

A Work Project, presented as part of the requirements for the Award of a Master's degree in Impact Entrepreneurship and Innovation from the Nova School of Business and Economics.

HOW INTERNET OF THINGS CAN CONTRIBUTE TO THE UNITED NATIONS
SUSTAINABLE DEVELOPMENT GOALS

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Abstract: This Work Project explores how Internet of Things (IoT) can contribute to achieve the United Nations Sustainable Development Goals. This research followed the Task-Technology Fit Theory to confirm that IoT adoption is an approach that effectively facilitates the achievement of the SDGs with the speed and scale necessary. It presents an analysis of how the world's 100 largest companies are taking advantage of IoT towards sustainable development. Drawing on the SDGs "wedding cake" system, the research was divided in three different categories: biosphere, society, and economy.

Keywords: Sustainable Development Goals, Sustainable Development, Internet of Things, IoT-enabled Solutions.

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Figure 1. United Nations Sustainable Development Goals

Introduction

In 1987, the UN defined the term sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations 2022d). Today, 193 countries are seeking ways to meet these necessities pledging to the United Nations Sustainable Development Goals (SDGs) (United Nations Foundation 2022). The SDGs address the greatest needs and challenges of the 21st century and the goals to achieve a better and more sustainable future (Mio, Panfilo and Blundo 2020). The goals were adopted in 2015 in a collective effort to generate a large impact until 2030 (United Nations Foundation 2022). Even though almost all countries pledged to support the UN Sustainable Development Goals, the world is still not on track to achieve them (Nonet, et al. 2022).

Business contribution to achieve the SDGs is crucial (Mio, Panfilo and Blundo 2020) however, Nonet et al (2022), argued that the approaches that corporations are pursuing are “arguably insufficient for delivering change at the speed and scale necessary”. Internet of Things can be adopted as a new approach to facilitate the achievement of the SDGs because of its highly attractive features like scalability, integration, and connectivity (InterviewBit 2022) and its many application domains (Lemke 2021). The Internet of Things can be described as an “open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data, and resources, reacting and acting in face of situations and changes in the environment” (Madakam, Ramaswamy and Tripathi 2015).

Therefore, this study focuses on the following research question: “**How can IoT contribute to the UN Sustainability Goals?**”. Even though IoT capabilities towards sustainable practices have been previously studied in literature, there is a lack of research on how IoT can impact the achievement of the 2030 Agenda for Sustainable Development.

This Work Project follows the Task-Technology Fit (TTF) theory initially developed by Goodhue and Thompson (1995) and later used by Marikyan, Papagiannidis and Alamanos (2021) to show that the use of IoT is well suited for the achievement of the SDGs. It presents a review of different applications of IoT-enabled solutions – a combination of products, services, and projects that are enabled by IoT devices and/or technology - that contribute to the achievement of the SDGs and an analysis of how the largest companies in the world are already taking advantage of IoT towards sustainable development.

Literature Review

Based on the work of Van Tulder (2018) “the active participation of corporations is seen as a vital part of reaching the SDGs” (Van Tulder 2018) and for that reason this review of the literature focuses on the importance of the involvement of organizations to achieve the SDGs. Additionally, it discusses the key features of Internet of Things and how it has been applied in different fields in order to have a full picture of IoT’s capabilities.

Sustainable Development Goals

The private sector is particularly important in the advancement of the Sustainable Development Goals (Berrone, et al. 2019). Large multinational companies have the power to finance projects that contribute to social, economic, and environmental sustainability (Mio, Panfilo and Blundo 2020). The Business & Sustainable Development Commission estimates that the opportunities that arise by addressing the SDGs are worth up to US\$ 12 trillion, so it is no wonder big firms want to participate in that (Fraser 2019). Investing in sustainability is not just an ethical duty but financially savvy (Cunha, et al. 2019).

In the past years, the concepts of “corporate sustainability”, “sustainable development”, and “corporate social responsibility” have been discussed by many (Rosati and Faria 2018). These terms generally refer to the incorporation of societal goals into the corporation’s strategy,

focusing not only on corporate growth and profitability (Wilson 2003). In fact, sustainability has been long seen as an opportunity to add brand value and competitive advantage, increase efficiency, attract talent, and create new opportunities (Rosati and Faria 2018; Rafi 2021).

Even though the SDG framework works as a practical guide for companies to determine how they can align their business practices towards SDGs achievement (Mio, Panfilo and Blundo 2020), the concrete action that companies should take is still blurry (PwC 2019). The publication from GEI and Support the Goals – State of Progress: Business Contributions to the SDGs – highlights that 83% of companies state that they support SDGs, recognizing the value of aligning their reports with the goals, but only 40% of companies set measurable commitments for how they will achieve the SDGs. This study confirms the urgent need for more in-depth planning, target setting, and reporting with respect to the SDGs (GRI 2020). According to Rosati and Faria (2018), sustainability reporting is fundamental for the advancement of an organization’s sustainability orientation.

To enhance sustainability development, companies should communicate their sustainability ambitions, their action plan, and progress towards those objectives (Greenly 2022). By doing this, companies will not only accomplish milestones in an easier manner, but they will also transfer their knowledge and techniques to others (Accenture 2021).

Internet of Things

The Internet of Things (IoT) aims to “connect everything and everyone at any time and any place, giving rise to innovative new applications and services” (Lu, Papagiannidis and Alamanos 2018). It needs to have the ability to be identifiable, to communicate, and to interact “among themselves, building networks of interconnected objects, or with end-users or other entities in the network” (Miorandi, Sicari and Pellegrini 2012). IoT envisions a “smart

world” with a whole new class of settings (Miorandi, Sicari e Pellegrini 2012; Lu, Papagiannidis and Alamanos 2018).

IoT is expected to have a great impact on businesses and consumers (Wortmann and Fluchter 2015; Paternò 2022). The estimated economic value of IoT is between \$3.9 trillion to \$11 trillion by 2025 (Mouha 2021). Additionally, it offers a unique chance to help meet the UN SDGs (Martínez, et al. 2021) because of its versatility of use and low cost (Morais, et al. 2021). Some applications that are being developed range from doctors treating patients in rural areas remotely (Hooda, et al. 2021), autonomous driving and connecting vehicles to reduce accidents and traffic (Mohanta, et al. 2022), connected sensors that alert for conditions that could lead to environmental disasters, and many more (Cui 2020).

IoT towards sustainability

The United Nations doesn't prioritize any of the SDGs (Forestier and Kim 2020), but without a clear framework, people can “cherry-pick” their favorite (Rockström 2020) according to their “political and economic interests” (Forestier and Kim 2020). The “wedding-cake” system, by the Stockholm Resilience Centre (2016), solves this risk by presenting the Sustainable Development Goals in three different layers: biosphere, society, and economy. According to the “wedding cake” methodology, shown in figure 2, biosphere is the foundation for global sustainability and economies and societies are “embedded parts of the biosphere” (Stockholm Resilience Centre 2016). In fact, studies have shown that preserving biosphere is fundamental to achieve sustainable societies and economies and that it is vital for “human resilience, livelihoods and wellbeing” (Obrecht, et al. 2021). Based on this framework, this section is split into 3 different categories: **biosphere, society, and economy**. Each subsection presents use cases that have been studied in literature that demonstrate how IoT can contribute to each of the United Nations Sustainable Development Goals.

