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The Road Towards Sustainability: Transforming Consumption Patterns with Artificial Intelligence

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Abstract

This study aims to contribute to a better understanding of the role of artificial intelligence (AI) in transforming modern consumption patterns and supporting international efforts to transition towards sustainable consumption. To meet this objective, a systematic literature review (SLR) was conducted, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for literature search and selection. Bibliographic searches were conducted in two well-regarded databases: Elsevier Scopus (Scopus) and the Web of Science (WoS), with the final search completed on May 1, 2024. Identified studies were assessed for eligibility and eleven peer-reviewed English articles published in respected journals were included in the final review. The author synthesized the included articles and used qualitative methods to present the current knowledge vis-à-vis AI's applications for sustainable consumption. Grey literature was consulted to avoid source selection bias. This SLR led to a conceptual understanding of how AI contributes to meeting Sustainable Development Goal 12 (SDG12) of the 2030 United Nations (UN) Agenda for Sustainable Development, particularly in evaluating, ensuring, and promoting sustainable consumption behaviors. The study also discusses the main challenges of adopting AI for advancing sustainable consumption initiatives. This theoretical understanding has important implications for informing sustainable consumption initiatives. The study also acknowledges its limitations, including the risk of bias and the questions left unanswered within the existing body of research.

Keywords*:* Artificial Intelligence, Sustainable Consumption Behavior, Sustainable Development Goals, Digital Transformation, Contemporary Strategies

Introduction

The need to consider the transition towards sustainable consumption patterns as a central milestone in achieving long-term sustainable development has been openly recognized by an extended body of research (Jackson, 2014; Akenji et al., 2015, p. 7). The concept of sustainable consumption can be understood as the use of goods and services to fulfill the needs of the current generation in such a way that the natural environment is not harmed

and that the preservation of adequate resources for future generations is ensured. Although the previous characterization may seem an intuitive practice for humanity (i.e. something that each generation naturally strives towards), achieving sustainable consumption is challenging. This is due to the many viewpoints surrounding its meaning and practices, but also because its realization requires coordinated action across multiple sectors and involves more than a single stakeholder, including professional associations and organizations at both the international and national levels, governments, industries, corporations, non-governmental organizations (NGOs), educational, scientific and cultural institutions, as well as the entire civil society (Jonkutė & Staniškis, 2019). Besides, our modern society still highly values goods and services consumption Zukin & Maguire (2004); Goodwin et al (2019); Boström (2020), making the goal of achieving sustainable consumption practices an even more complex task.

Admitting these limitations, the scientific community's focus has transitioned from solely measuring societal fairness, population well-being, and overall sustainable development in terms of gross domestic product (GDP) growth to either complementary or substitutive ideologies of development. The new economic ideologies go beyond GDP, providing several alternative indicators of development, such as the degree of human development, biocapacity, ecological footprint Kubiszewski et al (2013), and many other similar composite approaches (Georgeson et al., 2017). All these novel approaches reflect a rising acknowledgment of the interdependency between sustainable development, economic prosperity, environmental protection, social well-being, and more recently, digital transformation and emerging technologies (Litvinenko, 2019; Ghobakhloo, 2020).

Particularly within the context of the COVID-19 pandemic and highly driven by its physical boundaries (i.e. social distancing measures and lockdowns) leading to major socioeconomic consequences Nicola et al (2020), the importance of being digitally ready and the early adoption of emerging technology has been emphasized (Jones et al., 2021). Early adopters of new technologies were favored Agrawal et al (2021), and the digital transformation shifted from merely another sustainable development goal (SDG) to an imperative on the agendas of businesses and governments alike (Ting et al., 2020; Jones et al., 2021; Moser-Plautz & Schmidthuber, 2023). Moreover, the rise of the digital and the increasing acceptance of telecommuting and e-commerce contributed to changing how individuals interact, work, communicate, and participate in consumption activities (Pascucci et al., 2023).

In this Internet-driven hyper-connected society, if accompanied by robust and effective policies, cutting-edge technologies are believed to be an important resource for encouraging sustainability (Robertsone & Lapiņa, 2023). Among these developing technologies, artificial intelligence (AI) applications and algorithms offer promising prospects for optimizing resource allocation, efficiently managing waste, and encouraging sustainable behaviors (Abbasi & Hanandeh, 2016; Fang et al., 2023; Murta, 2024; Spair, 2024). Nonetheless, in the pursuit of sustainable consumption, much like the digitalization process, the author believes that AI technology's impact is twofold as it can either be "[…] the friend or foe of sustainable consumption […]" (Lehner et al., 2023). Although there has been considerable interest in the research and development (R&D) of AI solutions and applications, the extent to which AI facilitates sustainable consumption remained insufficiently explored. Therefore, this study aims to assess the current state of research, by addressing the following questions:

Q1. What AI applications support the transition towards sustainable consumption?
Q2. What are the challenges associated with the adoption of AI in sustainable consumption initiatives?

Research Methodology

The author started with a systematic literature review (SLR) methodology to address the study's specific research questions. This was considered the most suitable approach for identifying the existing knowledge on the role of AI in promoting (or inhibiting) sustainability in consumption and for identifying the areas where knowledge is scarce (Carrera-Rivera et al., 2022). Following the guidelines of Page et al (2021), the study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology in order to ensure the inclusion of relevant literature.

