How are GAFAM companies - Microsoft, Google, and Apple- utilizing AI systems' capabilities to drive their ESG/CSR initiatives?

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ABSTRACT,
Artificial intelligence has been on the agenda of numerous companies lately. Although primarily employed to facilitate prospects for risk reduction and profit maximization, the technology is increasingly driving the sustainability initiatives of businesses as well. This paper aims to demonstrate how Microsoft, Google, and Apple are using AI systems to support their ESG and CSR initiatives. The benefits of AI for social good will be illustrated through an in-depth analysis, which will also discuss the dangers and mitigation strategies related to the innovation.

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1. INTRODUCTION

Organizations across various industries have increasingly started to adopt AI systems to automate and improve their systems in the supply chain, marketing, Research & Development, and other business units. Technology is progressing faster than ever before; sometimes urgent need for transition pushes the demand for rapid developments (Leszkiewicz et al., 2021). For example, recently, due to the COVID-19 pandemic, society required prompt digitalization of most services and business activities. Artificial Intelligence (AI) was one of the technologies that helped businesses transition more effortlessly and even improve their performance in terms of revenue and cost reduction (McKinsey & Company, 2020b).

While beneficial for the financial performance of an organization, the systems of Artificial Intelligence can also facilitate social good. Currently, there is limited research on the aspects and ways that pave the future of AI as a source of solutions for critical social problems (Floridi et al., 2020).

Large organizations are increasingly expected to showcase evidence about their efforts on the three Environmental, Social, and Governance (ESG) pillars more straightforwardly and transparently. ''Approximately 95% of the largest 250 companies now issue a formal CSR.'' (Brooke-Lander et al., 2014, p.1) Moreover, in 2013 the Global Reporting Initiative tightened content and performance data reporting requirements. They now seek more specific data on the essential criteria, such as the organization's sustainability, with strong ties to its governance framework and management style (Brooke-Lander et al., 2014).

McKinsey Global Institute (2018) has published a discussion paper focusing on AI for Social Good. The report states that AI will significantly contribute to the realization of some of the most challenging social problems, which have also resonated with the 17 Sustainable Development Goals (SDG). Various capabilities of AI for social welfare have been analyzed, from computer vision to deep learning of structured data and beyond. Moreover, big technical organizations, like Google and Microsoft, have been provided as good examples of pioneers in using AI in a socially beneficial way.

This research will focus on analyzing the capabilities of AI beyond profit maximization and cost reduction; it will define how its systems have been and/or will be used to realize the Environmental, Social, Governance (ESG) / Corporate Social Responsibility (CSR) projects of companies like Google, Apple, and Microsoft. Moreover, the potential risks associated with incorporating AI in this context will be discussed, as well as possible mitigation tactics. The thesis paper will be based on an archival study of secondary sources centered on the topic of "AI for Social Good" concerning use cases, predominantly drawn from the business practice of the three major GAFAM corporations, Google, Apple, and Microsoft.

1.1 Research objective

Major technology firms are under increased pressure from the public, governments, and non-governmental organizations (NGOs) to behave transparently and fund initiatives addressing social and environmental issues. Companies' CSR initiatives & ESG projects concerning their financial results have been extensively researched lately (Cherkasova et al., 2022). Although the results vary, many authors have concluded a positive correlation between a company's financial performance and its ESG initiatives. By demonstrating concern and empathy for environmental and social issues, large corporations lower their financial risk and draw in more investors and clients who value their commitment to sustainability (Cherkasova et al., 2022). Although multinational enterprises with the necessary finances and investment objectives are especially interested in ESG initiatives, financing such projects typically equates to a loss for small and medium-sized businesses. Therefore, this research paper will be focused on the three most prominent technical organizations, Apple, Microsoft, and Google.

Even while there has been much research on how businesses disclose their sustainability efforts annually, little is known about the social effects of AI and how they utilize them (Saetra, 2021). As already noted, there are several recently implemented guidelines and laws that pertain to the reporting of CSR initiatives. And while AI has, to a considerable extent, been a part of them, no framework specifically addresses the socially beneficial applications of the technology. Additionally, this allows businesses to downplay unfavorable impacts (Saetra, 2021).

Due to the limited research on the subject, the goal of this bachelor thesis will be to provide an answer to the following research question:

How are the three big GAFAM companies, Google, Microsoft, and Apple, utilizing AI systems to drive their ESG/CSR projects?

Followed by two sub-questions:

1. *What are the benefits associated with the incorporation of AI into sustainable projects?*
2. *What risks and uncertainties follow from this integration?*

2. THEORETICAL FRAMEWORK

2.1 Corporate Social Responsibility (CSR)

Carroll's four-part model of corporate social responsibility (CSR) is a concept that continues to grow in impact (Carroll, 2016). It is depicted as a pyramid that encompasses society's economic, legal, ethical, and philanthropic expectations for businesses to fulfill (Carroll, 1979).

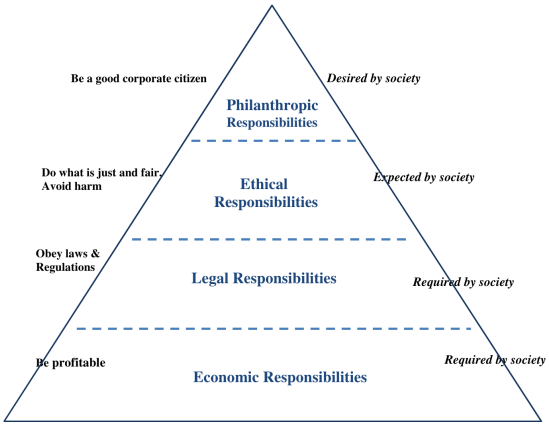

Figure 1. Carroll's pyramid of CSR (Carroll, 2016, p.5)

The economic demands that the public places on all companies determine to what extent they may remain in business and provide a return on investment to their owners and shareholders (Carroll, 2016). The second level is a representation of the legal provisions that the government, as well as its authorities, have enacted and that society expects enterprises to follow. Along with their legal responsibilities, corporations also have an ethical duty. The regulations themselves are insufficient; society views the law as a set of fundamental values that must be adhered to. In addition to them, it is anticipated that firms will operate in a socially, ethically, and morally responsible manner. Finally, the

philanthropic responsibilities represent companies' socially valuable voluntary actions. Although corporate philanthropy is not a statutory requirement for businesses, the public is becoming increasingly interested in it. Giving can take many forms, including financial contributions, donations of goods and services, volunteer work by staff members and management, support for the community's growth, and any other type of discretionary benefaction (Carroll, 2016).

Society started to expect firms to pay attention to societal needs in the 1960s and 1970s. Few, though, understood that social and commercial obligations could coexist. Today, neither the social nor the economic elements can be disregarded while making decisions (Chrisman et al., 1984).

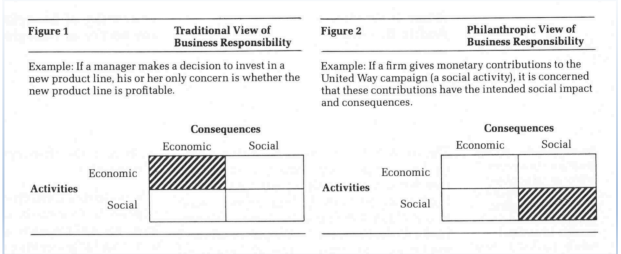

Figure 2. Traditional vs Philanthropic View of Business Responsibility (Chrisman et al., 1984, p.60)

It becomes essential for businesses, especially the large ones, to understand and balance the trade-offs between the four types of responsibilities. Organizations should consider implementing CSR efforts for several reasons, according to Crane (2016), including cost and risk reduction, profit maximization and competitive advantage, reputation and legitimacy, and synergistic value creation.

The concept is increasingly impacting how well corporations operate; in France, publicly traded companies are required to highlight any environmental and social activities in their annual reports. That is a strategy through which businesses will examine the impacts of their operations on all concerned stakeholders in addition to the interests of the shareholders and their desire to maximize profits (Syarizal et al., 2021).

CB Bhattacharya, an eminent author in the field, has contributed further work on the idea of CSR in marketing. In his professional life, he emphasizes the significance of considering how social actors affect businesses' operations and vice versa. Stakeholders, like employees, regulators, and investors are now pushing organizations to be more inclusive of the social needs and consider those aspects in their marketing campaigns (Bhattacharya, 2016). According to the author, there is only one successful course of action for businesses: launching programs that benefit both people and the environment, boosting their bottom lines. This suggests that they are effective in developing a strategy that has fundamental sustainability drivers and resonates with the business culture.

Additionally, Bhattacharya links this phenomenon to the notion of the triple bottom line, which states that businesses should develop specialized sustainability activities that precisely reflect their brand rather than just any social efforts whatsoever. CSR and sustainability programs have been used interchangeably (Bhattacharya, 2016).

Bhattacharya (2016) outlined three key pillars that drive CSR returns in his article "Responsible Marketing: Doing Well by Doing Good": *understanding*, *usefulness*, and *unity*. Understanding is the first pillar, and it shows how aware stakeholders are of the sustainable initiatives the organization has commenced. When stakeholders perceive sincere interest and proof of the company's social activities, they are compelled to support it. The second factor, usefulness, measures how much benefit these activities provide to the stakeholders. The advantages may be practical (energy savings) or emotional (better integration of work) (Bhattacharya, 2016). The final factor is whether the stakeholders represent themselves alongside the corporation.

The author has also developed a framework that illustrates the success elements of CSR initiatives. The 4Cs - *Co-creation* (fostering loyalty), *Commitment* (dedicated to what they do), *Communication* (to foster trust, businesses should be open about their motivations), and *Calibration* (having a clear understanding of their influence) - all have an impact on one another (Bhattacharya, 2016).

