AI & THE SUSTAINABLE DEVELOPMENT GOALS: THE STATE OF PLAY

2030VISION

Global Goals Technology Forum

THE GLOBAL GOALS
For Sustainable Development

INTRODUCTION

In 2015, 193 countries agreed to the United Nations (UN) 2030 Agenda for Sustainable Development, which provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries – developed and developing – in a global partnership. Achieving the SDGs is not just a moral imperative, but an economic one.

While the world is making progress in some areas, we are falling behind in delivering the SDGs overall. We need all actors – businesses, governments, academia, multilateral institutions, NGOs, and others – to accelerate and scale their efforts to deliver the SDGs, using every tool at their disposal, including artificial intelligence (AI).

In December 2017, 2030Vision published its first report, *Uniting to Deliver Technology for the Global Goals*, which addressed the role of digital technology – big data, robotics, internet of things, AI, and other technologies – in achieving the SDGs.

In this paper, we focus on AI for the SDGs. AI extends and amplifies the capacity of human beings to understand and solve complex, dynamic, and interconnected systems challenges like the SDGs. Our main objective was to survey the landscape of research and initiatives on AI and the SDGs to identify key themes and questions in need of further exploration. We also reviewed the state of AI and the SDGs in two sectors – food and agriculture and healthcare – to understand if and how AI is being deployed to address the SDGs and the challenges and opportunities in doing so.

"WE ARE AT A PIVOTAL MOMENT. AS ARTIFICIAL INTELLIGENCE BECOMES MORE WIDELY ADOPTED, WE HAVE A TREMENDOUS OPPORTUNITY TO REEVALUATE WHAT WE'VE CREATED AND ENSURE THAT AI IS DEVELOPED COLLABORATIVELY AND APPLIED TO THE UN SUSTAINABLE DEVELOPMENT GOALS TO ACHIEVE A BETTER AND MORE SUSTAINABLE FUTURE FOR ALL."

Tabitha Goldstaub

Co-Founder at CognitionX & Chair of the UK Government's AI Council

ABOUT 2030VISION

Founded in 2017, 2030Vision is a partnership of businesses, NGOs, and academia that aims to transform the use of technology to support the delivery of the SDGs. 2030Vision serves as a platform to convene cross-sector leaders to raise awareness of the SDGs, to showcase thought-leadership on the role of technology in addressing the SDGs, and to stimulate partnerships for action.

2030VISION

CognitionX

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AI AND THE SUSTAINABLE DEVELOPMENT GOALS:

THE POTENTIAL FOR GOOD

"...CLIMATE CHANGE IS A MASSIVE PROBLEM ACROSS NEARLY EVERY SECTOR AND MEASURE OF HUMAN DEVELOPMENT. TO ADDRESS IT AT THE SPEED AND SCALE THAT CURRENT CONDITIONS REQUIRE, WE'LL NEED TO TAKE A MORE DATA-DRIVEN APPROACH – ONE THAT HARNESSES THE FULL POWER OF ARTIFICIAL INTELLIGENCE AND OTHER ADVANCED TECHNOLOGIES TO ACCELERATE DISCOVERY AND INNOVATION AT A TRULY PLANETARY SCALE."

Lucas Joppa

Chief Environmental Scientist, Microsoft

"PERHAPS THE MOST IMPORTANT QUESTION WE HAVE LOOKED AT IS WHETHER AI WILL POSE A THREAT – OR PROVIDE NEW OPPORTUNITIES – FOR DEVELOPING REGIONS SUCH AS AFRICA. OPTIMISTS SAY THAT SUCH PLACES COULD USE RAPIDLY ADVANCING AI SYSTEMS TO BOOST PRODUCTIVITY AND LEAPFROG AHEAD. BUT I AM BECOMING INCREASINGLY CONCERNED THAT AI WILL, IN FACT, BLOCK THE TRADITIONAL GROWTH PATH BY REPLACING LOW-WAGE JOBS WITH ROBOTS."

Ian Goldin

Professor of Globalisation and Development, Oxford University

As illustrated by the quotes opposite, there are a variety of perspectives about AI and its potential impact on sustainable development. For some, AI is a job killer, a tool that will benefit wealthier nations and citizens. Worse, AI could pose existential threats, for example Stephen Hawking warned that AI could lead to the end of humanity.

However, AI promises – and is starting to deliver – benefits across sectors and geographies, and holds great potential to help solve complex and interconnected sustainable development challenges such as climate change, access to health care, and inequality. While 2030Vision recognizes the potential risks of AI, we believe AI will be a positive force for global sustainable development. Guided by the SDGs, we must now work together to accelerate and scale the development and use of AI.

DEFINING ARTIFICIAL INTELLIGENCE

Whether we know it or not, AI is now part of the fabric of our daily lives. For example, AI helps power predictive Google searches, Spotify music recommendations, Waze driving directions, and Facebook facial recognition.

There are a variety of definitions of AI, which we paraphrase as follows:

AI IS AN OVERARCHING TERM FOR A COLLECTION OF TECHNOLOGY ALGORITHMS AND APPROACHES THAT ALLOW MACHINES TO PERFORM HUMAN-LIKE COGNITIVE FUNCTIONS SUCH AS REASONING AND LEARNING.

AI is also being used to address sustainable development challenges: improving the diagnosis of various diseases, fighting wildlife poaching, and improving crop yields to name a few. Other examples of SDG-related applications of AI are included throughout this report.

PROGRESS ON THE SDGS

In its most recent progress report on the SDGs, the UN cited success in some areas, for example:

GOAL 1: NO POVERTY

Since 1990, the percentage of people living in extreme poverty (living on less than $1.90 per day) has declined from

33% TO 9%

GOAL 3: GOOD HEALTH AND WELL-BEING

Since 2000, maternal mortality has declined by

↓37%

and under-five mortality has declined by

↓47%

GOAL 7: AFFORDABLE AND CLEAN ENERGY

87%

of the global population has access to electricity, up from 78% in 2000.

However, progress has been insufficient in other areas, for example:

GOAL 4: QUALITY EDUCATION

617m

children of primary and secondary school age do not meet minimum proficiency in mathematics and reading.

GOAL 5: GENDER EQUALITY

Globally, women represent just

23% OF SEATS

in single or lower houses of national parliaments.

GOAL 13: CLIMATE ACTION

In May 2019, the concentration of CO_2 in the atmosphere reached

415ppm

for the first time in human history, and it continues to rise.

GOAL 14: LIFE BELOW WATER

GOAL 15: LIFE ON LAND

UN scientists recently warned that

1million

out of the world's eight million species are at risk of extinction due to human activities.

With 10 years remaining to achieve the ambitions of the 2030 agenda, it is up to all of us – businesses, governments, academia, multilateral institutions, NGOs, and others – to strengthen and quicken our efforts to build a better future for everyone.

