Can Immersive Systems Help Address Sustainability Goals? Insights from Research in Information Systems

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Abstract Several developments in recent years have highlighted the urgent need for an increase in sustainable behavior. In an effort to systematically achieve global human well-being and create a more sustainable and equal world by 2030, the United Nations passed the Sustainable Development Goals in 2015. In this chapter, we discuss several different approaches for Information Systems (IS) to contribute to these goals. We present ideas and first results from different research approaches in which we analyze how immersive systems, in particular, are capable of addressing challenges regarding awareness, motivation, information transfer, and educating citizens to act in a sustainable manner. We conclude that the main features of immersive systems are particularly suited to approach challenges related to sustainable behavior and attitude change. With this chapter, we hope to inspire further research efforts on how IS can make a contribution to a more sustainable world.

1 Introduction

In 2015, the United Nations' General Assembly passed the Sustainable Development Goals (SDGs) as an agenda to achieve a more sustainable and equal world by 2030. The 17 goals aim to address all sectors of society and seek to rethink social,

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economic, and environmental interactions globally. They stretch from “zero hunger” to “climate action” to “peace and justice strong institutions.”

Five years prior to the launch of the SDGs, Watson et al. (2010) criticized the hesitancy within the Information Systems (IS) community to address issues of sustainability and pointed toward the “transformative power of IS to create an environmentally sustainable society” (Watson et al. 2010). In 2015 vom Brocke and others took up this call to action by publishing *Grand Societal Challenges in Information Systems Research and Education* (vom Brocke et al. 2015), the results of a student research project on this topic.

In 2020, the societal consequences of not taking action seem very present: The global refugee crisis, the global protests for climate justice around the Fridays for Future movement, and the Covid-19 pandemic have revealed the necessity to implement the SDGs as soon as possible. Gradual processes such as the transformation toward a digital and more sustainable economy as well as the worldwide urbanization of cities highlight the challenges lying ahead and the need for the field of IS to focus on the interests of society.

Building on the research mentioned above and the call for urgent action by Gholami et al. (2016), this chapter addresses several SDGs, in particular: SDG 1 (no poverty), SDG 3 (good health and well-being), SDG 10 (reduced inequalities), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), SDG 13 (climate action), and SDG 16 (peace, justice, and strong institutions). This chapter presents concrete findings of IS research studies that discuss the possibilities of immersive systems to accomplish their realization.

As we believe in diversifying the efforts to tackle societal challenges, we propose the strategy that IS researchers should first take initiatives in their respective domains. We thus focused on immersive systems, such as virtual reality (VR) and augmented reality (AR), as our expertise lies in this research field, and we found several indicators that such immersive systems can be used as a powerful instrument to address issues of sustainable development.

Achieving the SDGs is challenging for several reasons. We focus on the following four challenges in this chapter: *Awareness*, *Motivation*, *Information Transfer*, and *Learning to Act*. First, in our everyday lives, we are rarely aware of all the different problems and consequences of our actions that actually relate to sustainability issues. The consequences of unsustainable behavior can be far in distance and time for at least part of the population. Unfortunately, this ignorance is often true for that part of the population which is highly responsible for it but does not feel its immediate consequences; for example, climate change still has few noticeable consequences for individuals living in Central European countries or the USA but very noticeable consequences for the population of South Africa. Second, there is little extrinsic motivation to act and participate in order to reach the sustainability goals. Intrinsic motivation as a sole driver may be too weak to compete against other tasks and duties of our everyday lives. Third, in a world of information overload and complex facts, transferring the relevant information at the right time is difficult. The challenge at hand is to provide easy-to-understand information exactly when sustainable actions are needed and can be implemented.

For example, knowing about a phenomenon such as an inferior working situation in the cloth industry particularly helps in reaching the UN goals if this information is available during the purchasing process. Fourth, some of the necessary actions can be trained in order to incorporate them into our everyday lives. For example, continually looking up the right bin for a waste item is tedious, and thus learning how to act by being trained to recycle properly would help with the necessary behavioral change.