Archie Carroll was one of the first authors to offer a framework for CSR that businesses could easily understand. His idea, which has been investigated and used thus far, serves as the cornerstone of what is thought to be a socially responsible organization. It does not, however, consider any recent trends and observations because of its early development. One of the main objections of the framework is that it maintains a hierarchy by leveling the various organizational responsibilities, implying that they are not entirely integrated. Bhattacharya adds to Carroll's findings by outlining additional elements that affect the organization's social responsibility. The author emphasizes the interconnectedness component and the need for social efforts consistent with the company's mission, vision, and values instead of any social initiatives. Companies must be clear about the change they envision and understand how their activities influence all stakeholders if they are to promote excellent CSR.

2.2 Environmental, Social, and Corporate Governance

In addition to the environmental initiatives that the majority of big enterprises include in their ESG and CSR strategies, like reducing waste, going net-zero, reusing raw materials, switching to renewable energy, and lowering pollution, there are two other crucial pillars, social and governance, that should be monitored (Cherkasova et al., 2022). The social aspect is how the business treats its workers and suppliers regarding workplace conditions and safety precautions. Additionally, it guarantees that all employees are treated fairly and promotes an impartial and fair employment procedure. Transparency in financial reporting and board member advancement is suggested through governance.

According to the discussion in the publication by Cherkasova et al., governments, investors, consumers, and suppliers have raised their sustainability expectations. As a result, businesses have begun investing in and studying ways to make their manufacturing and production processes as clean as possible. Additionally, enterprises emphasize how their staff members feel about the company's culture, goals, and ethics. Financial losses would be more likely if the social, managerial, and environmental challenges were not considered.

A corporate sustainability strategy would foresee the impact the organization’s operations will have on society, the environment, and the economy. Due to investors' rising awareness and passion for ESG, this perspective also brings additional incentives for the firm, such as a more substantial competitive advantage and market power (de Lucia et al., 2020).

Most scholars cite Brundtland's definition from 1987 to explain what sustainability is, which states that "Sustainable Development is a development that satisfies the requirements of the present without compromising the ability of future generations to satisfy their own needs" (Voukkali et al., 2014). Additionally, there are non-governmental organizations (NGOs),

such as the United Nations (UN), whose mission is to inform the business community and society about the significance of acting on climate change, developing renewable energy sources, eradicating poverty, providing access to clean water, and all other environmental, social, and economic factors that influence what it means to be sustainable. The United Nations Member States came together in 2015 to take concrete steps toward achieving the 17 Sustainable Development Goals (SDGs). The SDGs represent a mutual partnership between developed and developing countries to create strategies for tackling global issues (United Nations, 2018).

In 2018, one of Europe's leading privately owned banks, Barenberg, conducted an ESG office study to match the SDGs to sustainable investing (Barenberg, 2018). The research, initiated by Barenberg, was based on a survey sent out to different client groups from NGOs, family offices, and academics. The participants were asked to respond to questions on their opinions about sustainable investing and the SDGs. As a result, ''96% of the respondents indicated that sustainability is part of their investment philosophy'' and ''85% of the respondents indicated that they are aware of the SDGs'' (Barenberg, 2018, p. 5). The organization suggests that if a business is provided with a representation of how relevant SDGs can be placed under the three ESG criteria - Environmental, Social, and Governance; their management team will be more aware of the critical goals that have to be considered.

Figure 3. Mapping the SDGs to ESG criteria (Barenberg, 2018, p. 14)

2.3 ESG/CSR comparison

Investor interest in ESG/CSR efforts is considerable; for example, in 2019, 300 mutual funds with ESG mandates earned a combined 20 billion in net inflows, which is four times the amount received in 2018 (Gillan, 2021). ESG and CSR projects are frequently compared in the reader's mind. They are benchmarks that lead to the same idea: "... (the) adoption of practices and policies by organizations that are meant to have a good effect on the world" (Gupta, 2021, p.1).

ESG, which replaced CSR, merely builds on the concepts of its predecessor by illustrating why businesses are driven to create beneficial externalities for their stakeholders. In a nutshell, ESG offers the instruments to assess the level of company participation with the sustainability concepts represented by both acronyms (Gupta, 2021). Additionally, it includes the internal component, which stands for the ethical standards and convictions held within the organization.

2.4 Artificial Intelligence

Artificial Intelligence (AI) represents a technology that enables machines to process information like humans. Its models mimic the traits of intelligent human behavior. (Collins et al., 2021) The term comprises concepts like machine and deep learning, algorithms, and the most widely known – robotics.

John McCarthy first defined AI as "the science and engineering of making intelligent machines, especially intelligent computer programs " in 1995 (McCarthy, 2004). There are three categories associated with the innovation, ANI (narrow artificial intelligence), AGI (artificial general intelligence), and ASI (artificial super-intelligence). AI is believed to continuously improve in a way that will soon outperform human intelligence under different scenarios (Yeh et al., 2021). In addition, an increasing number of businesses are making technology investments and incorporating AI into their operations, customer support, security, and forecasting systems. By 2023, companies are anticipated to spend more than $97.7 billion developing AI-based solutions (Padigar, 2022).

Although humans developed AI to increase the precision of decision-making and problem-solving, the subject has generated intense debate and bipolar views. The technology proponents think it would lead to sustainable development, while the opponents emphasize the risks and uncertainties. Stuart Russel, a computer science professor who wrote a book titled "Artificial Intelligence: A Modern Approach," has a very utter perception in which the effect of AI is described as being the same as the one of an atom bomb (Davis, 2021). Most technological drawbacks identified by academics are predicated on the assumption that AI may one day get self-improving and attain its total capacity for superintelligence. Due to the machine's disregard for fundamental human rights and values, its operations will turn hostile and negatively impact society (Yeh et al., 2021; Soares, 2017).

In contrast, Yudkowsky (2012) asserts in his book "Friendly Artificial Intelligence" that AI isn't always hostile. Most of its negative impacts are caused by human actions motivated by logical or technological errors. The dark side of AI could well be less distressing if an engineering approach is in place that would program ethical/moral ideas and values into the system. (Yeh et al., 2021). According to Muehlhauser & Bostrom (2013), a more sophisticated version of AI may even outperform humans in morality.

Despite being relatively new, AI has already permeated our daily lives in various ways, from social media to the personal assistants Siri and Alexa we use daily, navigation, shopping applications, chatbots, and more (Boden, 2016).

AI has hazards, just like any other technology. However, its prospects provide value for future research, not just for organizations' financial and economic success but also for their commitment to sustainable development (Miailhe, 2019). The technology opens a new frontier in how businesses, governments, and society communicate, learn, live, and make decisions. The intelligence behind all its elements, like robotics, deep learning, and algorithms, might push the realization of the 17 SDGs (Goralski, 2020).

The SDGs may be perceived as the more general sustainability ambitions of the world's economic, political, and civil society communities, whilst ESG reporting seeks to educate and build trust between stakeholders and corporations (Saetra, 2021). Therefore, The Sustainable Development Goals of the UN and the ESG pillars provide the foundation for most of the research on AI's social value.

2.4.1 *AI for social good*

By examining application scenarios and displaying the various possibilities of the technology with reference to the SDGs, the McKinsey Global Institute produced a discussion paper in December 2018 intending to demonstrate the potential of AI for generating social good. The analysis is based on a library of use cases, developed using a hybrid approach concerning society and technology. The Institute reports that they have found evidence of an actual AI deployment for around one-third of the use cases in their library thus far. In more than half of the use cases, AI systems were already implemented (McKinsey Global Institute, 2018).

The figure below represents all the ten domains, the types of issues they contain, and the number of use cases, 160 in total.

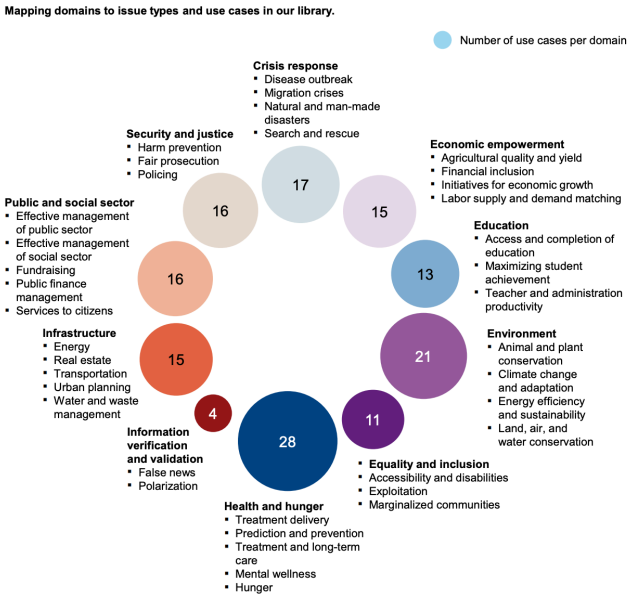

Figure 4. Mapping domains to issue types and use cases in the library of McKinsey Global Institute (McKinsey Global Institute, 2018, p. 2)

Based on the information provided, it can be deduced that a sizeable proportion of solutions that already incorporate AI systems deal with environmental issues such as the preservation of animals and plants, climate change, energy efficiency, the well-being of society, especially medical diagnosis and treatment, and crisis management. (McKinsey Global Institute, 2018).

Moreover, the use cases have been matched and analyzed later in the paper against the UN's Sustainable Development Goals.