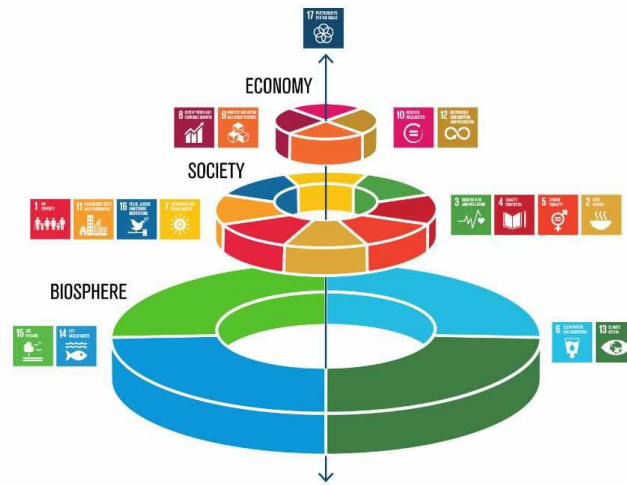


Figure 2. The SDGs wedding cake (Stockholm Resilience Centre 2016)

Biosphere

Since the 18th century, industrialization and overconsumption led to environmental degradation. (United Nations Environmental Programme 2019). Organizations can leverage IoT solutions to help restore the world’s biosphere (Cohen 2022). With tools for sensor data collection and analysis, AI and machine learning companies can address climate change (Ullo e Sinha 2020). Many authors (Miorandi, Sicari and Pellegrini 2012; Singh, et al. 2021; Talib, et al. 2021; Andrić, et al. 2022) have studied how IoT can be used to tackle environmental issues.

The reasons for the IoT technology’s success in environmental monitoring is due to its low cost and low power sensors (Liu, Giambene and Zambon 2021). Its advanced features range from monitoring temperature, moisture, and pressure (Jaladi, et al. 2017). IoT is also beneficial because its data is easy to interpret and there is no interrupted communication (Talib, et al. 2021).

The table below (table 1) summarizes use cases studied in literature that present some of the possibilities to address biosphere SDGs with IoT-enabled solutions. For more information about each study, check out appendix 1.

Table 1. Summary of studies – Biosphere

Study	Description	SDG	Indicators
Liu, Giambene and Zambon (2021)	IoT sensory systems to detect illegal tree-cutting activity	15: Life on Land	15.2: “By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally” (United Nations 2022e)
			15.3: “By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world” (United Nations 2022e)
Andrić, et al. (2022)	Smart water-systems that increase efficiency and maintain water resources’ sustainability	6: Clean Water and Sanitation	6.4: “By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity” (United Nations 2022e)

Talib, et al (2021)	Smart system for water monitoring for the conservation of marine life	14: Life Below Water	14.4: “By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics” (United Nations 2022e)
Chen, Shao and Zhu (2021)	IoT sensors for environmental monitoring for early warning of natural disaster and post-disaster recovery	13: Climate Action	13.1: “Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries” (United Nations 2022e)
			13.3: “Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning” (United Nations 2022e)

Society

The widespread of IoT in society improves the well-being of communities and industries. Its features like energy efficiency, reliability, scalability, and security (Atzori, Lera and Morabito 2010) allow for various sectors’ applications (Lemke 2021). In the table below (Table 2) it is presented a review of studies that show how it is possible to achieve a fair and just society using IoT. In appendix 2 there is more information about each study.

Table 2. Summary of studies – Society

Study	Description	SDG	Indicators
Singh, et al. (2021)	IoT sensors for air quality monitoring	11: Sustainable Cities and Communities	11.6: “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management” (United Nations 2022e)
Muangprathub, et al. (2019)	IoT devices to gather data to reduce land pollution/erosion	2: Zero Hunger	2.4: “By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality” (United Nations 2022e)
Gul, et al. (2017)	Smart Classrooms that make the learning process easier	4: Quality Education	4.4: “By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship” (United Nations 2022e)
Kim (2018)	IoT device for indoor pollution monitoring	3: Good Health and Well-Being	3.4: “By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and

			treatment and promote mental health and well being” (United Nations 2022e)
	Internet of Things Big Data Initiative to access markets and finance	1: No Poverty	1.4: “By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance” (United Nations 2022e)
Rodríguez-Rodríguez, et al. (2019)	Telemonitoring using IoT to detect and prevent violence	5: Gender Equality	5.2: “Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation” (United Nations 2022e)
		16: Peace, Justice and Strong Institutions	16.2: “End abuse, exploitation, trafficking and all forms of violence against and torture of children” (United Nations 2022e)
Motlagh, et al. (2020)	IoT to improve energy efficiency and increase the share of renewable energy	7: Affordable and Clean Energy	7.2: “By 2030, increase substantially the share of renewable energy in the global energy mix” (United Nations 2022e)
			7.3: “By 2030, double the global rate of improvement in

			energy efficiency” (United Nations 2022e)
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Economy

Achieving higher levels of economic productivity is one of the main selling points for IoT, especially in labor-intensive sectors. IoT allows for an increase in quality, quantity, and cost effectiveness of multiple processes (Satish, Bhavani and Begum 2017). It also enables improvements in energy management, increasing energy efficiency and reducing emission (Gan, et al. 2018). In the table below (table 3) it is presented a review of studies that show how IoT can impact the economy SDGs. In appendix 3 there is more information about each study.

Table 3. Summary of studies – Economy

Study	Description	SDG	Indicators
Satish, Bhavani and Begum (2017)	IoT devices to increase productivity and efficiency of material consumption	8: Decent Work and Economic Growth	8.2: “Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors” (United Nations 2022e)
		12: Responsible Consumption and Production	12.2: “By 2030, achieve the sustainable management and efficient use of natural resources” (United Nations 2022e)
Gan, Li, Wang and Cameron (2018)	IoT system to improve energy saving and emission reduction	9: Industry Innovation and Infrastructure	9.4: “By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective

			capabilities” (United Nations 2022e)
Figueira, et al. (2016)	IoT sensors to keep migrants safe	10: Reduced Inequalities	10.7: “Facilitate orderly, safe, regular, and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies” (United Nations 2022e)

Methodology

Research Context

This exploratory research follows the 100 largest companies in the world and investigates if they are taking advantage of IoT to achieve the SDGs they align with. Since organizations involvement is key towards the achievement of the SDGs (Mio, Panfilo and Blundo 2020), and IoT offers unique capabilities to help meet the SDGs faster (Martínez, et al. 2021), it was decided to analyze these companies portfolio of IoT-enabled solutions and check if they are consistent with the 17 SDGs.

