Type of the Paper: Article

The Ethical Balance of using Smart Information Systems for Promoting the United Nations' Sustainable Development Goals

Mark Ryan [1]*, Josephina Antoniou [2], Laurence Brooks[3], Tilimbe Jiya[4], Kevin Macnish[5] and Bernd Stahl [6]

[1] KTH Royal Institute of Technology, Stockholm, Sweden; mryan@kth.se
[2] UCLan Cyprus, Larnaka, Cyprus; JAntoniou@uclan.ac.uk
[3] De Montfort University, Leicester, the United Kingdom; laurence.brooks@dmu.ac.uk
[4] University of Northampton, the United Kingdom; Tilimbe.Jiya@northampton.ac.uk
[5] The University of Twente, Enschede, the Netherlands; K.macnish@utwente.nl
[6] De Montfort University, Leicester, the United Kingdom; bstahl@dmu.ac.uk
* Correspondence: mryan@kth.se

Abstract: The Sustainable Development Goals (SDGs) are internationally agreed goals that allow us to determine what humanity, as represented by 193 member states, finds acceptable and desirable. The paper explores how technology can be used to address the SDGs, and in particular Smart Information Systems (SIS). SIS, the technologies that build on big data analytics, typically facilitated by AI techniques such as machine learning [1], are expected to grow in importance and impact. Some of these impacts are likely to be beneficial, notably the growth in efficiency and profits, which will contribute to societal wellbeing. At the same time there are significant ethical concerns about the consequences of algorithmic biases, job loss, power asymmetries, and surveillance, as a result of SIS use. SIS have the potential to exacerbate inequality and further entrench the market dominance of big tech companies, if left uncontrolled. Measuring the impact of SIS on SDGs thus provides a way of assessing whether an SIS or an application of such a technology is acceptable in terms of balancing foreseeable benefits and harms. One possible approach is to use the SDGs as guidelines to determine the ethical nature of SIS implementation. While the idea of using SDGs as a yardstick to measure the acceptability of emerging technologies is conceptually strong, there should be empirical evidence to support such approaches. The paper describes the findings of a set of 10 case studies of SIS across a broad range of application areas, such as smart cities, agriculture, finance, insurance and logistics, explicitly focusing on ethical issues that SIS commonly raise and empirical insights from organisations using these technologies.

Keywords: Smart Information Systems (SIS); Sustainable Development Goals (SDGs); ethics; case studies; impact

1. Introduction

Smart information systems (SIS), those technologies that build on big data analytics, typically facilitated by artificial intelligence techniques such as machine learning implemented through deep neural networks [1], are expected to grow in importance and impact. Some of these impacts are likely to be beneficial, notably the growth in efficiency and profits, which will contribute to societal wellbeing [2,3]. Beyond purely economic benefits, SIS can also be used to address global challenges, such as those outlined in the United Nations' 17 Sustainable Development Goals (SDGs). The SDGs are internationally agreed goals that allow us to determine what people, as represented by 193 UN member states, find acceptable and desirable and represent a plan to 'build a better world' by 2030[1]. For instance, regarding the attainment of the SDGs, SIS hold great potential to increase crop yields, expose discrimination, reduce pollution and improve infrastructure, amenities, and livability of cities, are all aims of the SDGs. Regardless of their benefits, if SIS are not used responsibly, they may actually harm the progress being made towards the SDGs. SIS can raise significant worries and ethical concerns, such as algorithmic bias, job loss, power asymmetries, privacy infringements, and unchecked surveillance. SIS also has the potential to exacerbate inequality and further entrench the market dominance of big tech companies.

The question that we explore in this paper is how the societal and global benefits of using SIS to meet the SDGs relate to potential difficulties, downsides and concerns in their implementation. For this purpose, we use an interpretive case study approach [4], where we take ten empirical cases that focus on the implementation of SIS across a range of sectors to explore how they impact the SDGs.[2]

In order to get a better understanding of the broader picture of the impact of SIS, we undertake an ethical analysis of ten case studies that explicitly relate to six out of the 17 SDGs (SDGs 2, 3, 7, 8, 11, and 12). The cross-case ethical analysis demonstrates that, despite the potentially beneficial impact on achieving SDGs, SIS raises significant ethical concerns. The assumption that meeting the SDGs can simply be promoted through the use of SIS without a need to explore the issues more carefully is likely to be ethically problematic.

The paper makes several important contributions to literature. It is one of the first pieces of research to conduct an empirical cross-case analysis of the ethical consequences of SIS use. It contributes to better understanding these technologies, which is crucial in a range of fields and disciplines, including Information Systems and Sustainability Studies. Understanding potential dilemmas is also of crucial importance to organisations that aim to develop or employ SIS, particularly if such employment has the intention of addressing global challenges as represented in the SDGs. The paper deepens the understanding of the role that responsible development of technologies has with regards to organisational, social and environmental sustainability (cf. [5-7]).

The contribution of the paper is thus twofold. On the one hand, the theoretical contribution is towards a critical reflection and evaluation of the use of ethical issues as a measure to understand the role of SIS towards achieving the SDGs. On the other hand, we provide a contribution to organisational working towards the SDGs by highlighting current practice and initiating a framework for implementing practical ethics in AI and Big Data use.

The paper begins by outlining its theoretical position, covering the rationale for examining the use of SIS to meet the SDGs. This is followed by a description of the multiple case study approach used in the empirical research component of this paper. The results and analysis section, which follows, describes the impact of the cases on a number of the SDGs, and an analysis of the ethical issues they raise is presented. In the discussion section, the paper explores how it may be possible to understand or even reconcile the somewhat contradictory results, characterised by the idea that the cases show how SIS can have a positive impact on SDGs, while simultaneously raising significant ethical concerns. Finally, the paper concludes by making suggestions based on lessons learnt from the findings, both theoretically and practically, and proposes next steps that should be taken.

2. Theoretical Background and Rationale

The section defines the concepts used in the paper and outlines the theoretical approach taken. It begins by defining the concept of Smart Information Systems (SIS) and then explains why it is more suitable than the widely used terminologies of Artificial intelligence (AI) and Big Data. Finally, it provides a brief overview of ethical questions related to these technologies.

2.1. *What are Smart Information Systems?*

[1] https://sustainabledevelopment.un.org/

[2] The cases were originally constructed by their domain application and carried out as part of the SHERPA Project.

A significant problem with the current discussion (in academia, media and policy) concerning AI and Big Data is that the terms are frequently ill-defined. A recent study indicates that there is very little overlap in the understanding of AI across different aspects of this discussion [8]. The concept of AI goes back at least to the 1950s and despite this long history of the term, there still is limited agreement on its exact definition and limitations. A typical definition of AI is "systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals" [9, p.2]. The problem with such a definition is that it does not clarify the exact extent to which a thing counts as AI. This is problematic because it neglects important distinctions such as those between narrow AI and general or broad AI [10]. Narrow AI refers to technologies that are capable of undertaking specific and clearly delineated activities whereas broad AI is a replication of general cognitive functions similar to those of humans. AI has benefited greatly from the creation, influx, and capitalisation of large datasets, commonly referred to as Big Data [11,12], another concept that is often ill-defined or unclear. Big Data is often defined with the help of some of its attributes, most notably volume, velocity and variety [13]. More recently it has been supplemented by the attributes of veracity, variability, visualisation and value [14]. One problem of this definition is that it offers a moving target. For example, what counts as a large volume or high velocity of data changes along with technical capabilities and experiences. What was an unmanageable volume of data in the 1990s is no longer considered to be problematic in terms of storage or processing capacities.

Our decision to use the term SIS is motivated by the desire to sidestep some of these definitional problems. We use the term to denote socio-technical systems that make use of one particular type of AI technique, machine learning, usually based on artificial neural networks, to draw inferences from large amounts of typically unstructured data. By focusing on machine learning applications, we sidestep many of the ethical issues that are associated with general AI, such as the possibility of autonomous moral agents [15], the emergence of superintelligence [16], the singularity [17], or transhumanism [18].

A second advantage of using the term SIS is that it clearly links to the field and discourse of information systems (IS). There are long-standing discussions within IS about what exactly lies at its core z[19-22]. Nonetheless, the field has developed a strong history of methodological and philosophical principles that are useful for understanding and dealing with IS, and by extension SIS.

