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AI for Sustainability:

An overview of AI and the SDGs to contribute to the European policy-making

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List of Acronyms

AI: Artificial Intelligence

SDG(s): Sustainable Development Goal(s)

UN: United Nations (Organization)

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Introduction

Artificial Intelligence (AI), on the one hand, and Sustainable Development, on the other hand, are two subjects in which I have a definite interest, but, above all, that are in my opinion highly relevant in our current global context. I was introduced to the subject of Sustainable Development during my pre-university studies in advanced economics and social sciences, where I could become aware of its importance. Artificial Intelligence, on the other hand, is a fascinating technology with great potential, which aspires to greatly affect, and is already affecting, the different social, economic and environmental aspects of our world - which are the main areas of concern of Sustainable Development – and whose balance and virtuous coexistence is, in theory, the key to the sustainability of the world in which we live. I had the chance to approach AI applications during student projects and, later, in the professional world, within the multinational software company SAP, which possesses its own proprietary artificial intelligence technologies. It is in this spirit that I am seeking to confront the almost euphoric, overpowering technological trend that is AI, in the face of our duty to develop and, above all, to preserve our world in a sustainable and urgent manner.

This report aims to reflect on the place of Artificial Intelligence within the framework of a complex global contemporary world in the context of a Sustainable Development effort, by portraying AI in its plurality of nature and implications with the understanding of a multi-societal world concerned by socio-economical-environmental factors and issues, and by comparing it with the Sustainable Development Goals (SDGs) of the United Nations (UN).

As a member of the *European AI Alliance,* this work will attempt to produce a relatively up-to-date, simplified yet qualitative overview to enable the re-establishment of a well-founded basis for the European and global dialogue on the exploited and exploitable potential of AI for Sustainable Development.

To do so, this report is based on scientific research, intergovernmental resources, and

further references of interest, as well as interviews with actors from the professional and humanitarian world on the application of AI in real contexts related to sustainable development.

It is through this paper that we will attempt to study the hypothesis of an AI that is (un)fortunately not providential, but presents an unparalleled opportunity for humanity to address the problems of our societies through the medium of the different state, intergovernmental, professional and humanitarian players, and the resulting policies and initiatives.

I. Artificial intelligence

A. The definition of Artificial Intelligence

Defining what Artificial Intelligence is is not easy. Although here we will limit ourselves to the object, as well as to the modern associated scientific discipline, there is no consensus on a universal and definitive definition of AI. The first modern name for the discipline and entity of AI was given to John McCarthy in 1956, with the other co-founders of the discipline. [1] For its founders, it was defined as based on "the conjecture that every aspect of learning or any other

[1] J. McCarthy, M. L. Minsky, N. Rochester & C. E. Shannon, « A proposal for the Dartmouth summer research project on artificial intelligence », Computer Based Learning Unit, Université de Leeds, 1955. http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html

feature of intelligence can in principle be so precisely described that a machine can be made to simulate it". Much less optimistic or straightforward, it would be defined more recently, according to the Encyclopædia Britannica, as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings". [2] In a similar vein, Emerj Artificial Intelligence Research*, a* renowned consulting firm specializing in AI, one of the entities contacted in the course of the research for this report (see Appendix 5), attempted to provide a lively and inclusive definition of AI by analyzing the definitional attempts of various experts and then synthesizing them to define AI as " an entity (or collective set of cooperative entities), able to receive inputs from the environment, interpret and learn from such inputs, and exhibit related and flexible behaviors and actions that help the entity achieve a particular goal or objective over a period of time". [3]

Nowadays, AI is primarily defined by concepts and their applications. Although the concept of AI is too complex to define the relationships between its various concepts, technologies and disciplines, it is accepted that they could be modeled as subsets of it.[4] One of the fundamental concepts of AI, and perhaps the best known, is "machine learning", a term that we owe to Arthur Samuel, in 1959, famous in particular for his Samuel Checkers-playing Program, one of the first machine-learning programs in the world and, as such, a very early demonstration of machine learning. The latter which

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[2] B.J. Copeland, Artificial intelligence, Encyclopædia Britannica, 2019. https://www.britannica.com/technology/artificial-intelligence.

[3] Faggella, Daniel. “What Is Artificial Intelligence? An Informed Definition”. (2018). Emerj Artificial Intelligence Research. https://emerj.com/ai-glossary-terms/what-is-artificial-intelligence-an-informed-definition.