Although originally intended for medical research, the PRISMA methodology has been documented as suitable for reviews in many other sciences, including economics, marketing, and management studies Ter Huurne et al (2017); Haynes & Alemna (2022); Lim & Rasul (2022), warranting rigor, transparency, and reproducibility of the literature search and selection processes. *Figure 1* illustrates the PRISMA flow diagram and a brief overview of the search process is provided in the following paragraphs.

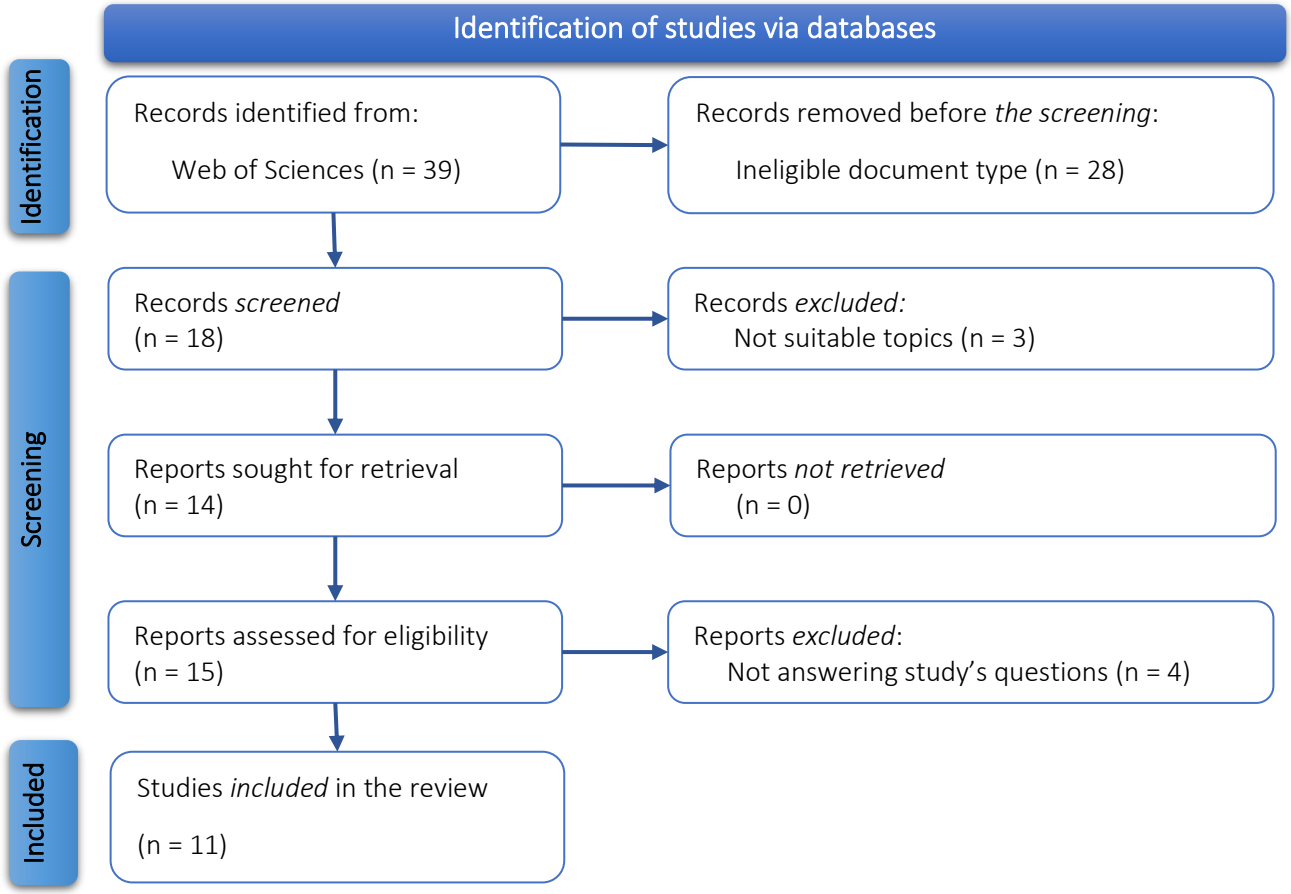

Figure 1 PRISMA flow diagram of included studies

Source: Adapted based on Page et al (2021).

A. Identification

Following Verma et al (2021), the literature search was performed in two well-regarded databases: the Elsevier Scopus (Scopus) and the Web of Science (WoS) digital libraries, with the final search completed on May 1, 2024. The study began with complete database searches to identify any documents containing "artificial intelligence" or "AI", along with "sustainable consumption". For consistency, the search was performed in documents' abstracts, keywords, or titles. The complete search logic is described in *Table 1*.

Table 1
Search query for the identification of records in the selected databases

Database	Query
Elsevier Scopus	TITLE-ABS-KEY (“sustain* consum*”) AND (TITLE-ABS-KEY (“artificial intelligence”) OR TITLE-ABS-KEY (“AI”))
Web of Science	(TS=(“sustain* consum*”) AND TS=(“artificial intelligence” OR “AI”))

Source: Author’s contribution based on database interrogations.

To include alternative terms such as “sustainable”, “sustainably”, “sustainability”, or “consume”, “consumer”, or “consumption” related to the notion of “sustainable consumption”, the search logic included the asterisk wildcard to capture variations after the root word. This logic returned 20 documents in the WoS database and 39 in Scopus.

