefits from DT, as new technologies can enable more efficient resource management, waste tracking, and material reuse. Pro-environmental behavior is the foundation that encourages individuals and organizations to adopt sustainable practices paving the way for a mindset shift that prioritizes resource conservation, waste reduction, and environmental stewardship.

Research backgroud

Literature suggest that incentives can effectively stimulate PEB and various factors that influence its adoption have been analyzed, such as demographic elements, external factors (e.g. economic, social, and cultural factors), and internal factors (e.g. motivation, environmental knowledge, awareness, values, attitudes, and priorities) (Kollmuss & Agyeman, 2010). Although several studies explored the internal and external influences on the adoption of PEB across countries and demographic groups (Clark et al., 2003; Hansmann et al., 2020; Lee et al., 2014), social norm interventions have proven to be most effective in influencing PEB (Farrow et al., 2017). Social norms are rules and standards that guide and constrain human behavior without the force of laws (Keizer & Schultz, 2018). For instance, social influence and digital technology play an important role in the formation of consumer preferences for pro-environmental technologies (Arora et al., 2022; Bobeth & Kastner, 2020; Manca et al., 2019; Morton et al., 2016).

The change in behavior facilitates a smoother transition to a CE by fostering increased awareness and support for eco-friendly solutions, requiring collaboration among all stakeholders. Consumer attitudes and behaviors towards the CE vary across different cultures. The design of the circular business model should consider cultural differences to increase acceptance of the concept. Cheng and Chou investigated consumer attitudes and behaviors related to the notion of CE

through the implementation of different innovative business models in different parts of Europe (Cheng & Chou, 2018). Their findings highlight the importance of considering different consumption behaviors across cultures when designing circular business models. This approach increases consumer acceptance of the CE concept and subsequently enhances resource efficiency, helping to achieve the potential goal of sustainable development. The CE presents businesses with opportunities to develop eco-friendly products, which can emphasize a positive consumer response. For the CE approach to become widespread, shifts in both industrial practices and consumer consumption patterns are needed, and thus government, enterprises, and media should all contribute to raising awareness and influencing consumer behavior, encouraging the purchase of green products (Ferdousi & Qiang, 2016).

Digital technologies play a crucial role in supporting sustainable practices, leading to improved environmental performance (Piscicelli, 2023; Umar et al., 2022); they are believed to strengthen the role of citizens and consumers by informing, educating and transforming them into active participants in the move towards a CE (OECD, 2019). While the influence of DT in relation to CE have been mostly explored for the manufacturing sector (Khan, 2022; Tang et al., 2022), the role of consumers or community in the concept of circular economy was scarcely explored (de Filippi & Carbone, 2021; Maiurova et al., 2022; Warmington-Lundström & Laurenti, 2020). For the effective utilization of DT, it is essential to combine regulatory measures, incentives, and promotional activities. The sustainable transformation of cities depends on the proper use of new technologies, along with providing appropriate tools for implementation and monitoring.

Reward-based system

In the current context, we would refer to the mobile apps as a component in the broader process that advocates for DT. Mobile apps could play a vital role in facilitating the customers reach for businesses, increasing productivity and helping organizations to become more efficient.

Reward-based systems can act as a catalyst for promoting PEB by offering incentives that motivate individuals and organizations to adopt sustainable practices. Various types of rewards can be utilized, including monetary incentives, social recognition, and gamification elements, to engage users and create a sense of achievement (Abrahamse et al., 2005; Bolderdijk et al., 2012). By leveraging the capabilities of digital technologies, such systems can be personalized and adapted to individual needs, preferences, and cultural contexts, thus increasing their effectiveness in fostering PEB (Froehlich et al., 2009; Hamari et al., 2014).

Several studies have shown that reward-based systems can promote sustainable behavior in various domains, including energy conservation (Delmas et al., 2013; Gölz & Hahnel, 2016), waste reduction (Tudor et al., 2007), and sustainable transport (Bamberg et al., 2011; Creutzig et al., 2019). These systems may be adopted in both the private and public sectors, encouraging employees and people to engage in pro-environmental behaviors at work and at home (Kormos & Gifford, 2014; Osbaldiston & Schott, 2012).

However, the design and implementation of reward-based systems must be carefully considered to avoid potential pitfalls, such as crowding out intrinsic motivation, creating perverse incentives, or exacerbating social inequalities (Bénabou & Tirole, 2003; Bowles & Polanía-Reyes, 2012; Frey & Jegen, 2001). To maximize their effectiveness, reward-based systems should be transparent, fair, and adaptable to changing circumstances and user feedback (Gneezy et al., 2011; Ostrom, 2000).

Conclusions

This report provides an innovative approach to promoting pro-environmental behavior by going beyond existing methodologies and developing new concepts behind this mechanism. It suggests that reward-based mechanism could be effective in adopting and encouraging pro-environmental behavior. Future research should concentrate on designing and testing novel reward-based systems in a variety of situations, analyzing their efficacy, and establishing best practices for their design and implementation.