2.2. Promises and Concerns of SIS

One open question in the SIS discourse refers to the criteria that could be used to determine whether innovation and its consequences can be seen as acceptable, desirable or sustainable. At its core, this is a question of universal values, on which all those affected by an innovation could agree. The agreed principles expressing these shared values are human rights, as notably expressed in the UN's Universal Declaration of Human Rights [23]. Human rights tend to be abstract and theoretical and need to be translated into practical measures and actions. This is what the SDGs intend to achieve. The SDGs constitute a set of internationally agreed aims that the United Nations has agreed to pursue [24]. The SDGs are based on clearly recognised human needs, such as the ending of hunger, poverty or exclusion. The SDGs are presented in terms of broad and abstract aims, but these are broken down into more manageable and implementable goals. They are supported by specific and measurable targets and indicators, existing collaborations and networks and a growing literature. Recent guidance from the European Commission's High Level Expert Group on AI suggests that benefits of AI can be expected to be conducive to the achievement of the SDGs. The group suggests that "AI is not an end in itself, but rather a promising means to increase human flourishing, thereby enhancing individual and societal well-being and the common good, as well as bringing progress and innovation. In particular, AI systems can help to facilitate the achievement of the UN's Sustainable Development Goals, such as promoting gender balance and tackling climate change, rationalising our use of natural resources, enhancing our health, mobility and production processes, and supporting how we monitor progress against sustainability and social cohesion indicators" [25].

The moral benefits of SIS should be seen in the context of possible downsides and problems [26,27]. We are particularly interested in those social impacts that are seen as generally undesirable and which are often discussed under the heading of "ethical issues". The reference to ethics here does not refer to a particular position in moral philosophy but to the public perception of something as bad or undesirable. There is a significant and rapidly growing literature covering these ethical issues in both AI [28] and Big Data [29-31]. The general ethical concerns can be broken down into particular issues and concerns including algorithmic bias [32,33], impact on employment [34], etc. These ethical concerns are not just an academic research topic, but are taken up by the media and have been translated into a number of policy interventions [35-37].

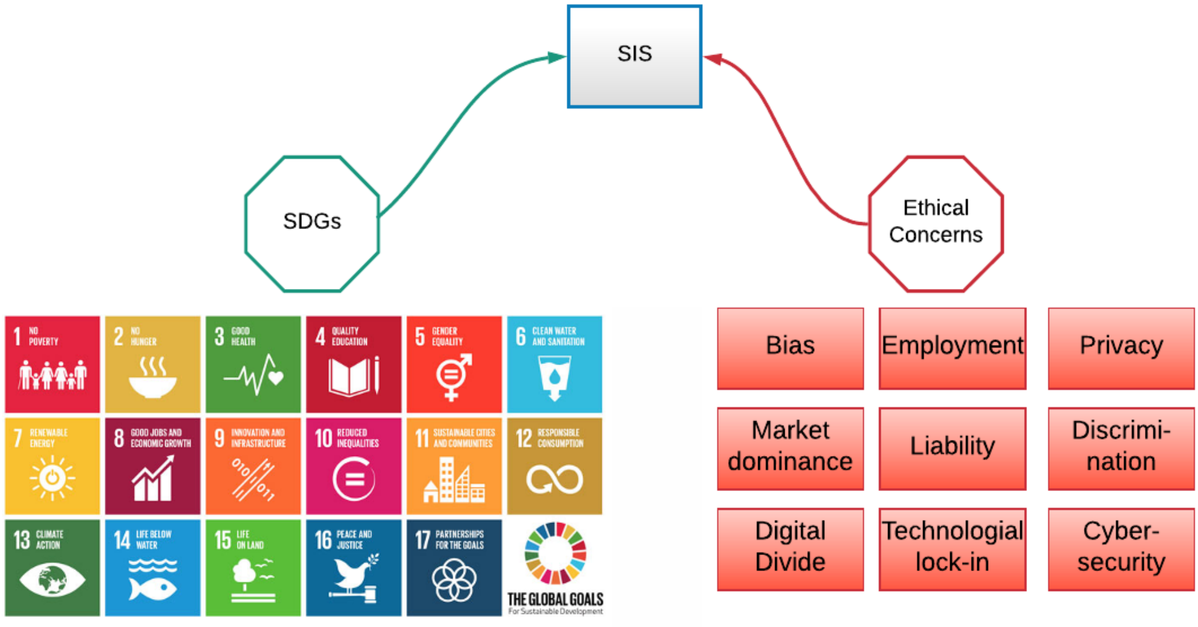

Figure 1. Overview of SIS influences

For the purposes of this paper, we consider the implementation of SIS in order to achieve SDGs and how this implementation process may be hindered by the lack of consideration of important relevant ethical issues (see Figure 1). In order to promote desirable outcomes and minimise negative impacts, it is crucial first to understand both sides. A key challenge here is that there is very little empirical research into these ethical aspects and no research, to the best of our knowledge, as to how the ethical concerns relate to the achievement of SDGs. We therefore undertook a series of six case studies of SIS in different application areas, with a focus on the ethical aspects embedded in each. The following sections provide an overview of the methodology of this research and then outline our findings.

3. Multi-Case Study Approach

The section outlines the multi-case study approach and discusses why this provides a suitable approach through which to understand ethical issues related to SIS.While there is a large body of literature on social and ethical impacts of AI and Big Data, much of it is written from a philosophical perspective, focusing on conceptual aspects. There are some convincing and high-profile book-length accounts [38,39], but there is very little rigorous academic research that looks at more than one specific subject area, such as autonomous vehicles or financial services. We therefore undertook a study that would allow us to understand better the impact of SIS across a number of relevant subject areas.

In order to gain a detailed understanding of the use of the technologies in their social environment, we opted for a case study approach [40,41]. More specifically, we were interested in the lived experience of those involved in the research and development of SIS-related activities and therefore pursued an interpretive case study approach [4]. The structure of the case study approach was defined in a case study protocol that allowed all participants to ensure consistency and conformity of data collection and analysis [42,43].

3.1. Research setting

Based on areas of specialisation, expertise, associations involved and potential contacts with suitable case study organisations, we focused on six key social domains, as listed below in Table 1. The six case studies described here are a sample of a larger set of case studies that were developed in the context of a collaborative European research project. This project covered additional case studies and other methods (scenario development, online survey, focus groups, Delphi Study, technical investigation). We selected the case studies presented here because of their clear links to SDGs.The paper will henceforth use the term case study to mean case study domains, which refer to the collection of organisations that relate to the same SDG.

For each case study domain as listed in Table 1, we undertook a literature review of ethical issues and undertook a number of interviews (see Table 1). An interview protocol (consisting of 15 pages) was developed and agreed among all the people involved in conducting the case interviews, and for the subsequent analysis. All interviews were held in English and transcribed. Most cases involved 1-3 members from a single organisation, except sustainable development, where we interviewed members from four different organisations. The interviews took place between June - December 2018 and lasted between 30 - 90 minutes each. Across all six cases, 13 interviews were carried out from 9 different organisations.

Table 1. An overview of case domains, interviews and organisations

Case Study Domain	Interviewee(s) Role	Organisation
Human Resources Management	Two Experts on Software & Interaction Design	Software & Interaction Design Company
Government	Project Owner	Large Municipality
Agriculture	1. Governmental Affairs Management; 2. Head of Agronomy Digital Farming; 3. Global Sustainability Assessment	Large Agricultural Multinational
Sustainable Development	1. Chief Technology Officer Innovation Department; 2. Solutions Lab; 3. Head of Innovation; 4. Chief Digital Officer	1. Large Municipality; 2.Public Organisation; 3. Telecommunications Company; 4. Large Municipality
Science	1. Biotechnologist; 2. Data Scientist, 3. Ethicist	Large Scientific Research Project
Energy and Utilities	Two Industry Experts	National Energy Company

4. Data analysis

The data analysis was supported by the use of NVivo 10, Server edition. Starting from a set of top-level nodes that were agreed by the team, researchers were free to develop further new nodes. Data analysis was undertaken by the researchers who were responsible for individual case studies. Weekly meetings between all members of the study team ensured agreement on nodes and the process. All case studies were published individually.

The work undertaken for this paper was a cross-case analysis of how some of the SDGs can be met through the use of SIS. This is demonstrated across the social domains of the cases and the ethical issues that arise from using SIS as a result. Based on the full versions of the case studies, and going back to the original data, evidence of links to SDGs was sought. In addition, ethical issues that arose across different application areas and that seemed to have broader relevance were explored.

5. Findings

The results of the cross-case analysis provide empirical insights into how SIS are being used across a wide range of different social domains, how they are being advocated to promote and drive some of the SDGs, and how they impact society and create their own ethical issues. This section outlines how SIS are being used in different social domains to explicitly promote six of the 17 SDGs (SDGs 2, 3, 7, 8, 11, and 12). These SDGs were selected as being the most prominent goals identified in the multi-case study analysis in the use of SIS in these areas[3]. The section demonstrates the usefulness and effectiveness of implementing SIS to meet the SDGs and the most pressing ethical issues evaluated in the case studies. Also, we indicate that while SIS offer great potential to meet societal challenges and global concerns, they also pose threats to the well being of individuals and society which need to be addressed. We discuss the benefits, and potential ethical issues, of using SIS for each of the six SDGs that are the focus of this paper.