[4] Pamela McCorduck (2004, pp. 424) writes of "the rough shattering of AI in subfields—vision, natural language, decision theory, genetic algorithms, robotics ... and these with own sub-subfield—that would hardly have anything to say to each other."

is, for Samuel, the field of study and, indeed, the ability itself, given to computers or machines, to learn without being explicitly programmed.[5] Tom M. Mitchell, a leading researcher in the field of AI and machine learning, attempted to schematically define the algorithmic operation of the machine learning where "a computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E." [6] This definition by the explanation of the operational model of the algorithms intrinsic to this learning, machine learning, allows a better understanding of the logic of this complex concept. Vulgarly, it is a fundamental subset of AI, in terms of discipline and application, where the machine "learns" by itself from its experience. There are three main categories, or paradigms of machine learning: supervised learning, where defined (so-called "labelled") data and examples are submitted to carry out the task; unsupervised learning, where the task is carried out autonomously and usually allows for the identification of structures and trends; and finally, reinforcement learning, where actions are learned through the experiences themselves, tending towards the quantitative optimization of the "rewards" obtained in the task environment. [7]

Similarly, another concept that is increasingly emphasized today is "deep learning", a concept introduced in 1986 by Rina Dechter.[8] Deep learning is a specific class of machine learning methodologies based on artificial “neural networks, computer systems inspired by the neural logic of a brain. [9] Going further

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[5] Samuel, Arthur L. « Some studies in machine learning using the game of Checkers ». Ibm Journal of Research and Development, 1959, 71–105.
[6] Mitchell, T. (1997). *Machine Learning*. McGraw Hill. p. 2.
[7] Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar (2012) Foundations of Machine Learning, The MIT Press
[8] Rina Dechter (1986). Learning while searching in constraint-satisfaction problems. University of California, Computer Science Department, Cognitive Systems Laboratory
[9] Schmidhuber, J. (2015). "Deep Learning in Neural Networks: An Overview". Neural Networks. 61: 85–117

as "basic" machine learning, deep learning uses several progressive, hierarchical algorithmic layers to extract more complex properties from raw data. All these methods, more particularly, deep learning, are used for various end applications such as facial recognition systems or automatic speech recognition, vulgarly referred as "voice recognition". [10]

Finally, we could distinguish two “types” of AI. First the narrow AI, “weak AI” or applied AI. It is the AI that is being actively studied and used today, an AI confined to one or even a few specific tasks with controlled environment and data. Then would come the artificial general intelligence (AGI), or “strong AI”. The term AGI was already used in 1997 by Mark Gubrud, an American physicist, in a military context. [11] It grew in popularity around the year 2002 thanks to Ben Goertzel and Cassio Pennachin, researchers of modern AI, assisted by Shane Legg. Although not unanimously established, AGI is the theory of an AI whose capabilities are no longer limited to defined tasks, environments or thresholds. Consequently, AI would have the same "intellectual" capacities, mainly cognitive, as a human in terms of plurality, complexity and performance, insofar as a quantitative and qualitative measure is observable. It would then be, compared to the human being, literally a form of artificial "intelligence". [12]

B. The Glory of Artificial Intelligence

Numerous AI applications have proven its impressive potential. Among the many contexts of use, games and sports are a point of

[10] Deng, L.; Yu, D. (2014). "Deep Learning: Methods and Applications". Foundations and Trends in Signal Processing

[11] Gubrud, Mark (November 1997), "Nanotechnology and International Security", Fifth Foresight Conference on Molecular Nanotechnology

[12] Goertzel, Ben; Pennachin, Cassio, eds. (2006), Artificial General Intelligence, Springer

ideal reference for evaluating AI performance and progress. Indeed, many have a large base of professional and amateur players and a well-established competitive ranking system. A striking example is that of board games, essentially dependent on cognitive faculties, and the computer program AlphaGo and its versions, an AI developed by the company DeepMind (Alphabet group, owner of the company Google). In October 2015, AlphaGo becomes the first computer-based Go game program to beat a professional human Go player, here the reigning European champion, on a non-reduced board and handicap-free game.[13] In 2017, his successor, AlphaGo Master, defeated the number one ranked player a global one at the time.[14] In terms of progress, the next version, AlphaGo Zero, created without the use of human game data, surpassed the original AlphaGo version after only three days of reinforcement learning, equaled the AlphaGo Master version after twenty-one days, and surpassed all previous versions after forty days.[15] The next, and current, version, AlphaZero surpasses all that has been accomplished so far by mastering not only the game of Go, but also the game of chess and shōgi ("Japanese Chess"). AlphaZero was trained only against itself, without any game database (in the case of chess) other than the rules of the game. After thirty-four hours, AlphaZero surpassed its predecessor AlphaGo Zero in the game of Go. After nine hours of training, he triumphed over Stockfish, the software dominating the world of chess. And after only two hours of training, he dominated elmo, one of the leading software at shōgi. This shook up the world of board games perhaps like never before.[16] In the same perspective of evaluating the potential of AI through competition in strategy games, contrary to the perfect-knowledge games seen above - where each player is perfectly informed of events