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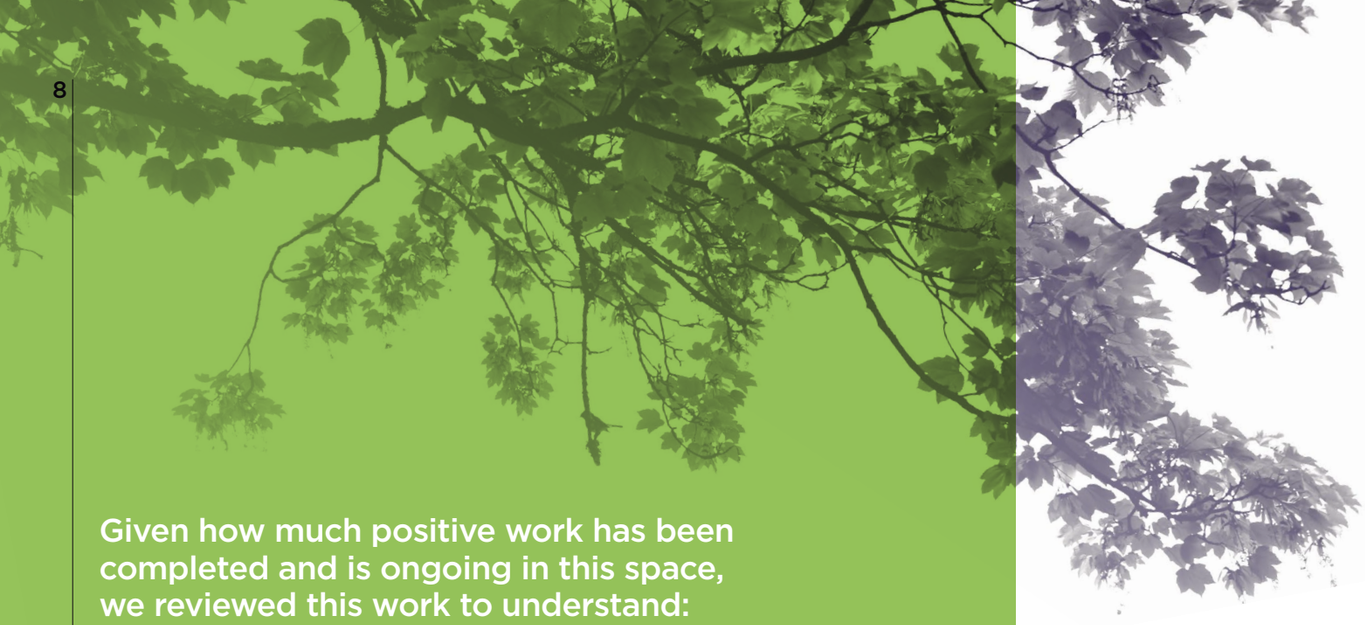
AI AND THE SUSTAINABLE DEVELOPMENT GOALS:

CAPTURING THE STATE OF PLAY

Over the last two years, we have seen a considerable increase in discussion about the role that AI can play in sustainable development issues.

Organizations such as McKinsey and PwC have published reports with a wealth of information – including use cases, economic impacts, risks, enabling factors, and more. We've seen a number of non-profit organizations and events emerge at the intersection of AI and the SDGs, for example the AI for Good Foundation and ITU's AI for Good Summit. And every day there are multiple media pieces on the role of AI and some sustainability topic.



Given how much positive work has been completed and is ongoing in this space, we reviewed this work to understand:

- What ground has been covered with respect to AI and the SDGs?
- What questions are in need of further exploration?
- What frameworks are useful for connecting AI to the SDGs?
- Can AI be used to better understand the interaction between the SDGs?
- How is AI being used to address the SDGs in both the food and agriculture and health sectors?
- What should different stakeholders do to foster the use of AI for the SDGs?

From our research across a variety of reports, organizations, articles, and other sources, we identified a number of consistent themes.

AI extends and amplifies our capacity to solve complex challenges like the SDGs. This is beneficial for picking up the pace towards the SDGs.

The various forms of AI – machine learning, natural language processing, predictive analytics, and more – can bring great efficiencies, speed, and intelligence to tasks and processes.

The capabilities of AI – including automating routine tasks, analyzing big data, and bringing intelligence and learning to various processes – have enormous potential to address a wide range of sustainable development issues. In combination with other technologies (e.g. sensors), tools (e.g. data analytics), and infrastructure (e.g. data centers), AI enables us to access, analyze, and act on ever-growing sets of data.

To illustrate:

WIND AND SOLAR

AI can be applied to the design and operation of wind and solar farms to make them more efficient, for example orienting turbine heads to capture a greater portion of incoming wind. Google and DeepMind are deploying machine learning to manage 700 MW of wind power capacity in the US, resulting in a 20% increase in value.

DIAGNOSIS AND TREATMENT

A growing number of researchers are exploring the use of AI in the diagnosis and treatment of various diseases and the design of health interventions. For example, researchers in Germany, the US, and France found that AI is on par or better than dermatologists at diagnosing skin cancer. Researchers from IBM and New York University recently published a paper on how AI can be used to detect glaucoma, the second leading cause of blindness in the world. Such AI-based systems hold promise to make diagnostic and other health services more readily available in regions that have a lack of health care workers.

REDUCING MATERNAL MORTALITY IN UTTAR PRADESH, INDIA

Researchers at the University of Sussex have partnered with the Surgo Foundation, the Bill and Melinda Gates Foundation, GNS Healthcare, and the University of Manitoba to better understand the causes of high maternal mortality rates in Uttar Pradesh, India. Through the application of machine learning algorithms to data about mothers' perceptions and behaviors, the partners hope to design evidence based, effective, and acceptable interventions that will reduce the number of deaths in this community.

WILDLIFE CONSERVATION

AI is being used to conserve wildlife. For example, Wildbook is a software that allows researchers to more efficiently assess animal populations by using AI to help identify individual animals from photos by their unique features and markings.

THE HIGH COST OF ILLEGAL TRADE IN WILDLIFE

Illegal and unsustainable wildlife trade is a threat to the existence of certain species and human livelihoods. The UN estimates that illegal wildlife trade worldwide is worth $8 billion to $10 billion per year, and the value of the ivory trade alone is roughly $1 billion. Non-profit RESOLVE is deploying cameras enhanced with image processing and deep neural network algorithms across a range of reserves in Africa to allow rangers to detect and respond to poachers in near real-time.

URBAN PLANNING

AI is increasingly used for urban planning and management, and to help build smart and resilient cities around the world.

TOWARDS RESPONSIVE AND RESILIENT URBAN SYSTEMS

PetaBencana.id combines AI, citizen reporting via social media, government flood alerts, and hydraulic sensor data to help megacities in South and Southeast Asia respond to and manage emergencies and disasters.

FINANCIAL CRIME

Financial institutions are using AI to analyze ever larger and more varied data sets to spot fraud and money laundering. Banks spend £5 billion per year on fighting financial crime in the UK, and AI can reduce the cost and increase the effectiveness of such efforts.

COMBATTING FRAUD AND OTHER FINANCIAL CRIMES

HSBC is using AI to help spot money laundering, fraud, and terrorist funding. AI enables the bank to screen the vast amounts of data it holds on customers and their transactions against publicly available data, in the search for suspicious activity.