B. Screening and Eligibility

The citation details and abstracts of the peer-reviewed articles were downloaded as Excel files from each of the two sources (WoS, n = 20; Scopus, n = 39) and merged into a single file in order to allow for cross-checking and de-duplication. In line with existing SLRs Sivarajah et al (2017); Lim & Rasul (2022), this study excludes early-access papers, conference proceedings, book chapters, reviews, and editorials. Only English peer-reviewed articles published in journals were included. Before evaluating their eligibility for inclusion, 28 ineligible document types and 12 duplicate titles were excluded.

After screening the remaining documents’ abstracts, three studies were excluded as they did not address the role of AI in sustainable consumption initiatives or practices. These studies addressed one of the following topics (1) a consumption-work dialectical interaction conceptual model (O’Sullivan & Kraisornsuthasinee, 2019); (2) groundwater seasonal quality assessment Tyagi & Sarma (2020); (3) the use of Bayesian algorithms for evaluating reading comprehension (Rodriguez-Barrios et al., 2021).

The remaining 15 articles were retrieved and read in full. Four more articles were excluded as they did not help answer any of the research questions of this study. These articles had the following topics: (1) generating green fuel from carbon emissions and the use of AI for plastic waste recycling Sankaran (2020); (2) factors affecting pro-environmental behavior without specifically addressing the role of AI Sarmento & Loureiro (2021); (3) investigating the effect of disconnection from nature on consumers’ preference for automated products Zhang & Tao (2022) and (4) the role of context-aware systems in addressing the seven societal challenges established by the European policy (Diaz et al., 2024).

C. Data Synthesis

To consolidate its findings and synthesize the data, this study employs qualitative methods that are recommended for inhomogeneous and mixed-method studies (Wohlin et al., 2012). Methodologies from previous review articles Rana & Paul (2017) were adapted for a narrative synthesis. While analyzing the review’s findings, the author made an active effort to mitigate source selection bias by exploring additional relevant academic libraries and journals to identify additional sources.

II. Towards A Shared Understanding of Sustainable Consumption

Sustainable consumption remained a central topic of research over time and has gained the interest of numerous scientific communities coming from diverse cultural backgrounds and distinct disciplines, including the fields of environmental sciences, economics, marketing and management, computer sciences, information technology, and public policies (Thøgersen and Ölander, 2002; Vermeir & Verbeke, 2006; Zhang et al., 2014; White et al., 2019). The need to consider sustainability in consumption was officially discussed for the first time in 1992 during "The United Nations Conference on Environment and Development" (UNCED).

Nevertheless, despite the many scientific efforts made since then, a consensus on the meaning of sustainable consumption has not been achieved and a working definition has not yet been proposed (Jackson, 2014; Dawkins et al., 2019). Perhaps, the concept can be more easily grasped when placing it in the context of sustainable development. Different schools of thought have been developed, each offering an alternative perspective to what the concept of sustainable development represents and how it can be achieved. Asserting that economic growth is not viable in the long run, some of these schools of thought have proposed theories that oppose economic growth and encourage fundamental changes in civilization's core values, such as the "degrowth theory" or "Buen Vivir" (Ruggerio, 2021).

For instance, accounting for the finiteness of resources, the degrowth theory states that economic development should not be pursued at any cost and advocates for "[…] the equitable downscaling of the overall capacity to produce and consume […]" (Sekulova et al., 2013). As a more holistic approach, Buen Vivir serves as a life philosophy and guiding ethos in favor of a change in civilization. This change inspires alternative ways of describing, experiencing, and living a "good human life", which is seen as life in "[…] harmony with nature (as a part of it)", suggesting there is "[…] inseparability of all life's elements (material, social, spiritual)" and opposing to perpetual accumulation (Kothari et al., 2014).

On the other end of the spectrum, supporters of economic development are placing "growth" at the core of civilization's development as "[…] a necessary condition for a 'good human life' […]" (Muraca, 2012). Although several alternative viewpoints emerged regarding the meaning, value, and practices of a "good human life" and the ones of "sustainable development", the latter term continues to be recurrently used as a straightforward synonym for "sustainability" (Ruggerio, 2021). Therefore, the concept of "sustainable development" continues to be understood through its first formal definition, originating from the 1987 World Commission on Environment and Development's Brundtland report 'Our Common Future', which referred to it as "[…] development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN. Secretary-General & World Commission on Environment and Development, 1987).

Correspondingly, one of the first definitions of "sustainable consumption" referred to it as "[…] the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of further generations […]" (Ofstad et al., 1994, p.10). Building on this definition, succeeding attempts to define the concept suggest understanding sustainable consumption by taking into account consumer's social responsibility (Vermeir and Verbeke, 2006).

Vermeir and Verbeke (2006) proposed that the daily consumption patterns of individuals are inseparable from their inherently human preferences and their world views, including subjective perceptions of quality and price, the convenience of available options, the

inclination towards hedonism or utilitarianism, particular health considerations, or consumers' adherence or resistance to social and institutional norms. Opposing to consumers' default decision-making, the practice of sustainable consumption requires "[…] a decision-making process that takes the consumer's social responsibility into account in addition to individual needs and wants" (Vermeir & Verbeke, 2006).