[13] "Google achieves AI 'breakthrough' by beating Go champion". BBC News. 27 janvier 2016
[14] “World's best Go player flummoxed by Google’s ‘godlike’ AlphaGo AI”. The Guardian. 23 mai 2017
[15] Silver, David et al. (19 October 2017). "Mastering the game of Go without human knowledge". Nature. 550 (7676): 354–359.
[16] Silver, David et al. (7 December 2018). "A general reinforcement learning algorithm that masters chess, shogi, and go through self-play". Science.

having occurred previously, including the game initialization event - imperfect knowledge games pose new challenges for AI. Nevertheless, it was in 2017 that the AI, Libratus, developed by the Carnegie-Mellon University, marked one of the milestones of AI prowess by decisively defeating four of the best professional players of no-limit Texas hold 'em poker card game. [17] Andrew Ng, prominent expert in AI, summarizes the certain potential of Artificial Intelligence in his suggestion of a "highly imperfect rule of thumb" where "almost anything a typical human can do with less than one second of mental thought, we can probably now or in the near future automate using AI".

In the 21st century, AI techniques have experienced a resurgence following advances in the computing power of computers, big data and theoretical advances in the field. This is what led to the prowess presented earlier. Moreover, AI techniques have become an essential part of the technology industry, helping to solve many complex problems in computer science, software engineering and in operations research.[18] AI also presents the interesting case of a paradox of recognition and notoriety. Indeed, it seems to appear as a technological but also media "boom" even today, although it has already been omnipresent since the second half of the 2000s. In fact, AI had already known alternation between active periods, or “booms”, and loss of interest, ever since the 1950s. And since the 1990s, AI technology, although different from current technology, has been widely used as part of large systems, but these successes are rarely attributed to it.[19] This could be due to the fact that many AI applications are not perceived as such. Many of these advanced applications have integrated more general applications or packages, often without being called "AI". One would then observe this phenomenon of a propensity to omit the nature of an AI when its application becomes more or less generalized or its

[17] Brown, Noam; Sandholm, Tuomas (26 January 2018). "Superhuman AI for heads-up no-limit poker: Libratus beats top professionals". Science. pp. 418–424.
[18] Clark, Jack (8 December 2015). "Why 2015 Was a Breakthrough Year in Artificial Intelligence". Bloomberg News.
[19] National Research Council (1999), "Developments in Artificial Intelligence", Funding a Revolution: Government Support for Computing Research, National Academy Press.

perceived added value is reduced.[20] This is, however, different, in my view, from the "AI effect", where the performance of an AI application is minimized or even discredited under the pretext that it wouldn' t be real "intelligence". [21] And yet again, we are indeed witnessing a substantial rise in AI in such a context. Its interest has been growing steadily over the last ten years. This is, for instance, observable by analyzing the evolution of web search queries, which can reflect, albeit imperfectly, a certain trend in the public interest. Indeed, with 30% (2010), then 48% (2017) of the world's population being Internet users, this can potentially represents a relatively representative sample.[22] I therefore analyzed the search queries on Google, the world's most popular search engine, for the keyword "Artificial Intelligence" in the five most used languages on the Internet since 2009.[23] [24] We can then witness a steady and growing interest in the topic for the last ten years (see Annex 1). In the press and media, since 2013, interest in AI has been growing. But above all, its reception, mostly neutral, is becoming increasingly positive. As far as the political sphere is concerned, AI is becoming an increasingly central topic, especially in the Anglosphere. AI is rapidly becoming an increasingly important issue for many players around the world. The number of scientific publications dealing with AI increased eightfold between 1996 and 2017, i.e. in less than twenty years. In ten years, between 2004 and 2014, the number of patents related to AI increases fivefold. Within this trend, however, private capital investment in the industry remains the most important and, above all, the fastest growing activity compared to academic publishing and education. Government actors quickly took initiatives on the topic of AI. Since 2014, the Government of the People's Republic of China (China) has been

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[20] Kaplan, Andreas; Haenlein, Michael (2019). "Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence". Business Horizons. 62: 15–25.
[21] Haenlein, Michael; Kaplan, Andreas (2019). "A Brief History of Artificial Intelligence: On the Past, Present, and Future of Artificial Intelligence". California Management Review.
[22] "ICT Facts and Figures 2005, 2010, 2017". Telecommunication Development Bureau, International Telecommunication Union (ITU).
[23] "Google.com Traffic, Demographics and Competitors - Alexa". www.alexa.com.
[24] "Number of Internet Users by Language", Internet World Stats, Miniwatts Marketing Group, 30 April 2019.