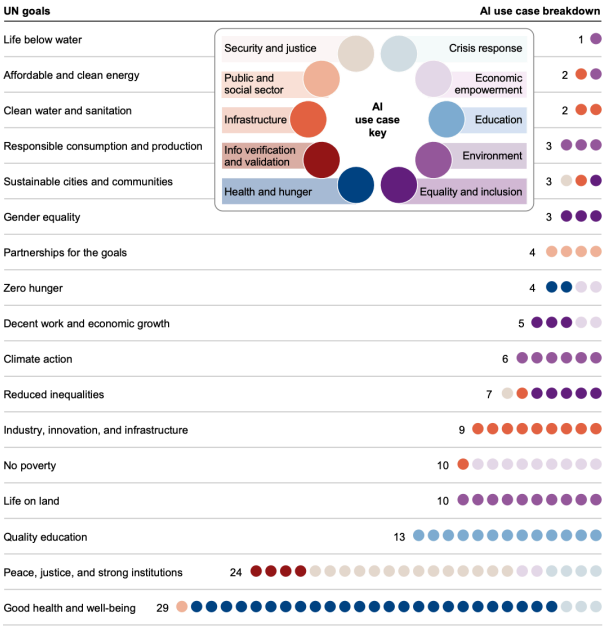

Figure 5. Use cases matched with the UN's SDGs (McKinsey Global Institute, 2018, p.8)

The Institute has identified 18 AI capabilities that could be used to address social and environmental issues, of which 14 are related to computer language, natural language processing, and speech and audio processing, while the remaining three fall into reinforcement learning, content generation, and structured deep learning. (McKinsey Global Institute, 2018).

The International Telecommunication Union of the United Nations has also embraced the idea of ''AI for Good'' and developed a digital platform where businesses, governments, and, but not limited to, international organizations can share and partner in finding AI solutions for the achievement of the 17 SDGs (International Telecommunication Union, 2022).

2.4.2 *AI capabilities & the issues they solve*

Image classification and object detection are potent capabilities of AI, which serve to classify, categorize, and find an object based on the data provided. These two attributes are frequently combined; the discussion paper from the McKinsey Global Institute gives an example of how drones would need to employ both to locate a more secluded area of the forest during a rescue attempt. Using object detection, one may avoid barriers like trees while using picture classification to discriminate between a pathway and typical ground cover. (McKinsey Global Institute, 2021). Many application sectors can benefit from object recognition, which already tremendously helps the visually impaired (Khakurel, 2018).

An instance is the Microsoft My Eye app, which utilizes the smartphone's camera to recognize items and provide information about them to help blind people be more aware of their surroundings (Microsoft, 2017). The app combines capabilities like identifying objects, text, products (scanning the barcode), people, currencies, and scenes (Kelley, 2020). Another exciting project that capitalizes on the computer vision capabilities of AI is The Snapshot Serengeti Challenge. Serengeti is a region in Africa famous for its national park. An AI approach to better conserve endangered species there has been discovered. To follow the movement of animals, the application uses photographs that have been geo-located, time-stamped, and tagged from several covert cameras in the area (Tomašev et al., 2020). In a recent study, researchers compared the diagnostic accuracy of "deep learning CNN" with one of 58 doctors when a

computer was shown images of melanoma lesions. The findings revealed a 9 percent difference in accuracy in favor of the AI technology (Haenssle et al., 2018).

Natural language processing (NLP) serves as a conduit for communication between people and machines via various computational techniques (Patel & Patel, 2021). NLP may help when there is a language barrier, such as in education, health, and extraordinary circumstances like migration. It can also assist in tracking disease outbreaks by analyzing tweets made in several local languages (McKinsey Global Institute, 2021). Van Erp et al. (2021) claim that NLP may be effectively utilized to determine the nutritional value and sustainability of food and meals. This kind of processing can also be applied in the analysis of companies' sustainability reports (Rivera, 2014). Additionally, the project Troll Patrol has used computational statistics and NLP to quantify harassment against women on Twitter. The initiative was established by various volunteers, partners, researchers, and technical specialists (Tomašev et al., 2020).

Artificial neural networks (ANNs), which are algorithms inspired by the structure and operation of the brain, are used in *structural deep learning (SDL)* (Soowook, 2018). A deep learning application for forecasting traffic accidents is covered in the Cai 2019 paper. Another 2016 research by Jean et al. describes how deep learning skills, particularly conventional neural networks, may predict poverty using satellite photos, nighttime maps, and deep learning capabilities (CNN).

Sound detection, recognition & reinforcement learning, and content generation have also been included as AI's valuable capabilities for facilitating social good.

Refer to the Appendix for more information on how the aforementioned AI capabilities may be applied for social benefit.

Furthermore, a study conducted by the Policy Department for Structural and Cohesion Policies, a branch of the European Parliament, provided examples of how AI is used in smart cities (Pellegrin et al., 2021).

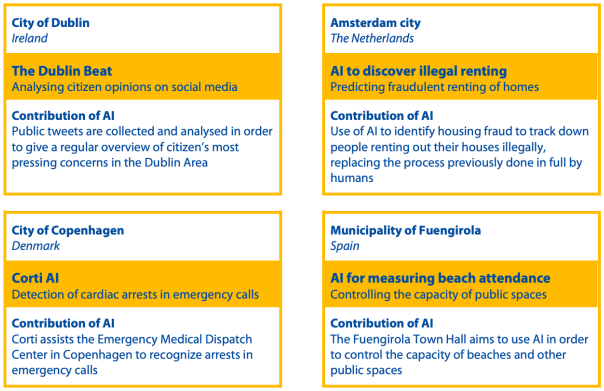

Figure 6. AI use cases in city management (Pellegrin et al., 2021, p.20)

3. RESEARCH DESIGN

Nowadays, a large pool of digital data is provided by businesses, governmental and non-governmental organizations, so an archival and documentary research strategy is applicable. This research will entirely rely on secondary data sources, like organizational press releases, plans, policy statements, strategy statements, government and media documents, and online articles and publications (Saunders et al., 2019).

The companies at hand - Microsoft, Google, and Apple - publish yearly reports outlining their environmental and social strategies, business and financial performance, and technological breakthroughs. Due to time restrictions, this research will only look at the time frame from 2018 to the present day. For a richer analysis and better comparison of the organizations' ESG actions, the research will also incorporate data from before and after the COVID-19 pandemic.

Additionally, all the publications and articles regarding Google, Apple, and Microsoft that will be used are open to the public. The journal articles are accessed through Google Scholar, Nexis Lexis, and Mendeley. For the data collection, the following keywords have been used: ''Apple'' AND ''Google''; ''Microsoft'' AND ''AI'' AND ''ESG projects'' AND ''Sustainability'' AND ''CSR'' AND ''SDGs''.

The study will give readers a theoretical framework that clarifies the meaning of the phrases "AI," "CSR," "ESG," and "SDGs" and what they mean in relation to the subject—followed by an in-depth analysis of the environmental, social, and governance efforts of the three GAFAM companies, Google, Apple, and Microsoft, and the AI systems that promote them. The diverse AI for Good initiatives gathered from the three organizations will be compared and linked in the findings section that follows the analysis, along with a discussion of what risks they represent. The research will conclude with potential mitigation tactics and suggestions for future research.

4. ANALYSIS OF THE ESG/CSR INITIATIVES OF APPLE, GOOGLE & MICROSOFT CONCERNING AI

4.1 GAFAM companies

GAFAM represents the world's most powerful and technologically advanced companies - Google, Apple, Facebook, Amazon, and Microsoft. Nowadays, these companies have one of the highest financial values – more than 4 trillion dollars (Fontanel, 2019). Moreover, the Big Five are leaders in the Artificial and Digital Intelligence industry. Amazon and Microsoft are specialists in cloud computing, while Google is very advanced in search engine optimization (Fontanel, 2019).

Due to their control over data-driven knowledge, GAFAM enterprises have been labeled as "Intellectual Monopolies" in the article by Rikap, (2020). As a result, these businesses have largely been condemned for their size, acquisitions, and rivalry, but they have also frequently been called out for making false claims about their sustainability initiatives and overall reliability (Varian, 2021).

This research seeks to shed light on the sustainability initiatives made by Microsoft, Google, and Apple in relation to their most aggressively used technology in recent years– Artificial Intelligence. Moreover, due to the limited research on the topic, this bachelor thesis will continue discussing the socially-value adding aspects of AI and the risks that come with them.

4.2 Artificial Intelligence at Microsoft

The American company Microsoft dates to 1975, founded by Bill Gates and his partner Paul Allen. (Microsoft, 2022d). The founders are specialists in computer technology and have developed the renowned operating system – Windows.

Nowadays, Microsoft is highly focused on finding new economic and social opportunities using AI technologies, such as cloud and edge computing (Microsoft, 2022d). Therefore, it stimulates organizations to search for ways to utilize AI's capabilities to solve global challenges (Microsoft, 2020). The company's initiative, ''Humans and AI'', is developed with the mission to share the storylines of people working in different sectors who use AI systems to tackle various issues present in their lives, communities, or worldwide. Part of the narratives portrayed on

the website of Microsoft under the page ‘’Humans and AI’’ 2020 are summarized below.

''HUMANS AND AI'' - MICROSOFT

Kürşat Ceylan	Co-founder of WeWalk (a smart cane that navigates and alerts visual impaired people during their route through haptic feedback)
Dr. Anshu Sharma	Co-founder of Seeds India (Through AI and satellite imagery, people in different regions are advised on how to act during a disaster, like flood)
Dr. Denise Hardest	Dr. Hardest found a way to use AI as a tool helping in the fight against plastics degrading in the oceans.
Hadas Bitran	Developed the Coronavirus Self-Checker Bot, at first it helped reduce the number of ER visits, but then it was also used for finding plasma donors.