THE COMMON THREAD ACROSS THESE EXAMPLES IS THAT AI BRINGS NEW CAPABILITIES AND EFFICIENCIES TO ADDRESS COMPLEX GLOBAL CHALLENGES SUCH AS THE SDGS.

The SDGs are dynamic, complex, and interconnected – AI can help us better understand and achieve them.

The SDGs are inherently a complex, systems problem that will require collaboration across subject matters (climate, water, poverty, etc.), sectors (private, civil society, government, etc.), and industries (finance, healthcare, food, etc.) to understand and solve. We will need to avoid the temptation to implement fixes to individual goals without addressing the connections between goals.

Academic institutions, especially those that encourage interdisciplinary working, are effective platforms for this type of approach. For example, in 2018, the Sussex Sustainability Research Programme convened a workshop with diverse experts and stakeholders that explored how targeting efforts around the interactions between the SDGs, whether synergies or trade-offs, will be critical for driving progress forward.

ANALYZING TRADE-OFFS BETWEEN SDG'S IN URBAN ENVIRONMENTS

In 2017/18, the Sustainability Research Programme at the University of Sussex conducted a research project to better understand the trade-offs between development, food security, and poverty alleviation. Focused on Wuhan, China and Varanasi, India, the researchers applied deep learning techniques to map and better understand trade-offs in peri-urban agriculture systems, as well as inform urban sustainability policy.

In conversation, Sussex researchers emphasized the following elements as being key to establishing an effective AI approach for the SDGs, grounded in interdisciplinary thinking:

- **SDG-related problems must be articulated and rephrased such that they can be solved by AI, for example drought can be rephrased as a problem of water management;**
- **Experts from different areas should agree a shared language and understanding of research opportunities;**
- **Steps should be taken to ensure that AI is applied appropriately in specific contexts;**
- **Provide robust interpretations of research results, built on an understanding of the technology as well as the challenge, area or context in which it is applied.**

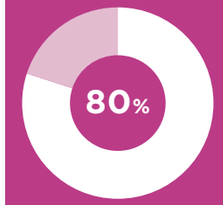
The researchers also suggested it may be possible to identify appropriate data and build AI models that improve our understanding of the interconnections between the SDGs and their 169 targets, whether they are synergies or trade-offs. To illustrate, a billion people globally do not have access to electricity in their homes, and three billion rely on dirty fuels such as charcoal and animal waste for cooking. This lack of access to clean energy (Goal 7) has negative impacts on education (Goal 4), economic status (Goals 1 and 10), and gender equality (Goal 5). In specific contexts such as this, the researchers suggested it may be possible to use AI to improve our ability to understand and prioritize our efforts, ultimately helping to accelerate progress towards the SDGs.

While AI promises benefits for the SDGs, it will only be as positive and impactful as designed and utilized.

Much has been written about how AI reflects the experiences, intentions, and biases of its designers, and this is certainly true in the context of the SDGs.

An often-cited example is how facial recognition technology can be more accurate for white men than for men of other ethnicities and women – a result of machines being trained on images of white males (presumably by white males). This has serious implications for privacy and security, for example African American males may be improperly identified as crime suspects via poorly trained AI. This challenge is one reason why the city of San Francisco recently became the first US city to ban the use of facial recognition technology.

LACK OF DIVERSITY PERPETUATES BIAS IN AI



According to an April 2019 report from the AI Now Institute, 80% of AI professors are male, and women comprise only 15% of AI research staff at Facebook and 10% at Google.

China is using facial recognition and surveillance cameras to identify and in some cases detain Uighurs, a Muslim minority group, in the western region of the country. Amazon and others have faced criticism for holding discussions with US customs officials about using facial recognition technology to identify immigrants crossing the US / Mexico border. Such applications of AI can have profound human rights implications, which is one reason why some technology executives are calling for clearer regulatory guidance on the technology.

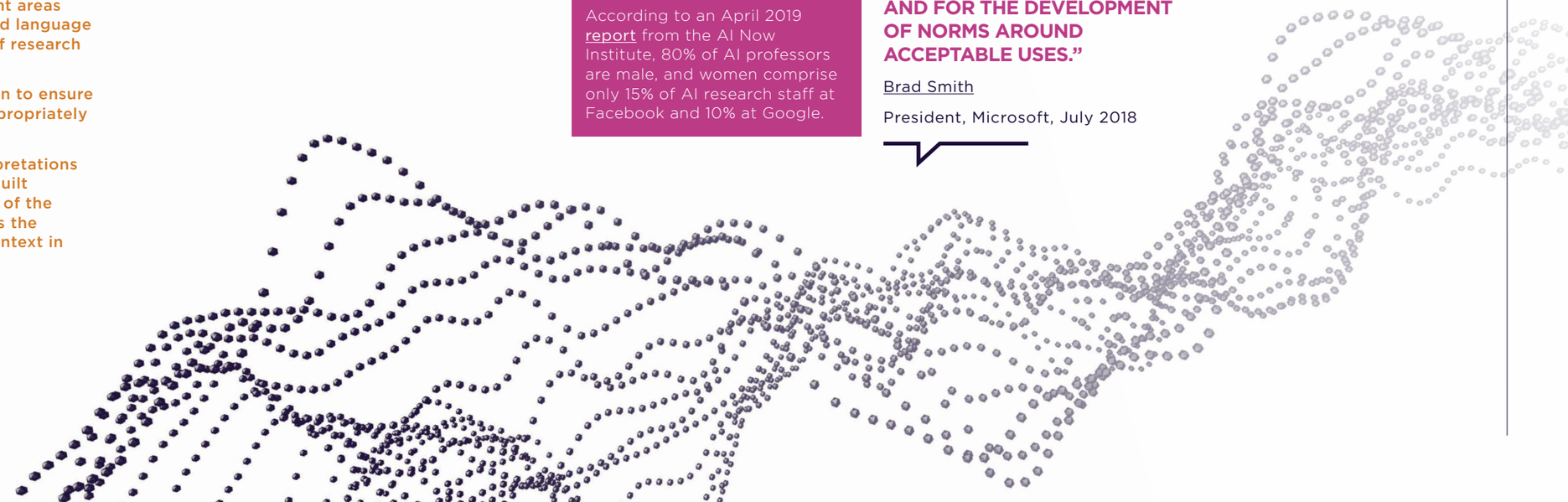
"FACIAL RECOGNITION TECHNOLOGY RAISES ISSUES THAT GO TO THE HEART OF FUNDAMENTAL HUMAN RIGHTS PROTECTIONS LIKE PRIVACY AND FREEDOM OF EXPRESSION. THESE ISSUES HEIGHTEN RESPONSIBILITY FOR TECH COMPANIES THAT CREATE THESE PRODUCTS. IN OUR VIEW, THEY ALSO CALL FOR THOUGHTFUL GOVERNMENT REGULATION AND FOR THE DEVELOPMENT OF NORMS AROUND ACCEPTABLE USES."