launching a series of national initiatives with the aim of creating a $14.7 billion market for AI in China by 2018, and to become the leader by 2030. In 2016, the government of the United States of America (USA) proposes a national AI Research and Development strategy with multiple claims, and publishes the first policy report on AI: Preparing for the Future of Artificial Intelligence. In Europe, it is in 2018 that the EU Member States sign the Declaration on Cooperation on Artificial Intelligence, in which they commit themselves to work together on this subject. The European Commission aims to invest twenty billion euros in AI research over the next ten years and is launching several initiatives, including Digital Europe, which led to the creation of the European AI Alliance, for instance.[25] In the same year, the government of the Republic of France (France) published several reports, including the Villani Report, dealing with AI policies, the reduction of human capital flight (or "brain drain"), and the importance of diversity in AI research, and, together with the government of Canada, worked on the creation of an International Expert Group on Artificial Intelligence (G2IA).[26] [27] All around the globe, different state actors are playing the AI card, with the promise of paying attention to it for years to come.

C. The Shadow of Artificial Intelligence

But AI not only presented opportunities with its impressive growth, it also presented implications and concerns. Just as we needed to research, apply and invest in AI, we also needed to think about AI. From this, one could predict the close links that AI has with philosophy. Indeed, they have several concepts in common, including intelligence, action, consciousness, epistemology and even free will. [28]

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[25] Yoav Shoham et al, "The AI Index 2018 Annual Report", AI Index Steering Committee, Human-Centered AI Initiative, Stanford University, Stanford, CA, December 2018.
[26] Cédric Villani et al, "Making sense of artificial intelligence...", "Villani Report". (2018).
[27] Terms of Reference for the International Expert Group on Artificial Intelligence. Office of the Prime Minister of Canada. (December 6, 2018).

Moreover, AI is concerned with the creation of (artificial) animals or creatures, in the literal sense, which presents a considerable interest for philosophers.[29] These various factors then contributed to the emergence of the discipline of philosophy of artificial intelligence. The latter attempts to answer various questions such as: "Can a machine act intelligently? Can it solve any problem that a person would solve by thinking," "Are human intelligence and artificial intelligence the same thing? Is the human brain essentially a computer" and "Can a machine have a mind, mental states and consciousness in the same way as a human being? Can he feel the way things are?". Such questions reflect the divergent interests of AI researchers, linguists, cognitive scientists and philosophers, respectively.[30] The scientific answers to these questions obviously depend on the definition of "intelligence" and "consciousness" and the "machines" under discussion. Important propositions in the AI philosophy include: Alan Turing's "Turing test," according to which if a machine behaves as intelligently as a human being, then it is as intelligent as a human being;[31] Dartmouth's proposal seen above, suggesting that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it"; Newell and Simon's physical symbol system hypothesis that "a physical symbol system has the necessary and sufficient means of general intelligent action"[32]; Searle's "strong AI" hypothesis that "the appropriately programmed computer with the right inputs and outputs would thereby have a mind in exactly the same sense human beings have minds"[33];

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[28] McCarthy, John. "The Philosophy of AI and the AI of Philosophy". jmc.stanford.edu.

[29] Bringsjord, Selmer; Govindarajulu, Naveen Sundar (2018), Zalta, Edward N. (ed.), "Artificial Intelligence", The Stanford Encyclopedia of Philosophy (Fall 2018 ed.), Metaphysics Research Lab, Stanford University,

[30] Russell, Stuart J.; Norvig, Peter (2003), Artificial Intelligence: A Modern Approach (2nd ed.), Upper Saddle River, New Jersey: Prentice Hall

[31] Turing, Alan (October 1950), "Computing Machinery and Intelligence", Mind, LIX (236): 433–460

[32] Newell, Allen; Simon, H. A. (1976), "Computer Science as Empirical Inquiry: Symbols and Search", Communications of the ACM, 19 (3)

[33] Searle, John (1999), Mind, language and society, New York, NY: Basic Books

and finally, Hobbes' "Mechanism" which suggests that "reason' […] is nothing but 'reckoning,' that is adding and subtracting, of the consequences of general names agreed upon for the 'marking' and 'signifying' of our thoughts".[34]

There is also the issue of AI ethics. It is part of the ethics of technology, or technoethics, specific to artificially intelligent beings. Ethical issues associated with AI are proliferating and attracting public attention as it becomes ubiquitous. Among other things, this raises the issue of responsible and/or reprehensible AIs operating openly in society at large, with profound implications for the ethics that must then consider the morality of AIs. We must also take into account the fact that human social infrastructure, such as energy or public transportation systems, is increasingly moderated by machines, AI, which are increasingly intelligent. This then raises many moral and ethical concerns. For example, who or what is responsible in the event of an accident due to system error, design flaws or correct operation outside the intended constraints? Finally, as AIs become increasingly intelligent, it seems legitimate to be concerned about the possibility that AIs may be managing human systems based on the values of AIs, rather than directly programmed by human designers. These issues often have an impact on the long-term security of intelligent systems, not only for human beings, but also for the human species and life on Earth as a whole. But the human designers themselves and their values can be the subject of concerns, for example in (un)intentional gender or racial discrimination through AI-involving processes. These and many other issues are at the heart of AI ethics.[35]