Recent efforts to define the concept of sustainable consumption focus on various standards and criteria, such as "[…] that the ecological footprint is not greater than the corresponding biocapacity" (Fischer et al., 2023). In other words, Fischer et al (2023) suggests that the practice of sustainable consumption means that *consumers living in a particular geographic location are utilizing the resources naturally found in that area, all the while ensuring that their waste and emissions do not go beyond the natural absorption capabilities of the region*. Therefore, in cases where consumption goes beyond these limits, disregarding the natural environmental boundaries, and leading to ecological deficits or overshoots, the practice of consumption can be considered unsustainable.

Following previous definition attempts, in this paper, we will explore AI's role in promoting sustainable consumption by defining the concept as the utilization of goods and services required to fulfill essential needs or enhance the quality of life for the current generation without endangering the needs and desires of future generations. Thus we've considered as relevant the literature that discussed AI's contribution to meeting one of the following objectives of sustainable consumption: (1) efficient allocation of available resources; (2) encouraging product reuse and/or recycling; (3) mitigation and responsible management of waste, emissions and pollutants; (4) aligning supply's offerings to consumers' demands and avoiding inventory surpluses or product waste; and (5) ensuring social equity and well-being for current or future generations.

III. Transforming Consumption Patterns with Artificial Intelligence

A. Evidence from Included Studies

Sustainable consumption is a normative concept, stressing the actions that governments, multinational corporations, small and medium-sized enterprises (SMEs), households, and individuals altogether ought to take in order to minimize and prevent the negative effects of their suboptimal and occasionally inappropriate practices of consumption on the natural environment and its resources. The practice of sustainable consumption is aimed at preserving ecological integrity and safeguarding the natural environment for generations to come (de Oliveira et al., 2022).

While it is true that achieving sustainability in consumption requires a mutual effort, involving all the relevant stakeholders, a deeper understanding of artificial intelligence capabilities and leveraging them in everyday life activities as well as in the core production and distribution operations could contribute to "[…] encouraging sustainable consumption and facilitating the return, recycling, or refurbishing of products […]" (Sánchez-García et al., 2024) in various sectors and industries of the economy. These objectives can be achieved through the use of applications such as:

*a) **Ai As A Data Analysis Tool for Alignment with Sdgs***

Repeatedly recognized as a valuable automation tool for data processing and analysis, AI can enable efficient decision-making and management that align with and facilitate the United Nations' Sustainable Development Goals (SDGs) outlined in the 2030 Agenda for Sustainable Development (Guo et al., 2022). Such an example includes the study conducted by Borsatto

and colleagues 2024. By employing techniques specific to AI's subfield, namely natural language processing (NLP), they conducted a documentary analysis of more than 15.000 community outreach projects directed by a higher education institution in Brazil between the years of 2009 and 2022 (Borsatto et. al., 2024). Combining NLP with statistical techniques, they compared the descriptions of the community outreach actions with 17 different word dictionaries, each built around one of the SDGs of the 2030 UN Agenda.

Following this methodological approach, they uncovered a high level of alignment between the community outreach projects and the social and economic dimensions of the Sustainable Development Goals (SDGs). A select few SDGs were emphasized in the community outreach projects, with SDG 12 (Sustainable Consumption and Production) being one of them. This research showcased how the efforts of the higher education institution align with SDGs and demonstrated the effectiveness of AI in analyzing large amounts of data, as it enables the identification of "[…] gaps that can serve as guidance for the development of actions that help eradicate poverty and hunger, and reduce emissions […]" Borsatto et. al (2024), thus, aiding the global goal of achieving sustainable consumption practices.

Advancing our understanding of AI's contribution to analyzing sustainable consumption practices, Di et. al (2024) employ a mix of Artificial Neural Networks (ANNs) with structural equation modeling to identify the factors contributing to green and low-carbon consumption behaviors and to capture the non-linear relationships between them. Their study revealed the importance of using "carbon labels" to promote low-carbon consumption behaviors and propose clear directives for companies to improve their "environmental image" through "fostering alliances with environmental organizations, engaging in eco-friendly initiatives, and introducing green products" (Di et. al., 2024). Additionally, Di et. al (2024) revealed that individual willpower, consumers' attitudes, and environmental awareness have a significant influence on low-carbon consumption behaviors. From a practical standpoint, their study emphasized the need for governments and companies to enhance public awareness and encourage environmental protection through educational programs and initiatives aimed at inspiring active public engagement in low-carbon consumption practices.

b) ***Sustainable Product Development and Production***

Choy et al (2016) proposed a new conceptual model called the recursive operations strategy (ROS) as a means of enhancing sustainability of the development and production processes in the chemical industry. The effectiveness of this model was demonstrated through a case study conducted at a Hong Kong-based company specializing in the manufacturing of personal care products. The ROS model combined business and operations strategies and utilized artificial intelligence techniques, such as case-based reasoning and fuzzy set theories. As opposed to the traditional trial-and-error method of developing chemical products, their model led to substantial decreases in the number of trials needed and reduced the resulting chemical waste. In addition, the study suggests that the application of fuzzy logic theory can assist in optimizing parameter settings, thereby optimizing energy consumption.

c) ***Ai Demand Forecasting, Product Design, and Curation in The Fashion Industry***

Traditional supply chains that are based on forecasting approaches are often times resulting in discrepancies between anticipated and actual consumer demand. This causes inventory surplus and markdown pricing that lower manufacturers' earnings. As it is able to provide real-time insights, AI technology can overcome these unique, but frequent challenges faced by the fashion industry, aiding core operations such as demand forecasting and product

design. For instance, Jin and Shin (2020) highlighted that organizations such as Stitch Fix and Amazon already employ purpose-built artificial intelligence solutions to alleviate the aforementioned specific challenges.