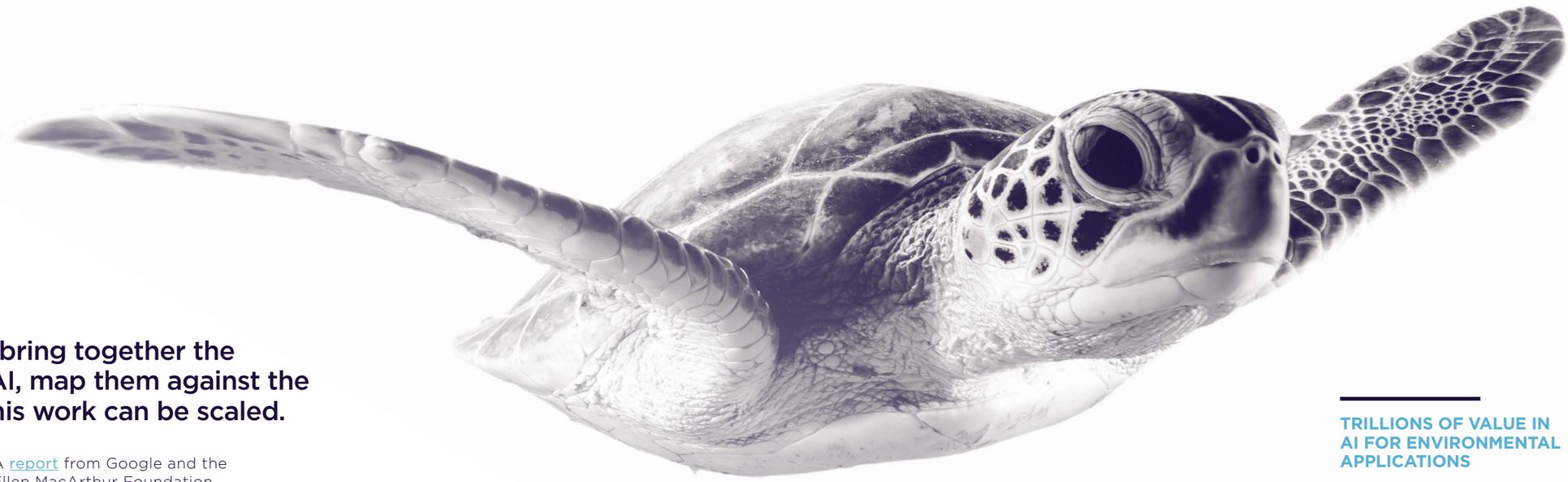
Brad Smith

President, Microsoft, July 2018

Bias also shows up in realms such as financial services, where AI is being used for credit decisions (for purchasing property, starting companies, etc.). While AI allows financial institutions to evaluate more data points, if the algorithms are based on biased data (i.e. people of color have historically been denied credit), then the AI model will be biased.

There are a number of organizations working to address bias in AI, for example AI4All, which aims to increase diversity and inclusion in AI, Humans for AI (similar mission), and the Partnership on AI. Companies such as Google (AI hub in Ghana) and Microsoft (4Afrika) are investing in AI capabilities away from their home markets to ensure that local experiences are reflected in the design of AI.





More work is needed to bring together the current applications of AI, map them against the SDGs, and assess how this work can be scaled.

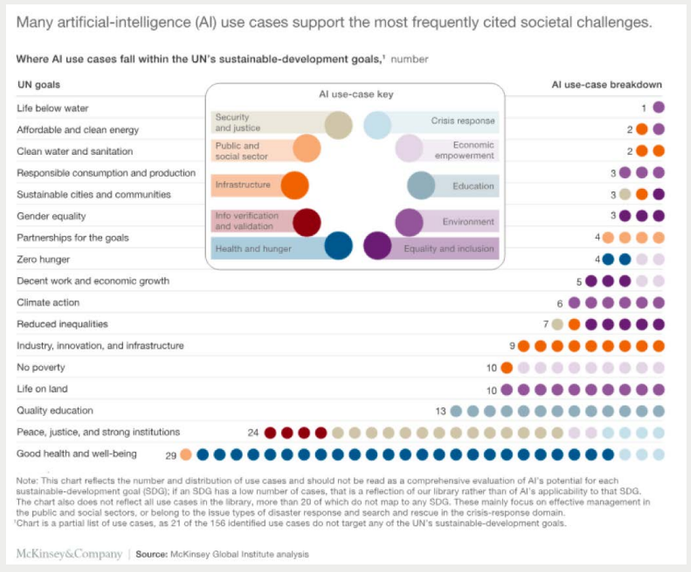
Researchers examining the connection between AI and the SDGs are fortunate to have a growing number of use cases to draw upon.

For their 2018 report *Applying AI for Social Good*, McKinsey developed a library of over 160 instances in which AI is being used for social impact, and created a number of useful frameworks, including the one in Figure 1 that categorizes the use cases by Goal. As illustrated in the chart, there is an imbalance across the SDGs, which is something we discuss below.

A report from PwC and the World Economic Forum, *Fourth Industrial Revolution for the Earth*, is full of use cases for AI and various sustainability topics, primarily environmental. It describes how AI can be deployed across six environmental impact areas – climate change, biodiversity and conservation, healthy oceans, water security, clean air, and weather and disaster resilience – and illustrates each with use cases.

A report from Google and the Ellen MacArthur Foundation has examples specific to AI and the circular economy, while the International Telecommunications Union (ITU) has started an open source repository of AI and SDG use cases. Across these resources and others, there are plenty of examples that illustrate the potential of AI and the SDGs.

FIGURE 1: Mapping AI Use Cases for the SDGs
Source: McKinsey Global Institute, *Applying AI for Social Good*, December 2018



Looking across these reports and others, we are keen to explore a number of areas. For example, looking at the McKinsey use case framework (Figure 1), it appears that AI is more beneficial or useful for certain SDGs – good health and well-being (Goal 3) has 29 use cases, while life below water (Goal 14) has one use case. While this pattern may not hold for a broader sample size, we are keen to understand if AI is inherently better suited for certain SDGs, or if other factors are at work such as capital investment or availability of academic research.

Lastly, we recognize that the field of AI for the SDGs is new and we are eager to see more work on the cumulative benefits of AI and the SDGs. PwC has done valuable work to estimate the potential climate change and economic benefits of applying AI to environmental applications, while Google and the Ellen MacArthur Foundation have quantified the financial and environmental benefits of applying AI, with a circular economy lens, to the food and electronics sectors. Yet, more work is needed on this as AI matures, and the use cases get more significant (many to date are pilot or small scale).

MICROSOFT AI FOR GOOD

Through its AI for Good initiative, 2030Vision partner Microsoft provides technology, resources, and expertise to address environmental, accessibility, and humanitarian challenges around the world. The website includes a variety of use cases, for example Seeing AI, a free app that helps the blind and low vision community access the visual world, and SilvaTerra, a satellite and machine learning system that allows forest managers to take more accurate and efficient surveys of forests. Microsoft also has an online map where users can search over 300 projects.