Many authors (Brous, Janssen and Herder 2020; Ahmetoglu, Cob and Ali 2022) focused on studying the advantages of IoT, such as improved productivity, efficiency, and reduced costs, but very few discuss how industries can take advantage of all of that, and at the same time, do some good (PwC 2019). The decision to interconnect the SDGs and companies’ projects was done to analyze if there is a match between the sustainability goals of organizations, and what they are doing to achieve them. It is crucial that corporations start aligning their core business strategies with the SDGs (Mio, Panfilo and Blundo 2020). It is important to note that even though some companies are not taking advantage of IoT to meet the SDGs, they might have other ways to contribute to it.

Research Design

Inspired by the Task-Technology Fit Theory by Goodhue and Thompson (1995), this Work Project lays on that framework to show that IoT (technology) fits the task of achieving the Sustainable Development Goals and that it can result in improved performance, which in this case means, achieving it with the “speed and scale necessary” (Nonet, et al. 2022).

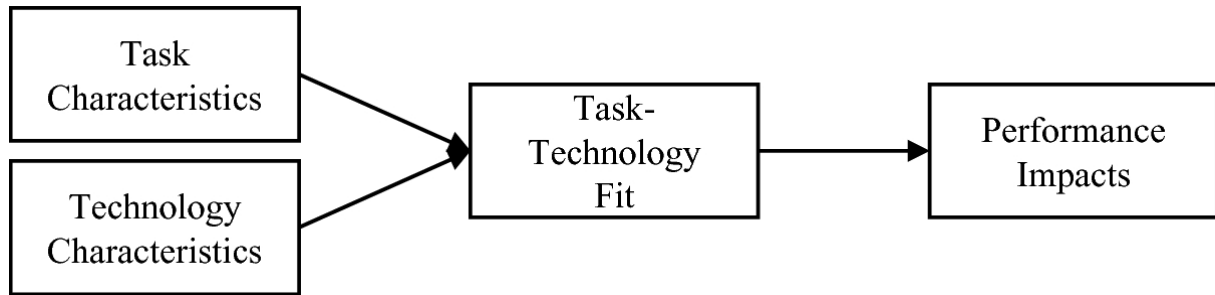


Figure 3. Basic task-fit model (Spies, Grobbelaar and Botha 2020)

Because this theory “can be applied in various ways” (Spies, Grobbelaar and Botha 2020), it was decided to follow the first 5 stages methodology proposed by Arksey and O’Malley (2005), but instead of focusing on relevant studies to reach a conclusion, focus on the use-cases (Marikyan, Papagiannidis and Alamanos 2021). The research was therefore divided in five different stages: (1) **identify the research question**, “how can IoT contribute to the United Nations Sustainable Development Goals; (2) **identify relevant use cases**; (3) **select use cases**; (4) **chart the data**; (5) **collate, summarize and report the results** (Arksey and O’Malley 2005). Stages 2-5 are discussed in the following sections and subsections.

Sampling Process and Data Collection - Identify Relevant Use Cases

Even though all companies can play a role in the achievement of the SDGs, the choice to focus the analysis on the 100 largest companies in the world was done based on their great power to invest and innovate (Mio, Panfilo and Blundo 2020). The top 100 companies were retrieved from the 2022 Forbes Global 2000 ranks, and it considers four metrics: sales, profits, assets, and market value (Forbes 2022).

Table 4. 100 largest companies (Forbes 2022).

Company									
Apple	BNP Paribas	Cisco Systems	Gazprom	Johnson & Johnson	Morgan Stanley	Procter & Gamble	Saudi Arabia Oil Company	TotalEnergies	
Agricultural bank of china	AT&T	BP	CITIC	General Motors	JP Morgan	Nestlé	Prudential financial	Shell	Toyota
Group	AXA Group	Brookfield Asset Management	Citigroup	Glencore international	Lloyds Banking Group	Novartis	RBC	Siemens	United Parcel Service
a group	Bank of America	Chevron	Comcast	Goldman Sachs	LVMH	NTT	Reliance Industries	Sinopec	UnitedHealth Group
ianz	Bank of China	China Construction Bank	CVS Health	Home Depot	Mercedes-Benz	PepsiCo	Rio Tinto	SoftBank	Verizon
abet	Bank of communications	China Life Insurance	Deutsche telekom	HSBC Holdings	Merk and Co	Petrobras	Roche Holding	Sony	Volkswagen
azon	Bank of Nova Scotia	China Merchants Bank	Elevance Health	IBM	Meta Platforms	PetroChina	Rosneft	Stellantis	Walmart
n Express	Berkshire Hathaway	China Mobile	Equinor	ICBC	MetLife	Pfizer	Samsung	Taiwan Semiconductor	Walt Disney
American International Group	BHP Group	Chubb	Exxon	Industrial Bank	Microsoft	Ping An Insurance Group	Sanofi	TD Bank Group	Wells Fargo
Anheuser-busch inbev	BMW Group	Cigna	Ford Motor	Intel	Mitsubishi	Postal Savings Bank of China	Santander	Tencent	Zurich Insurance Group

The research on the IoT-enabled products, services, and projects was done through the following keywords: “name of the company” IoT, “name of the company” IoT strategy, “name of the company” press release. On total, 219 solutions were found and analyzed belonging to 88 different corporations (Table 5). Also, all 100 sustainability reports were examined to find each company’s plans to support the UN Sustainable Development Goals, and which ones they state to prioritize.

Table 5. Companies that presented IoT-enabled solutions. Highlighted in red are the companies that don't have any significant evidence of using IoT in their operations.

Company									
Apple	BNP Paribas	Cisco Systems	Gazprom	Johnson & Johnson	Morgan Stanley	Procter & Gamble	Saudi Arabia Oil Company	TotalEnergies	
Agricultural bank of china	AT&T	BP	CITIC	General Motors	JP Morgan	Nestlé	Prudential financial	Shell	Toyota
Group	AXA Group	Brookfield Asset Management	Citigroup	Glencore international	Lloyds Banking Group	Novartis	RBC	Siemens	United Parcel Service
a group	Bank of America	Chevron	Comcast	Goldman Sachs	LVMH	NTT	Reliance Industries	Sinopec	UnitedHealth Group
ianz	Bank of China	China Construction Bank	CVS Health	Home Depot	Mercedes-Benz	PepsiCo	Rio Tinto	SoftBank	Verizon
abet	Bank of communications	China Life Insurance	Deutsche telekom	HSBC Holdings	Merk and Co	Petrobras	Roche Holding	Sony	Volkswagen
azon	Bank of Nova Scotia	China Merchants Bank	Elevance Health	IBM	Meta Platforms	PetroChina	Rosneft	Stellantis	Walmart
n Express	Berkshire Hathaway	China Mobile	Equinor	ICBC	MetLife	Pfizer	Samsung	Taiwan Semiconductor	Walt Disney
American International Group	BHP Group	Chubb	Exxon	Industrial Bank	Microsoft	Ping An Insurance Group	Sanofi	TD Bank Group	Wells Fargo
Anheuser-busch inbev	BMW Group	Cigna	Ford Motor	Intel	Mitsubishi	Postal Savings Bank of China	Santander	Tencent	Zurich Insurance Group

Throughout the conduction of this study, it was considered the option of doing Web Scraping with Python to automate the process of collection and parsing raw data from the web. Web Scraping requires consistency of patterns and since this research is done on 100 different companies that communicate their information in different ways, there wasn't a clear pattern to look for (Phoenix 2020).