On a practical level, this report highlights the benefits of integrating PEB, DT, and CE concepts into a reward-based system as a viable method for supporting sustainable practices and hastening the transition to climate-neutral smart cities. Policymakers and practitioners can play an essential role in promoting sustainable behaviors, and contributing to the global battle against climate change, by carefully planning and executing these systems while taking cultural, demographic, and individual aspects into account.

Another implication lies in the collaboration and the multidisciplinary of research activities. These are essential not just for tackling complicated challenges, but also for encouraging sustainable behavior and hastening the transition to climate-neutral smart cities. Researchers may create and test innovative reward-based systems that encourage pro-environmental behavior by integrating knowledge from environmental psychology, behavioral economics, information systems and other relevant fields. It is critical to recognize and support collaboration and interdisciplinary research in academia, industry, government, and society as they have the potential to provide significant benefits in terms of knowledge transfer, innovation, and impact, as well as the potential to accelerate the adoption of sustainable practices using tailored and situation-aware reward-based systems.

References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 25(3), 273–291.

Arora, S. C., Sharma, M., & Singh, V. K. (2022). Using diffusion of innovation framework with attitudinal factor to predict the future of mobility in the Indian market. Environmental Science and Pollution Research.

Bamberg, S., Fujii, S., Friman, M., & Gärling, T. (2011). Behaviour theory and soft transport policy measures. Transport Policy, 18(1), 228–235.

Bénabou, R., & Tirole, J. (2003). Intrinsic and Extrinsic Motivation. The Review of Economic Studies, 70(3), 489–520.

Bleischwitz, R., Spataru, C., VanDeveer, S. D., Obersteiner, M., van der Voet, E., Johnson, C., Andrews-Speed, P., Boersma, T., Hoff, H., & van Vuuren, D. P. (2018). Resource nexus perspectives towards the United Nations Sustainable Development Goals. Nature Sustainability, 1(12), Article 12.

Bobeth, S., & Kastner, I. (2020). Buying an electric car: A rational choice or a norm-directed behavior? Transportation Research Part F: Traffic Psychology and Behaviour, 73, 236–258.

Bolderdijk, J. W., Steg, L., Geller, E. S., Lehman, P. K., & Postmes, T. (2012). Comparing the effectiveness of monetary versus moral motives in environmental campaigning. Nature Climate Change, 3(4), 413–416.

Bowles, S., & Polanía-Reyes, S. (2012). Economic Incentives and Social Preferences: Substitutes or Complements? Journal of Economic Literature, 50(2), 368–425.

Cheng, C.-C., & Chou, H.-M. (2018, April). Applying the concept of circular economy—Using the cultural difference of European consumers as an example. 2018 IEEE International Conference on Applied System Invention (ICASI).

Clark, C. F., Kotchen, M. J., & Moore, M. R. (2003). Internal and external influences on pro-environmental behavior: Participation in a green electricity program. Journal of Environmental Psychology, 23(3), 237–246.

Creutzig, F., Acemoglu, D., Bai, X., Edwards, P. N., Hintz, M. J., Kaack, L. H., Kilkis, S., Kunkel, S., Luers, A., Milojevic-Dupont, N., Rejeski, D., Renn, J., Rolnick, D., Rosol, C., Russ, D., Turnbull, T., Verdolini, E., Wagner, F., Wilson, C., … Zumwald, M. (2022). Digitalization and the Anthropocene. Annual Review of Environment and Resources, 47(1), 479–509.

Franzen, M., Moeckel, R., Heinrichs, D., Nagel, K., Nieland, S., & Weisz, H. (2019). Leveraging digitalization for sustainability in urban transport. Global Sustainability, 2.

de Filippi, F., & Carbone, C. (2021). ICT as innovative tools for circular planning in urban areas. TECHNE, 22, 96–103.

Delmas, M. A., Fischlein, M., & Asensio, O. I. (2013). Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. Energy Policy, 61, 729–739.

EC. (2022). On making sustainable products the norm. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0140&from=EN

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social Norms and Pro-environmental Behavior: A Review of the Evidence. Ecological Economics, 140, 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017

Ferdousi, F., & Qiang, D. (2016). Implementing Circular Economy and Its Impact on Consumer Ecological Behavior. Journal on Innovation and Sustainability RISUS, 7(1), 3–10.

Frey, B. S., & Jegen, R. (2001). Motivation Crowding Theory. Journal of Economic Surveys, 15(5), 589–611.

Froehlich, J., Dillahunt, T., Klasnja, P., Mankoff, J., Consolvo, S., Harrison, B., & Landay, J. A. (2009). UbiGreen: Investigating a mobile tool for tracking and supporting green transportation habits. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1043–1052.

Gasper, D., Shah, A., & Tankha, S. (2019). The Framing of Sustainable Consumption and Production in SDG 12. Global Policy, 10(S1), 83–95.

Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and why incentives (don't) work to modify behavior. The Journal of Economic Perspectives, 25(4), 191–210.