[3] While we acknowledge that many SDGs are very important, and SIS are being developed and deployed to meet them, these goals were not explicit aims for the SIS organisations that we interviewed. There was also not enough scope in the paper to tackle all 17 SDGs, as it would do a disservice to the time spent on each, but also, it would have forced some of those SDGs into our analysis that were not already clearly identified within the cases.

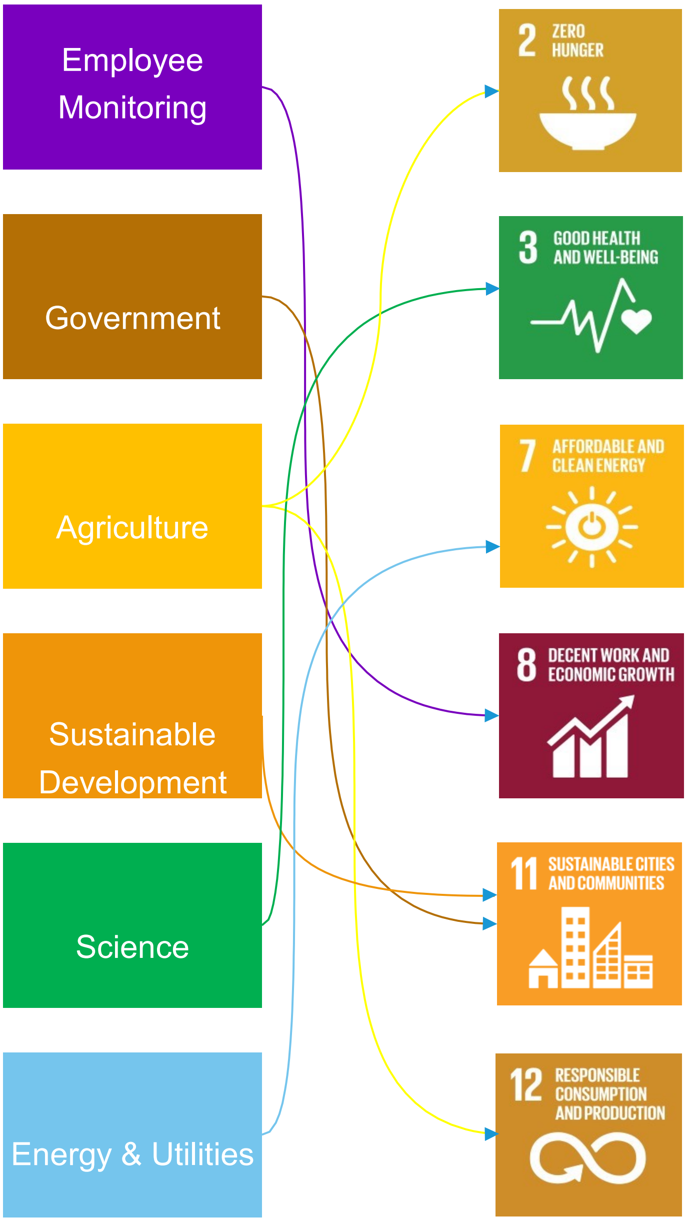

Figure 3. Mapping the Case Study Domains to the SDGs

5.1. SDG 2 - Zero Hunger

Currently, there are 815 million people who are undernourished, a number which is expected to increase to 2 billion by 2050, if adequate measures are not put in place [44]. It is estimated that we need to increase our food production levels by up to 70% by 2050 to meet global demands [45,46]. However, increasing agricultural production may also increase waste and environmental damage, in an industry which already has a high ecological impact. 'The food sector accounts for around 30 percent of the world's total energy consumption and accounts for around 22 percent of total Greenhouse Gas emissions' [44]. Ultimately, the agricultural sector is faced with producing more food to feed a growing global population, in line with the aim of SDG 2 - to ensure zero hunger in the world - while also reducing our ecological impact.

The aim of SDG 2 (Zero Hunger) is to dramatically reduce undernourishment, starvation, and nutritional defects in the world; through increased agricultural produce, food security, and improvements in farming in the developing world. The UN has created a number of targets to decrease the levels of global hunger, such as doubling the 'agricultural productivity and incomes of small-scale food producers' (target 2.3) and ensuring sustainable food production systems (targets

2.4) [44]. These targets can be reached by increasing investment into technological development (target 2.A), such as SIS.

The use of SIS is being heralded as an innovative way to adapt to the challenges in a sustainable way [47-50]. It is hoped that agricultural SIS can provide data-driven answers and more efficient ways to seed, harvest, grow, and detect plant disease within the industry. Agricultural SIS has the potential to 'improve water and air quality, improved soil health, food quality and security, protection of biodiversity, improvements to the quality of life, increased output, cost reductions, crop forecasting, and improved decision-making and efficiency' (Agricultural Case Study).

While agricultural SIS offer great potential to help achieve SDG 2, there is the possibility that they may create additional ethical issues in their implementation, as demonstrated in our case study "Agriculture". For example, when agricultural SIS are used to provide farmers with assistance, incorrect, limited, or misleading data may lead to inaccurate recommendations and advice [51, p. 13]. Interviewee 3, from "Agriculture", stated that inaccurate and limited data were the main causes for poor or ineffective recommendations, rather than flaws with their algorithms. Issues relating to flawed data are also exacerbated by farmers with poor record-keeping, an inability to use SIS, or failing to implement recommendations (Agricultural Case Study). Inaccurate recommendations, resulting from SIS, may cause poor harvests, harm to crops and livestock, and damage to the farmer's business.

A challenge for effective agricultural SIS use is that most farming is done on small farms or in LMICs (low-to-middle-income countries) with low technological capacities, whereas current agricultural SIS use focuses on large monoculture farms [52,53]. In order to meet SDG 2, agricultural SIS should be affordable, usable, and accessible to LMIC farmers in an economically sustainable way [54-56]. The interviewees from "Agriculture" reiterated this sentiment, stating that if SIS are not economically affordable and beneficial to the farmer, they will not be adopted.

5.2. SDG 3 - Good Health and Well-being

While SDG 2 aims to promote a healthy population by preventing malnourishment and ensuring there are adequate food supplies, SDG 3 (Good Health and Well-being) aims to improve global health through areas such as maternal mortality, communicable diseases, mental health, and healthcare workforce [57]. SDG 3 aims to 'ensure healthy lives and promote well-being for all at all ages' [58]. Better health and well-being is not only viewed as a single goal for sustainable development but is regarded as being essential for achieving all three pillars of sustainable development [59]. Health, well-being and sustainable development are considered to be intrinsically connected, with health regarded as a precondition indicator, as well as an outcome of successful sustainable development.

By combining the complex elements of human biology with the computational power of SIS, it is in theory possible to pave a path to good health and well-being. Merging biology and SIS can offer insights into the delivery of precise and speedy diagnostics and treatments by eliminating uncertainty through analysing trillions of data points per tissue sample in a matter of days; something impossible for humans [60]. SIS supports the comparison of massive amounts of data, including from health data of individual patients to those of the greater population, which is crucial for determining what treatments work best for each patient. Using SIS also offers the potential to reduce development costs and bring new treatments to patients in a time-efficient manner [61].

The "Science" case study was used to understand some of the ethical concerns that arise from the use of SIS in health, specifically, health-related issues that affect the brain and how they could be treated. The organisations interviewed used SIS to build a research infrastructure aimed at the advancement of neuroscience, medicine and computing. Results from the case study indicate that the main ethical concerns are privacy and confidentiality. There is a risk of identifying patients because hackers could access patient data. The data could be re-identified, violating privacy and potentially being used to harm the individual concerned [62].

Security at the software-level is an issue when using health SIS. With the use of the internet, the systems are opening ports into hospitals which means that there should be safeguards for specific parts of a specific server [63]. There was also a concern in the "Science" case study about discrimination and bias resulting from the use of health SIS and the issue of transparency of the processes that are involved in research used to understand diseases and treatments (Science Case Study). The use of SIS in promoting health also has implications associated with the availability of resources, which could result in a digital divide between those who have the resources to use most of the SIS platforms and those who have not, an issue that was also addressed in case study "Energy" (see below).

5.3. SDG 7 - Affordable and Clean Energy

The aim of SDG 7 (Affordable and Clean Energy) also places an emphasis on cost-efficiency and the global health of the population. SDG 7 aims to ensure affordable, reliable and modern energy for all [44], emphasizing the need to strengthen policy in order to meet specific energy targets. In fact, between 2000 and 2016 access to electricity around the world increased from 78% to 87%. However, the demand for electricity is increasing as the world population increases. Upgrading technology, such as through the use of SIS, can significantly reduce energy consumption [64]. By 2030, the UN aims to ensure that there is 'universal access to affordable, reliable and modern energy services', while doubling 'the global rate of improvement in energy efficiency' [44].