Stitch Fix relies on big-data analytics to offer personalized fashion recommendations, which improves demand forecasting and customer satisfaction. Meanwhile, Amazon is investing in AI and automated on-demand production to eliminate inventory issues and align production with current trends. According to Jin and Shin (2020), while improving efficiency and bringing products more in line with consumer demand, these applications are placing AI technology as one of the main business disrupters in the fashion industry. Also, in regard to the fashion industry, following a wide-ranging review of the literature, Akram et al (2022) suggest that AI has the potential to aid in clothing curation according to weather conditions and predicting customer fashion trends. These varied use cases within the fashion industry, are believed to contribute to constructive personalized shopping experiences and enable retailers to match their product offerings effectively with the preferences of consumers.

Furthermore, Shin et al (2022) pursued an investigation of the AI-driven fashion curation "Style Bot" mobile application. The researchers carried out an online survey targeting women in their 20s and 30s residing in a metropolitan area and demonstrated that AI-based clothing curation applications promote environmentally sustainable behaviors. Study's participants were firstly instructed to install the "Style Bot" app, try its coordination functions, and submit their feedback on the app's various features, including its convenience, speed, usefulness, and recommendation accuracy. Similarly, participants were asked to rate their post-use clothing utilization, and overall satisfaction they had with the service. Shin's et al (2022) findings revealed that users' perceived convenience, and the usefulness and recommendation suitability of the AI tool, had a positive impact on respondents' use of their already-owned personal clothing. According to the authors, this result is an important one as it promotes environmental sustainability by potentially reducing the amount of discarded or neglected clothing. Moreover, the results indicate that participants expressed satisfaction with AI's role in supporting their sustainable fashion practices efforts and prolonging their wardrobe's lifespan.

d) ***Supply Chain Optimization in Agri-Food Sector***

Within the agri-food sector, employing AI applications through various stages of the production and supply chain operations holds promise for advancing sustainable consumption practices on a global scale. As AI models can be trained to detect certain patterns, AI-driven supply chain management systems can contribute to achieving more balanced consumption patterns by extending the shelf lives of perishable products. Amani and Sarkodie (2022) demonstrated this by training a classification model using deep convolutional neural networks image classification and Particle Swarm Optimization algorithms which achieved 100% accuracy in distinguishing fresh meats from spoiled ones. Furthermore, the use of this model across various stages of the meat supply chain "[…] increases productivity, reduces cost, and avoids the bacteria effects of rotten meats on healthy ones by automating the separation process" (Amani & Sarkodie, 2022). By utilizing AI to extend the shelf life of perishable meat produce, the authors anticipate that consumer trust will grow, leading to a higher meat demand and ultimately to increased economic productivity.

e) ***Behavioral Nudging***

Numerous techniques and strategies can be employed to gently influence consumers' decision-making processes without resorting to coercion or visible persuasion. To refer to these practices under a single common term, Richard Thaler and Cass Sunstein introduced the notion of "nudging" within the field of study concerned with consumer behavior. Correspondingly, a "nudge" can be defined as any aspect "[…] that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler & Sunstein, 2012). Individuals involved in the art and craftsmanship of nudging tactics are called "choice architects". Over the years, many academics have raised their concerns about nudging's potential to undermine individual autonomy Saghai (2013); Schmidt & Engelen (2020), especially as it can exploit innate psychological vulnerabilities (Vinuesa et al., 2020), yet, the growing belief is that AI technology can facilitate "green nudging" and encourage sustainable consumption behaviors (Bartmann, 2022).

For instance, employing the "Stimulus-Organism-Response" (S-O-R) theory and the "Theory of Planned Behavior" (TPB), Cao & Liu (2023) analyzed data from 280 users of a mobile application that was built based on Big Data and AI technology, to explore how and if it nudges sustainable consumption practices. The mobile application, named Ant Forest, uses gamification principles and interactive elements in order "[...] to prompt the public in practicing sustainable consumption behavior while also addressing climate change and environmental issues". Cao & Liu (2023) have shown that there is a significant "linkage effect" between "online green consumption habits and offline sustainable consumption behavior". The research findings suggest that the emotional and social values perceived by customers have a favorable influence on customer stickiness (i.e. the inclination of users to continue engaging with the AI application), which leads to sustainable consumption behavior.

f) ***Ai As A Comprehensive Solution for Advancing The Circular Economy***

Lastly and with equal importance, artificial intelligence together with other emerging Industry 4.0. technologies (i.e. blockchain, the internet of things, and big data) can be integrated to support various circular economy initiatives, "[…] offering profound economic and environmental benefits while fostering sustainable consumption and collaborative innovation […]" (Sánchez-García et al., 2024). Sánchez-García and colleagues (2024) suggest that the integration of AI and blockchain supports and advances collaborative consumption as they facilitate synchronizing supply and demand in real-time, strengthen the security of person-to-person transactions, optimize resource allocation, and contribute to waste reduction. As an alternative model to the one of traditional consumption, collaborative consumption is based on the "use rather than own" approach, which is normally believed to achieve "a general resource-saving potential […] as long as the framework conditions associated with using the service do not cancel out the savings achieved" (Leismann et al., 2013). Adding to this knowledge, by conducting an extensive literature search and mapping the 169 targets within the 17 SDGs of the UN Agenda with relevant literature, Vinuesa, and colleagues (2020) contend that AI serves as a facilitator for nearly 80% (134 targets) of them and concluded that this result is achieved mainly via "[…] a technological improvement, which may allow to overcome certain present limitations". In conclusion, if its challenges are properly accounted for, AI technology is not only an important aid in the international efforts to attain sustainable consumption practices, but also a key resource in achieving overall sustainable development and transition towards the circular economy.