Table 1. Own elaboration on several projects from Microsoft's "Humans and AI" initiative (Microsoft, 2020)

The company has developed an initiative called ‘’AI for Good’’ encompassing six programs, ‘’AI for Earth’’; AI for Health’’; ‘’AI for Humanitarian Action’’; ‘’AI for Cultural Heritage’’; ‘’Data for society’’. Microsoft aims to provide the intellectual knowledge and financial resources it has to dedicated organizations whose mission is to solve global challenges through AI (Microsoft, 2019b).

AI for Earth is a program concentrated on organizations and individuals that have the goal to tackle environmental challenges – in terms of climate, agriculture, biodiversity, and water (Smith, 2017). It aids initiatives that track and simulate changes in biodiversity and the effects of climate change using cutting-edge computer techniques (Horton & Horton, 2019).

Moreover, Microsoft is awarding grants so firms can reach new horizons with their sustainability efforts (Microsoft, 2019b). Numerous projects are part of the AI for Earth initiative; a summary of just four will be provided in the table below.

Ag-Analytics – to give farmers precise recommendations, a cloud-based platform integrates information from agricultural equipment, satellite photos, and weather predictions.
Conservation Metrics – increases the scope and efficiency of wildlife surveys by combining machine learning, remote sensing, and scientific knowledge.
Imazon - prototypes deforestation risk using AI and Microsoft Azure services to stop more damage to the Amazon rainforest.
NCX – changing how conservationists and landowners assess and monitor forests using AI and drone images nationally.

Table 2. Own elaboration based on projects from the ‘’AI for Earth’’ initiative (Microsoft, 2019a)

The technical resources which the company is openly providing are tools, models, infrastructure, data, and open-source codes for ‘’classifying birds in acoustic recording’’; ‘’using AI to detect beluga whale calls’’; ‘’accelerating camera trap survey workflows’’ etc. (Microsoft, n.d.-b).

Microsoft is also enabling internal research, which means that in addition to the funds it provides to its partners, the business has collaborators who are exchanging and working on ideas for using AI for environmental sustainability at the Microsoft Research lab (Microsoft, n.d.-b). A table of the complete list of in-house projects in the program ‘’AI for Earth’’ will be provided below.

‘’Microsoft Premonition’’ - ‘’…scalable monitoring of the environment to detect disease threats early, using robotics and genomics.’’ (Microsoft, 2021b)
‘’FarmBeats’’ – the need for additional food production and the scarcity of land and water, have pushed Microsoft to develop data-driven farming (through sensors and cloud). (Microsoft, 2022e)
‘’Land cover mapping’’ – ‘’environmental scientists use satellite and aerial imagery to understand patterns of land use, … to understand the impacts of climate change and human population expansion on Earth’s natural resources.’’ (Microsoft, 2022c)
‘’Subseasonal Climate Forecasting’’ – ‘’our team has undertaken a parallel effort to demonstrate the value of machine learning methods in improving subseasonal forecasting’’ (Microsoft, 2022a)
‘’Accelerating Biodiversity Surveys with AI’’ – ‘’ we apply machine learning tools to a variety of image sources – including motion-triggered camera traps, aerial cameras, and microphones – to accelerate ecologists’ workflows.’’ (Microsoft, 2022b)

Table 3. Own elaboration based on Microsoft Research projects (Microsoft, n.d.-b)

Radiant Earth Foundation is a non-profit organization dedicated to finding new Earth observation (EO) technologies using machine learning algorithms. Microsoft AI for Earth and Radiant Earth Foundation have joined forces to tackle environmental problems (MENAFN, 2021). The first innovation that they have developed together is the launching of the Planetary Computer, able to monitor the whole Earth’s environment and gather data with intuitive APIs, which then transfer the information to a catalog, so it’s easier for users and conservation stakeholders to find it (MENAFN, 2021; Microsoft, n.d.-a).

In an interview for McKinsey Global Institute, the Chief technology officer of Microsoft – Kevin Scott, shared that concerning ‘’AI for Health’’ and the COVID-19 pandemic, the company is using a ‘’bot-based technology’’ to help people having mild COVID-19 symptoms treat them at home. In this manner, medical professionals may handle the most serious situations. Moreover, scarce testing resources will be saved. He further adds that one of the most complex things being done with AI is utilizing molecular simulations to understand how medicinal chemicals and possible vaccinations can be discovered in a simulation environment. (McKinsey Global Institute, 2020).

In another podcast for the McKinsey Global Institute, Microsoft’s Head of Healthcare innovation – Jim Weinstein, explains the impact that Microsoft has had on communities with no access to medical care or medication. The company has been invested in meeting their needs by supplying health resources and ‘’remote’’ medical attention. Moreover, Microsoft has launched a product called ‘’EmpowerMD’’, helping doctors through NLP to store all the patient's information without needing to type it down. Chatbots have also been a great assistant when patients call the practitioners (McKinsey & Company, 2020a).

In 2020, Microsoft published its first annual Environmentally Sustainability Report ‘’A Year of Action’’ (Satish, 2021). The critical sustainability initiatives of Microsoft in 2020 are outlined in the Ksheeraja Satish article. By 2030 the company promises to become carbon negative throughout its supply chain; build technologies to monitor and protect ecosystems; restore water resources and bring down the consumption in the places it operates; tackle the problem of waste by adopting a circular economy approach (Satish, 2021).

In its latest Sustainability report, Microsoft has shared that it is continuously progressing toward becoming carbon-neutral by 2030. The ESG/CSR targets the company has accomplished using AI in 2021 have been numerous. It has already succeeded in ‘’optimizing offshore wind turbines with AI’’; ‘’ targeting carbon neutrality with Azure Digital Twins (IoT-based solution); ‘’improving service efficiency through remote assistance’’; ‘’matching the supply and demand for carbon sequestration with AI and machine learning’’ (Microsoft, 2021a, p.33). Moreover, it has found AI-powered ways to ‘’forecast electricity load; predict carbon reduction, other climate-related outcomes’’ and

''classify defects in solar panels'' early on (Microsoft, 2021a, p.42; p.35).

Microsoft is establishing a robust CSR, and AI for Good is a significant step in that direction, according to Sehgal et al., 2020 - "Corporate Social Responsibility: A Case Study of Microsoft Corporation. According to Gretchen O'Hara, Microsoft's vice president of US AI and sustainability strategy, the potential for AI is limitless, with benefits for everyone, including increased social impact, social good, and sustainability (O'Hara, 2020). In response to a query from the McKinsey Global Institute, Kevin Scott, another Microsoft official, said that AI also benefits people in rural places. He added that it creates a ton of high-skilled employment in a little community in central Virginia that wouldn't otherwise exist (Manyika & Chui, 2021).

Table 4 illustrates the ESG projects of Microsoft that use the image classification and object detection power of AI as being one of the most widely applied capabilities of the technology.

''Machine learning to automatically distinguish and quantify Mexico's mangroves from drone and satellite imagery'' – used for guiding the management of the habitat and limiting mangrove deforestation (Microsoft, 2021a, p.38)
'' The intelligent visualization using ArcGIS detects field boundaries, identifies crops, and provides water demand forecast estimates for decision-makers, resulting in more accurate allocations for sustainable agriculture and fair water distribution for citizens. '' (Microsoft, 2021a, p.56)
''Using Azure, Conservation Science Partners aggregates and analyzes satellite imagery at high resolutions to better understand how the forest cover across the western United States changes from forest disturbance events and how this influences water supply records.'' (Microsoft, 2021a, p.56)
''BeachBot uses AI to spot cigarette butts, pluck them out, and dispose of them in a safe bin.'' (Microsoft, 2021a, p.70)
''Let's Do It Foundation has developed an AI algorithm for detecting trash in geolocated images'' (Microsoft, 2021a, p.72)

Table 4. Own elaboration based on the AI-enabled Microsoft ESG projects (Microsoft, 2021a)

4.3 Artificial Intelligence at Google

In 1998, the company Google was launched by Larry Page and his partner Sergey Brin. Currently, Google offers a vast range of platforms and products that are utilized around the globe, including YouTube, Android, Gmail, and the most well-known Google Search. (Google, n.d.-b).

''Google's mission is to organize the world's information and make it universally accessible and useful. AI is helping us do that in exciting new ways, solving problems for our users, customers, and the world.'' (Google, n.d.-a). The people behind Google believe that AI should be used to help people – ''that it is socially beneficial, fair, accountable and works for everyone'' (Google, n.d.-a).

Like Microsoft, Google has also developed a program called ''AI for Social Good'', which focuses on solving global environmental and social challenges. Additionally, the company announced an initiative, ''AI Impact Challenge'', to attract organizations to share their ideas about using AI for Social Good. The selected companies receive a grant of 25 million dollars and the ability to learn new things directly from the AI specialist at Google (Business World, 2018).

Google was one of the first big companies to become carbon neutral in early 2007. Moreover, the company aims to run entirely on renewable energy sources by 2030 and shares that advancing AI technologies is the only way to achieve this (Google, 2021).

In the following section, an analysis of all ''AI for Good'' projects/partnerships of Google will follow.

PlantVillage is a project that capitalizes on the engineering capabilities of Google and other partnering organizations to develop a plant disease diagnostic app that uses AI technologies (Goralski, 2020). The application is suitable for phones on the low-budget side, so all farmers in Africa can afford it. ''Behind the app… is a database of 150,000 photographs of disease plants – a number the team intends to grow to three million'' (Brewster, 2020). Farmers can put the crop type, location, and planting date into the app, so through AI, satellite technology, and field force, the algorithms will send farming advice to them in the most accessible way (Plant Village, n.d.). Wadhwani AI is a similar project, which has been developed with the help of Google's experts; it is targeting Indian farmers, who, via the app ''Cotton Ace'', based on AI systems, can get some advice on how to treat their pest-infested crops (Talib, 2021).