Greencoin project (2021) Retrieved from http://greencoin.pl/index.php/en/__trashed/ April 2023

Gölz, S., & Hahnel, U. J. J. (2016). What motivates people to use energy feedback systems? A multiple goal approach to predict long-term usage behaviour in daily life. Energy Research & Social Science, 21, 155–166.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does Gamification Work? – A Literature Review of Empirical Studies on Gamification. 2014 47th Hawaii International Conference on System Sciences, 3025–3034.

Hansmann, R., Laurenti, R., Mehdi, T., & Binder, C. R. (2020). Determinants of pro-environmental behavior: A comparison of university students and staff from diverse faculties at a Swiss University. Journal of Cleaner Production, 268, 121864.

Hickel, J., O'Neill, D. W., Fanning, A. L., & Zoomkawala, H. (2022). National responsibility for ecological breakdown: A fair-shares assessment of resource use, 1970–2017. The Lancet Planetary Health, 6(4), e342–e349.

Keizer, K., & Schultz, P. W. (2018). Social Norms and Pro-Environmental Behaviour. In Environmental Psychology (pp. 179–188). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119241072.ch18

Khan, S. A. R. (2022). Circular economy and digital technologies: An evolving trend in environmental research. Integrated Environmental Assessment and Management, 18(4), 853–854.

Kollmuss, A., & Agyeman, J. (2010). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environmental Education Research, 8(3), 239–260.

Kormos, C., & Gifford, R. (2014). The validity of self-report measures of proenvironmental behavior: A meta-analytic review. Journal of Environmental Psychology, 40, 359–371.

Lee, Y., Kim, S., Kim, M., & Choi, J. (2014). Antecedents and interrelationships of three types of pro-environmental behavior. Journal of Business Research, 67(10), 2097–2105. https://doi.org/10.1016/j.jbusres.2014.04.018

Maiurova, A., Kurniawan, T. A., Kustikova, M., Bykovskaia, E., Othman, M. H. D., Singh, D., & Goh, H. H. (2022). Promoting digital transformation in waste collection service and waste recycling in Moscow (Russia): Applying a circular economy paradigm to mitigate climate change impacts on the environment. Journal of Cleaner Production, 354.

Manca, F., Sivakumar, A., & Polak, J. W. (2019). The effect of social influence and social interactions on the adoption of a new technology: The use of bike sharing in a student population. Transportation Research Part C: Emerging Technologies, 105, 611–625.

Moore, G. A. (1991). Crossing the chasm: Marketing and selling technology products to mainstream customers. HarperBusiness.

Morton, C., Anable, J., & Nelson, J. D. (2016). Exploring consumer preferences towards electric vehicles: The influence of consumer innovativeness. Research in Transportation Business & Management, 18, 18–28.

OECD. (2019). Going Digital: Shaping Policies, Improving Lives. OECD. https://doi.org/10.1787/9789264312012-en

Osbaldiston, R., & Schott, J. P. (2012). Environmental Sustainability and Behavioral Science: Meta-Analysis of Proenvironmental Behavior Experiments. Environment and Behavior, 44(2), 257–299.

Ostrom, E. (2000). Collective Action and the Evolution of Social Norms. The Journal of Economic Perspectives, 14(3), 137–158.

Piscicelli, L. (2023). The sustainability impact of a digital circular economy. Current Opinion in Environmental Sustainability, 61, 101251. https://doi.org/10.1016/j.cosust.2022.101251

Rogers, E. M. (1962). Diffusion of innovations. Free Press of Glencoe. https://bac-lac.on.worldcat.org/oclc/301676794

Sala, S., Crenna, E., Secchi, M., & Sanyé-Mengual, E. (2020). Environmental sustainability of European production and consumption assessed against planetary boundaries. Journal of Environmental Management, 269, 110686.

Steinmann, Z. J. N., Schipper, A. M., Hauck, M., Giljum, S., Wernet, G., & Huijbregts, M. A. J. (2017). Resource Footprints are Good Proxies of Environmental Damage. Environmental Science & Technology, 51(11), 6360–6366.

Tang, Y. M., Chau, K. Y., Fatima, A., & Waqas, M. (2022). Industry 4.0 technology and circular economy practices: Business management strategies for environmental sustainability. Environmental Science and Pollution Research, 29(33), 49752–49769.

Tudor, T. L., Barr, S. W., & Gilg, A. W. (2007). Linking intended behaviour and actions: A case study of healthcare waste management in the Cornwall NHS. Resources, Conservation and Recycling, 51(1), 1–23.

Umar, M., Khan, S. A. R., Zia-ul-haq, H. M., Yusliza, M. Y., & Farooq, K. (2022). The role of emerging technologies in implementing green practices to achieve sustainable operations. The TQM Journal, 34(2), 232–249.

UN. (2015). Take Action for the Sustainable Development Goals. United Nations Sustainable Development. https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. The Journal of Strategic Information Systems, 28(2), 118–144.

Warmington-Lundström, J., & Laurenti, R. (2020). Reviewing circular economy rebound effects: The case of online peer-to-peer boat sharing. Resources, Conservation and Recycling: X, 5. Scopus.