TRILLIONS OF VALUE IN AI FOR ENVIRONMENTAL APPLICATIONS

According to PwC, by 2030, the use of AI for environmental applications could contribute up to

$5.2tn

to the global economy, and greenhouse gas emissions reductions of

2.4Gt CO2e

AI could also create

38.2million

net new jobs globally.

MAPPING DATA AVAILABILITY ACROSS THE SDGS

Researchers from Sussex offered that a systematic mapping of data availability across the 17 SDGs (and the 230 indicators) would be a beneficial first step in determining how AI can be applied to the SDGs. This would be a significant undertaking, and one that academic institutions would likely be well suited to address.

AI's benefits will flow to the "have's" and not the "have not's" – unless it is designed and deployed deliberately.

As mentioned above, AI is a tool that takes on the biases, intentions, and objectives of its developers – it is not inherently good or bad.

Much of the AI that we see in the world today tends to benefit wealthier individuals and nations. Applications such as predictive search (e.g. Google), facial recognition for mobile device security (e.g. Apple iPhone), and image recognition and computer vision for autonomous vehicles tend to benefit those individuals, countries, or companies with access to technology and the resources to power it.

ACCORDING TO PWC, ALMOST

70%

OF THE GLOBAL ECONOMIC IMPACT FROM AI WILL ACCRUE TO CHINA AND NORTH AMERICA.

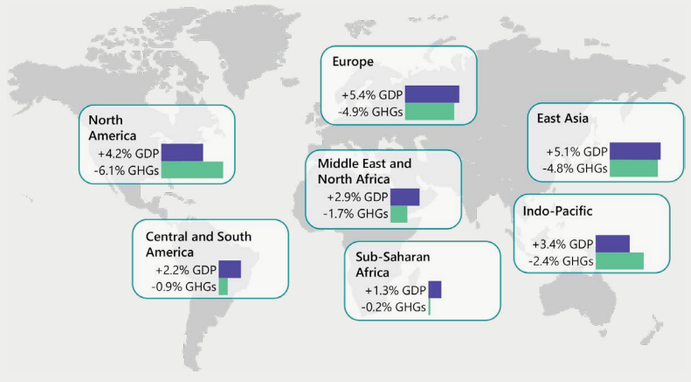
This is not unexpected, given that wealthier nations and actors (e.g. companies and universities) have been first movers on AI. Countries such as the US, China, Germany, the UK, and France are out in front on AI, and the application of AI is thus aimed at challenges these countries face. Such countries also have the enabling environments – computing infrastructure, robust electricity systems, better data sets, skilled workers (for development and use of AI), and so on. Oxford Insights publishes an annual index on AI government readiness for countries members of the Organization for Economic Co-operation and Development (OECD), and the top performing countries are the wealthier ones.

SDGS AND NATIONAL AI STRATEGIES

A number of countries have developed national AI strategies or positions, yet the SDGs are generally not included in such documents. For example, China's plan does not mention the SDGs or individual issues like climate change, though it does have a section on intelligent environmental protection. The UK's AI Sector Deal and the US's executive order on AI similarly do not mention the SDGs. Given the central role that governments will play in delivering the SDGs, it will be important for such AI strategies and plans to connect the dots between AI and the SDGs.

The potential to "make the rich richer" is illustrated in PwC and Microsoft's latest report, *How AI can enable a Sustainable Future* that finds that the economic and greenhouse gas reduction benefits of AI applied to four sectors will be greater in North America, Europe, and China than for the Middle East and North Africa, Sub-Saharan Africa, and Central and South America. Again, this may be in part because the former regions have the enabling environments that allow them to reap the benefits of AI, but more attention to and investment in the latter regions is needed to avoid worsening inequalities.

FIGURE 2: Economic and greenhouse gas reduction of AI
Source: Microsoft & PwC UK, *How AI can enable a Sustainable Future*, April 2019



"TRANSFER LEARNING" AS A MEANS TO DEMOCRATIZE AI

In discussing how to get AI into the places where it is needed most, researchers from the University of Sussex suggested "transfer learning" as one solution. Transfer learning is a machine learning method where a model trained on one problem is reused as the starting point for a model on another problem – thus reducing the development costs. For example, a team from Penn State University has applied transfer learning to train a deep convolutional neural network to identify different types of cassava disease, using a dataset of images taken in the field in Tanzania. The best model achieved an overall accuracy of 93% for data not used in the training process.

AI will result in economic dislocation – we must manage it.

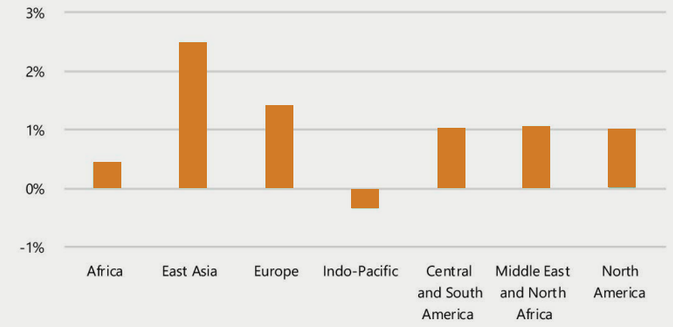
PwC and Microsoft also found that AI applied to four sectors – agriculture, water, energy and transport – will result in a net gain of up to 38 million jobs globally.

However, these added jobs will be created outside of the four sectors studied (these four sectors will actually experience a decline in jobs). We presume the added jobs will come in higher-value areas, for example AI programmers for autonomous vehicles, while jobs such as taxi drivers will diminish. Higher skilled jobs such as technicians and managers will increase, while agricultural and unskilled jobs will decline.

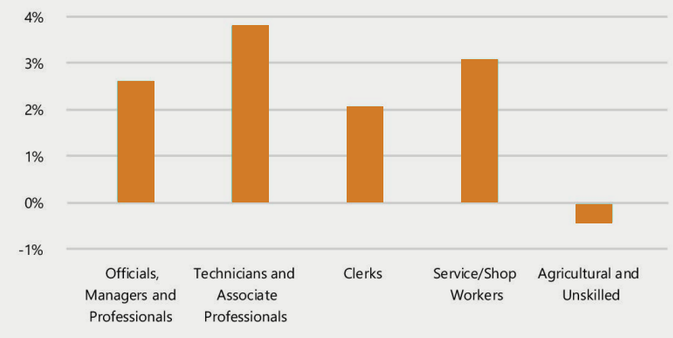
Much has been written about the potential economic dislocation and job loss to which AI could contribute, particularly to jobs that are based on routine tasks. For example, the Brookings Institute found that 25% of jobs in the US face high exposure to automation in the coming decades. McKinsey found that roughly half of the activities people are paid to do in the global workforce could be automated by adapting currently available technology. These organizations and many others have written about this potential dislocation and possible ways to address it.

FIGURE 3: AI Impact on Employment by Region and Skill Level
Source: Microsoft & PwC UK, *How AI can enable a Sustainable Future*, April 2019

Impact by region



Impact by skill level



AUTOMATION'S IMPACT ON EMPLOYMENT IN SOUTHEAST ASIA

According to a 2016 ILO report, more than half of workers in five Southeast Asian nations – Cambodia, Indonesia, the Philippines, Thailand, and Vietnam – are at risk of losing their jobs due to automation in the next two decades, with those in the garment sector particularly vulnerable (many of whom are female).