The expected demands on the energy sector over the coming years will be immense as a result of these changes. It has been proposed that technologies, such as SIS, used in the energy sector can help solve the Energy Trilemma: how to secure (energy security) affordable energy for all (energy equity) in a sustainable manner (environmental sustainability) (Energy Case Study). The use of SIS in smart grid systems allows for renewable energy integration, delivery of significant environmental benefits, and can provide an efficient solution for energy security [65].

The use of SIS systems in energy distribution holds the promise that countries will be able to ensure affordable and sustainable energy for the ever-increasing energy demands of smart living [35]. It also presents a number of ethical challenges, which were identified in our case study "Energy". This case study explored ethical issues that occur in the use of SIS in the energy sector. According to the interviewees, the current barrage of GDPR articles in the media has raised the public's privacy concerns and suspicion towards the company and the use of SIS in the energy industry. The company in "Energy" was vocal about addressing issues of social acceptability of smart meters and privacy concerns that the end-user may have. For example, it has coordinated the development of a code of conduct to address public concerns and sought to have it approved by the national Personal Data Authority to ensure that the company remains within the law and attracts public trust (Energy Case Study).

Another major concern identified in "Energy" related to issues around cybersecurity. As a result of the complexity of the decentralised architecture, and the digitisation of multiple points in the grid, there is a concern that these can be attacked to trigger a cascading response, leading to energy disruptions or a failure of the infrastructure (e.g., blowing the fuses of energy exchanges). As it will be impossible to safeguard the infrastructure entirely, the emphasis is shifting towards containing possible contagion and its cascading effects. Specific cyber threats and implications for cybersecurity are difficult to predict in order to make provisions into the system design and the institutional environment (Energy Case Study). A concerted effort to put together a pan-European Cybersecurity Act, which includes an EU Cybersecurity that will affect the management of critical infrastructures and related equipment as well as consumer products is currently underway [66].

5.4. SDG 8 - Decent Work and Economic Growth

SDG 8 (Decent Work and Economic Growth) promotes the need to ensure economic growth while acknowledging the need to resolve tensions between available jobs and the growing labour force. These tensions are exacerbated by the increasing need for technological skills in jobs, for both new and existing work positions [67]. New skill requirements, in addition to an expanding labour force, are predicted to affect unemployment negatively in the coming years, according to the UN Development Programme [68]. SDG 8 also explores the idea of "decent" work, such that employment allows individuals to rise out of poverty currently affecting approximately 700 million workers [69].

SDG 8 aims to increase economic productivity ‘through diversification, technological upgrading and innovation’, and aims to ensure ‘full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value’ [44]. The UN also wants to protect labour rights for all, particularly the most disadvantaged within society. The use and development of SIS may help the workforce by reducing demanding work, assisting the processing of complex tasks, and increasing productivity in the workplace. There is the opportunity for SIS to help doctors and surgeons perform operations, provide employers with important business analytics, and even to identify and prevent slavery [70].

In many businesses, SIS are being used as a means to deliver enhanced customer service and improved business management procedures. By using SIS to monitor business operations, through tracking-capable software, businesses are, for instance, able to track products but also to monitor employees. Case study “Human Resources Management” focused on an international company that develops IoT-based software and tracking equipment, for the purpose of deducing how assets are used in order to either bill according to their usage, or to identify usage fraud. The case study examined IoT-based SIS that make use of data collection and manipulation to support monitoring and tracking in businesses.

The most prominent ethical issues that arose in “Human Resources Management” were the possibility for malicious use, privacy infringements, and the responsibility, transparency and trust required by the organisation using these technologies (Human Resource Management Case Study). A measure to safeguard many of these issues from occurring was ensuring accurate informed consent was granted. Providing the opportunity to stakeholders to consent to the collection, manipulation, or deletion of data is very significant to ensuring data protection. Nevertheless, even though the technology provides for features that can encourage ethical use of the system, the possibility for system abuse cannot be totally excluded.

One of the overriding concerns identified in the case study focused on how to design ethical employee monitoring software for other companies to use with their own assets and resources (Human Resource Management Case Study). Design with respect to access controls is therefore important as well as the issue of consent. It was not unusual that several of the identified ethical issues interconnected for a particular SIS, and going forward it is important to be cautious with the handling of data across the hierarchy of system users. This strongly correlates with SDG 8, namely to promote good working environments for people around the world.

5.5. SDG 11 - Sustainable Cities and Communities

SIS can be used in industry and infrastructure for personalising services [71], streamline processes, predictive maintenance of machinery [72], and even to automatically register and respond to potholes [73]. SIS can also help to successfully analyse past crises in an attempt to predict likely future problems, such as threats to infrastructure and food security in the event of severe unrest, and to ensure the protection of economic growth in developing countries [74]. Such predictions can enable businesses and aid agencies to plan effectively for the future, account for changes in costs and identify ways to promote economic growth measures, particularly in the rapidly growing urban population in the developing world [75].

By 2050, over 70% of the global population is expected to live in cities [76]. This is set to place a great strain on resources and healthcare, create overcrowding, and have serious environmental impacts. SDG 11 (Sustainable Cities and Communities) attempts to achieve sustainable, resilient, safe and inclusive cities. One way to do this is by creating innovative approaches such as the adoption of SIS to ‘reduce ecological harm, pollution, and injustice on the one hand; while increasing safe and affordable housing, improving infrastructure, and providing safe cities for people to live in’ (Sustainable Development Case Study). SIS are being proposed as a way to help achieve SDG 11 by improving mobility, reducing ecological impact, improving air quality, disaster response and economic growth [77-80]. SIS are being used in cities to make them ‘smarter’ through economic development, developing skills for the public, mobility, governance, environment and improved living standards [81, p. 111, 82,83].

SIS offers great benefit to the public sector to ensure sustainable cities and communities, but may also create their own ethical concerns as a result, which were identified in case studies ″Government″ and ″Sustainable Development″. Municipalities benefitting from the development and use of SIS need to ensure that they work effectively. One way to ensure this is through the provision of sufficient, dynamic, and rich data. In the case studies, interviewees emphasised the importance of retrieving and using accurate datasets for successfully running their SIS. If the algorithms do not have sufficient training data, then the recommendations provided may be misleading or inaccurate.

If there are issues with the accuracy of data, these may misrepresent the city and its inhabitants [83]. There is a threat that SIS may compartmentalise cities, reducing their complexity and richness, which may lead to harmful or biased recommendations and policy [84]. With the increased integration of SIS in cities, there is also a threat of a digital divide at different levels. There is the possibility that rural areas will get left behind as a result of increased technological development within cities; some areas and citizens within cities may benefit from SIS, while others are disadvantaged; certain cities (such as capitals) may receive far greater SIS investment and development that other cities; and there may also be a greater digital divide and resulting inequalities between developing and developed nations who can or cannot afford to implement these technologies (Government Case Study).

Another concern about the increased digitalisation of the city infrastructure is the increased vulnerability to malicious hacking, stolen data, disruption of systems within the city, or privacy infringements [85,86]. Privacy was an issue raised in all five organisations in these two case studies. Interviewee 1, from "Sustainable Development", stated that whenever data are collected about citizens, their privacy should be protected (Sustainable Development Case Study). Whenever cities have access to citizens' data, there is a threat that these data will be used for unauthorized or unchecked surveillance purposes. Also, with the increased integration of private organisations in SIS public projects, there is also a threat that they will use these data for morally illegitimate purposes.

There is a further concern that private organisations will prioritise their interests in public-private SIS projects and push a technologizing approach, which may not be in the best interests of the city or its citizens [87]. For example, in our Sustainable Development case study, one of the interviewees stated that: 'Corporations are providing advice, guidance and implementing technologies within cities, and this may not be done impartially or in the best interests of the city' (Sustainable Development Case Study). Cities may become dependent on private SIS companies, which may lead to 'technological lock-in', thus jeopardising a municipality's self-governance. The interviewee from "Government" stated that obtaining data from third-party organisations often incurred substantial costs, but that their data often far surpassed publicly-available data, thus necessitating these partnerships. However, there is a concern that, 'if corporations are heavily involved with any SIS government project, the city may become overly dependent on those corporations, putting public decision-making and governance in jeopardy' (Government Case Study).

Most of the public servants working on SIS projects indicated that they were aware of this threat and many expressed that they tried to initiate a data sovereignty approach, if possible, and were cautious to avoid technological lock-in with private companies. Some were concerned about the high costs required for investing in SIS projects. While technologically-savvy cities may encourage national and foreign investment, there are no guarantees that a city will see a return on their SIS investment. For example, interviewee 3 from "Sustainable Development", stated that their SIS project was loss-making and would have been terminated earlier if it were run by a private company (Sustainable Development Case Study).