Data Analysis

Select Use Cases

In the beginning of this study, it was performed a first round of examination to the companies in the Tech Sector, such as: Alphabet, Amazon, Cisco, Meta, Microsoft, and Siemens. It was important to study these companies at the start to understand if the companies who are expected, *a priori*, to have more IoT solutions, had enough information about their use cases to take relevant conclusions. After that initial examination turned out to be a success, the other set of companies were also explored. Once there was a clear picture of the information available and what was relevant about it (Braun and Clarke 2006) - case studies to see how companies addressed their IoT solutions and how they added value - the examination started.

To ensure the objectivity of the research, the following method was applied to analyze if the activities undertaken by a company, with their IoT solutions, contributed towards the advancement of the SDGs.

Table 6. Method to assess whether an IoT solution contributes to the achievement of the SDGs.

Actions	Status
A company that has no evidence of taking action to tackle environmental and/or social issues that contributes to the achievement of the SDGs	no
A company that provides evidence of actions taken that tackle issues that indirectly support the Goals	yes
A company that provides evidence of the actions taken and explicitly links that to their support of any given SDG	yes

One example of a case that is considered to tackle issues that indirectly support the goals (second row of table 5.) is SoftBank's BOLDLY (Appendix 26): a project with the aim of addressing rural mobility challenges through the creation of an autonomous bus that connects towns with difficult access and where the majority of the population was classified as elderly (SoftBank 2022a). This IoT solution contributes to the advancement of the SDG11 (11.2), but SoftBank doesn't make that link directly.

SoftBank also has an initiative, SmaGO (Appendix 27), to create an environment that discourages littering. Because of this project, SoftBank implemented a solution that uses IoT sensors to compress garbage in outdoor trash cans, which increases trash capacity, and remotely tracks how much litter has been accumulated to reduce the frequency and cost of garbage collection trips (SoftBank 2022b). This turn, SoftBank's directly connects their SmaGO project to the SDG 11 (11.6). In fact, this project is part of the UN Future City initiative (United Nations 2022c).

Drawing on the process presented by Spies, Grobbelaar and Botha (2020), first **each use case was identified** and analyzed to understand its effects on society. Second, the **effects were screened** to understand their interconnection to the 17 SDGs. Thirdly, their **eligibility was assessed** by comparing with the 169 targets. Lastly, a **codification matrix was created** (Appendix 4) with all use cases that were eligible. It was decided to use the SDGs targets because they've been defined by UN to guide activities and check progress (Bouma, Montanarella and Evanylo 2019).

Charting the Data

A first dataset was created (Appendix 5) using the information gathered in the "Select Use Cases" section. This dataset gathers companies' names and the SDGs they contribute to using IoT Solutions. After this analysis was complete, it was time to research the SDGs that each

company states to contribute to. This information was taken from companies Sustainability Reports. The analysis of data was done according to the following method:

Table 7. Method to assess the SDGs a company commits to.

Commitments	Status
A company that does not reference the SDGs	No
A company that indicates their support towards specific SDGs	Yes, only in the SDGs mentioned
A company that indicates overall support of all 17 SDGs	Yes, in all SDGs
A company that indicates overall support of the 17 SDGs and which SDGs they prioritize	Yes, in all SDGs

A second dataset (Appendix 6) was created with the information gathered from the Sustainability Reports. The third phase was to join both datasets based on the company name and changed every “no” to a zero and every “yes” to a 1 to better analyze the data collected (Appendix 7).

Presentation of Findings - Collate, Summarize, and Report the results

The analysis conducted in this study allows to understand whether IoT is capable of helping corporations reach the SDGs and to see if companies are taking advantage of it. It also allows to get a picture of which type of SDGs (biosphere, society, and economy) companies are contributing the most to.

Throughout the course of this study, out of the 219 IoT-enabled solutions analyzed, 149 applications supported the achievement of the SDG. These applications belonged to 58



different companies. The companies highlighted in red do not present IoT-enabled solutions that contribute to the achievement of the SDGs.

Table 8. Corporations that present IoT-enabled solutions that contribute to the SDGs. Highlighted in red are the companies that don't support the SDGs using IoT technology.

Company									
Abbvie	Apple	BNP Paribas	Cisco Systems	Gazprom	Johnson & Johnson	Morgan Stanley	Procter & Gamble	Saudi Arabia Oil Company	TotalEnergies
Agricultural bank of china	AT&T	BP	CITIC	General Motors	JP Morgan	Nestlé	Prudential financial	Shell	Toyota
AIA Group	AXA Group	Brookfield Asset Management	Citigroup	Glencore international	Lloyds Banking Group	Novartis	RBC	Siemens	United Parcel Service
Alibaba group	Bank of America	Chevron	Comcast	Goldman Sachs	LVMH	NTT	Reliance Industries	Sinopec	UnitedHealth Group
Allianz	Bank of China	China Construction Bank	CVS Health	Home Depot	Mercedes-Benz	PepsiCo	Rio Tinto	SoftBank	Verizon
Alphabet	Bank of communications	China Life Insurance	Deutsche telekom	HSBC Holdings	Merk and Co	Petrobras	Roche Holding	Sony	Volkswagen
Amazon	Bank of Nova Scotia	China Merchants Bank	Elevance Health	IBM	Meta Platforms	PetroChina	Rosneft	Stellantis	Walmart
American Express	Berkshire Hathaway	China Mobile	Equinor	ICBC	MetLife	Pfizer	Samsung	Taiwan Semiconductor	Walt Disney
American International Group	BHP Group	Chubb	Exxon	Industrial Bank	Microsoft	Ping An Insurance Group	Sanofi	TD Bank Group	Wells Fargo
Anheuser-busch inbev	BMW Group	Cigna	Ford Motor	Intel	Mitsubishi	Postal Savings Bank of China	Santander	Tecent	Zurich Insurance Group

Microsoft and Intel were the two corporations that showed more use cases of IoT-enabled Solutions towards sustainable development. The results revealed that organizations working in the Information and Technology sector were the most engaged.

Table 9. Summary of results

<p>Companies who showed more use cases of IoT Solutions towards sustainable development</p>	
<p>3 most common goals supported through IoT Solutions</p>	

<p>3 least common goals supported through IoT Solutions</p>			
<p>3 most common goals companies commit to</p>			
<p>3 least common goals companies commit to</p>			

It is worth mentioning that none of the 219 IoT Solutions studied presented significant evidence of targeting SDG5 (Gender Equality), SDG10 (Reduce Inequalities), and SDG17(Partnerships for the Goals).