B. Challenges in Integrating AI Into Sustainable Consumption Initiatives

Even though AI brings technological advancements that help society overcome current limitations and transition towards sustainable consumption practices, its large-scale adoption raises several questions about the likely negative impacts in individual and collective contexts. AI is a relatively new and constantly evolving technology. As a result, the challenges associated with its adoption are unique, complex, and varied. These include *privacy and security concerns*, *balancing individual privacy costs versus the collective benefits*, *ensuring transparency and accountability*, *bias propagation and (un)fairness, manipulative or fake content generation, the risk of undermining one's autonomy, ensuring equity*, *the risk of technological lock-in*, *as well as unintended consequences*. The aforementioned challenges alongside the SLR-identified AI applications supporting sustainable consumption initiatives are depicted in *Figure 2*.

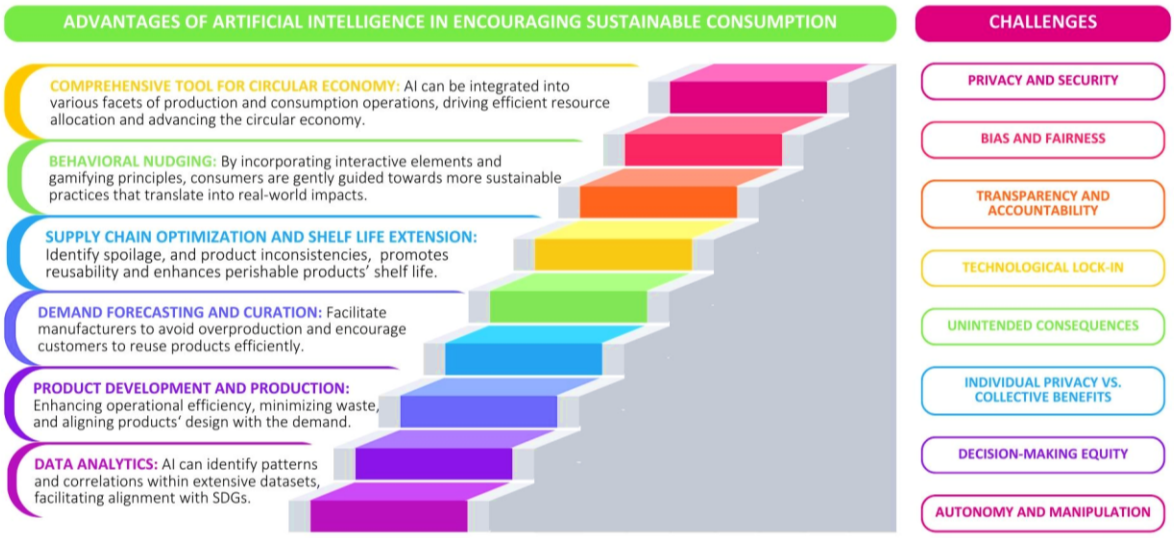

Figure 2 Advantages and challenges of integrating Artificial Intelligence in Sustainable Consumption Initiatives

Source: Author's contribution based on the assessed literature. The figure was prepared using the free Canva graphic design software.

At the core of artificial intelligent systems is data. Especially in the case of the recent large language models (LLMs), enormous amounts of data retrieved from many sources were used for training them to be able to perform advanced NLP tasks. For instance, OpenAI's GPT-4 model was trained using around 5-6 trillion tokens, including in its sources both publicly available data, as well as scientific literature (Crouse, 2024; McGuinness, 2023). The machine learning (ML) algorithms used for training these LLMs make them "[…] susceptible targets for cyberattacks", thereby making information within the system "[...] vulnerable to theft or abuse" (Dwivedi et. al., 2023). Almost in all cases, in addition to the data they have been trained on, the interaction with an AI application also requires the share of user-generated data (Price & Cohen, 2019). Thus, with the increasing adoption of AI for everyday activities, the risk of privacy and security infringements becomes imminent (Radanliev et al., 2024).

Both individuals and organizations adopting AI solutions are at risk of being exposed to several vulnerabilities such as surveillance attempts, unauthorized access, or data breaches. At the individual level, this matter is an especially delicate one in case sensitive information (i.e. personally identifiable information, financial and healthcare data, confidential data, etc.) is exchanged with the AI systems (Saeed et al., 2023). In the context of sustainable consumption

initiatives driven by AI, it then becomes crucial to carefully weigh the personal privacy implications against the broader societal advantages when evaluating the trade-offs between individual costs and collective benefits.