5.6. SDG12 - Responsible Consumption and Production

SIS technologies provide us with the opportunity to make cities more sustainable and resilient, but cities also need to incorporate responsible consumption and production of water, energy, and food, for our growing population, as advocated in SDG 12 (Responsible Consumption and Production). SIS can also play a significant role by providing an improved understanding of consumption patterns that support devising effective environmental measures targeting specific groups, such as consumers and policymakers [88]. Despite challenges posed by the use of SIS in industry, there are opportunities such as efficient and sustainable use of resources including finance, raw materials and labour that can be realised through SIS [89]. Many of the ethical issues that were identified in the use of SIS to ensure SDG 12 strongly correlated with those of SDG 2.

There is a possibility, for example, that agricultural SIS will exacerbate inequalities, rather than prevent them, which is in contrast to target 12.C – reducing harm to poor and disadvantaged communities [90]. The retrieval of farm data may cause privacy infringements, particularly in LMICs where there is little data regulation and protection [91]. There is also the possibility that farmers may lose control of their farm because companies, such as John Deere, are preventing farmers from tampering with machinery which contains SIS, on the grounds of protecting intellectual property [92,93]. Farmers are also concerned that their data may be leaked or given to third-parties, making them sceptical about adopting SIS [94]. Their data may be used against them by commodity traders, governmental bodies, or competitors, so they need to be confident that their data will be protected 'from misuse, hacking, and the misappropriation for economic or marketing purposes' (Agricultural Case Study).

Agricultural SIS may also provide recommendations that do not take into account effects on land external to the farm being analysed, which could lead to harmful runoff, habitat damage, and pollution [95]. Countries have varying sustainability standards, so it is difficult for SIS to accurately take these into account: 'Different algorithms are required because of the varying climatic conditions, crop types, and needs of farmers worldwide' (Agricultural Case Study). In addition to sustainability metrics, SIS may 'upset, injure or even kill livestock and/or local wildlife. Robots, sensors and unmanned aerial vehicles (UAVs) also have the potential to emit toxic material, fumes and waste into their surrounding environment' (Agricultural Case Study), causing harm to the health of animals, humans, and communities in the surrounding areas.

6. Discussion

This paper has shown that SIS holds the potential to contribute to achieving desirable social goals, such as the SDGs, while at the same time creating a range of ethical concerns. These unintended side-effects are a key motivating factor in a range of approaches that reflect on the role of technology in society, such as technology ethics [96], science and technology studies [97] and technology assessment [98]. An interesting component of this is the so-called 'Collingridge Dilemma', which holds that interventions into the trajectory of technology are easy at an early stage, when it is difficult to predict the consequences. When the consequences are predictable, it is often difficult or too late to change the trajectory or impact [99].

The paper can be read as an attempt to address this problem. The analysis of SDGs and ethical implications shows that these are not simple and linear, but nor are they entirely unpredictable. SIS are at their core complex statistical tools that allow for better categorisation of data and thereby facilitate drawing conclusions and making predictions that are statistically sound. This is the reason why they can be used for crop optimisation, scientific health analysis, in smart city projects, and a wide variety of other applications. Altogether, the case studies have demonstrated that the range of applications, and the potential benefits accrued by society from using SIS, are far-reaching.

While at least some of the benefits are thus predictable, the same can be said for related ethical issues. The expanding academic literature and policy discussions of SIS show that there is an awareness of some problematic aspects in these technologies. The case studies have shown that these issues are not just theoretical, but are also perceived as relevant by actors who employ these technologies. The case studies have furthermore demonstrated that there is a degree of overlap between ethical issues identified in the literature and those perceived on the ground. This implies that researchers, funders or policymakers who aim to use SIS to address social issues and SDGs can draw on a rich source of information to predict the possible side-effects of their actions. This study has shown that such prediction is possible and even has plausible outcomes that can be integrated into current decision-making processes.

If the aim is, for example, to eliminate hunger (SDG 2), which is a noble goal against which very few people would argue, then the quality of this goal clearly warrants the mobilisation of significant resources on a local, regional and global level. SIS can and most likely will play an important role in increasing the efficiency of food production and reduction of waste. What our analysis has shown, however, is that such applications may lead to a number of ethical issues concerning land and data ownership, which may benefit large corporations while disadvantaging small companies or farmers. To use SIS ethically to address global hunger, issues such as this will have to be taken into account. This may take place through open access and freely available data pools; publicly-owned agencies that help producers lacking the resources to benefit from SIS; or cooperative movements, which can assist in ensuring the ethical use of SIS.

Similarly, meeting SDG 3 can involve SIS in ensuring that the good health and well-being of the global population is met through disease prediction and prevention, and innovative ways to develop medicines and cures. However, the analysis identified privacy concerns and re-identification issues when using SIS in healthcare. There is a range of procedures that can be put in place to reduce privacy and confidentiality concerns. For example, decision-makers can ensure that organisations developing and using SIS in health research follow protocols and measures to ensure that data acquisition, storage, and usage are protected. Developers of health SIS may also ensure that their technologies are not designed to retrieve personal information and there are ways to effectively anonymise users.

Furthermore, adequate cybersecurity procedures can be set in place to ameliorate concerns. These include: penetration testing, vulnerability testing, adversarial training, gradient masking, differential privacy, and improved anomaly detection methods (XXX). These cybersecurity issues were also a prevalent issue in the "Energy" case study, which looked at the use of SIS to meet SDG 7 (Affordable and Clean Energy). There was a concern that energy providers' systems would be hacked as a result of using SIS, which could lead to energy failures and disruptions in energy infrastructures. As the results of this could have devastating effects, national and international bodies need to ensure that energy providers are abiding by cybersecurity policies and standards [66]. Energy providers should also use ethical guidelines to proactively respond to potential cybersecurity threats, rather than being forced to by legislation.

When the aim of SIS is to ensure fair and sustainable work (as advocated in SDG 8), employees need to be protected against the harmful use of SIS in the workplace, as outlined in the 'Human Resources Management' case study, such as infringements on their privacy and that they consent to these activities. Decision-makers should implement policy to ensure that employee monitoring SIS is in accordance with strict informed consent procedures, which are clear and understandable, employees are not coerced or feel pressured to conform to them, they have the opportunity to 'opt out' throughout the process, and have procedures in place to delete data collected about them. Employee monitoring designers need to ensure, to the best of their ability, that SIS do not have the possibility to be used to harm, disenfranchise, or manipulate people in the workplace. Increased security policies need to be implemented by companies to ensure that data retrieved about employees is not used for external malicious, illegal or nefarious purposes.

SIS also offers public servants the opportunity to dramatically improve their cities in accordance with the aims of SDG 11 - the promotion of sustainable and liveable cities. However, as a result of trying to encourage development and efficiency in their cities, the public sector may become technologically locked-in to relationships with private SIS companies, enabling those companies to surveil, harm, or manipulate citizens. There is a need to strike a balance between successfully using and exploiting SIS, while also ensuring public self-governance. There need to be careful procedures set in place for when issues arise, steps in place to ensure governance is not handed over to private companies, and ways to avoid over-dependence on SIS companies. The public sector should encourage internal development of SIS departments under their control, but if this is not possible, agreements should be created for a mutually-beneficial partnership with private companies.

SIS can offer solutions to the aims of SDG 12, such as providing insights into planting, seeding, and harvesting in a responsible manner. The use of SIS may also come with certain ethical concerns, such as inequalities resulting from limited access to farm SIS; privacy issues; and harm to externalities, such as livestock, wildlife, and the natural environment. However, steps can be put in place to avoid or minimise these threats. For example, farm SIS can be made more accessible and easier to use, and provided free-of-charge (or at a low cost), as exemplified in the Agriculture case study. Farm data is often seen as less problematic than medical, financial, and insurance data, but it still comes with the potential to infringe upon farmers' privacy. There needs to be stronger policy on the protection of farm data and the need for companies retrieving those data to ensure they abide by existing policy. Physical and ecological threats resulting from agricultural SIS should also be recognised, along with steps developed to counter and halt these impacts from causing harm.

This discussion of the balance of promotion of SIS to meet the SDGs versus creation of ethical issues demonstrates that there are a number of recurring issues that cut across many domains. The most obvious of these is that of data protection and privacy. This is an issue that arises by necessity when personal data is targeted, such as in human resource applications. What our analysis has shown is that it is also relevant in other domains where it might be less obvious, such as agriculture, where technical data may still have personal components, for example by allowing one to pinpoint the exact location of a farmer at any moment.