Biosphere

Climate Action, SDG13, has the highest support with 85% of companies showing their commitment, interestingly the same result was found on the research by GRI and Support the Goals (GRI 2020). One question that needs to be asked, however, is why there are only 6 organizations (Appendix 20) actually using IoT to take action to combat climate change and its impacts since its capabilities can contribute meaningfully to mitigate climate change (Pee and Pan 2022). All six of these projects were conducted to support governments and/or agencies reaction to an event of a natural disaster. It seems that only those who are responsible for ensuring communities safety are investing in IoT Solutions for climate action, when in fact, climate change threatens “farming, water resources, energy generation and industrial projects” (Financial Times 2021).

A similar situation happens with SDG 6 – Clean Water and Sanitation. Even though 57 corporations commit to this goal, only 5 (Appendix 13) are taking actions to fight for it using

IoT capabilities. These numbers are surprising since there are strict laws related to industrial wastewater (United States Environmental Protection Agency 2022) and there is a clear need for industrial companies to take a step towards efficient water systems (Daigavane and Gaikwad 2017). One possible reason for this mismatch can be the lack of communication about the water resources management that businesses use.

Looking at the big picture, not much is being done to preserve biosphere even though there are IoT devices and technologies capable of conserving biodiversity and safeguard the world's natural resources (Maheswaran 2020), all fundamental for achieving other SDGs (Obrecht, et al. 2021). The biosphere SDGs, 6, 13, 14, and 15 are “nonnegotiable”, and should be prioritized over all others (Rockström 2020).

Society

The Society SDGs aim to achieve a fair and just society (Stockholm Resilience Centre 2016). There were plenty use cases that contributed to SDG 3 – Good Health and Wellbeing - and SDG 7 – Affordable and Clean Energy. There was a similarity between IoT-enabled Solutions from corporations working in the same sector. For instance, manufacturers of automobiles and motorcycles, like Toyota, General Motors and Stellantis have created IoT devices which contribute to a reduction of road accidents and an increase in the safety of vehicles (SDG 3: 3.6). Also, it was observed a large amount of Industrial IoT applications to improve the share of renewable energy and to increase energy efficiency.

It is also worth mentioning the truly innovative projects that contribute to SDG 11- Sustainable Cities and Communities. Cities all around the globe face serious environmental and public disorder problems (ChuanTao, et al. 2015) and so there are many companies, like Microsoft, Cisco, Softbank and Amazon who are developing technologies that can be

employed to increase air quality (Microsoft 2022), manage waste more efficiently (Cisco 2022), and provide transport to those in vulnerable situations (SoftBank 2022a) .

Economy

The three Sustainable Development Goals most supported using IoT were 8, 9 and 12, which are all integrated in the economy category of the “wedding cake” (Stockholm Resilience Centre 2016). Even though it would be helpful to have more companies taking advantage of Internet of Things for the preservation of the biosphere, it is not surprising that organizations focus on the SDGs that match their usual business practices (Song, et al. 2022). Most of the companies studied are using IoT for technological upgrading and innovation. Since the corporations researched in this Work Project belong to the 100 largest companies in the world, it is no wonder that they are looking for ways to improve their productivity, replace traditional renewable energy sources to green ones, and aiming to become more sustainable and efficient when it comes to natural resources (Parletta 2019).

Overall, SDG 8 – decent work and economic growth - was the one that most companies supported through their IoT-enabled products, services, and projects. There were 44 companies who stated their support (on their sustainability reports) towards the SDG number eight and who have taken advantage of internet of things devices or technologies to contribute to the advancement of that same Sustainable Development Goal (Appendix 15). It is worth mentioning that five companies who don't commit to this SDG in their Sustainability Reports' showed evidence of products, services or projects which indirectly or directly help accomplish SDG8 (Appendix 15). As mentioned throughout this study, it is important that organizations correctly communicate their plans, actions, and commitments towards the UN Sustainable Development Goals because it has a positive influence in sustainable development (Greenly 2022).

Discussion and Contribution

This Work Project confirms the theory that IoT can indeed contribute to the UN SDGs because of its powerful capabilities and flexible application domains, as seen in the literature review section. This Work Project also shows signs that corporations are taking advantage in IoT to contribute to the United Nations Sustainable Development Goals, but not in the area which is needed the most – biosphere (Stockholm Resilience Centre 2016). The challenges to reach the 2030 Agenda ask for changes in the behavior of businesses towards more “responsible and sustainable practices (GRI 2020). As it is illustrated in the chart below (figure 4) companies are lacking IoT initiatives within the boundaries of the biosphere.

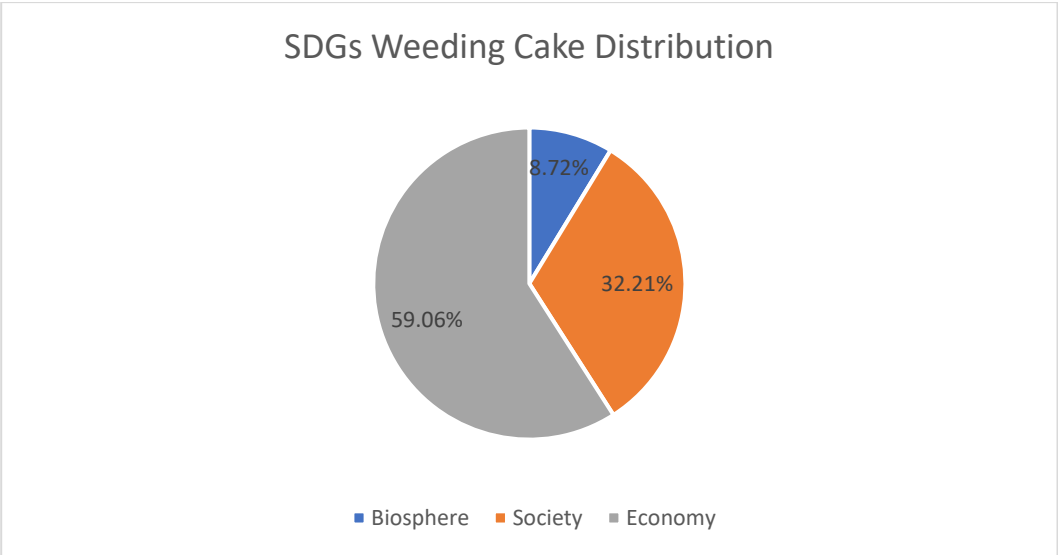


Figure 4. SDGs Weeding Cake Distribution of the IoT-enabled Solutions

The results support that most IoT-enabled solutions that contribute to the achievement of the SDGs are connected to the core business of the company in question. For instance, companies in the mining sector, like BHP Group and Rio Tinto, focus their IoT-enabled solutions to create more safe and secure working environments (SDG8: 8.8). It is also worth mentioning that because Microsoft and Intel, the corporations that presented the most use-cases, generate revenue by developing, licensing, and supporting a wide range of products and services

(Microsoft 2013), they were pioneers when it comes to the advancement of IoT in plenty of fields.