Finally, in a probably more pragmatic aspect, the rise of AI has raised the following questions on the question of man with machine, in the idea of optimization. Who,

over the decades, even before the modern AI era we know, could get closer and closer to transhumanism. The latter is an international cultural, intellectual and philosophical movement whose ultimate goal is to transform the human condition through the

[34] Hobbes (1651), Leviathan

[35] Müller, Vincent C. (ed.) (2016). “Risks of artificial intelligence”. CRC Press - Chapman & Hall.

development and manufacture of widely available technologies that would enhance human capabilities, whether physical, psychological or intellectual.[36] Transhumanist thinkers consider the possible benefits and dangers of new technologies that could overcome fundamental human limitations, as well as the appropriate "technoethics" for developing and using these technologies.[37] Marvin Minsky, one of the "founders" of AI in the 1950s seen earlier, wrote about the relationship between man and artificial intelligence as early as the 1960s.[38] In the decades that followed, this field continued to generate influential thinkers, such as Hans Moravec and Raymond Kurzweil, who oscillated between technical and futuristic speculation in the transhumanist current related to AI. [39] [40]

Whether in its relation to transhumanism, its ethics, its philosophy or any other more contextual aspect such as its history, its current status, or even its nature, AI would require the work of an entire report to explore and study more than its contours. However, the above overview will remain of solid relevance to expose, through this work, its connection and its impact on our societies in the logic of sustainable development, as we will try to analyze it.

II. The challenges of our societies

A. Which society? Societies?

[36] Bostrom, Nick (2005). «A history of transhumanist thought». Journal of Evolution and Technology.
[37] Carvalko, Joseph (2012). The Techno-human Shell-A Jump in the Evolutionary Gap. Sunbury Press.
[38] Minsky, Marvin (1960). “Steps toward artificial intelligence”.
[39] Moravec, Hans (1998). «When will computer hardware match the human brain?». Journal of Evolution and Technology 1.
[40] Kurzweil, Raymond (1999). The Age of Spiritual Machines. Viking Adult.

Different sociological definitions usually treat a society as "a relatively independent or self-sufficient population characterized by its internal organization, territoriality, and cultural distinctiveness". This is reminiscent of the definition of Caroline Hodges Persell of the New York University and the American Sociology Association (ASA), who defines society as "a group of people with a shared and somewhat distinct culture who live in a defined territory, feel some unity as a group, and see themselves as distinct from other peoples".[41] Specific definitions vary considerably with regard to the importance of any of these elements. For example, when emphasis is placed on internal organization, society can be defined as the organization and not the people. Definitions also vary as to the specific meaning given to concepts such as "self-sufficiency", "organization" and "culture". Nevertheless, the basic concept of the inclusive and self-sufficient group remains a constant element in most concepts of society. The functional conception of society proposed by Aberle and colleagues in 1950 has served to illustrate a detailed concept of society and how it fits into a sociological system of thought. According to the latter, a society is “a group of human beings sharing a self-sufficient system of action, which is capable of existing longer than the life-span of an individual”. [42] [43]

Therefore, contrary to some potential abuse of language or misconceptions, it may seems wise to assume and consider the existence, and coexistence, of many different societies in the human world.[44] In order to do this, it is also necessary, I think, to abandon forms of ethnocentrism, in particular Eurocentrism and Western-centrism, which are prevalent in many discourses, including scientific ones.[45] An ideology, in my opinion, intellectually obscuring that overlooks a universal reflection that is essential in

[41] Caroline Hodges Persell. “An Introduction to Sociology”. (1996). American Sociological Association.
[42] "Society." International Encyclopedia of the Social Sciences. (2008)
[43] Aberle, David F. et al. 1950 The Functional Prerequisites of a Society. Ethics 60:100-111.
[44] Mabel Lee, Meng Hua, Cultural dialogue & misreading (1997), p. 53.
[45] Houman A. Sadri, Revolutionary States, Leaders, and Foreign Relations: A Comparative Study of China, Cuba, and Iran (1997), p. 35.

the current global context, which is moreover the task and subject of this research work. Indeed, different countries and societies around the world affect, and are affected by AI. As seen above, specific regions of the world and specific states view AI differently. Among other things, there are very marked differences in terms of financial investment. Between 2013 and 2018, for example, three countries lead the way in terms of the amount of investment in AI: China, the United States and the Republic of India. However, China leads all these countries, and the rest of the world, accounting for 70% of the $39.5 billion (USD) invested in AI internationally that year.[46] However, the United States remains the world's largest AI market leader with 40% of the global market share, with more than 2,028 AI companies, including 1,393 startups, as of May 2018. In comparison, China had 1,011 companies, including 383 start-ups.[47] All in all, one could, in the manner of the global economy itself, distinguish the three main hubs of AI activity: East Asia, led mainly by China; North America, led mainly by the United States; and finally, Europe, which is essentially the European Union, thanks in particular to the initiatives discussed above. This similarity of geographical repartition of activity intensity between AI and macroeconomics seems to underline the close link between economics and technology, at least as far as AI is concerned.[48] Yet, all these societies, as well as the rest of the world, face certain challenges from which no one is immune. Above all, it is together that we must face, in a common effort, urgent, global challenges.