Some of the broader issues that the analysis has shown are located not so much in the particular technology or the data used, but in the socio-economic environment in which the technologies are developed and used. A key concern is that of ownership of data, algorithms and the resulting allocation of benefits and costs. SIS across various SDGs require large amounts of data to be useful and create the efficiency savings they are credited with. That means that the owner of the data is likely to be able to benefit. Ownership of a sufficient amount of good data requires significant resources, which means that large organisations such as the big technology firms stand to benefit to the potential detriment of smaller organisations or individuals. This is an economic issue, but it is directly linked to questions of power and control. While there is nothing fundamentally stopping a distributed ownership of SIS and democratic governance, at present the socio-economic environment seems more likely to favour monopolies, oligopolies and concentration of economic and political power. At the very least these technologies open the possibility of misuse for the benefits of powerful actors, as the Cambridge Analytica scandal has demonstrated.

7. Conclusion

The importance of SIS in society will continue to grow in the future. It is clear from the multiple case study that SIS are playing a significant role in efforts towards meeting the SDGs. When SIS are used to meet the SDGs, there is the possibility that they may not make progress to achieve them; stagnate other efforts trying to achieve them; exacerbate problems the SDGs are actually trying to reduce; or create new allied problems. The first step towards the effective use of SIS to meet the SDGs is to acknowledge potential issues and identify ways to ensure that society benefits, while reducing harms, from their use. These issues were outlined in this paper through the use of an interpretivist multi-case study analysis. Six SDGs (2, 3, 7, 8, 11, 12) were examined to extrapolate beneficial aspects of using SIS, while also identifying ethically problematic issues. Domain-specific literature was analysed and contrasted with what is actually being used to gain some empirical insights regarding the ethical issues that relate to the use of SIS. In the discussion section, the paper evaluated the main benefits and drawbacks of using SIS for those six SDGs and proposed steps that can be implemented to ensure their ethical use.

8. Limitations and further research

While acknowledging that a great deal more work should be carried out on the remaining 11 SDGs, this was not within the scope of this paper. The aim was to provide a snapshot of some of the SDGs, how SIS can be used to promote them, and ethical tensions that may arise as a result of their use, while providing insights into how these issues can be addressed in practice.

While the paper carefully examined ethical concerns in the literature regarding the use of SIS in these applications, the empirical analysis was typically confined to 1-4 organisations per case, with a similarly low range of interviewees per organisation. They were all European organisations, which limited the paper from having a more culturally nuanced view of these issues. Therefore, incorporating a greater diversity of organisations, particularly those from the Global South, would benefit further analysis of SIS used to promote the SDGs.

9. Recommendations

There is a wide array of stakeholders and organisations involved in the development and use of SIS to directly, or indirectly, promote the SDGs. This paper highlighted six distinct cases where public organisations (SDG 11), private companies (SDG 2, 7, 8, and 12), and research projects (SDG 3) used SIS. Further, it highlighted the need for stakeholders to ensure the ethical use of SIS by following cybersecurity protocols, implementing informed consent procedures, and establishing fair public-private partnerships in SIS projects.

Private companies should be aware of the ethical issues SIS may cause and abide by policies and implement frameworks to address them (e.g. [9,37,100]); identify how their SIS will impact society (e.g. the Agriculture case); while also developing procedures to receive input, feedback, and consent from the end-user (e.g. the Human Resources Management case). Public organisations should ensure that they do not become locked-in to relationships with SIS companies, which may cause adverse impacts on their citizens, through legal obligations to ensure their sovereignty; and ways to address accountability if things go wrong in public-private SIS partnerships.

These recommendations for organisations have direct implications for managers and technical specialists working for them. Many companies are currently trying to find ways to make use of AI and big data to further their business goals. Many organisations that take seriously their social responsibilities and accept that they have a role to play in contributing to the overall state of the world and use the SDGs as measures to assess their progress [101]. A manager involved in such work, in light of these findings, cannot assume that the ends of promoting the SDGs implies that the work is unproblematic and ethically sound. Even with the best intention of doing the right thing, AI and big data raise ethical issues that need to be taken into account and form part of the technology development and deployment strategy. Our work also shows that the actual nature of the ethical issue is rather predictable. While the eventual use of technology is never fully predictable and it is thus impossible to know in advance which ethical issues will arise, the work on ethics in AI and big data has identified a number of ethical issues that can reasonably be expected. Our work has shown that many of these arise in projects and that it is therefore reasonable to expect managers to respond to them in a proactive manner.

But of course not all responsibilities rest on companies and their managers and employees. The broader socio-economic and political environment also needs to be active. Nation states and international bodies such as the UN need to initiate guidelines, frameworks, and policy for both public and private organisations to follow in the successful and ethical management of SIS in practice. While the UN's SDGs work as an effective template to follow, there needs to be further extrapolation on how to get there. As SIS will be one of the effective tools to meet these goals, there needs to be careful analysis and recommendations drafted by the UN on how to do so in a responsible manner. There is yet to be a cohesive ethical framework on how organisations should pursue the SDGs, through SIS use, but the concerns in this paper have highlighted why there is a need for such guidance.

10. Contribution

This paper has provided a diverse range of cases on the ethical consequences of using SIS in practice, while trying to achieve the SDGs. In order for SIS to help promote the SDGs, while reducing harmful impacts, it is vital that the consequent challenges are understood and faced as they happen. However, there is very little empirical research in this area. This paper provides a valuable contribution to those working in the development sector, academics writing in the fields such as Sustainability Studies, Information Systems and Computer Science, as well as developers and users of SIS. It also highlights the ability of case studies to identify ethical issues not covered (or covered to an inadequate degree) in academic literature, but which practitioners face in different sectors. The contribution of the paper is thus twofold. On the one hand, the paper contributes to organisational working towards the SDGs by highlighting current practice, and, on the other hand, it highlights a theoretical contribution focusing on critical reflection and evaluation of the use of ethical issues to understand the role of SIS towards achieving the SDGs.

Funding: This research was funded by the European Union's Horizon 2020 Research and Innovation Programme Under Grant Agreement no. 786641.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Stahl, B.C.; Wright, D. Ethics and Privacy in AI and Big Data: Implementing Responsible Research and Innovation. *IEEE Security & Privacy* **2018**, *16*, 26-33, doi:10.1109/msp.2018.2701164.
2. Chui, M.; Harryson, M.; Manyika, J.; Roberts, R.; Chung, R.; Heteren, A.v.; Nel, P. *Notes from the AI Frontier: Applying AI for Social Good*; McKinsey Global Institute: 2018.
3. APICS. *APICS 2012 Big Data Insights and Innovations Executive Summary*; 2012.
4. Walsham, G. Interpretive case studies in IS research: nature and method. *European Journal of Information Systems* **1995**, *4*, 74-81, doi:10.1057/ejis.1995.9.
5. Stahl, B.; Obach, M.; Yaghmaei, E.; Ikonen, V.; Chatfield, K.; Brem, A. The Responsible Research and Innovation (RRI) Maturity Model: Linking Theory and Practice. *Sustainability* **2017**, *9*, 1036, doi:10.3390/su9061036.
6. Martinuzzi, A.; Blok, V.; Brem, A.; Stahl, B.; Schönherr, N. Responsible Research and Innovation in Industry—Challenges, Insights and Perspectives. *Sustainability* **2018**, *10*, 702, doi:10.3390/su10030702.
7. Chatfield, K.; Iatridis, K.; Stahl, B.; Paspallis, N. Innovating Responsibly in ICT for Ageing: Drivers, Obstacles and Implementation. *Sustainability* **2017**, *9*, 971, doi:10.3390/su9060971.
8. De Kleijn, M.; Sibert, M.; Huggett, S. Artificial Intelligence: how knowledge is created, transferred and used. In Proceedings of IFLA WLIC 2019, Athens, Greece, 22 August 2019.
9. European Commission. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Artificial Intelligence for Europe (No. COM(2018) 237 final). Availabe online: http://ec.europa.eu/transparency/regdoc/rep/1/2018/EN/COM-2018-237-F1-EN-MAIN-PART-1.PDF (accessed on
10. Russell, S.J.; Norvig, P. *Artificial intelligence: a modern approach*; Pearson Education Limited: 2016.
11. Fink, L. Big Data and Artificial Intelligence. *Zeitschrift fuer Geistiges Eigentum/Intellectual Property Journal* **2017**, *9*, 288-298, doi:10.1628/186723717x15069451170874.
12. Hernández, Á.B.; Perez, M.S.; Gupta, S.; Muntés-Mulero, V. Using machine learning to optimize parallelism in big data applications. *Future Generation Computer Systems* **2018**, *86*, 1076-1092, doi:10.1016/j.future.2017.07.003.
13. Sagiroglu, S.; Sinanc, D. Big data: A review. In Proceedings of 2013 International Conference on Collaboration Technologies and Systems (CTS), 2013/05.
14. Uddin, M.F.; Gupta, N. Seven V's of Big Data Understanding Big Data to Extract Value. In Proceedings of Proceedings of the 2014 Zone 1 Conference of the American Society for Engineering Education; pp. 1-5.