In addition to existent data privacy and security concerns, Li et al (2024) noted that, unlike Google which hosts its model, most generative AI systems integrate LLMs via web APIs. This practice may not be transparent enough for users in terms of third-party data-sharing. Besides, present-day AI systems are recognized to operate as "black-box" systems (Ribeiro et al., 2016), meaning that they cannot provide explicit descriptions for how their output is being generated as their internal decision-making remains opaque and not easily understandable (Linardatos et al., 2021). This lack of transparency, paired with the risk of perpetuating frequent human judgment errors learned during their training and the risk of generating "artificial hallucinations", leads to the important question of who can be made accountable when errors are made (Naik et al., 2022).

For instance, in the context of clinical decision-making, Bleher and Braun (2022) argue that the implementation of AI systems "[...] causes diffusions of responsibility with respect to a causal, moral, and legal dimension". Without clear accountability and explainability mechanisms, AI could harm consumers' trust in sustainable initiatives, lead to unnoticed algorithmic errors, and perpetuate fake ideas and information about environmentally friendly consumption practices. Consumers' ability to identify or rectify these wrongful behaviors could also be inadvertently affected, especially when the AI-generated content is taken as is, without being filtered by expert judgment. If these solutions are used for advancing public policies and sustainable consumption initiatives, one must also consider the risk of reinforcing prejudices against underrepresented populations, which could lead to negative or discriminatory outcomes (Ferrara, 2023). A solution to mitigate the impact of these risks could be that of liability-replacing insurance, yet Zech (2021) suggests that "[…] if the incentive effects of liability are lost, moral hazards loom", thus the question of whom should be held liable still pertains.

As previously stated, the main challenge AI solutions raise is the perpetuation of learned stereotypes and *human bias* – defined as "any tendency which prevents unprejudiced consideration of a question" (Pannucci & Wilkins, 2010). A bias is any human-specific cognitive mistake that very frequently might have even been shared across many years and different generations. These systematic, repetitive errors can manifest consciously or unconsciously as unfair favoritism or discrimination toward situations, demographic groups, or individuals with distinct features, beliefs, physical attributes, cultural backgrounds, races, or genders (Soprano et al., 2024). Biases can also affect one's judgment when evaluating a current situation based on misattributed learnings attained during a previous similar experience (Marcelin et al., 2019). For AI systems, there are multiple possible sources of bias, including the "[…] different stages of the machine learning pipeline, including data collection, algorithm design, and user interactions" (Ferrara, 2023).

Mehrabi et. al. (2021) described several algorithmic applications where bias propagation and unfairness were identified, resulting in real-world unjust outcomes or discriminatory practices. As the increasing prevalence of digitalization is characterized by biases in societal issues and the importance of sustainability as a purchase criterion can be influenced by misinformation (Geissmar et al., 2023), there is a risk that AI perpetuates inaccurate sustainability information about products and practices that are not as sustainable as they claim to be. According to Acuti et al (2022), biased perceptions can lead to undesired

behavioral consequences, such as consumers' hesitations towards genuinely sustainable brands and the maintained preference for traditional products.

Hermann (2022) proposes that consumers "[….] should be able to decide themselves whether and how to engage with AI-powered psychologically tailored messages to facilitate consumer autonomy". Although the use of positive behavioral nudges in mobile AI applications has been shown to encourage a preference for environmentally friendly consumption habits Cao & Liu (2023), it's mandatory we consider that similar interactive elements and gamification principles could lead to the opposite effect. As evidence has already shown in the case of manipulating online behavior during public elections, "[…] AI can be purposefully misused causing harm" (Gupta et al., 2021). The ongoing debate about using AI-driven nudges and techniques to influence human behavior and its impact on individual autonomy hasn't yet found its resolution. While we may perceive the role of AI as helping us navigate complex decision-making processes by "[…] enlarging our choice and action possibilities […] and freeing our hands from tasks we cannot or would rather not carry out" (Fossa, 2024), the contrary viewpoint remains just as valid. For instance, AI integration in streaming decisions was shown to lead to autonomy-technology tension, leading to a decline in consumers' performance expectancy and satisfaction levels (Gonçalves et al., 2024).

Going further, concerns also arise regarding the equitable distribution of the risks and benefits of AI technologies (Goodman et al., 2020). AI systems reduce the need for trial-and-error approaches in production Choy et al (2016), contribute to optimal resource allocation in project management Sravanthi et. al (2023), guarantee research objectivity and repeatability Burger et al (2023), encourage product reuse and sustainable behaviors (Shin et al., 2022; Cao & Liu, 2023). In this case, an idealistic view is that their contribution is to mitigate "[…] the possible impacts of human error by making accurate predictions and assisting humans with decision-making" (Ravanera & Kaplan, 2021). In reality, these solutions often act as a "double-edged sword", having the potential to perpetuate biases and misinformation, reinforce stereotypes and marginalization Ravanera & Kaplan (2021), negatively impact the workforce and society Wilkens (2020), and bring negative outcomes in terms of overuse and misuse, particularly among very young populations (Chen & Lin, 2023). Therefore, there remains the need to properly account for the risk of AI generating inequity in decision-making and to effectively counterbalance the risks versus advantages of adopting such a solution.