On another note, through the course of this study it was possible to understand that even the 100 largest corporations in the world are still failing to communicate their sustainability ambitions, action plan and progress. Take the example of the companies in the oil and gas industry, which directly and indirectly account for 42% of global emissions (OCDE 2018). In this study, only Exxon Mobil presents its IoT projects that make their refineries more efficient and minimize their emissions. TotalEnergies, for instance, released a press release stating that they have partnered up with Siemens for IoT monitoring of its NGV stations. In this press release they mention how they will reduce costs but explain very little about their emissions reduction. This comes to show that even though this partnership might in fact contribute to sustainable energy (SDG 7. Affordable and Clean Energy), as they state briefly in the press release, because they don't communicate their strategies properly, they won't transfer their knowledge and techniques to others (Accenture 2021), which is key to reach the Agenda 2030 (Greenly 2022).

Conclusion

The current study inhibits signs that there is indeed an alignment between the use of Internet of Things and the achievement of the United Nations Sustainable Development Goals. However, even though there is a strong fit between the technology (IoT) and the task (achieving the Agenda 2030), it seems that there is still some lack of knowledge of the endless possibilities that IoT offers towards sustainability. The findings of this study shed a light on how some of the most influential corporations are already taking advantage of IoT capabilities to support the achievement of the SDGs, which might come as an inspiration to others.

Although more investigation is required, this Work Project contributes to a new approach on how to reach the Sustainable Development Goals in the speed and scale that is so much needed. As Van Tulder (2018) stated “the private sector (...) has a vital role in reaching the SDGs” and “is uniquely positioned to drive progress”, so it is time to move from business as usual and begin to act now.

Limitations and Directions for Future Research

The main limitations of this study arise from the possibility of missing some companies' IoT-enabled solutions that might contribute to the SDGs. Some corporations might use IoT but might not promote or they might fail to communicate all the features of their products, services, and projects. Additionally, some companies might state to have good practices, but in reality, they might act differently.

Additionally, the process of studying each IoT-enabled solution was extremely time consuming because companies present their information in many different manners. While SoftBank has its own IoT page with press-releases of all their applications, others, like Microsoft, only present the description of their IoT-enabled solution and not the use cases. In cases like Microsoft, deeper research was needed to understand the use cases of their IoT devices and technologies.

This study focused on understanding if IoT could in fact contribute to the Sustainable Development Goals, and, to check if the largest corporations in the world were already taking advantage of IoT for good purposes and how. Thus, it would be interesting to understand how governments are acting to incentive these corporations to utilize new technologies and devices, like IoT, for greater good.

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Appendix

Appendix 1 – Review of studies that show how IoT can address biosphere SDGs.

One study by Liu, Giambene and Zambon (2021) presents the adoption of IoT sensory systems to automatically detect illegal tree-cutting activity (SDG 15: 15.2 and 15.3). This solution can “detect and notify tree-cutting events for efficient and cost-effective forest monitoring (...), with an accuracy of 85% (Liu, Giambene and Zambon 2021). Another report by Andrić, et al. (2022) presents the design and implementation of smart water systems that increase efficiency and maintain water resources’ sustainability (SDG 6: 6.4).

A study by Talib, et al (2021) addresses the conservation of marine life by proposing a smart and centralized system that controls and monitors water activities. The authors state that connected mobile devices with remote sensing are more effective than other existing systems because data is easy to interpret, there is no interrupted communication, it is less costly than Unmanned Aerial Vehicles, and it performs functions with minimal energy consumption (Talib, et al. 2021). This smart monitoring and control equipment leverages IoT to combat illegal, unreported, and unregulated fishing (SDG 14: 14.6).

A research article by the European Alliance for Innovation (EAI) describes how IoT-enabled technology is responding to natural disasters. Since IoT sensors can monitor in real time environmental conditions, they’ve become essential for early warning and post-disaster recovery (Chen, Shao and Zhu 2021). In the same paper, the authors say that by detecting abnormal data in a short time allows for more time to evacuate people and reduce the loss of life before the disaster threatens them (SDG 13: 13.1 and 13.3).

Appendix 2 – Review of studies that show how IoT can address society SDGs.

Singh, et al. (2021) shows the sensors and systems available for air quality monitoring, and how these smart sensors can “support developing nations in achieving the clean air goals of SDGs” (SDG11: 11.6). One other study by Muangprathub, et al. (2019) presents how IoT sensors and edge devices can help farmers collect real time information about “temperature, humidity, and soil moisture” to respond with tailored approaches in order to reduce land pollution/erosion, water ecosystems impacts and food/materials waste (SDG2: 2.4).

In the report “A Survey on Role of Internet of Things in Education” the authors Gul, et al. (2017) describe the usefulness and applications of IoT in the field of education. One of the many applications discussed in this study are IoT-based Smart Classrooms, that help the students understand not only the real purpose of technology and makes the learning process easier (SDG4: 4.4).

On different note, Jim Kim, President at The World Bank, stated that the World Bank is committed to tackle the world’s biggest challenge, poverty, by using the power of Big Data and IoT. In India, the World Bank was able to identify many homes with toxic levels of air pollution – indoor pollution kills more than 2.31 million people every year (Our World in Data 2022) – using IoT devices, and later intervened with cash incentives to encourage people to stop using fuel from biomass (wood or animal dung), and shift to clean (Kim 2018) cooking and heating (SDG3: 3.4) . Additionally, the World Bank (Kim 2018) did a partnership with Global System for Mobile Communication Association (GSMA) where they’ve created a new Internet of Things Big Data Initiative for the poor to access markets and finance (SDG1: 1.4).

The MDPI journal features an article focused on the “Review Towards a Holistic ICT Platform for Protecting Intimate Partner Violence Survivors Based on the IoT Paradigm”. In fact, “intimate partner violence is one of the most common forms of violence against women” (World Health Organization 2012). Girls and women around the globe are subject to physical,

sexual or psychological violence every day. In this review, the authors showcase how telemonitoring solutions using IoT can identify expressions of violence by detecting movement, heart rate temperature, perspiration, location, velocity, and acceleration in motion (Rodríguez-Rodríguez , et al. 2019). This solution can prevent effectively against violence against women and girls (SDG5: 5.2 and SDG16: 16.2)

Lastly, many authors (Ilyas 2021; Naqbi, et al. 2021; Nguyen, et al. 2022) have studied IoT-Enabled devices and their capacity to decrease energy consumption. Both authors agree that IoT will play a big role in the future of energy. The article “Internet of Things (IoT) and the Energy Sector” by Mitlagh, et al (2020) reviews the exiting literature on the application of IoT and presents how IoT can be employed to improve energy efficiency and increase the share of renewable energy (SDG7: 7.2 and 7.3).

Appendix 3 - Review of studies that show how IoT can address economy SDGs.

One research by Satish, Bhavani and Begum (2017) focused on the Agricultural Productivity Enhancement System using IoT shows that, by using IoT, farmers can increase the quality, quantity, sustainability, and cost effectiveness of their agricultural production (SDG8: 8.2 and SDG12: 12.2). Additionally, the authors Gan, Li, Wang and Cameron (2018) presented a design of an IoT enabled system that can assist industry energy management and, most importantly, provide a platform to “improve energy saving, emission reduction, and along with other potentials” (SDG9: 9.4) (Gan, et al. 2018).