In this chapter, we postulate that immersive systems can be used to support the implementation of certain SDGs in addressing the four challenges mentioned above. Immersive systems are characterized to “purposefully change or enhance the user’s perception of reality” (Cavusoglu et al. 2019) and comprise AR as well as VR. Immersion describes the degree to which a VR system’s output is comparable to physical stimuli (Bowman and McMahan 2007). The key characteristic of immersive systems, in particular VR, is the capability to create telepresence (Steuer 1992), which means feeling present in an environment mediated by any communications technology (Pfeiffer et al. 2020). We argue that high telepresence can help people to be fully present and involved in contexts that are distant in time and space, and thus evoking telepresence could help with processes aimed to increase awareness. Second, immersive systems have been considered among the most notable evolving technologies in the area of Information and Communications Technology (ICT) (Steininger 2019). We therefore further assume that using this technology as a way to participate in sustainable behavior or to provide information about sustainability problems might be very motivating. Third, immersive systems allow for novel forms of information representation which can strongly benefit cognitive load and information transfer. The technology also facilitates the application of smart algorithms that use multi-modal data input for intelligent personal assistants that transfer information at suitable moments. For example, when going shopping in a virtual reality store, nudges about poor manufacturing conditions during the purchasing process can lead to more sustainable purchase decisions. Finally, because of the possibilities to imitate interactions of the real world, immersive systems allow for novel training opportunities that have the potential to aid more efficiently with the transfer of skills and knowledge to reality in comparison to standard e-learning contexts.

The goal of the chapter is to stimulate both researchers and professionals to think about how and whether immersive IS can help with the process of reaching the goals set by the UN. For this, the chapter provides first evidence and ideas from our research.

2 Immersive Systems as a Tool to Increase Awareness

The SDGs were set in 2015 by the members of the United Nations General Assembly, but achieving these ambitious goals doesn’t only require support from the political leaders who put their signature on the resolution. It also requires people all over the world to align their everyday decisions and behaviors with these goals.

With several large campaigns, the United Nations attempted to raise awareness, but action to meet the goals in 2030 is not yet advancing at the speed or scale required.

With just under 10 years left to achieve the SDGs, world leaders at the SDG Summit in September 2019 called for a “Decade of Action” on different levels including “people action” in order to generate a strong movement pushing for the required transformations. Raising awareness is a crucial prerequisite for encouraging action, but it is a difficult endeavor when it comes to global challenges such as those addressed by the SDGs. In 450 BC Confucius is reputed to have said: “Tell Me and I Will Forget; Show Me and I May Remember; Involve Me and I Will Understand.” This is also reflected in more recent theories of learning or behavior stating that personal experience plays a decisive role when it comes to behavior change. How can we make people all over the world more aware of the most pressing contemporary global challenges such as climate change that will not affect our lives tomorrow but those of the generations to come, or poverty affecting populations living thousands of kilometers away?

Based on first evidence from literature and our own studies, we propose that by allowing people to engage in experiences that reach far beyond their own physical reality independent of time and physical location, immersive systems can change the way people see the world. This is made possible because of the immersive system’s feature that allows people to feel present in an artificially created world. This digital world can be a replication of the real one that makes people aware of and experience geographically remote places or lets them experience the future. This digital world can also show completely fictional worlds and allow, for example, behaviors that would be harmful to the self, others, or the environment in the physical world. This might make people experience emotionally difficult or physically harmful situations and increase awareness. With the development of affordable hardware and the emergence of a wide range of content, the concept is already within the reach of the general public.

For example, in most cases taking action against global climate change (SDG 13: climate action) requires the sacrifice of concrete, immediate benefits for the sake of abstract, distant goals. Many theories deal with the psychological background of human behavior associated with future consequences of present behavior, or decisions showing that humans tend to discount the importance of an outcome with greater temporal, social, or geographical distance. Construal level theory, for example, posits that humans have distinct psychological associations with events based on their perceived temporal and personal distance (Liberian and Trope 1998). Abstract representations of consequences in the distant future usually lack the concrete associations connected to near-present events and thus may not be as feared (Gifford et al. 2009). The closer and the more personally relevant potential consequences seem to be, the more people are aware of these problems and take them seriously, and the more likely it is that protective or mitigating action is taken. The use of immersive systems to promote more sustainable environmental behavior has been evaluated since 2008 (Fiore et al. 2009). In particular, the influence of

VR experiences on risk perception regarding wildfires (Fiore et al. 2009) or floods (Bateman et al. 2009; Zaalberg and Midden 2010) is widely addressed. Further attention is given to the consequences of wasteful energy consumption (Bailey et al. 2015), napkin wastage (Ahn et al. 2014), environmental pollution (Fox et al. 2020), and climate change (Nelson et al. 2020). However, more research is needed to examine the long-term effects of virtual experiences and to increase the external validity and generalizability of the findings that are mainly based on hypothetical decisions in artificial lab settings.