In the article by Goralski 2020, it has been discussed that children increasingly use AI for educational purposes and that the language barrier gets broken through its technologies.

Moreover, Google has significantly tried reducing energy consumption by developing ''earth-friendly'' AI systems. ''DeepMind AI'' has helped the company cut down the energy usage of its data centers by 40% and lower greenhouse emissions (Manzoor, 2021, p. 9).

Google Research in Ghana has started an initiative that maps the distribution of all buildings in hard-to-reach places so that authorities can more easily estimate the number of affected locals in a natural disaster. This has been facilitated through satellite imagery that captures ''516 million buildings with coverage across most of the African continent'' (Google Research Blog, 2021).

Another Google invention is a device called Net thermostats, which now has a feature called "Nest Renew." The idea behind it is that the thermostat will be able to shift its peak heating and cooling electricity usage to coincide with times when the electricity grid is cleaner or less expensive thanks to AI technologies (Freedman, 2021). This way, users can switch to solar, and wind energy from the plants partnering with Google and reduce their greenhouse gas emissions (Freedman, 2021).

Additionally, The Indian Blog Google has shared six research projects they promote in public health, education, disaster prevention, and conservation using AI systems (Gupta, 2020). Organizations in India and Asia initiate these projects with the support of AI experts in the area, Google engineers and researchers. An overview of which is provided in Table 5 below.

Through AI, information for HIV/AIDS risk communities is gathered, so a better health service is provided, information campaigns, and initially reduction in the HIV contamination (Gupta, 2020)
AI also helps in finding ways to retain women in health programs and improve their maternal health outcomes. It's a free voice call service that sends preventive information (Indian Education News, 2021)
The systems of AI have also been used for the more effective collection and monitoring of health data. (Gupta, 2020)
''…Novel AI techniques provide over 80% accuracy in predicting human-wildlife conflict in Bramhapuri forest division…'' (Indian Education News, 2021)
AI is also being used for gathering information about on-time ''dam and barrage water releases'', so early warning systems that minimize the risk of disaster are built (Gupta, 2020)
''Supporting publishing of underserved Indian language content'' (Gupta, 2020)

Table 5. Own elaboration based on ''AI for Good'' projects supported by Google (Gupta, 2020)

In 2022, Google announced that it would introduce a ''10-shade skin tone scale'' to help AI tools become racially unbiased (EuroNews, 2022). The company is also active with the project ''Euphonia'', which uses AI tools to help people with atypical speech be more easily understood and socially included (Google Research, n.d.).

Further environmental projects that have been facilitated through the AI systems of Google are:

''Monitoring Canada's leaf canopy with Google Earth Engine on Google Cloud'' (Amalfi, 2022). These maps help build climate

sustainability and ''reduce uncertainty in weather and climate forests'' (Amalfi, 2022).

''Google Flood Forecasting Initiative has been working with governments to develop systems that predict when and where flooding will occur—and keep people safe and informed'' (Matias, 2022).

''Tree Canopy Lab'' is a tool ''combining AI and aerial imagery'' to support cities in planning future tree planting by showing them their ''current tree canopy coverage'' (Lombardo, 2020).

4.4 Artificial Intelligence at Apple

In 1976, in a garage in California, two friends - Steve Jobs and Steve Wozniak, started developing the first Apple computer – Apple I (Brashares, 2001). Nowadays, ''Apple is the world's largest information technology company by revenue and the first-ever public company to be valued at over 1 trillion US dollars'' (Marr, 2021). The business creates, produces, and markets portable digital music players, personal computers, and mobile communication and media devices. It also offers a range of associated software services. (Johnson et al., 2012). The product portfolio that has been provided in its annual report from 2021 includes iPhone, iPad, Mac, and iPad, as well as different wearables, home, and accessories.

The main AI tools that Apple is using have been displayed on its website, so users can even apply for a job position - machine learning infrastructure, deep learning, reinforcement learning, NLP, and speech technologies (Apple, n.d.-a). However, unlike its competitors, Google and Microsoft, the company doesn't have a dedicated platform that showcases its ''AI for Good'' initiatives.

Since 2008, Apple has provided an annual report on its website detailing its environmental progress. The company has been carbon neutral across its operations since 2020 but aims to achieve the same by 2030 – for its supply chain process & initial use of the products (Apple, n.d.-b).

In its Environmental Progress Report from 2019, Apple stated that it had been focused on ''maximizing material recover rates''; ''protecting privacy''; '' maintaining standards for the environment, health, and safety'' (Apple, 2019-b, p.42). In the following year, 2020, the company announced that it has been using machine learning and AI tools to develop reuse programs (Apple, 2020).

In 2021, Apple included a sustainability initiative driven by machine learning and other AI tools in its Environmental Progress Report. The project concerns the organization's efforts toward designing a new, more efficient recycling technology (Apple, 2021). The research has been facilitated through a partnership with Carnegie Mellon University's Biorobotics Lab. A representative of which shares ''Carnegie Mellon University is excited to work with Apple in developing key robotics and artificial intelligence to advance electronics recycling…'' (Apple, 2021, p.46). Through this partnership, the organizations have created software models that learn from different device images. ''The research applies the concept of domain randomization, by synthetically creating the real data images would provide, grant robots the ability to recognize the broad, varied stream of e-waste for recycling at scale'' (Apple, 2021, p.46).

Previously, in 2016, the company had another project in this direction called Liam, a line of robots that could disassemble the iPhone 6. This project provided solutions for the better segregation of materials into ''homogenous streams''; in this way, Apple succeeded in closing the loop on material use within its product line due to the high quality of recycled material – almost identical condition to the originals (Rujanavech et al., 2016). Later, Apple introduced another robot from the line called Daisy, which specialized again in separating parts of old iPhones and recovering them for reuse (Laser & Stowell, 2020). ''Apple iPhones include rare earth magnets, alloys, tantalum capacitors, titanium screws, extremely high end, varying grades of pure aluminum, course semiconductors, bonded glass, and displays. Daisy separates nine different iPhone models into logical parts that can be recycled today, recycled in the future, or disposed of as safely as reasonably possible.'' (Moorhead, 2018). Moreover, by incorporating these two robots, Apple launched a program called ''Apple Trade-In''; Apple consumers could return their old devices without worrying about their condition or model. In this way, their old devices get recycled, and they receive a credit for a future purchase (Apple, 2019-a).

In Apple's Environmental Progress Report, issued in 2022, the company has reported its progress regarding its partnership with Carnegie Mellon University's Biorobotics Lab. The two organizations successfully developed new machine learning models for recycling ''to sort e-waste at scale''; this way, recyclers can recover valuable components from a significant waste stream (Apple, 2022, p.50). Moreover, they have also worked on developing ''…X-ray imaging with RGB imaging to improve the accuracy of disassembly and recovery of materials'' (Apple, 2022, p.50). Finally, robots have been given the ability to ''feel'' through a ''high-frequency force feedback'' and ''machine learning''; this is how, they can behave in a way that considers the type of object they are holding (Apple, 2022, p.50).

Additionally, next to the environmental initiatives of Apple, there have been sources pointing to the health benefits the Apple Watch is serving. In 2017, Apple announced that for the Apple Watch Series 3, the company partnered with Stanford Medicine, part of the Stanford University, for the development of a program that measures the heart rate samples through the Apple Watch to catch irregular heart rates and alert the person wearing the device (Calero, 2018). There has been a case with a 34-year-old man who got medical attention due to the ECG report from his watch showing irregular heart rhythm (India Today, 2022). Moreover, the company has introduced an AI feature called ''Fall Detection'', which gets enabled automatically on the Apple Watch when the person is 65 years old or older. There have been several reported cases in which the device has already saved the lives of people who suddenly fall; the gadget detects the incident and automatically sends information about the location and condition of the person to the emergency officials (Mishra, 2022; Hall, 2022; Indian Technology, 2022).

Another AI technology that Apple aims to implement in their devices is a ''remote monitoring of respiratory rate''; the company is currently active in the research with Cornell University. This feature is expected to be added to their future ''Airpods'' models (Chung & Busby, 2022).

IoT enterprises will ultimately embrace big data because it adds value by addressing new challenges, resolving old ones more quickly or inexpensively, or giving them a deeper, fuller knowledge (Ramadoss et al., 2018). In this regard, the search engine of Apple – Siri is now navigating ferries to the nearest shores and making emergency phone calls when there is a life-threatening situation (Ramadoss et al., 2018).

5. DISCUSSION AND FINDINGS

After researching the ESG/CSR initiatives of the three GAFAM companies – Microsoft, Google, and Apple, I discovered some trends in relation to the SDGs. Table 6 below represents my findings. To showcase how the companies' sustainability focus differs and/or overlaps, all ''AI for Good'' projects that have

been portrayed above are mapped against the United Nations 17 SDGs. Due to their considerable contributions, most activities are connected to multiple SDGs. All 17 SDGs are included in the table below. To the right of each target are three circles of varying colors: blue reflects the quantity of AI projects Microsoft has in connection to that goal, orange represents Google's, and green indicates Apple's.