The Brookings Institute highlighted the potential for AI to exacerbate geographic divides, with more economic gains and influence accruing to digitally-oriented metropolitan areas compared with lower tech locales. With lower- and middle-wage jobs such as some types of manufacturing being replaced with automation (enabled by AI), regions risk falling behind. This in turn could increase the degree of political polarization we are seeing around the world, that is reducing trust in institutions, and represents an obstacle to achieving the shared vision of the SDGs by 2030.

INVESTING IN AI STARTUPS OUTSIDE OF MAJOR CITIES

The Rise of the Rest® Seed Fund is a $150 million fund that invests in startups (including AI) outside of large US coastal cities like New York San Francisco with the goal of catalyzing economic growth in these regions.

The need to anticipate and manage trade-offs and unintended consequences in the SDGs.

While AI can benefit the SDGs, it can also negate progress.

For example, while AI can help make solar and wind power more efficient and productive, it brings the same supply benefits to oil and gas production. AI can make it easier to identify and map oil and gas reserves, thus lowering the cost to access them. The Brookings Institution suggests that AI might benefit oil and gas development more so than renewable energy.

EASIER FOSSIL FUEL DEVELOPMENT THROUGH AI

Through AI and other digital technology, ExxonMobil projects that it will generate billions of dollars in value over the next decade and expand production by as much as 50,000 oil-equivalent barrels a day by 2025 in the Permian Basin, USA.

Similar unintended consequences might arise as AI enables the deployment of autonomous vehicles, potentially exacerbating congestion and crowding out investment in public transportation. AI applied to farming techniques could allow big agriculture to get even bigger at the expense of smallholder farmers. And while AI might allow companies to better manage supply chains that are ever expanding geographically, this may run counter to the shorter value chains that are needed to deliver responsible consumption and production (Goal 12).

In the absence of an enabling environment that is pro-SDGs – including policies, trade rules, and financial mechanisms – AI will be used for whatever outcome its designers and users have in mind. In the example above of ExxonMobil using AI and other technology to drill for more oil and gas, if we are to achieve Goal 13 and the targets set forth in the Paris Agreement, we need robust policies that limit how much fossil fuels we combust – regardless of how easily AI might allow us to access them. We also need more AI developers and users to be aware of the imperative to meet the SDGs so that they are a starting point for the creation of new AI, not issues that get addressed after the fact.

The challenges and enablers are multiple – and solvable.

Other authors have articulated the key challenges and enablers for AI including:

ACCESS TO HIGH QUALITY DATA

AI is fundamentally dependent on high quality data, for example image recognition that helps identify pest damage in crops is reliant on having clear images of the damage. The image recognition that supports autonomous vehicles is based on the technology being fed thousands of images that enable the car to distinguish between objects. Good data may not exist for certain SDGs, thus limiting the capabilities of AI, and concerns about security and privacy may limit the extent to which data can be collected.

IMPROVING ACCESS TO DATA FOR THE SDGS

The Global Partnership for Sustainable Development Data is an independent, multi-stakeholder network that aims to improve data access and quality in support of advancing sustainable development. For example, the Global Partnership recently announced a collaborative initiative with the Government of Kenya and other partners to mine two decades of satellite imagery for insights on farming strategies to help cope with climate stresses.

DATA PRIVACY

While AI is fueled by data, there is the critical need to protect consumer privacy – particularly around sensitive topics such as health and finances. Interestingly, well-intentioned government privacy regulations could hinder the development of AI. For example, the Brookings Institution noted that the European Union General Data Protection Regulation (GDPR) prohibits the transfer of personal data to countries with inadequate protections, and generally limits how data can be used. This limits the potential for this data to be used to train AI.

"THERE'S GROWING RECOGNITION OF A PARADOX. IF WE FOCUS ONLY ON PRIVACY, THEN WE DON'T INNOVATE AND FIND WAYS TO USE THE DATA. YOU HAVE TO BALANCE THE RISK OF MISUSE AGAINST THE RISK OF MISSED USE. THE OPPORTUNITY COST OF NOT USING THIS DATA FOR THE PUBLIC GOOD IS REALLY QUITE HIGH. WE ARE INCURRING IT EVERY DAY, AND EVERYWHERE, LARGELY UNBEKNOWNST TO ANYONE."

Robert Kirkpatrick

Director, UN Global Pulse

EXPLAINABILITY

The ability to clearly convey what, why, and how AI makes decisions and achieves its objectives – opening up the "black box" – is essential to building trust with the public. Such transparency is particularly critical in matters of human health and well-being, and in other areas such as criminal justice. Without this trust and acceptance, the application of AI across the SDGs will be hindered. The AI community might take lessons from other technologies that are beneficial yet have faced public opposition (e.g. genetically modified foods).

INFRASTRUCTURE AND RELATED TECHNOLOGY

The computational needs for AI, and the needed storage for the underlying data, require robust computing and electricity infrastructure. Also, AI typically works in concert with other digital technology such as sensors and cameras. As mentioned above, countries that would benefit most from the application of AI to address the SDGs may not have the necessary infrastructure and supporting technology, meaning investment will be needed in these areas.

AI IN THE PALM OF YOUR HAND

Google is working to embed machine-learning models directly on remote devices. This has the potential to reduce reliance on central data centers, making the technology more useful in rural regions, and to protect data privacy.

ELEVATING SKILLS IN AI DEVELOPMENT AND USE

Training significantly more people in the development and use of AI is essential for its further evolution. We need to ensure we are training and supporting people to apply AI to the SDGs, as these fields are less lucrative than more commercially-oriented sectors (e.g. defense and medicine). We will also need to ensure that we train AI specialists in the regions in most need of support to address the SDGs.

INVESTING IN AI IN AFRICA

In May, Microsoft announced it would invest $100 million in its Africa Development Centres and hire 500 full-time developers by 2023 to work on AI, machine learning, and mixed reality innovation.

3

AI AND THE SUSTAINABLE DEVELOPMENT GOALS:

THE SECTORAL VIEW

A range of organizations have explored how AI can drive sustainable outcomes in different industries.

For example, PwC examined the greenhouse gas reduction benefits of AI in energy, transport, agriculture, and water, while Google and the Ellen MacArthur Foundation looked at how AI can enable the circular economy in food and agriculture and electronics.

Given the growing interest in companies using the SDGs as the basis for their sustainability efforts, and the proliferation of AI for a growing universe of commercial purposes, we were keen to explore how companies are linking the two. In our first report, we looked broadly at the role of digital technology and the SDGs. In this report, we specifically look at how two sectors – food and agriculture and healthcare – are starting to use AI to address the SDGs. Our intent is to work with our partners to explore other sectors in future research.