B. What challenges?

[46] "Share of global artificial intelligence (AI) investment and financing by country from 2013 to 1Q'18". Statista. (2018).
[47] "Artificial Intelligence – A strategy for European startups". Roland Berger, Asgard. (2018).
[48] "Number of artificial intelligence (AI) companies worldwide as of June 2018, by country". Statista. (2018).

A global issue, sometimes "global problem" or "global challenge", is any problem, or risk, that negatively affects the global community and the environment, possibly catastrophically. This also includes environmental issues and economic, political and social crises. And solutions to these problems usually require an international cooperation.[49] In any event, it is difficult to clearly or comprehensively define, nor even list, the various challenges facing our societies. Yet, some actors have attempted to synthesize these in the possible hope of allowing global plans of action to overcome these challenges. This is the example of the World Economic Forum*,* or "Davos Forum", which, in 2016, through an economic prism, formulated a list of the ten most urgent global challenges.[50] The 80,000 Hours organization of the Centre for Effective Altruism affiliated with the Uehiro Centre for Practical Ethics at Oxford University also worked to establish a list of urgent global issues in collaboration with researchers from the Global Priorities Institute at Oxford University and the Open Philanthropy Project, with the initial aim of identifying and promoting professional careers with optimal positive social impact. From this list of urgent global issues, “AI” was, as a matter of fact, at the top.[51] On a more corporate spectrum, the renowned multinational audit firm PricewaterhouseCoopers *(*PwC) also tried its hand at this difficult task in 2018 with its "ADAPT" framework (*Asymmetry; Disruption; Age; Populism; Trust*). aimed at "summarizing the extremely urgent problems facing society, businesses and individuals that are pronounced, divisive and for which there are no easy answers". It is essentially based on the postulate of the existence and impact of so-called "Megatrends", including AI, previously identified by the firm in 2013, and the response to them.[52] But the most representative synthesis, at least probably a reference, is that of

[49] Bhargava, Vinay (2006). Global issues for global citizens: an introduction to key development challenges. Washington, D.C.: World Bank.
[50] Hutt, Rosamond. (2016). "What are the 10 biggest global challenges?". World Economic Forum.
[51] « List of the Most Urgent Global Problems ». 80,000 Hours. https://80000hours.org/problem-profiles/.
[52] “ADAPT: Five urgent global issues and implications”. (2018). PwC.

the United Nations, with its "Global Issues" overview, listing 22 thematic of global challenges.[53] The effort to achieve sustainable development is of paramount importance and must be prescribed. Although many definitions abound, the most commonly used definition of Sustainable Development is that proposed by the UN Brundtland Commission, formerly the World Commission on Environment and Development, in its report "Our Common Future*",* published in 1987, better known as the "Brundtland Report". It defines sustainable development as "development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs".[54] [55] The concept of sustainable development is intrinsically based on three interconnected social, economic, and environmental "pillars" whose sustainability is to be preserved and developed.[56]

In order to achieve this sustainable development, objectives are necessary. This is why the United Nations General Assembly defined in 2015 the 17 Sustainable Development *Goals* (*SDGs),* adopted by all member countries, to be achieved by 2030. They replace the 8 Millennium Development Goals (MDGs), which ended in 2015.

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[53] « Global Issues Overview ». (2015). United Nations.

[54] World Commission on Environment and Development (1987). Our Common Future. Oxford: Oxford University Press.

[55] Rachel Emas. "The Concept of Sustainable Development: Definition and Defining Principles". Division for Sustainable Development Goals. Organisation des Nations Unies.

[56] "Environmental, Social and Economic Sustainability Framework". (2015). United Nations Environment Programme. United Nations.

In contrast to its predecessors, the SDGs establish standards not only for emerging and developing countries, but also for industrialized countries.

The SDGs are as follows:[57]

1. No poverty;
2. Zero hunger;
3. Good health and well-being;
4. Quality education;
5. Gender equality;
6. Clean water and sanitation;
7. Affordable and clean energy;
8. Decent work and economic growth;
9. Industry, innovation and infrastructure;
10. Reduced inequalities;
11. Sustainable cities and communities;
12. Sustainable consumption and production;
13. Climate action;
14. Life below water;
15. Life on land;
16. Peace, justice and strong institutions;
17. Partnerships for the goals.