It is also worth mentioning the study by Figueira, et al. (2016) that focuses on reducing inequalities. The European migrant crisis began in 2015 (Dinan, Nugent and Paterson 2017) and refugees, in particular women and children, are vulnerable to abuse as they transit Europe (Figueira, et al. 2016). In this study the authors focused on solutions to keep migrants safe.

IoT sensors were presented as the best solution to detect in real-time situations of violent attacks sending an alarm to surrounding citizens (Figueira, et al. 2016). This application shows how IoT can be used for humanitarian purposes (SDG10: 10.7).

Appendix 4 – Codification Matrix

Find the full Codification Matrix in this link: [Codification.Matrix.xlsx](#)

Goals and targets (from the 2030 Agenda)	Berkshire Hathaway	ICBC	Saudi Arabia Oil Company	China Construction Bank
Goal 1. End poverty in all its forms everywhere	no	no	no	no
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day	no	no	no	no
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	no	no	no	no
1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	no	no	no	no

Appendix 5 – Dataset with company’s names and the SDGs they contribute to by the use of IoT-enabled solutions.

Find the full Dataset in this link: [IoT enabled solutions contribution to the SDGs.xlsx](#)

Company	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
Berkshire Hathaway	no	no	no	no	no	no	no	no	no	no	yes	no	no	no	no	no	no
ICBC	yes	no	no	no	no	no	no	no	yes	no	no	no	no	no	no	no	no
Saudi Arabia Oil Company	no	no	no	no	no	no	no	yes	no	no	no	no	no	no	no	no	no
China Construction Bank	no	no	no	no	no	no	no	yes	no	no	no	no	no	no	no	no	no

Appendix 6 - Dataset with company's names and the SDGs they pledged based on their Sustainability Reports.

Find the full Dataset in this link: [Corporations commitment towards the SDGs .xlsx](#)

Company	SR.SDG1	SR.SDG2	SR.SDG3	SR.SDG4	SR.SDG5	SR.SDG6	SR.SDG7	SR.SDG8	SR.SDG9	SR.SDG10	SR.SDG11	SR.SDG12	SR.SDG13	SR.SDG14	SR.SDG15	SR.SDG16	SR.SDG17
Berkshire Hathaway	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
ICBC	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Saudi Arabia Oil Company	no	no	yes	no	yes	yes	yes	yes	yes	no	no	yes	yes	yes	yes	no	no
China Construction Bank	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	no	no

Appendix 7 – Joined Dataset with both the IoT-enabled solutions and the SDGs the companies contribute to, based on their Sustainability Reports.

Find the full Dataset in this link: [joined data set.xlsx](#)

Company	SDG3	SDG11	SDG9	SDG12	SDG13	SDG6	SDG7	SDG14	SDG15	SDG1	SDG2	SDG4	SDG16	SDG8	SDG5	SDG10	SDG17	SR.SDG1	SR.SDG2	SR.SDG3	SR.SDG4	
Berkshire Hathaway	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICBC	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Saudi Arabia Oil Company	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
China Construction Bank	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1

Appendix 8 – Confusion Matrix SDG1: On the top section it is presented the number of companies that stated in their Sustainability Reports that they support, or not, SDG1 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG1.

With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG1	
IoT SDG1		no	yes
	no	44	52
	yes	2	2

Appendix 9 – Confusion Matrix SDG2: On the top section it is presented the number of companies that stated in their Sustainability Reports their support, or not, of SDG2 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG2. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG2	
IoT SDG2		no	yes
	no	52	45
	yes	1	2

Appendix 10 – Confusion Matrix SDG3: On the top section it's presented the number of companies that stated in their Sustainability Reports their pledge, or not, to support SDG3 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG3. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG3	
IoT SDG3		no	yes
	no	24	62
	yes	0	14

Appendix 11 – Confusion Matrix SDG4: On the top section it's presented the number of companies that stated in their Sustainability Reports their support, or not, towards SDG4 and

on the left the number of companies that have, or not, IoT Solutions that contribute to SDG4. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG4	
IoT SDG4		no	yes
	no	27	70
	yes	0	3

Appendix 12 - Confusion Matrix SDG5: On the top section it's presented the number of companies that showed, in their Sustainability Reports, they support, or not, SDG5 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG5. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG5	
IoT SDG5		no	yes
	no	27	73
	yes	0	0

Appendix 13 – Confusion Matrix SDG6: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG6 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG6. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG6	
IoT SDG6		no	yes
	no	38	57
	yes	1	4

Appendix 14 - Confusion Matrix SDG7: On the top section it is presented the number of companies that stated in their Sustainability Reports they pledge, or not, to SDG7 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG7. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG7	
IoT SDG7		no	yes
	no	30	57
	yes	2	11

Appendix 15 - Confusion Matrix SDG8: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG8 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG8. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG8	
IoT SDG8		no	yes
	no	12	39
	yes	5	44

Appendix 16 - Confusion Matrix SDG9: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG9 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG9. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG9	
IoT SDG9		no	yes
	no	27	52
	yes	9	12

Appendix 17 - Confusion Matrix SDG10: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG10 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG10. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG10	
IoT SDG10		no	yes
	no	42	58
	yes	0	0

Appendix 18 - Confusion Matrix SDG11: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG11 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG11. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG11	
IoT SDG11		no	yes
	no	33	57
	yes	4	6

Appendix 19 - Confusion Matrix SDG12: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG12 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG12. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

	SR SDG12		
IoT SDG12		no	yes
	no	25	57
	yes	4	14

Appendix 20 - Confusion Matrix SDG13: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG13 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG13. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

	SR SDG13		
IoT SDG13		no	yes
	no	13	81
	yes	2	4

Appendix 21 - Confusion Matrix SDG14: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG14 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG14. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

	SR SDG14		
IoT SDG14		no	yes
	no	54	45
	yes	1	0

Appendix 22 - Confusion Matrix SDG15: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG15 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG15. With

this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG15	
IoT SDG14		no	yes
	no	42	57
	yes	1	0

Appendix 23 - Confusion Matrix SDG16: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG16 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG16. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG16	
IoT SDG16		no	yes
	no	45	54
	yes	0	1

Appendix 24 - Confusion Matrix SDG17: On the top section it's presented the number of companies that stated in their Sustainability Reports they support, or not, SDG17 and on the left the number of companies that have, or not, IoT Solutions that contribute to SDG17. With this table it's possible to see the alignment between the SDG companies are committed to and their IoT-enabled Solutions

		SR SDG17	
IoT SDG17		no	yes
	no	44	55
	yes	0	0

Appendix 25 – Study of the Context of all IoT-enabled solutions

In the report “The Internet of Things: Catching up to an accelerating opportunity”, Mckinsey disaggregated the potential economic value of IoT in 9 different settings: vehicle, office, retail environment, outside, home, city, human health, work site, and factory. In that same report, the authors state that the setting with the greatest potential for value creation factory thanks to the optimization of operations (Chui, Collins and Patel 2021b). It is important to keep in mind that efficiency equals energy savings.