15. Allen, C. Artificial life, artificial agents, virtual realities: technologies of autonomous agency. In *The Cambridge Handbook of Information and Computer Ethics*, Floridi, L., Ed. Cambridge University Press: 2010; 10.1017/cbo9780511845239.014pp. 219-233.
16. Torrance, S. SUPER-INTELLIGENCE AND (SUPER-)CONSCIOUSNESS. *International Journal of Machine Consciousness* **2012**, *04*, 483-501, doi:10.1142/s1793843012400288.
17. Kurzweil, R. *The Singularity is Near*; Gerald Duckworth & Co Ltd.: London, 2006.
18. Livingstone, D. *Transhumanism: The History of a Dangerous Idea*; CreateSpace Independent Publishing Platform: 2015.
19. Nambisan, S.; Lyytinen, K.; Majchrzak, A.; Song, M. Digital Innovation Management: Reinventing Innovation Management Research in a Digital World. *MIS Quarterly* **2017**, *41*, 223-238, doi:10.25300/misq/2017/41:1.03.
20. Lyytinen, K.; King, J. Nothing At The Center?: Academic Legitimacy in the Information Systems Field. *Journal of the Association for Information Systems* **2004**, *5*, 220-246, doi:10.17705/1jais.00051.
21. Ives, B.; Parks, M.; Porra, J.; Silva, L. Phylogeny and Power in the IS Domain: A Response to Benbasat and Zmud's Call for Returning to the IT Artifact. *Journal of the Association for Information Systems* **2004**, *5*, 108-124, doi:10.17705/1jais.00047.
22. Benbasat, I.; Zmud, R.W. The Identity Crisis within the Is Discipline: Defining and Communicating the Discipline's Core Properties. *MIS Quarterly* **2003**, *27*, 183, doi:10.2307/30036527.
23. UN General Assembly. Universal declaration of human rights (General Assembly resolution 217 A). Availabe online: https://www.un.org/en/universal-declaration-human-rights/ (accessed on 4 May 2020).
24. United Nations. Sustainable development goals - United Nations. Availabe online: United Nations Sustainable Development website https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed on June 9, 2018).
25. HLEG on AI. Ethics Guidelines for Trustworthy AI. Availabe online: European Commission - Directorate-General for Communication website: https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai (accessed on
26. Berendt, B. AI for the Common Good?! Pitfalls, challenges, and ethics pen-testing. *Paladyn, Journal of Behavioral Robotics* **2019**, *10*, 44-65, doi:10.1515/pjbr-2019-0004.
27. Taddeo, M.; Floridi, L. How AI can be a force for good. *Science* **2018**, *361*, 751-752, doi:10.1126/science.aat5991.
28. Dignum, V. Ethics in artificial intelligence: introduction to the special issue. *Ethics and Information Technology* **2018**, *20*, 1-3, doi:10.1007/s10676-018-9450-z.
29. Saltz, J.S.; Dewar, N. Data science ethical considerations: a systematic literature review and proposed project framework. *Ethics and Information Technology* **2019**, *21*, 197-208, doi:10.1007/s10676-019-09502-5.
30. Sivarajah, U.; Kamal, M.M.; Irani, Z.; Weerakkody, V. Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research* **2017**, *70*, 263-286, doi:10.1016/j.jbusres.2016.08.001.
31. Wieringa, J.; Kannan, P.K.; Ma, X.; Reutterer, T.; Risselada, H.; Skiera, B. Data analytics in a privacy-concerned world. *Journal of Business Research* **2019**.
32. Plotkina, D.; Munzel, A.; Pallud, J. Illusions of truth—Experimental insights into human and algorithmic detections of fake online reviews. *Journal of Business Research* **2020**, *109*, 511-523, doi:10.1016/j.jbusres.2018.12.009.

33. Tan, S.; Caruana, R.; Hooker, G.; Lou, Y. Distill-and-Compare: Auditing Black-Box Models Using Transparent Model Distillation. In Proceedings of Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society, 2018/02/02.
34. Floridi, L. Robots, Jobs, Taxes, and Responsibilities. *Philosophy & Technology* **2017**, *30*, 1-4, doi:10.1007/s13347-017-0257-3.
35. European Commission. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN INVESTMENT BANK: Clean energy for all Europeans*; Brussels, 30.11.2016, 2018.
36. Executive Office of the President. Artificial Intelligence, Automation, and the Economy. Availabe online: Executive Office of the President National Science and Technology Council Committee on Technology website: https://www.whitehouse.gov/sites/whitehouse.gov/files/images/EMBARGOED%20AI%20Economy%20Report.pdf (accessed on
37. House of Lords Artificial Intelligence Committee. AI in the UK: ready, willing and able. Availabe online: Select Committee on Artificial Intelligence website: https://publications.parliament.uk/pa/ld201719/ldselect/ldai/100/100.pdf (accessed on
38. Mayer-Schonberger, V.; Cukier, K. *Big Data: A Revolution That Will Transform How We Live, Work and Think*; John Murray: London, 2013.
39. O'Neil, C. *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*; Penguin: UK, 2016.
40. Eisenhardt, K.M. Building Theories from Case Study Research. *Academy of Management Review* **1989**, *14*, 532-550, doi:10.5465/amr.1989.4308385.
41. Farquhar, J. *Case Study Research for Business*; SAGE Publications Ltd: 2012; 10.4135/9781446287910.
42. Yin, R.K. *Applications of case study research*; SAGE: London, 2012.
43. Yin, R.K. *Case study research : design and methods*; SAGE: London, 2014.
44. United Nations. *The Sustainable Development Goals report 2018*; United Nations: New York, 2018.
45. Kamilaris, A.; Kartakoullis, A.; Prenafeta-Boldú, F.X. A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture* **2017**, *143*, 23-37, doi:10.1016/j.compag.2017.09.037.
46. Schönfeld, M.v.; Heil, R.; Bittner, L. Big Data on a Farm—Smart Farming. In *Big Data in Context*, Springer International Publishing: 2017; 10.1007/978-3-319-62461-7_12pp 109-120.
47. Kumari, S.V.; Bargavi, P.; Subhashini, U. Role of Big Data analytics in agriculture. *International Journal of Computational Science, Mathematics and Engineering* **2016**, *3*, 110-113.
48. Morota, G.; Ventura, R.V.; Silva, F.F.; Koyama, M.; Fernando, S.C. BIG DATA ANALYTICS AND PRECISION ANIMAL AGRICULTURE SYMPOSIUM: Machine learning and data mining advance predictive big data analysis in precision animal agriculture. *J Anim Sci* **2018**, *96*, 1540-1550, doi:10.1093/jas/sky014.
49. O'Grady, M.J.; O'Hare, G.M.P. Modelling the smart farm. *Information Processing in Agriculture* **2017**, *4*, 179-187, doi:10.1016/j.inpa.2017.05.001.
50. Zhang, H.; Wei, X.; Zou, T.; Li, Z.; Yang, G. Agriculture Big Data: Research Status, Challenges and Countermeasures. In *Computer and Computing Technologies in Agriculture VIII*, Springer International Publishing: 2015; 10.1007/978-3-319-19620-6_17pp 137-143.