All of these goals are interdependent and cross-cutting with regard to the different sustainability spectrums of Sustainable Development.

C. What developments?

[57] "Transforming our World: The Sustainable Development Agenda to 2030". (2015). United Nations General Assembly.

The seventeen SDGs each contain a list of sub-objectives, called “targets”, measured by indicators. There are 169 targets for the seventeen main objectives. Each target has between one and three indicators used to measure its progress. A total of 232 indicators were approved.[58] One of the keys to the success of the SDGs is to make data on the seventeen goals available and understandable to as many people as possible. To this end, the United Nations makes available the Global SDG Indicators Database, a platform providing access to data compiled by the United Nations system and providing information on the development and implementation of a global framework of indicators related to the goals and targets of the Sustainable Development Agenda to 2030. It is managed by the Statistics Division of the United Nations Department of Economic and Social Affairs (DESA).[59] The Sustainable Development Report (formerly SDG Index & Dashboards*),* the first global study to assess each country's position in achieving the SDGs, was also established. It is prepared by teams of independent experts from the UN Sustainable Development Solutions Network (SDSN) and the Bertelsmann Stiftung foundation. Different development actors can use the Report to identify priorities for action, understand key implementation challenges, monitor progress, ensure accountability and identify gaps that need to be filled in order to achieve the SDGs by 2030. This report includes the SDG Index & Dashboards, a format that preceded the report, and which, as their name indicates, respectively "Index" and "Dashboards", presents a ranking of countries according to their achievement of the SDGs and the cross-referenced data in a graphical way that is easier to consume. An interactive version was also developed, the SDG Dashboards, more

[58] “Technical report by the Bureau of the United Nations Statistical Commission (UNSC) on the process of the development of an indicator framework for the goals and targets of the post-2015 development agenda”

[59] Global SDG Indicators Database. (August 2019). United Nations Statistics Division. United Nations Department of Economic and Social Affairs.

playful to explore.[60] In the same vein, some external alternatives were born. Perhaps the best known of these is the SDG Tracker from Oxford University's “Our World in Data” project, a free, open-access resource where users can track and explore real-time global and national progress towards the achievement of each of the 17 SDGs through interactive data visualizations. The data used come from official sources such as the United Nations, the World Bank and the World Health Organization. The SDG Tracker has the interesting feature of being able to dynamically display the evolution over time of the progress of each SDGs, as far as possible. [61]

In terms of current overall progress towards SDGs, the Sustainability Report ranks the Kingdom of Denmark (Denmark) first, with the highest SDG index: 85.2 out of 100. The country that can be measured and with the lowest index is the Central African Republic (CAR), with an index of 39.1. France is fourth with an index of 81.5. However, developments at the global level are worrying, and fall short of the trend expected by the SDG initiative according to the latest Sustainability Goals Report 2019, which uses the most recent data available to monitor global progress on SDGs and to take stock of progress towards meeting commitments. The report shows that progress has been made in some critical areas, including extreme poverty, which has been significantly reduced, and the under-five mortality rate, which fell by 49 per cent between 2000 and 2017. In addition, vaccinations have saved millions of lives, and the vast majority of the world's population, the equivalent of nine out of ten people, now has access to electricity. Nevertheless, although progress has been made in some areas, daunting challenges remain. Of all the themes, the most urgent field of action is global warming. If

[60] Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2019): Sustainable Development Report 2019. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).
[61] Ritchie, Roser, Mispy, Ortiz-Ospina. "Measuring progress towards the Sustainable Development Goals." SDG-Tracker.org, website (2018).

we do not reduce greenhouse gas emissions now, global warming could reach 1.5°C in the coming decades. The resulting effects could make many parts of the world uninhabitable, and like many environmental hazards, would affect the poorest populations most. The other major issue of our time is that of growing inequality, both international and intranational. Precariousness, famine and health risks continue to be concentrated in the poorest and most vulnerable population groups and countries.[62]

In order to advance towards these objectives, and to challenge these global challenges, real international, transnational and intranational collaboration is necessary, as explained throughout this brief. For this, different actors are involved. Achieving sustainable development would require the active participation of all sectors of society and all types of people. At the first United Nations Conference on Environment and Development in 1992, the so-called "Rio de Janeiro Earth Summit", nine sectors of society were identified as the main channels through which broad participation would be facilitated in United Nations activities related to sustainable development. These are officially called "Major Groups" and include: women, children and youth, indigenous peoples, non-governmental organizations, local authorities, workers and trade unions, business and industry, the scientific and technological community, and farmers. [63] The importance of the effective participation of these nine sectors was reaffirmed by the United Nations Conference on Sustainable Development in 2012, known as "Rio+20". [64] However, in the AI paradigm with a similar sustainable development perspective, the conception of the actors would naturally seem to be altered in view of the nature, today, still as complex and, to a lesser extent, nearly

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[62] Report on Sustainable Development Goals 2019. (2019). United Nations Department of Economic and Social Affairs.