FOOD AND AGRICULTURE

FIGURE 4: Food and Agriculture Connections to the SDGs

Building a food system that can meet the nutritional needs of nine billion people by 2050, while staying within the carrying capacity of the planet, will take an enormous effort. Such a food system is needed to deliver a number of SDGs, as Figure 4 illustrates.

Given these interconnected challenges, AI promises to help make food production and consumption more efficient and sustainable. We offer a few examples below.

PRECISION / SMART AGRICULTURE

AI is increasingly being deployed with other digital technology to enable more efficient food production (i.e. more food with fewer inputs). AI helps farmers better predict weather patterns, adjust planting based on supply and demand, fight pests, and optimize inputs – water, fertilizer, pesticides, etc. AI can be used to analyze chemical and biological systems, and increase efficiency in plant breeding, biotechnology, and agrochemical discovery. With the growing amount of data being generated on farms, AI will be essential for farmers to utilize this data to make better decisions.

ONE ESTIMATE IS THAT BY 2050, THE TYPICAL FARM WILL CREATE

4.1million

DATA POINTS EVERY DAY.

DEPLOYING AI TO COMBAT CROP PESTS AND DISEASE

According to the FAO, between 20 to 40% of crop yields are destroyed each year by pests, and this could worsen due to climate change. A number of organizations are using AI-based systems to fight pests, including Farmwave, which uses machine learning to help farmers identify pest damage and disease, and PlantVillage which has developed Nuru, an AI platform that allows African farmers to identify disease in cassava, maize, potatoes, and wheat.

EMPOWERING FARMERS THROUGH AI

IBM's Watson Decision Platform for Agriculture leverages AI to help farmers make more informed choices about their crops. For example, one application uses big data and machine learning to predict crop yields two to three months out with limited data and computing power requirements. Another allows farmers to model the probability of disease and pests. Both of these applications help farmers improve profitability and a range of sustainability factors (e.g. soil health). In May, IBM announced an expansion of the platform, which now includes models for corn, soy, sorghum, potato, and more.

SUPPLY CHAIN OPTIMIZATION

AI brings efficiencies to global food supply chains, and enables better forecasting of consumer and retailer demand via historical and real-time data (which ultimately means less food waste). AI can also be used to map global food supply chains and help optimize them to source and consume ingredients locally where appropriate, and to process food as close as possible to where it is grown and consumed.

BRINGING TRANSPARENCY AND SECURITY TO FOOD SUPPLY CHAINS

ImpactVision has developed a platform that provides real-time insights into the quality and characteristics of food using image recognition and predictive learning. It uses hyperspectral sensors to take images of foods and uses classification software and algorithms to evaluate different characteristics (e.g. tenderness of meat, existence of foreign objects).

REDUCING FOOD WASTE

In our first report, we noted that roughly one third of all food is wasted, representing 8% of global greenhouse gas emissions and up to $405 billion in economic losses each year. AI can be deployed across the food and agriculture value chain to combat food waste, from reducing crop loss at the farm level, to improving storage, distribution, and processing of fresh food, to reducing food waste at retail and with consumers. Google and the Ellen MacArthur Foundation found that designing out food waste could deliver up to $127 billion of economic value in 2030.

IKEA REDUCING FOOD WASTE WITH AI

Winnow Vision deploys AI and computer vision to help restaurants and food service companies to better understand the volume and economic value of food waste. The camera sits above a waste bin and through image recognition, companies are made aware of the value of food waste. WinnowVision has been installed in over 20 IKEA stores across the UK and Ireland. This supports IKEA's goal to reduce food waste by 50% by 2020.

NEW PRODUCT DEVELOPMENT

AI is being deployed in the development of more sustainable products, for example alternative protein companies such as NotCo and Impossible Foods are using AI to identify the right combination of ingredients that mimic animal products.

The use of AI in food and agriculture is still in its early days, but holds tremendous potential for delivering commercial benefits and addressing the SDGs. To realize these aims, a number of barriers need to be overcome:

- **While larger food and agricultural companies are starting to deploy AI, we need to improve the understanding of AI and its benefits and risks across the value chain, especially with small and mid-sized companies and farmers. We need to do this in a way that respects the experiences and values of these small and mid-sized players.**
- **In agricultural settings, data availability and quality may be poor, as may be the necessary computing infrastructure to store data and run AI algorithms. As discussed above, there are promising new approaches that could overcome this barrier, for example Google's work on building AI capabilities into mobile devices.**
- **Realizing AI's full potential will require players from across the food and agriculture value chain to share data. This will be challenge for a host of reasons including competition and mistrust of "big ag." We will need to develop the necessary legal frameworks that allow for this, and consider approaches such as making SDG-beneficial data public goods (a topic raised by the Sussex researchers).**

PARTNERING TO SOLVE THE AGRICULTURAL DATA GAP

Noting that many governments, food companies, and farmers have incomplete agricultural information as they make policy and investment decisions, the Global Partnership for Sustainable Development Data is currently developing the 50 X 2030 Initiative, which aims to significantly improve data quality and availability by conducting regular surveys of farming households in 50 low and lower income countries by 2030 and sharing the data widely.

HEALTHCARE

FIGURE 5: Healthcare Connections to the SDGs

Delivering Goal 3 – ensuring healthy lives and promoting well-being for all at all ages – will require a healthcare system that is accessible, effective, and affordable. Good health and well-being are connected to a range of other SDGs, as Figure 5 illustrates.

As discussed in section 2, AI is being deployed in a growing number of ways in healthcare, often with positive implications for the SDGs.

DIAGNOSING AND TREATING DISEASE

AI is being used to augment, and in some cases improve, the ability of healthcare professionals to diagnose and treat diseases such as cancer and glaucoma. Many of these cases entail using machine learning to diagnose disease, for example Google's work on detecting lung cancer. While human involvement in critical healthcare decisions will likely always be necessary, AI brings efficiency and allows doctors to spend more time on higher value activities. AI could be particularly beneficial in regions that lack health care professionals for medical tasks that machines might perform as well or better than humans (e.g. reading CT scans).

IMPROVING FETAL HEALTH WITH AI

GE's AI-based SonoCNS tool allows gynecologists to take better measurements of the fetal brain and detect complications earlier. It also enables gynecologists to obviate mundane tasks and spend more time focusing on patients and less on working ultrasound machines.

MODELLING AND PREDICTING EPIDEMICS AND CHRONIC DISEASES

Through AI, it is possible to monitor patient populations and medical data to predict outbreaks of infectious diseases and public health emergencies. Through modelling cause-and-effect relationships, this can allow public health agencies to investigate and mitigate in real-time the progression of epidemics. AI can also be used to tackle more chronic diseases, for example using big data and satellite images to target regions where people are most vulnerable to dying from diseases or health problems.

MONITORING DISEASE OUTBREAKS

HealthMap is a website and mobile app that collates various data sources to monitor disease outbreaks and emerging public health threats. The site delivers real-time intelligence on a broad range of emerging infectious diseases for various audiences including local health departments, governments, and international travelers.