Based on the methodology proposed by Mckinsey (Chui, Collins and Patel 2021b) all IoT Solutions were divided into nine different categories based on the method below:

Setting	Description	Examples
Human Health	Devices attached to or inside the human body	Devices (wearables and ingestibles) to monitor and maintain human health and wellness; disease management; increased fitness; higher productivity
Home	Buildings where people live	Home voice assistants; automated vacuums; security systems
Retail Environments	Spaces where consumers engage in commerce	Stores, banks, restaurants, arenas—buildings where consumers physically consider and purchase products and services; self-checkout; in-store offers; inventory optimization
Offices	Spaces where knowledge workers work	Energy management and security in office buildings; improved knowledge-worker productivity
Factories	Standardized production environments	Manufacturing plants, hospitals, and farms; operating efficiencies; optimizing equipment use

		and inventory
Work Sites	Custom production environments	Mining, oil and gas exploration and production, construction; operating efficiencies; predictive maintenance; health and safety
Vehicles	Systems inside moving vehicles	Vehicles, including cars, trucks, ships, aircraft, and trains; condition-based maintenance; usage-based design; presales analytics
Cities	Urban environments	Public spaces and infrastructure in urban settings; adaptive traffic control; smart meters; environmental monitoring; resource management
Outside	Between urban environments (and outside other settings)	Railroad tracks, autonomous vehicles (includes level 2 autonomy and up outside urban locations), and flight navigation; real-time routing; connected navigation; shipment tracking

Table. Method to define the settings of each IoT-enabled solution

Home	Retail Environments	Work Sites	Offices	Factories	Human Health	Vehicles	Cities	Outside	Other
14	25	28	17	31	18	15	20	23	28

Appendix 26. SoftBank BODLY project that contributes to SDG 11 (11.2).

Full Article: https://www.softbank.jp/en/sbnews/entry/20221011_01

October 4, 2022

SoftBank Corp.'s BOLDLY Rolls Out New Autonomous Bus Demonstration to Address Mobility and Healthcare Challenges

Future Tech | Automated driving | IoT | DX | Healthcare



Appendix 27. SoftBank BODLY project that contributes to SDG 11 (11.6).

Full Article: https://www.softbank.jp/en/sbnews/entry/20221011_01

October 11, 2022

SoftBank Corp. Helps Kyoto Prefecture's Kameoka City Utilize IoT to Realize its Goal of Eliminating Litter

Future Tech | IoT | SDGs | Sustainability



Appendix 28. General Motors Vehicle Intelligence that envisions zero crashes, zero emissions and zero congestion. This IoT-enabled solution contributes to SDG3 (3.6) SDG 7 (7.2) (7.3) and SDG9 (9.4).

Full Article: <https://www.gm.com/stories/digital-vehicle-platform>



TECHNOLOGY

GM's Vehicle Intelligence Platform Enables Adoption of Future Technologies

Share this story



General Motors has developed an all-new vehicle intelligence platform necessary for its next-generation of vehicles, EVs, active safety, infotainment and connectivity features, and the evolution of the Super Cruise driver assistance feature.¹

General Motors President Mark Reuss debuted the company's all-new intelligence platform during the 2019 Wall Street Journal Future of Everything festival. The platform is necessary for its next-generation of vehicles, EVs, active safety, infotainment and connectivity features, and the evolution of the Super Cruise driver assistance feature¹. These and many other advancements are central to GM's vision for a world with zero crashes, zero emissions and zero congestion.

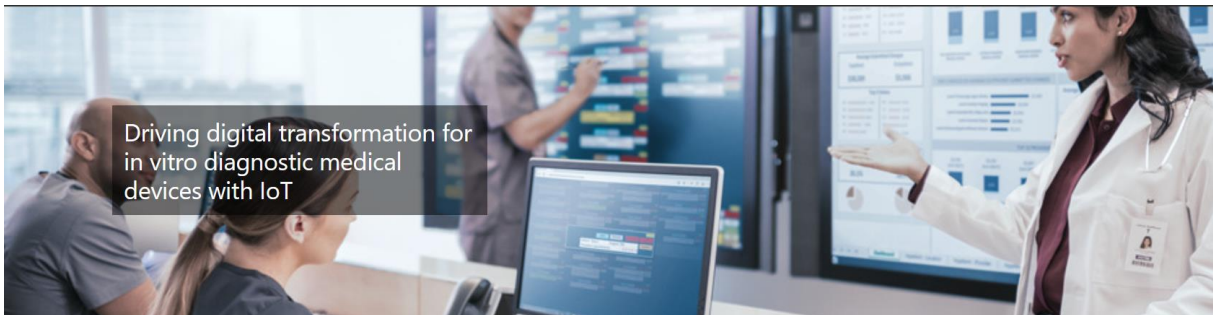
Appendix 29 – BHP's solution to increase safety in the workplace SDG8 (8.8).

Full Article: <https://news.microsoft.com/en-au/features/bhp-increases-the-pace-of-innovation-despite-site-lockdown-with-mixed-reality-and-iot/>



Appendix 30.

Full Article: <https://advocacypublic.cloudamppe.microsoft.com/en-gb/story/roche-diagnostics>



Customer
Roche Diagnostics
Partner
Cleidon
Products and Services
Azure HDInsight

21 June 2017

Print

Background

Diagnostic devices play a vital role in helping to improve healthcare delivery. In fact, an estimated 60 percent of the world's medical decisions are made with support from *in vitro* diagnostics (IVD) solutions, such as those provided by Roche Diagnostics, an industry leader. Its IVD portfolio helps clinicians detect diseases, determine causes, monitor patient progress, and improve outcomes. Products include devices to assist in clinical chemistry and immunoassays, urinalysis, point-of-care testing, patient self-testing, and laboratory automation. More and more, these devices incorporate sophisticated underlying technologies.

Appendix 31. SoftBank’s “e-kakashi” that contributes to SDG2 (2.4)

Full Article: https://www.softbank.jp/en/sbnews/entry/20211130_01

November 30, 2021

e-kakashi's Science-based Approach to Agriculture is Raising Yields While Helping Make Farming Sustainable



Future Tech

AI

IoT

SDGs



The AI-powered “e-kakashi,” an agriculture science and technology solution from SoftBank Corp. (TOKYO: 9434), made business news headlines in October with the launch of its advanced version. The e-kakashi collects and helps to analyze environmental data, weather, plant-growth-data and cultivation records to enable science-based farming. The Gateway in the new e-kakashi has a pre-tax price tag just under ¥100,000 (\$880)—one seventh the cost of the company’s previous ¥750,000 (\$6,600) model—yet it boasts greatly improved functionality and ease of use.

Appendix 32. Cisco’s IoT-enabled solutions that contribute to SDG4 (4.3)

Full Article:

https://www.cisco.com/c/dam/en_us/solutions/industries/docs/education/education_internet.p

[df](#)

Education and the Internet of Everything

How Ubiquitous Connectedness Can Help Transform Pedagogy