Immersive systems are not only capable of overcoming temporal or geographical distance, which may be key to raising awareness of global climate issues. Much hope is also based on the technologies' capability to convey another person's experience or feelings to a viewer by putting him or her either right into the body of that character (embodiment) or close to him or her in the virtual space. Several studies have looked at the effect of embodiment in virtual reality and suggest that when people have an illusion of body ownership over a body different to their own, this can induce perceptual, attitudinal, and behavioral change (Maister et al. 2015; Slater and Sanchez-Vives 2014). Findings show, for example, that virtual embodiment can reduce implicit racial biases toward dark-skinned people (Banakou et al. 2016; Maister et al. 2013; Peck et al. 2013), and embodiment of adults in the bodies of children results in their overestimation of object sizes and a shift in attitudes about the self toward being child-like (Banakou et al. 2013).

Immersive systems are already successfully used to increase empathy with refugees (Gürerk and Kasulke 2017), and as a part of the UN SDG Action Campaign, a series of VR films was published that are intended to provide a deeper understanding for those living with the most complex development challenges. There is some recent work indicating that immersion in VR might enhance empathy (Schutte and Stilinovic 2017; Shin 2018) and increase intentions to voluntarily support charitable purposes (SDG 1: no poverty). However, the best intentions are worthless if they are not put into action. But do immersion effects translate into real action, and what emotional and motivational mechanisms are the driving forces? In a first pilot study (Greif-Winzrieth et al. 2020), we use electroencephalography (EEG) to reveal cognitive processes during VR experiences and examine changes in frontal alpha asymmetry (FAA) scores as a measure of approach/avoidance motivation (Briesemeister et al. 2013) and a potential predictor of monetary donations (Huffmeijer et al. 2012). Our results indicate that donation behavior might be linked to changes in the FAA score. Building on this finding, we plan to further investigate the effects of immersion on cognitive-affective processes, hoping to gain a deeper understanding of how immersive systems can help not only to increase awareness but also to inspire action needed to achieve the SDGs.

3 Immersive Systems as a Tool to Increase Motivation to Participate

We argue that immersive systems can be used as a tool to increase motivation to participate in reaching the UN goals and provide a research example that addresses sustainable urbanization and reduced inequalities (SDGs 10 and 11). Since SDG 16, peace, justice, and strong institutions, points to the importance of the public sector in implementing the SDGs, we aim to show how immersive systems can be used by public institutions.

Urbanization has led to an increase in urban population worldwide (United Nations 2019). In recent years, disputes about the design of urban space have emerged in city planning. Especially when it comes to construction projects, public debates and protests may arise, if construction plans remain unshared with the citizens they may affect. This kind of behavior, shown by various governments and construction project initiators, seems to be short-sighted and is therefore unsustainable as it constructs urban space without the potential users of the space: the city's inhabitants. Involving citizens early on in processes of transformation can secure or even strengthen trust in public institutions and thereby leads to a sustainable relationship with the surrounding urban space. E-Participation, as a subform of Digital Government, tries to elaborate new forms of involvement of citizens created by making use of digital technologies. As those digital forms open up numerous new technological possibilities of involvement, we are researching the potential of immersive systems to increase the citizens' motivation to participate. Although there is a wide use of ICTs in the daily life of individuals all around the world, we have the feeling that classical e-participation lacks wide acceptance also due to the fact that from a user-centered design point of view, many tools are simply not comparable with the often fun and simple user experience of other applications. This might be related to out-of-date implementation of some apps and the challenge of translating complex political decision-making processes into a user-friendly platform design (Toots 2019). As Scholl (2008) already stated early on, Digital Government is an interdisciplinary field of study, where a shared understanding of public administration and IS design might lead to better Digital Government solutions. As we see the possibilities IS research offers mostly for the business context, and the lack of innovation public administration offers, we try to bring the disciplines closer together in an interdisciplinary research project, where we aim to counter the lack of motivation to participate in public services, by adding technological innovations such as immersive systems.