IMPROVING THE PROVISION OF PRIMARY HEALTHCARE SERVICES

Through advances in mobile connectivity, digitized health systems, and resource allocation data, AI is increasingly being used to optimize the allocation of basic health services and the organization of administrative tasks. For example, AI planning can improve the scheduling of health visitors, while natural language processing can be used to simplify clinical documentation and enable voice-to-text dictation. This can be valuable in developed countries where home care is increasing as a result of an ageing population, as well as in developing countries, where healthcare services may be delivered door-to-door.

ENHANCING MEDICAL RESEARCH

AI, and in particular machine learning, can lead to a drastic reduction of costs and time needed for drug discovery and development, through rapid analysis of health data; it can also support the analysis of drug efficiency in different contexts. AI is also used to research the diseases themselves – to find information in unstructured medical literature to support hypotheses, helping in the discovery of new medical insights.

AI BRINGS POWER AND EFFICIENCY TO DRUG DISCOVERY

A number of companies have developed AI solutions for drug discovery. For example, PrecisionLife has developed a platform that enables faster and deeper analysis of large genomic, clinical, and phenotypic datasets. This allows researchers to identify and validate multiple novel pathways, targets, and drug compounds involved in disease in weeks not years using clinical population datasets. This provides enormous productivity and innovation gain for biopharmaceutical research.

The successful application of AI to the health sector depends on many factors:

- **High-quality datasets can be difficult and time-consuming to collect, especially in developing countries. Yet they are necessary to train machine-learning algorithms to identify risk factors, diagnose diseases, and automate planning and scheduling.**
- **AI applications depend on the availability of strong electronic health record systems, which is a challenge considering the diversity of health records and languages in the world. For example, it is a challenge to adapt natural language processing systems in places where health records are handwritten in local languages.**
- **While internet connectivity is improving throughout the world, many regions lack access to the bandwidth necessary to upload large datasets to the cloud. Some applications, including mHealth tools, have the ability to work offline and sync with remote databases when the connection is sufficient. In addition, storing data locally requires strong local IT infrastructure.**
- **Improved diagnosis does not guarantee access to quality treatment options, especially in hard-to-reach areas: remote diagnostics applications may help to identify diseases, but the focus should also be on how to deliver treatment following the confirmation of disease.**

4

CALL TO ACTION:

MAXIMIZING THE POTENTIAL OF AI FOR THE SDGS

Given the ambition, complexity, and urgency of the SDGs, we need unprecedented collaboration and action from businesses, governments, academia, multilateral institutions, NGOs, and others to engage more with these challenges to deliver the world we want by 2030.

In itself, AI is a neutral tool that reflects the intentions, experiences, and biases of the people who design and use it. Given the moral and commercial imperative, the SDGs must be central to how AI is designed from the start. Each stakeholder group brings unique perspectives and capabilities to this collaboration.

"WHAT'S CLEAR IS THAT NO ONE NATION, NO ONE ORGANIZATION, NO ONE COMPANY, AND NO ONE COMMUNITY CAN MEET THESE CHALLENGES ALONE. THE PATH TO A TRANSFORMATIVE BUT ALSO A SAFE, TRUSTED AND INCLUSIVE AI WILL REQUIRE UNPRECEDENTED COLLABORATION BETWEEN GOVERNMENT, INDUSTRY, ACADEMIA AND CIVIL SOCIETY."

Houlin Zhao

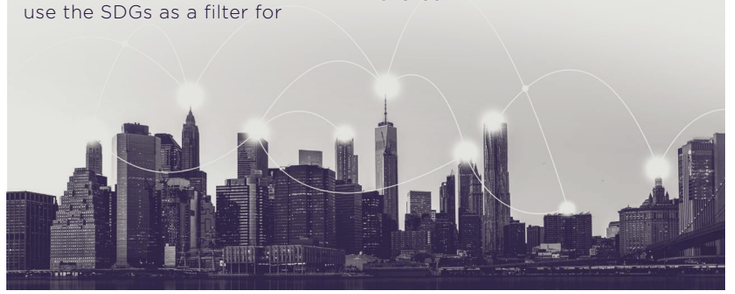
Secretary-General of International Telecommunications Union (ITU)

BUSINESSES, AND OTHER DEVELOPERS AND USERS

Although a growing number of companies have committed to addressing the SDGs, few to date are comprehensively looking across the SDGs to determine how AI can help advance progress towards them.

Businesses and other organizations **using** AI must engage more in collaborative multi-stakeholder efforts to identify opportunities to deploy AI to address the SDGs.

Meanwhile, organizations **developing** AI solutions should use the SDGs as a filter for assessing the potential benefits and risks of AI applications – both striving to amplify the benefits (e.g. improving renewable energy systems) and minimize the risks (e.g. less human surveillance). Organizations developing AI should also consider how models can be applied to different contexts (e.g. less developed nations) or challenges (e.g. applying pre-trained AI models to new data sets). These efforts would help stakeholders with a good understanding of particular issues but with access to fewer resources (e.g. NGOs) ensure the benefits of AI are more equitably shared.



ACADEMIA

Given the wide-ranging nature of the SDGs, academic institutions are well placed to bring researchers from across disciplines to explore how AI can be used to address the SDGs, and the interconnections across them.

Universities could also play a critical role in educating future generations of AI developers and users. Integrating the SDGs into curricula could shape how well the SDGs are addressed by AI as it evolves. Academia may also have the ability to explore AI use cases that are further out in time, or that are less commercial in nature.

MULTILATERAL INSTITUTIONS

Organizations such as the UN, Organization for Economic Co-operation and Development (OECD), and development banks can play a unique role given their institutional missions that address SDG-related topics and their frequent access to data on sustainable development issues.

Such organizations may be well placed to be central repositories for the SDG-related data that AI developers and users need.

GOVERNMENTS AND POLICY MAKERS

For AI to be trusted by the public, and to help scale efforts for achieving the SDGs, governments must set the right policies for AI's accepted development and use.

Tools such as image recognition can advance progress towards the SDGs (e.g. Goal 2 Zero Hunger, by improving food security) and impede it (e.g. discriminating against certain demographics). They can also help set rules around data governance, including for example, ownership and access. Lastly, national governments are the signatories to the SDGs, and some have developed national AI strategies. The SDGs should be explicitly addressed in such strategies.

WE WILL NEED UNPRECEDENTED COLLABORATION TO LEVERAGE THE POWER OF AI TO HELP ACHIEVE THE SDGS. 2030VISION IS PLEASED TO SHARE OUR NEW PAPER AS A MEANS TO HIGHLIGHT THE IMPERATIVES AND OPPORTUNITIES FOR AI TO SUPPORT A MORE PROSPEROUS AND SUSTAINABLE FUTURE

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2030Vision is a partnership that connects businesses, NGOs and governments with the technology and expertise they need to realize the Goals.

Founded and chaired by Arm, it is a partnership with UN Global Compact, UNICEF, The New York Academy of Sciences, SustainAbility, Fauna & Flora International, Centre for Global Equality, Cambridge Judge Business School, British Council and Be He@lthy Be Mobile and Project Everyone.

Our ambition is to transform the use of technology so that all people can live their lives to their full potential by 2030.

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