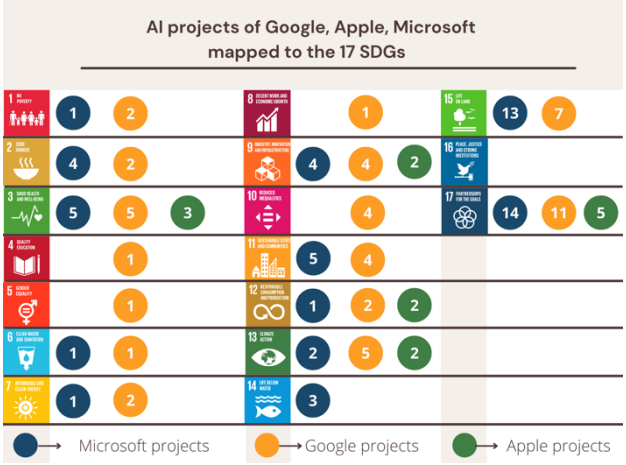

Table 6. Own elaboration based on Microsoft, Google, and Apple's AI initiatives aligned with the UN's 17 SDGs

All three companies have the highest number of AI initiatives concerning goal 17 - Partnerships for the goals. Through the program ''AI for Good'', Google and Microsoft grant financial resources and in-house expertise to selected organizations with the most creative solutions to environmental and social issues. As a result, both businesses have developed strong bonds with NGOs, governments, communities, and businesses in developing nations that seek to achieve the SDGs. Even though Apple doesn't have a dedicated program, the corporation regularly collaborates with academic institutions and governmental organizations to investigate novel applications of AI and robotics for recycling and climate action purposes.

Table 6 shows that Google and Microsoft are focusing on similar goals. Both companies are investing in projects looking at climate change, health, natural disasters, and inclusivity issues. While Microsoft is working with experts and scientists to lessen ocean contamination with plastic, Google is concentrating heavily on developing sustainable energy consumption options for the communities to utilize. On the other hand, Apple hasn't been very transparent about all the social and environmental efforts it develops using AI. According to press reports, the corporation uses its AI systems to uncover new, more effective recycling alternatives and design features for its devices that assist users in avoiding health problems.

Although AI has been characterized as a technology that generally benefits society, there has been much debate over its ethics. As stated in this study report, the machine disregards any moral values and might harm society if anyone with bad intentions employs it. Moreover, it leads to risks associated with privacy, safety, and biased outcomes. Another drawback is that the invention is still in its early stages of development and needs highly qualified staff to enhance it. This necessitates significant expenditures that developing countries cannot afford. For instance, even if Apple devices include features that are good for one's health, people in underdeveloped nations cannot buy them.

Governments should implement standards and restrictions limiting AI's use to reduce its hazards. Additionally, any bias should be minimized while utilizing its systems for diagnosis determination or emergency forecasts. Therefore, one should double-check all findings before employing them. A mitigating mechanism for the greater inclusion of underdeveloped economies will be provided by the close cooperation of corporations with strong financial and technological know-how and communities based in third-world countries.

6. CONCLUSION AND LIMITATIONS

The three GAFAM companies—Microsoft, Google, and Apple—and their ESG/CSR actions regarding AI were successfully analyzed in-depth in this research paper. All three businesses use different AI capabilities, such as machine learning, structured deep knowledge, natural language processing, etc., to facilitate initiatives solely aimed at benefiting society and the environment. As concluded in the discussion section Microsoft, Google and Apple are focused on forming alliances to accomplish sustainable goals that address climate change, health, and biodiversity challenges. The key advantages of adopting AI for sustainability projects include its capacity to estimate energy usage, identify climate and terrain changes, ocean pollution, and natural disasters, as well as monitor species and ensure their safety. Additionally, the technology may be used to develop sustainable management plans for cities and assist farmers in producing high-quality and efficient crops. The key risks resulting from integrating AI into sustainability are privacy violations and potential ethical ramifications if the technology is not handled wisely.

This study offers insight on a subject that hasn't received much attention—specifically, whether AI promotes sustainable growth. Its many social applications have been illustrated by relating the three largest technical organizations' AI endeavors to the 17 SDGs.

The research does, however, have its limitations. First, due to time and space restraints, the analysis has been restricted to three of the five different GAFAM enterprises. Moreover, it doesn't include the entire list of AI initiatives of Microsoft, Google, and Apple, as the public cannot access all information. Another flaw is that the technology's threats haven't been thoroughly investigated. Additionally, there is a discrepancy between the findings of this study about the three GAFAM firms' sustainability initiatives and what some media outlets claim to be insufficient given their position of influence. An accurate representation of their efforts and what is viewed as ample given the resources and influence these firms have may be a valuable continuation of the conversation that has been initiated with this thesis.

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8. REFERENCES

Amalfi, F. (2022, April 20). *Climate scientist monitors Canada's leaf canopy with Google Earth Engine on Google Cloud*. Newstex Blogs. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:658F-TND1-F03R-N057-00000-00&context=1516831

Apple. (n.d.-a). *Careers at Apple: Join our Machine Learning and AI team.* https://www.apple.com/careers/us/machine-learning-and-ai.html

Apple. (n.d.-b). *Environment*. https://www.apple.com/environment/

Apple. (2019-a). *Apple Trade-In*. Apple. https://www.apple.com/uk/shop/trade-in

Apple. (2019-b). *Environmental Progress Report 2019*. https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2019.pdf

Apple. (2020). *Environmental Progress Report 2020*. https://www.apple.com/environment/pdf/Apple_Environmental Progress Report 2020.pdf

Apple. (2021). *Environmental Progress Report 2021*. https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2021.pdf

Apple. (2022). *Environmental Progress Report 2022*. https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2022.pdf

Barenberg. (2018). *Understanding the SDGs in sustainable investing*. Joh. Berenberg, Gossler & Co. KG. Hamburg, Germany.

Bhattacharya,C.(2016).Responsible Marketing: Doing Well by Doing Good. NIM Marketing Intelligence Review,8(1) 8-17. https://doi.org/10.1515/gfkmir-2016-0002

Boden, M. A. (2016). AI: Its nature and future. Oxford University Press.

Brashares, A. (2001). *Steve Job: Thinks Different*. Twenty-First Century Books.

Brewster, S. (2020, April 2). *Wilting Shrubs? Diagnose Plant Diseases with an App*. MIT Technology Review. https://www.technologyreview.com/2016/11/07/107230/wilting-shrubs-diagnose-plant-diseases-with-an-app/

Brooke-Lander, Melanie, and Dina Kuykendall. "The Changing Landscape of Corporate Social Responsibility Reporting." Paper presented at the SPE International Conference on Health, Safety, and Environment, Long Beach, California, USA, March 2014. https://doi.org/10.2118/168451-MS

Business World. (2018, October 30). Google seeks to grant $25m to AI for "good" projects. *Business World*. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:6326-D7R1-F03R-N132-00000-00&context=1516831.

Cai, Q., Abdel-Aty, M., Sun, Y., Lee, J., & Yuan, J. (2019). Applying a deep learning approach for transportation safety planning by using high-resolution transportation and land use data. *Transportation Research Part A: Policy and Practice*, *127*, 71–85. https://doi.org/10.1016/j.tra.2019.07.010

Calero, A. (2018, September 24). *Apple Watch as a medical device*. CE Noticias Financieras. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:5TBC-WF41-F03R-W22X-00000-00&context=1516831.

Carrol, A.B. (1979) A three-dimensional conceptual model of corporate social performance. Academy of Management Review, 4, 497-505

Carrol, A.B (2016). Carroll's pyramid of CSR: taking another look. *International Journal of Corporate Social Responsibility, 1*(1). https://doi.org/10.1186/s40991-016-0004-6

Cherkasova, V., & Nenuzhenko, I. (2022). Investment in ESG Projects and Corporate Performance of Multinational Companies. *Journal of Economic Integration*, *37*(1), 54–92. https://doi.org/10.11130/jei.2022.37.1.54

Chrisman, J. J., Carroll, A. B. (1984). SMR forum: corporate responsibility—reconciling economic and social goals. Sloan Management Review. Winter. p. 59–65.

Chung, W., & Busby, Z. (Eds.). (2022). *STRATEGIC DATA ANNOTATION TO FACILITATE AIENABLED NEWS ASSESSMENT: THE CASE FOR APPLE AND TESLA*. Eastern Kentucky University.

Collins, C., Dennehy, D., Conboy, K., & Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management*, *60*, 102383. https://doi.org/10.1016/j.ijinfomgt.2021.102383

Crane, A., McWilliams, A., Matten, D., Moon, J., Seigel, D., (Eds.) *The Oxford Handbook on Corporate Social Responsibility*, 2008 p. 83-112. Oxford University Press: Oxford. ISBN: 978-0-19-921159-3

Davis, N. (2021, October 30). *'Yeah, we're spooked': AI starting to have big real-world impact, says expert*. The Guardian. https://www.theguardian.com/technology/2021/oct/29/yeah-were-spooked-ai-starting-to-have-big-real-world-impact-says-expert

de Lucia, C., Pazienza, P., & Bartlett, M. (2020). Does Good ESG Lead to Better Financial Performances by Firms? Machine Learning and Logistic Regression Models of Public Enterprises in Europe. *Sustainability*, *12*(13), 5317. https://doi.org/10.3390/su12135317

EuroNews. (2022, May 12). *Google unveils a new 10-shade skin tone scale to try to remove racial bias from its AI tools*. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:65F3-X341-DXJ7-N2RS-00000-00&context=1516831.

Floridi, L., Cowls, J., King, T.C. *et al.* How to Design AI for Social Good: Seven Essential Factors. *Sci Eng Ethics* **26,** 1771–1796 (2020). https://doi.org/10.1007/s11948-020-00213-5

Fontanel, J. (2019, April) GAFAM, a progress and a danger for civilization. Financial Architecture; Forced Economic Development ion the Context of External Shocks and Internal Inconsistencies, St. Petersburg State University of Economics (UNECON), Saint-Petersbourg, Russia. ffhal-02102188f

Freedman, A. (2021, October 6). *Your Google Map just got greener as company implements new features*. Newstex Blogs. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:63SM-4S41-JCMN-Y482-00000-00&context=1516831.

Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance*, *66*, 101889. https://doi.org/10.1016/j.jcorpfin.2021.101889

Google. (n.d.-a). *Bringing the benefits of AI to everyone*. Google AI. https://ai.google/about/

Google. (n.d.-b). *Hoe we zijn begonnen en waar we vandaag de dag staan - Google*. Google. https://about.google/our-story/

Google. (2021). *2021 Environmental Report*. Google Sustainability. https://sustainability.google/reports/

Google Research. (n.d.). *Project Euphonia*. https://sites.research.google/euphonia/about/

Google Research Blog. (2021, July 28). *Mapping Africa's Buildings with Satellite Imagery*. Google AI Blog. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:637R-NMN1-F03R-N4F8-00000-00&context=1516831.

Goralski, M. A., & Tan, T. K. (2020). Artificial intelligence and sustainable development. *The International Journal of Management Education*, *18*(1), 100330. https://doi.org/10.1016/j.ijme.2019.100330

Gupta, M. (2020, February 13). *Applying AI to big problems—six research projects we're supporting in public health, education, disaster prevention, and conservation*. Google. https://blog.google/intl/en-in/company-news/technology/applying-ai-to-big-problemssix-research/

Gupta, P. (2021). UNDERSTANDING AND ADOPTING ESG - AN OVERVIEW, Part I: The Evolution of ESG from CSR. *RHTLaw Asia*, 1–4.

Hall, Z. (2022, February 1). *Apple Watch credited with saving cyclist after being knocked out from electric bike crash*. Newstex. Retrieved June 21, 2022, from https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:64NY-JJC1-F03R-N4DH-00000-00&context=1516831

Haenssle, H., Fink, C., Schneiderbauer, R., Toberer, F., Buhl, T., Blum, A., Kalloo, A., Hassen, A. B. H., Thomas, L., Enk, A., Uhlmann, L., Alt, C., Arenbergerova, M., Bakos, R., Baltzer, A., Bertlich, I., Blum, A., Bokor-Billmann, T., Bowling, J., . . . Zalaudek, I. (2018). Man against machine: diagnostic performance of a deep learning convolutional neural network for dermoscopic melanoma recognition in comparison to 58 dermatologists. *Annals of Oncology*, *29*(8), 1836–1842. https://doi.org/10.1093/annonc/mdy166

Horton, P., & Horton, B. P. (2019). Re-defining Sustainability: Living in Harmony with Life on Earth. *One Earth*, *1*(1), 86–94. https://doi.org/10.1016/j.oneear.2019.08.019

Indian Education News. (2021, March 10). *Google AI helping improve maternal health, save wildlife*. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:625V-WJJ1-JBYT-H15V-00000-00&context=1516831.

India Today. (2022, March 19). *Apple Watch's ECG feature saves life of 34-year old Indian user*. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:651J-TKH1-DXX5-W53K-00000-00&context=1516831.

Indian Technology. (2022, March 21). *Apple Watch saves an elderly woman's life from fall; she then gets a cancer diagnosis early*. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:6520-XY01-DYDW-70V2-00000-00&context=1516831

International Telecommunication Union. (2022, May 26). *AI for Good - All Year Always Online*. AI for Good. https://aiforgood.itu.int/

Jean, N., Burke, M., Xie, M., Davis, W. M., Lobell, D. B., & Ermon, S. (2016). Combining satellite imagery and machine learning to predict poverty. *Science*, *353*(6301), 790–794. https://doi.org/10.1126/science.aaf7894

Johnson, Katherine; Li, Yang; Phan, Hang; Singer, Jason; and Trinh, Hoang. (2012) "The Innovative Success that is Apple, Inc.". Theses, Dissertations and Capstones. Paper 418.

Kelley, S. (2020, October 26). *Seeing AI: Artificial Intelligence for Blind and Visually Impaired Users*. VisionAware. https://visionaware.org/everyday-living/helpful-products/using-apps/seeing-ai-app/

Khakurel, J., Penzenstadler, B., Porras, J., Knutas, A., & Zhang, W. (2018). The Rise of Artificial Intelligence under the Lens of Sustainability. *Technologies*, *6*(4), 100. https://doi.org/10.3390/technologies6040100

Laser, S. and Stowell, A. F. (2020) *Thinking like Apple's recycling robots:towards the activation of responsibility in a most environmentalist world.* Ephemera : Theory and Politics in Organization, 20 (2). pp. 163-194. ISSN 1473-2866

Leszkiewicz, A., Hormann, T. M., & Krafft, M. (Accepted in press). Smart Business and the Social Value of AI. In T. Bondarouk, & M. R. Olivas-Lujan (Eds.), Smart Business and Better Management Emerald Group Publishing Ltd.

Lombardo, N. (2020, November 18). *Creating new tree shade with the power of AI and aerial imagery*. Google. https://blog.google/products/earth/helping-cities-seed-new-trees-with-tree-canopy-lab/

Manyika, J., & Chui, M. (2021, June 10). *Forward Thinking on artificial intelligence with Microsoft CTO Kevin Scott*. McKinsey & Company. https://www.mckinsey.com/featured-insights/future-of-work/forward-thinking-on-artificial-intelligence-with-microsoft-cto-kevin-scott

Manzoor, B., Othman, I., Durdyev, S., Ismail, S., & Wahab, M. (2021). Influence of Artificial Intelligence in Civil Engineering toward Sustainable Development—A Systematic Literature Review. *Applied System Innovation*, *4*(3), 52. https://doi.org/10.3390/asi4030052

Marr, B. (2021, July 13). *Does Apple Have AI?* Bernard Marr. https://bernardmarr.com/does-apple-have-ai/

Matias, Y. (2020, September 1). *A big step for flood forecasts in India and Bangladesh*. Google. https://blog.google/technology/ai/flood-forecasts-india-bangladesh/

McCarthy, J. (2004). What is artificial intelligence. URL: http://www.formal.stanford.edu.ezproxy2.utwente.nl/jmc/whatisai/

McKinsey & Company. (2020a, January 28). *'Test and listen': Microsoft's Jim Weinstein on healthcare tech*. https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/test-and-listen-microsofts-jim-weinstein-on-healthcare-tech

McKinsey & Company. (2020b, November 17). *The state of AI in 2020*. https://www.mckinsey.com/business-functions/quantumblack/our-insights/global-survey-the-state-of-ai-in-2020

McKinsey Global Institute. (2018, December). *Applying AI for social good*. McKinsey & Company. https://www.mckinsey.com/featured-insights/artificial-intelligence/applying-artificial-intelligence-for-social-good

McKinsey Global Institute. (2020, July 28). *AI in healthcare: Microsoft's Kevin Scott on how tech can treat a pandemic*.

McKinsey & Company. https://www.mckinsey.com/featured-insights/artificial-intelligence/ai-in-healthcare-microsofts-kevin-scott-on-how-tech-can-treat-a-pandemic

MENAFN. (2021, July 13). *Radiant Earth Foundation Partners with Microsoft AI for Earth to Accelerate Sustainability Solutions at Local and Global Levels* [Press release]. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:63M4-F891-F04Y-T0BM-00000-00&context=1516831.

Miailhe, N., Hodes, C., Jain, A., Iliadis, N., Alanoca, S., & Png, J. (2019). AI for Sustainable Development Goals. *Delphi - Interdisciplinary Review of Emerging Technologies*, *2*(4), 207–216. https://doi.org/10.21552/delphi/2019/4/10

Microsoft. (n.d.-a). *A Planetary Computer for a Sustainable Future*. Microsoft | Planetary Computer. https://planetarycomputer.microsoft.com/

Microsoft. (n.d.-b). *AI for Earth Tech Resources - Microsoft AI*. https://www.microsoft.com/en-us/ai/ai-for-earth-tech-resources

Microsoft. (2017). *Seeing AI App from*. https://www.microsoft.com/en-us/ai/seeing-ai

Microsoft. (2019a). *AI for Earth Partners - Microsoft AI*. https://www.microsoft.com/en-us/ai/ai-for-earth-partners?activetab=pivot_1%3aprimaryr3

Microsoft. (2019b). *Using AI for Good with Microsoft AI*. https://www.microsoft.com/en-us/ai/ai-for-good#primaryR3

Microsoft. (2020). *Humans and AI | Microsoft AI*. https://www.microsoft.com/en-us/ai/humans-and-ai

Microsoft. (2021a). *Microsoft 2021 Environmental Sustainability Report*. Microsoft | Corporate Social Responsibility. https://www.microsoft.com/en-us/corporate-responsibility/sustainability/report

Microsoft. (2021b, December 2). *Microsoft Premonition*. Microsoft Research. https://www.microsoft.com/en-us/research/project/project-premonition/

Microsoft. (2022a, January 27). *Subseasonal Climate Forecasting*. Microsoft Research. https://www.microsoft.com/en-us/research/project/subseasonal-climate-forecasting/

Microsoft. (2022b, March 21). *Accelerating Biodiversity Surveys with AI*. Microsoft Research. https://www.microsoft.com/en-us/research/project/accelerating-biodiversity-surveys/

Microsoft. (2022c, March 21). *Land Cover Mapping*. Microsoft Research. https://www.microsoft.com/en-us/research/project/land-cover-mapping/

Microsoft. (2022d, April 26). *Facts About Microsoft*. Stories. https://news.microsoft.com/facts-about-microsoft/#CorporateAddress

Microsoft. (2022e, May 24). *FarmBeats: AI, Edge & IoT for Agriculture*. Microsoft Research. https://www.microsoft.com/en-us/research/project/farmbeats-iot-agriculture/

Mishra, A. (2022, June 14). *Automated Apple Watch Feature Saves Unconscious Man's Life*. Newstex. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:65P3-HRY1-F03R-N0CV-00000-00&context=1516831.