51. Taylor, L.; Broeders, D. In the name of Development: Power, profit and the datafication of the global South. *Geoforum* **2015**, *64*, 229-237, doi:10.1016/j.geoforum.2015.07.002.
52. Carbonell, I.M. The ethics of big data in big agriculture. *Internet Policy Review* **2016**, *5*, 1-13, doi:10.14763/2016.1.405.
53. USDA NASS. *2012 Census of Agriculture Highlights: Farm Economics*; 2014.
54. Micheni, E.M. Diffusion of Big Data and analytics in developing countries. *The International Journal of Engineering and Science* **2015**, *4*, 44-50.
55. Panicker, R. Adoption of Big Data Technology for the Development of Developing Countries. In Proceedings of National Conference on New Horizons in IT-NCNHIT.
56. UN Global Pulse. *Big Data for development: Challenges & opportunities*; UN Global Pulse: New York, 2012.
57. Asi, Y.M.; Williams, C. The role of digital health in making progress toward Sustainable Development Goal (SDG) 3 in conflict-affected populations. *International Journal of Medical Informatics* **2018**, *114*, 114-120, doi:10.1016/j.ijmedinf.2017.11.003.
58. Nunes, A.R.; Lee, K.; O'Riordan, T. The importance of an integrating framework for achieving the Sustainable Development Goals: the example of health and well-being. *BMJ Glob Health* **2016**, *1*, e000068-e000068, doi:10.1136/bmjgh-2016-000068.
59. Hill, P.S.; Buse, K.; Brolan, C.E.; Ooms, G. How can health remain central post-2015 in a sustainable development paradigm? *Global Health* **2014**, *10*, 18-18, doi:10.1186/1744-8603-10-18.
60. Zhong, R.Y.; Newman, S.T.; Huang, G.Q.; Lan, S. Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives. *Computers & Industrial Engineering* **2016**, *101*, 572-591, doi:10.1016/j.cie.2016.07.013.
61. Novillo-Ortiz, D.; De Fátima Marin, H.; Saigí-Rubió, F. The role of digital health in supporting the achievement of the Sustainable Development Goals (SDGs). *International Journal of Medical Informatics* **2018**, *114*, 106-107, doi:10.1016/j.ijmedinf.2018.03.011.
62. Rommelfanger, Karen S.; Jeong, S.-J.; Ema, A.; Fukushi, T.; Kasai, K.; Ramos, Khara M.; Salles, A.; Singh, I.; Amadio, J.; Bi, G.-Q., et al. Neuroethics Questions to Guide Ethical Research in the International Brain Initiatives. *Neuron* **2018**, *100*, 19-36, doi:10.1016/j.neuron.2018.09.021.
63. Bentley, P.J.; Brundage, M.; Häggström, O.; Metzinger, T. *Should we fear artificial intelligence?: in-depth analysis*; 2018.
64. Jolley, A. *Technologies for Reducing Stationary Energy Use*; Victoria University of Technology: 2006.
65. Islam, M.A.; Hasanuzzaman, M.; Rahim, N.A.; Nahar, A.; Hosenuzzaman, M. Global renewable energy-based electricity generation and smart grid system for energy security. *Scientific World Journal* **2014**, 10.1155/2014/197136, 1-13, doi:10.1155/2014/197136.
66. European Commission. *State of the Union 2017 - Cybersecurity: Commission Scales up EU's Response to cyber-attacks. European Commission Press Release*; Brussels, 19 September 2017, 2017.
67. World Economic Forum. *The future of jobs report 2018*; World Economic Forum Geneva, 2018.
68. UN Development Programme. *Human Development Report 2015: Work for Human Development*; Communications Development Inc: USA, 2015.
69. International Labour Organisation. *World Employment and Social Outlook: Trends, ISBN 978-92-2-131535-3*; International Labour Office: Geneva, 2018.
70. Ballenger, G. A.I. could help combat modern slavery, if humans don't mess it up. *Slate Magazine* June 30th 2017, 2017.

71. Ved, M. The Promise of Big Data: From Big Data to Big Personalization to Big Profits. Availabe online: https://medium.com/@mehulved1503/the-promise-of-big-data-from-big-data-to-big-personalization-to-big-profits-545b93308e3c (accessed on 4.16.19).
72. Barnett, R. Why the promise of big data hasn't delivered yet. Availabe online: http://social.techcrunch.com/2017/01/29/why-the-promise-of-big-data-hasnt-delivered-yet/ (accessed on 04.16.19).
73. Crawford, K. The hidden biases in big data. *Harvard Business Review* **2013**, *1*, 1.
74. SAS. Big data and global development. Availabe online: https://www.sas.com/en_us/insights/articles/big-data/big-data-global-development.html (accessed on 4.16.19).
75. Ismail, N. Big Data in the developing world. Information Age. Availabe online: https://www.information-age.com/big-data-developing-world-123461996/ (accessed on 4.16.19).
76. Nigon, J.; Glize, E.; Dupas, D.; Crasnier, F.; Boes, J. Use Cases of Pervasive Artificial Intelligence for Smart Cities Challenges. In Proceedings of 2016 Intl IEEE Conferences on Ubiquitous Intelligence & Computing, Advanced and Trusted Computing, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People, and Smart World Congress (UIC/ATC/ScalCom/CBDCom/IoP/SmartWorld), 2016/07.
77. Kitchin, R. Making sense of smart cities: addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society* **2014**, *8*, 131-136, doi:10.1093/cjres/rsu027.
78. Kitchin, R. *Getting smarter about smart cities: Improving data privacy and data security*; Data Protection Unit, Department of the Taoiseach: Dublin, Ireland, 2016.
79. Nam, T.; Pardo, T.A. Smart city as urban innovation. In Proceedings of Proceedings of the 5th International Conference on Theory and Practice of Electronic Governance - ICEGOV '11.
80. Pan, Y.; Tian, Y.; Liu, X.; Gu, D.; Hua, G. Urban Big Data and the Development of City Intelligence. *Engineering* **2016**, *2*, 171-178, doi:10.1016/j.eng.2016.02.003.
81. Voda, A.I.; Radu, L.D. Artificial Intelligence and the future of smart cities. *Broad Research in Artificial Intelligence and Neuroscience* **2018**, *9*, 110-127.
82. Albino, V.; Berardi, U.; Dangelico, R.M. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology* **2015**, *22*, 3-21, doi:10.1080/10630732.2014.942092.
83. Kitchin, R. Data-Driven, Networked Urbanism. *SSRN Electronic Journal* **2015**, 10.2139/ssrn.2641802, doi:10.2139/ssrn.2641802.
84. Sholla, S.; Naaz, R.; Chishti, M.A. Ethics Aware Object Oriented Smart City Architecture. *China Communications* **2017**, *14*, 160-173, doi:10.1109/cc.2017.7942323.
85. Batty, M.; Axhausen, K.W.; Giannotti, F.; Pozdnoukhov, A.; Bazzani, A.; Wachowicz, M.; Ouzounis, G.; Portugali, Y. Smart cities of the future. *The European Physical Journal Special Topics* **2012**, *214*, 481-518, doi:10.1140/epjst/e2012-01703-3.
86. Kitchin, R.; Lauriault, T.P.; McArdle, G. Smart cities and the politics of urban data. In *Smart Urbanism: Utopian Vision or False Dawn?*, Routledge: London, 2015; pp. 16-33.
87. Cardullo, P.; Kitchin, R. *Being a 'citizen' in the smart city: Up and down the scaffold of smart citizen participation*; Center for Open Science: 2017/05/15, 2017.
88. Froemelt, A.; Dürrenmatt, D.J.; Hellweg, S. Using Data Mining To Assess Environmental Impacts of Household Consumption Behaviors. *Environmental Science & Technology* **2018**, *52*, 8467-8478, doi:10.1021/acs.est.8b01452.

89. Müller, J.M.; Kiel, D.; Voigt, K.-I. What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability. *Sustainability* **2018**, *10*, 247, doi:10.3390/su10010247.
90. Poppe, K.; Wolfert, S.; Verdouw, C. How ICTIs Changing the Nature of the Farm: A Research Agenda on the Economics of Big Data. In Proceedings of 11th European IFSA Symposium, Farming Systems Facing Global Challenges: Capacities and Strategies, Berlin, Germany, 1-4 April 2014.
91. Taylor, L. Safety in Numbers? Group Privacy and Big Data Analytics in the Developing World. In *Group Privacy: The Challenges of New Data Technologies*, Taylor, L., Sloot, B.v.d., Floridi, L., Eds. Springer: 2017; pp. 13-36.
92. Carolan, M. Publicising Food: Big Data, Precision Agriculture, and Co-Experimental Techniques of Addition. *Sociologia Ruralis* **2016**, *57*, 135-154, doi:10.1111/soru.12120.
93. Wolfert, S.; Ge, L.; Verdouw, C.; Bogaardt, M.-J. Big Data in Smart Farming – A review. *Agricultural Systems* **2017**, *153*, 69-80, doi:10.1016/j.agsy.2017.01.023.
94. Ferris, J.L. Data privacy and protection in the agriculture industry: is federal regulation necessary. *Minn. JL Sci. & Tech.* **2017**, *18*, 309.
95. Kosior, K. Agricultural education and extension in the age of Big Data. In Proceedings of Proceednigs of the 23rd European Seminar on Extension and Education (ESEE), Chania, Greece, 4-7 July 2017.
96. Brey, P.A. Anticipatory technology ethics for emerging IT. *CEPE 2011: Crossing Boundaries* **2011**, 13.
97. Grunwald, A. Techno-visionary Sciences: Challenges to Policy Advice. Science. *Technology & Innovation Studies* **2013**, *9*, 21-38.
98. Palm, E.; Hansson, S.O. The case for ethical technology assessment (eTA). *Technological Forecasting and Social Change* **2006**, *73*, 543-558, doi:10.1016/j.techfore.2005.06.002.
99. Collingridge, D. *The Social Control of Technology*; Palgrave Macmillan: 1981.
100. House of Commons Science and Technology Committee. Robotics and artificial intelligence. Availabe online: http://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/145/145.pdf (accessed on
101. Varadarajan, R.; Kaul, R. Doing well by doing good innovations: alleviation of social problems in emerging markets through corporate social innovations. *Journal of Business Research* **2018**, *86*, 225-233, doi:10.1016/j.jbusres.2017.03.017.