Within the research project "Take Part" (funded by the German Federal Ministry of Education and Research), we have the possibility to experiment with immersive systems as a means to improve digital citizen participation (Fegert et al. 2019). Cooperating with public institutions, we have the opportunity to get direct feedback from citizens and initiators. The application enables the public to participate in construction projects. Moreover, it allows participants to see the respective construction project from different perspectives and eventually see different versions

of the construction project both in AR and VR. The users can submit their feedback, comments, and design suggestions within the applications. The application is designed for smartphones, tablets, and head-mounted displays (HMDs) and is controlled by lifting, lowering, and turning the mobile device, or in the case of HMDs is navigated with the help of controllers.

As we have shown within our research, there is an overwhelming interest in using AR and VR for e-participation to better visualize construction planning and to engage with urban planning (Fegert et al. 2020a). Furthermore, the technologies helped the participants imagining the construction project, positively impacting their willingness to engage with and donate to the construction project.

The United Nations (2018) points out that “online tools can enhance access to information and public services, as well as promote better public policy decision-making” (p. 33) and thereby might help lower the digital divide and produce more accountability. Based on our research, we definitely agree with the statement and go one step further, by seeing in the combination of the e-participation and immersive systems one of the (hopefully many) possible ways to achieve SDGs 10 and 11.

For SDG 10, reduced inequalities, we see the potential of immersive systems in the user’s fascination with the technology experience and the effect of telepresence. There seems to be a high interest in the use of the technology regardless of gender, age, or educational background (Fegert et al. 2020a, b). Moreover, in our quantitative study, most participants felt virtually transported from the study’s environment to the construction project site when using the VR prototype. By this means, we could prove that the technologies offer the possibility to participate more easily in decision-making processes from a distance, thereby making participation more accessible and inclusive for those who could not travel due to financial reasons or because their special needs restrict them to one place.

SDG 11, sustainable cities and communities, responds to the boom of urbanization and suggest the following measures: “investment in public transport, creating green public spaces, and improving urban planning and management in participatory and inclusive ways” (UNDP 2020). This call seems to fit perfectly with the mission of “Take Part” which aims to be an IS tool that improves urban and construction planning by making it more participatory and through its visualization more inclusive. Wolf et al. (2020) go in a similar direction by showing with their literature review the potential in the use of mixed reality for urban planning.

4 Immersive Systems as a Tool for Smart Information Transfer

Even though many people state that they strive to behave in an environmentally conscious manner, they often fail to do so because they receive incorrect, misleading, overly complex, insufficient, or even no information during their decision-making process. Immersive systems could remedy some of the information deficits (i.e.,

information transfer) and at the same time support the decision-making process in an intelligent (i.e., smart) way to avoid a potential information overload or even nudge people to select a more sustainable option. Numerous examples of decisions that hinder reaching the sustainability goals can be seen in the context of purchase decisions.

Even today, one of the major drawbacks of e-commerce transactions encompasses “the inability of online consumers to feel, touch, and sample products through Web interfaces, as they are able to do in conventional in-store shopping” (Jiang and Benbasat 2004, p. 111), which may still lead to difficult product quality assessments and thus product uncertainties (Suh et al. 2011; Hong and Pavlou 2014; Dimoka et al. 2012). To address this issue, various attempts have already been made to enrich the product presentation in e-commerce settings (e.g., through virtual product experiences) (Jiang and Benbasat 2007a, b), which, however, were mostly implemented in a desktop environment and were not overly effective. Especially from a sustainability point of view, the numerous product returns as a result of a poor product fit and false expectations constitute an ecological disaster that could be avoided through a better a priori presentation of products. Furthermore, false expectations naturally lead to dissatisfied consumers. Consequently, Hong and Pavlou (2014, p. 342) demand that “online marketplaces should allocate more resources to reduce consumers’ uncertainty about product fit with the aid of new Internet-enabled systems, such as virtual reality and 3D representations.” Indeed, practitioners such as Amazon (Amazon AR), Alibaba (Buy+), or IKEA (IKEA Immerse), but also scholars (e.g., Peukert et al. 2019a, b; Meißner et al. 2020), followed the call by launching immersive shopping environments or studying the effect of immersive systems on consumer behavior in experiments. With the help of VR and AR visualizations, consumers are now able to evaluate products in real-scale and from different perspectives (Peukert et al. 2018). In a fashion-shopping context, Yang and Xiong (2019) revealed that virtual fitting rooms reduce product returns, providing first evidence of the potential effectiveness.