Moorhead, P. (2018, April 19). *Apple's New iPhone Recycling Robot "Daisy" Is Impressive, And In Austin*. Forbes. https://www.forbes.com/sites/patrickmoorhead/2018/04/19/apples-new-iphone-recycling-robot-daisy-is-impressive-and-in-austin/?sh=6bacf1f7f2e4

Muehlhauser, L., & Bostrom, N. (2013). WHY WE NEED FRIENDLY AI. *Think*, *13*(36), 41–47. https://doi.org/10.1017/s1477175613000316

O'Hara, G. (2020, March 24). *My next chapter: Shaping a sustainable future with AI - US Partner Community Blog - Microsoft*. US Partner Community Blog. https://www.microsoft.com/en-us/us-partner-blog/2020/03/02/my-next-chapter-shaping-a-sustainable-future-with-ai/

Padigar, M., Pupovac, L., Sinha, A., & Srivastava, R. (2022). The effect of marketing department power on investor responses to announcements of AI-embedded new product innovations. *Journal of the Academy of Marketing Science*. https://doi.org/10.1007/s11747-022-00873-8

Parra, C., Ripoll-i-Alcon, J., & Marti, G. (2018). Putting in Value Corporate Social Responsibility. *Symphonya. Emerging Issues in Management*, *1*, 111–130. https://doi.org/10.4468/2017.1.09parra.ripollialcon.marti

Patel, R., & Patel, S. (2021). Deep Learning for Natural Language Processing. *Information and Communication Technology for Competitive Strategies (ICTCS 2020)*, 523–533. https://doi.org/10.1007/978-981-16-0882-7_45

Pellegrin, J, Colnot, L & Delponte, L. (2021). Research for REGI Committee – Artificial Intelligence and Urban Development, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels

Plant Village. (n.d.). *We help African smallholder farmers adapt to climate change*. https://plantvillage.psu.edu

Ramadoss, T. S., Alam, H., & Prof Seeram, R. (2018). Artificial Intelligence and Internet of Things enabled Circular economy. *The International Journal of Engineering and Science (IJES)*, *7*(9 Ver.III), 55–63. https://doi.org/10.9790/1813-0709035563

Rikap, C. & Lundvall, B-Å. (2020). Big tech, knowledge predation and the implications for development. Innovation and Development, doi: 10.1080/2157930x.2020.1855825

Rivera, S. J., Minsker, B. S., Work, D. B., & Roth, D. (2014). A text mining framework for advancing sustainability indicators. *Environmental Modelling & Software*, *62*, 128–138. https://doi.org/10.1016/j.envsoft.2014.08.016

Rujanavech, C., Lessard, J., Chandler, S., Shannon, S., Dahmus, J., & Guzzo, R. (2016, September). *Liam - An Innovation Story*. Apple. https://www.apple.com/environment/pdf/Liam_white_paper_Sept2016.pdf

Sætra, H. S. (2021). A Framework for Evaluating and Disclosing the ESG Related Impacts of AI with the SDGs. *Sustainability*, *13*(15), 8503. https://doi.org/10.3390/su13158503

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research methods for business students ebook*. Pearson Education, Limited.

Satish, K. (2021, April 10). Embracing Environmental Sustainability: The Case of Microsoft Corporation. Available at SSRN: https://ssrn.com/abstract=3882786 or http://dx.doi.org/10.2139/ssrn.3882786

Sehgal, G., Kee, D. M. H., Low, A. R., Chin, Y. S., Woo, E. M. Y., Lee, P. F., & Almutairi, F. (2020). Corporate Social Responsibility: A Case Study of Microsoft Corporation. *Asia Pacific Journal of Management and Education*, *3*(1), 63–71. https://doi.org/10.32535/apjme.v3i1.744

Smith, B. (2017, July 28). *Announcing AI for Earth: Microsoft's new program to put AI to work for the future of our planet*. Microsoft On the Issues. https://blogs.microsoft.com/on-the-issues/2017/07/12/announcing-ai-earth-microsofts-new-program-put-ai-work-future-planet/

Soares, N. (2017, April 19). *Ensuring smarter-than-human intelligence has a positive outcome*. Machine Intelligence Research Institute. https://intelligence.org/2017/04/12/ensuring/

Soowook, L. (2018). Deep Structured Learning: Architectures and Applications. *The International Journal of Advanced Culture Technology*, *6*(4), 262–265.

Syarizal A R, Hartinie Abd Aziz, S. N. M. (2021). Obligatory CSR Via Social Enterprise Corporate Business Entities. *Psychology and Education Journal*, *58*(2), 1584–1588. https://doi.org/10.17762/pae.v58i2.2313

Talib, V. (2021, May 27). *Google is helping deploy AI to prevent pests devastating Indian crops*. Fast Company. https://advance-lexis-com.ezproxy2.utwente.nl/api/document?collection=news&id=urn:contentItem:62SM-NVD1-JC1K-F1MS-00000-00&context=1516831.

Tomašev, N., Cornebise, J., Hutter, F., Mohamed, S., Picciariello, A., Connelly, B., Belgrave, D. C. M., Ezer, D., Haert, F. C. V. D., Mugisha, F., Abila, G., Arai, H., Almiraat, H., Proskurnia, J., Snyder, K., Otake-Matsuura, M., Othman, M., Glasmachers, T., Wever, W. D., . . . Clopath, C. (2020). AI for social good: unlocking the opportunity for positive impact. *Nature Communications*, *11*(1). https://doi.org/10.1038/s41467-020-15871-z

Unitated Nations. (2018). *THE 17 GOALS | Sustainable Development*. United Nations. https://sdgs.un.org/goals

van Erp, M., Reynolds, C., Maynard, D., Starke, A., Ibáñez Martín, R., Andres, F., Leite, M. C. A., Alvarez De Toledo, D., Schmidt Rivera, X., Trattner, C., Brewer, S., Adriano Martins, C., Kluczkovski, A., Frankowska, A., Bridle, S., Levy, R. B., Rauber, F., Tereza Da Silva, J., & Bosma, U. (2021). Using Natural Language Processing and Artificial Intelligence to Explore the Nutrition and Sustainability of Recipes and Food. *Frontiers in Artificial Intelligence*, *3*. https://doi.org/10.3389/frai.2020.621577

Varian, H. R. (2021). Seven deadly sins of tech? *Information Economics and Policy*, *54*, 100893. https://doi.org/10.1016/j.infoecopol.2020.100893

Voukkali, I., Pantelitsa, L., & Zorpas, A. A. (2014). Definitions of sustainability. In *Sustainability behind Sustainability* (pp. 1–6). Nova Science Publishers, Inc

Yeh, S. C., Wu, A. W., Yu, H. C., Wu, H. C., Kuo, Y. P., & Chen, P. X. (2021). Public perception of artificial intelligence and its connections to sustainable development goals. *Sustainability (Switzerland)*, *13*(16). https://doi.org/10.3390/su13169165

Yudkowsky, E. (2012). Friendly Artificial Intelligence. *The Frontiers Collection*, 181–195. https://doi.org/10.1007/978-3-642-32560-1_10

APPENDIX

AI Capabilities and Examples of Social Problems They Can Solve

Capability category	Relative maturity	Capability	Example of problems the AI capability can solve
Computer vision	More developed	Person identification (image and video)	▪ Identifying a known missing child through publicly posted pictures and video (commonly referred to as facial recognition)
		Face detection (image and video)	▪ Detecting the presence of people in surveillance camera footage
		Image and video classification	▪ Identifying endangered animals in image and video for enhanced protection ▪ Detecting explicit content
		Near-duplicate or similar detection (images and video)	▪ Detecting hate-speech content for removal of image or video
		Object detection and localization (images and video)	▪ Detecting fires in satellite imagery
		Optical character and handwriting recognition (OCR, images)	▪ Digitizing hard-copy records for quicker patient health history search
		Tracking	▪ Tracking illegal fishing vessels via satellite imagery
	Developing	Emotion recognition (image and video)	▪ Measuring level of student engagement in classrooms
Speech and audio processing	More developed	Person identification (speech)	▪ Verifying individuals through mobile phone for inclusive banking access based on sound and pattern of voice
		Speech-to-text (audio)	▪ Real-time captioning for the deaf or people hard of hearing to facilitate live conversation
		Sound detection and recognition (audio)	▪ Identifying chain-saw sounds in rainforests for alerts on illegal logging activities
	Developing	Emotion recognition (speech)	▪ Assisting individuals on the autism spectrum who have difficulty in social interactions
Natural language processing	More developed	Person identification (text)	▪ Detecting a paper's author through handwriting analysis and identification of syntax patterns
		Language translation (text)	▪ Enabling larger distribution of online education services to underserved populations
		Other natural language processing (text)	▪ Identifying plagiarism in student assignments to enhance instructor productivity
	Developing	Sentiment analysis (text)	▪ Using automated review of public sentiment about specific topics to inform policy
		Language understanding	▪ Enabling chatbots that understand abstract concepts and ambiguous language, eg, ones that can do second-level, nuanced health screens
Content generation	Developing	Content generation	▪ Generating text and media (video, audio) content for educational purposes with quick production turnaround for wide distribution
Reinforcement learning	Developing	Reinforcement learning	▪ Large-scale and high-speed simulation modeling, for example in drug trials, doing millions of simulations to determine best treatment for breast cancer in population with a specific genetic makeup
Deep learning on structured data	More developed	Structured deep learning	▪ Identifying tax fraud and underreporting of income based on tax return data
Analytics	More developed	Analytics	▪ Any analytics technique not involving deep learning, eg, for optimization, journey mapping, network analysis

Note. From ‘’Applying artificial intelligence for social good’’, by McKinsey Global Institute, 2021, p.11 https://www.mckinsey.com/featured-insights/artificial-intelligence/applying-artificial-intelligence-for-social-good