Likewise, when a new transformative technology, such as the case of AI, becomes extensively used for a purpose or to advance a particular desiderate, the tendency to excessively rely on it for many applications can lead to technological lock-in. This affects both the development of the technology and its impact on society (Gruetzemacher & Whittlestone, 2022). An overreliance on AI systems to advance and support the majority of the core activities involved in societal progress could lead, as argued by Robbins and Van Wynsberghe (2022), to us becoming locked into an unsustainable future. Last but not least, large-scale AI adoption in sustainable consumption programs and initiatives could lead to unintended consequences or externalities. Examples of such externalities can be observed in different scenarios. For instance, Curry (2023) highlights the issue of job displacement within the IT industry. Another one could be that the environmental costs stemming from the technology's implementation itself – such as the carbon footprint associated with AI Heikkilä (2023) – surpass the advantages of the sustainable consumption initiative. Finally, it is very much possible that unanticipated unsustainable changes in consumer behavior emerge upon interacting with AI systems – that could include a tendency to overconsume or ignore environmental messages.

Conclusions

The R&D of artificial intelligence technology opens the door to unprecedented opportunities for the realization of SDG12 of the 20230 UN Agenda, concerning "sustainable consumption". Through its advanced data analytics capabilities, AI enables the detailed study of community initiatives' alignment with the 17 SDG objectives Borsatto et. al (2024), a task that would otherwise be time-consuming using conventional manual methods. As they allow for processing, evaluating, and identifying patterns in vast amounts of data, AI techniques such as Deep Artificial Neural Networks machine analysis help uncover the underlying relationships within extensive datasets Di et al (2024) and contribute to the advancement of the knowledge gained through common statistical procedures. The very same capabilities that facilitate the analytics of large amounts of data and pattern identification make AI technology an instrumental resource for assisting manufacturing industries in their efforts to minimize trial-and-error losses and maximize return on investment. Various AI applications can provide insights that contribute to efficient product development, demand forecasting, and supply chain optimization while allowing manufacturers to have the guarantee of obtaining quality products that meet or exceed consumer expectations (Choy et al., 2016; Jin & Shin, 2020; Amani & Sarkodie, 2022).

AI has overcome the constraints of time and space in promoting sustainable consumption efforts by incorporating gamification principles and interactive elements. These features are central incentives for users of AI-powered applications to actively participate in energy-saving and emission-reducing behaviors, especially when the positive outcomes of consumers' efforts are further amplified if the organization responsible for the application demonstrates a commitment to the environment by reforestation (Cao & Liu, 2023). The interactivity of these applications encourages innovative wardrobe reuse and extends the life of clothing items (Shin et al., 2022). In the same way, if applied to the detection of spoilage in perishable products, AI technologies achieve supply chain optimization and extend the shelf life of these products, thus increasing consumers' confidence (Amani and Sarkodie, 2022). In conclusion, AI enables the transition toward a circular economy, due to its many advanced NLP features that can be utilized in various applications and for many use cases, ultimately contributing to the prevalence of collaborative consumption (Sánchez-García and colleagues, 2024).

While AI technology effectively overcomes several present-day dilemmas and contributes to the improvement of central operations related to the achievement of sustainable consumption objectives, the large-scale adoption of AI technology for driving sustainable consumption presents ongoing challenges for both individuals and organizations. From simple concerns about privacy and security to the accurate assumption of responsibility and accountability in the event of harm, many questions remain unanswered, leaving consumers vulnerable to surveillance and privacy infringements. Balancing the individual privacy costs against the potential collective benefits that could be achieved after the implementation of AI is an important step in ensuring fairness. Controlling biased outputs and preventing the spread of damaging ideas about underrepresented populations are equally critical considerations for the proper implementation of AI technology and avoiding technological lock-in.

The present study has some notable limitations to mention. Firstly, limiting the document search to only the two databases WoS and Scopus may result in omitting important publications that were indexed in different academic or non-academic databases. Also, the choice of keywords used for conducting the database searches may unintentionally restrict the scope of this review by excluding alternative notions that also refer to sustainable

consumption practices, such as “environmentally friendly consumption”, “low-carbon consumption” or “green consumption behavior”, among others. At the same time, artificial intelligence is still in the early stages of its advanced capabilities, so some studies addressing sub-branches of AI in the context of sustainable consumption, without explicitly mentioning “artificial intelligence” in their abstracts, keywords, or titles may have been omitted.

The contributions of this paper are twofold. Firstly, based on a comprehensive systematic literature review, the study qualitatively summarizes the current state of empirical evidence regarding the role of artificial intelligence in the context of sustainable consumption. From a theoretical standpoint, this allows for a better understanding of how this emerging technology can be employed in various sustainability initiatives that could advance businesses and governments’ common efforts to achieve Goal 12 ‘Sustainable Consumption and Production’ of the 2030 United Nations Agenda for Sustainable Development. Additionally, the author categorized the peer-reviewed articles into main topics, providing a clear overview of the primary use cases for AI in sustainable consumption. This approach might encourage future research endeavors to focus both on the key topics identified within the current “box of knowledge and applications”, as well as outside it.

Secondly, the study acknowledges the main challenges associated with the integration of AI technology. As it was presented, this includes but is not limited to concerns about data privacy and security, the potential for bias and unfairness, the risk of becoming locked into a single technological solution, and the need to balance individual privacy with collective benefits. From a practical standpoint, this allows the interested parties to better prepare before taking into consideration the implementation of artificial intelligence solutions into their sustainable consumption initiatives. In turn, by presenting both the empirical evidence on AI’s advantages for sustainable consumption and its potential challenges side by side, we gain a clear overview of the current research landscape and can identify areas where research is lacking (i.e. the long-term impacts of AI on consumer autonomy, AI’s potential to drive overconsumption and balancing the negative effects of technological development on the environment with the benefits obtained).

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