Whereas the previous paragraph focused on the presentation of the product itself via immersive features, additional product information may also be transferred by immersive systems. Thereby, the timing as well as the content plays a crucial role. For instance, Peukert et al. (2020) propose the idea of an “intelligent invocation” by a context-aware user assistance system that takes over the decision of *how* to assist and *when* based on the on-the-fly detection of different decision phases. In the same vein, Pfeiffer et al. (2020) show how machine learning can help to train models based on eye-tracking data in order to detect the consumer’s shopping context. This knowledge can then be used for smart information transfer in assistance systems. Such systems may reduce the overall cognitive load and thus release cognitive capacities to also consider aspects related to a product’s sustainability. In addition, the assistance system could also transfer targeted information related to sustainability, for example, the listing of unhealthy ingredients in food (SDG 3: good health and well-being) or the CO₂ emissions (SDG 13: climate action). Such information can be conveniently displayed in an additional AR view supporting the consumer in identifying a sustainable product or service. Moreover, the indication

of the consequences of consumption or the conditions under which the product was manufactured might be more convincing when transferred in an immersive way than by the mere listing of facts and numbers as described earlier. Think of an application sketching out how you would look (from the outside and inside) when eating 5 kg of candy on a daily basis (post-consumption perspective) or an application letting you perceive how it feels to be locked up in a tiny cage such as experienced by some fattening animals. Yet again, the challenge is to transfer this kind of information to the consumer at the right point in time, so that they can be nudged toward a more environmentally conscious alternative.

However, application areas of immersive systems for the purpose of smart information transfer are by no means restricted to sustainable purchase behavior, but are manifold: For instance, as mentioned in the section above, Fegert et al. (2020a, b) support public participation in construction projects via AR and VR visualizations of a planned construction area. This *a priori* visualization transfers essential information to involve stakeholders in the project and to foster informed decision-making. Similarly, AR and VR are increasingly used for early prototyping to avoid waste in the form of many different models and modeling materials, which later only end up in the dumpster. In the tourism and real estate sectors, VR is already used to provide potential visitors or buyers a realistic virtual image of the accommodation or the object of interest, which could reduce the number of physical on-site inspection appointments, hence saving time and avoiding CO₂ emissions due to travel.

5 Immersive Systems as a Tool for Learning to Act

One of the ongoing challenges for sustainable living is the battle for waste reduction and increase in recycling quality (SDG 12: responsible consumption and production). The EU, acknowledging this problem (“waste has a negative impact on the environment, climate, human health and the economy” [European Parliament 2018]), responded with a plan to raise EU-wide recycling to 55% and decrease landfill use to 10% by 2025 (European Parliament 2018). However, many recycling and waste sorting facilities are still unable to reach maximum efficiency without pre-sorting measures (Buccioli et al. 2011). In countries like Germany, Austria, and Switzerland, this domestic pre-sorting is made a citizen’s responsibility (Buclet and Godard 2000), while municipal waste sorting authorities are tasked with providing the necessary education. However, often the actual conduct of teaching is insufficient, among other reasons because of a lack of offered incentives (intrinsic or extrinsic), as well as due to outdated measures of communication and information (Hoffmann and Pfeiffer 2021).

Due to their intrinsic qualities, games have long been used as tools for entertainment as well as education. However, with the launch of the commercial video game

industry in the early 1970s (with the Arcade Game (Atari Inc. 1972) Pong having sold more than 8000 units by the end of 1974 [Kent 2001]), digital gameful systems started to be developed, affording fully immersive experiences of being transported to an elaborately simulated location (Murray 1997). During the same period, the theory of experiential learning was formulated and expanded by David A. Kolb (1984). The rapid developments in both fields laid the foundation for the emergence of a market successfully providing serious games and digital edutainment in domains ranging from health to business trainings to general education. In 2016 the global serious games market was valued at \$2731 million with expectations to reach \$9167 million by 2023 (Sonawane 2020).¹ Furthermore, research on serious games and gamification measures in the field of Information Systems has shown promising results in regard to raising learning outcomes in unremunerated contexts (Santhanam et al. 2016; Franceschi et al. 2009; Cavusoglu et al. 2015), by intrinsically enhancing the fun and intrigue of interacting with the application while transmitting its content through the experience of the players (Deterding 2015).

However, while according to the theory of experiential learning every interaction and experience contributes to learning, it can be difficult to control what is learned from the experience and how and where the learned content is reproduced. In a study that measured learning outcomes under different constellations of game design configurations in an educational game on correct waste sorting, we found that by playing the game, participants' learning outcomes had been successfully and significantly increased (between 7% and 10% better sorts of waste items) when tested within the game. Yet, the effect could not be reproduced in a measure with real-life waste objects, indicating that the transfer of the trained knowledge to real life was not as successful. Other studies have struggled with a similar translation problem. In a study on gamification in business simulators, Größler et al. (2000) state: "Participants were not capable of accessing the knowledge gained outside the gaming context" (p. 271). Such insights highlight the importance of measuring the reproducibility of trained knowledge across different media—especially if the context medium in which the knowledge should be applied differs from the medium in which the knowledge is trained. As identified by Kolers and Paradis (1980), different tasks nominally tapping the same skill, and different symbols used in the tasks, yield different outcomes depending on attitude and mental state. Studies on context-dependent learning find strong evidence that the informational value of contexts affects the strength of context-dependent learning (Lucke et al. 2013). Such findings make the case for the necessity of implementations of real-life applied learning tasks in VR environments, where a strong fit between the training and real-life application context can be afforded (Hoffmann and Pfeiffer 2021). By combining immersive technology (affording surrounding sensory experiences) with immersive content, prospects are raised of reaching optimal learning outcome for the respective training matter.

¹<https://www.alliedmarketresearch.com/serious-games-market>. Accessed 22 Feb 2020.

6 Conclusion and Outlook

Many challenges lie ahead for the IS community to help in forwarding efforts to achieve the SDGs. In this publication, we provide insights from research on immersive systems and how different approaches can help to address some of the challenges that we face in reaching these goals, namely, *Awareness*, *Motivation*, *Information Transfer*, and *Learning to Act*.

Our research presents the starting points for addressing different aspects of several SDGs. For example, regarding SDG 1: no poverty, an immersive system can virtually put its user in the shoes of another, thus holding the potential to foster stronger feelings of empathy, which might help to inculcate intentions to volunteer for charitable purposes. By integrating assistance systems for smart information transfer into immersive systems, users can be reached directly with targeted information relating to sustainability. We gave several examples of SDGs that can be supported by this means: Listing of unhealthy ingredients in food on demand can lead to an increase of SDG 3: good health and well-being, while on-the-spot information on CO₂ emissions could drastically help to further SDG 13: climate action. For SDG 10: reduce inequalities, the effect of adjustable telepresence (with regard to a person's digital representation) can serve as a leveling mechanism with the potential to overcome prejudices relating to gender, age, or educational background. Furthermore, by allowing instant "transport" to any digital location, such technologies afford participation independent of distance. This inherent feature further supports SDG 16: peace, justice, and strong institutions, through its enhanced possibilities for participation. For SDG 11: sustainable cities and communities, immersive systems allow for more efficient urban planning processes through accessible and inclusive visualizations. Finally, in SDG 12: responsible consumption and production, educating the public is directly addressed as a subgoal. With their high congruence with real life, immersive systems are particularly suitable for the training of sustainable behavior, and thus we recommend fostering the development of learning and training software for VR in particular.

To some readers the presented research might seem impractical in terms of immediate application, as immersive systems have not yet fully penetrated the market. However, current developments relating to the ongoing crisis (Covid-19) have led to a formerly unpredicted increase in teleworking and virtual meetings, as well as a general increase in digitization efforts. Educational and entertainment institutions are forced to migrate to digital formats such as virtual tours in museums or virtual concerts, while the digital entertainment industry, the biggest driver of commercial use of immersive systems, is at an all-time high. With these developments boosting the market, the relevance for research in immersive systems—specifically with its focus on sustainability—is rapidly increasing, especially as certain areas of human welfare are projected to suffer greatly during the pandemic.

Arguably, all of the different facets of the research discussed in this publication have a very optimistic perspective. We did not discuss, for example, the CO₂ footprint of immersive systems, which still seems to be an under-researched field.

This is crucial because the footprint of ICT is growing continuously (Gelenbe and Caseau 2015) and computational effort toward rendering and so on needed for immersive system technology is high. It is already estimated that around 4% of all electricity consumption and over 2% of all CO₂ emissions are the result of ICT use (Fagas et al. 2017). Thus, in future research, benefits and disadvantages must be balanced thoroughly (Dedrick 2010), in order to judge the actual effect of IS, and in our case immersive systems, on SDG. With this in mind, we believe that this publication can give readers an overview of promising approaches in the light of an optimistic outlook.

For the future, we hope to inspire further research efforts into how IS can make a real contribution to a more sustainable world.

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