[63] United Nations Conference on Environment & Development in Rio de Janeiro, Brazil, 3-14 June 1992. Agenda 21.

[64] "The future we want". (2012). United Nations General Assembly.

elitist of AI. Despite this, the AI is already showing a very promising opportunity in the quest to reach SDGs. That's what we're going to try to examine now.

III. AI for sustainability

In view of the interconnectivity inherent in the different SDGs, as well as the spectra of Sustainable Development and its actors, it would not be wise to strictly separate this third part, which then preferably presents a general overview of the use of AI today by Sustainable Development actors, as well as more specific views on specific cases through the study of interviews with AI application experts conducted for the research of this work.

In this brief, we seek to explore how AI, in the hands of the different actors involved or able to get involved, knows, and can, advance progress towards the different SDGs, and ultimately Sustainable Development. The proposed hypothesis is that, by becoming aware of the potential precariousness of the resources, room for maneuver and other properties intrinsic to the nature of the actor, the business and industry sector, non-governmental organizations, the scientific and technological community, and local authorities, i.e. the State, are the actors best placed not only to impact generally on the progress towards the SDGs, but also to be the channels through which AI can most ideally, until then, impact beneficially on Sustainable Development and reach the SDGs. This would in particular be due, for my part, to the pyramidal effect then created, where these actors with more favorable predispositions and greater opportunities and means of action than other actors, can impact, or equip, in

a top-down dynamic the other strata and actors of society in a beneficial effort thanks to AI, here in the great framework of Sustainable Development.

AI has the potential to assist in the achievement of each of the SDGs. This is illustrated by a study by the McKinsey Global Institute*,* which by November 2018 had identified as many as 135 cases of AI use worldwide that support the SDGs. Whether concrete, partial or simply potential, these cases demonstrate real opportunities for AI applications. In this case, the distribution was disparate. There was at least one case per SDG, as in the case of Objective 14 on "Life below water", where some Objectives were represented by more than 20. Objective 3 for "Good health and well-being", the most represented, had encountered twenty-nine cases. More generally, the area most represented in these samples was "Health and Hunger", which includes contexts such as "Prediction and Prevention" or "Care and Treatment", with twenty-eight cases. The area least represented was "Information Verification and Validation", including for example uses against misinformation and "false news", with only four cases of AI usage. [65] It would be tempting to confuse such numbers with an actual assessment of the potential applicability of AI to a particular area or objective. However, it is, in my opinion, the truncated representation of the evolution and discovery of AI for applications perhaps more obvious in some cases than in others, also biased by a relatively small sample. It is nonetheless refreshing to witness so many scenarios, not only of participation in the attainment of the SDGs, but this with the involvement of AI, less than 4 years after the definition of these objectives. This was understood and encouraged, with initiatives such as the AI for Good of the International Telecommunication Union of the United Nations, contacted during this research, which, with the help of annual world summits, tries to bring together and focus the strengths of actors from different sectors of society in order to respond to the SDGs through AI. [66]

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[65] Michael Chui et al. “Notes from the AI frontier: Applying AI for social good”. (2018). McKinsey Global Institute.

[66] “AI for Good Global Summit”. International Telecommunication Union. https://aiforgood.itu.int.

AI is deployed in different ways depending on the domain, capacity, barriers and risk profiles of specific use cases. To illustrate the range of areas in which AI could be applied for sustainable development, and, more generally, for good, we will deal in more detail with a few cases that I think are representative. Three of these cases are the result of interactions that occurred during the research for this paper, and have been the subject of direct exchange with those responsible for the AI applications discussed. Although these are only a set of specific examples, they highlight the range of uses and capacities that could exist as well as the potential impact that could result.

The previously discussed study showed a bias towards AI applications in the health field. Indeed, many textbook cases have florished by now. Early in my research, I contacted Emerj Artificial Intelligence Research for a request for their expertise. Daniel Faggella, founder, and international AI specialist, presented me with the paper by Abder-Rahman Ali, PhD student in Artificial Intelligence at the University of Stirling. It discusses different examples of deep learning applications in medical imaging. An overview that would actually present the trend outlined earlier.[67] Indeed since 2015, a strong, profuse economic activity around this field of imaging and medical diagnosis has been emerging. In fact, no less than one third of AI startups in the health sector, having raised funds after January 2015, would have worked on imaging and diagnosis.[68] In addition, researchers from International Business Machines Corporation (IBM), one of the historic multinationals in the IT world, would estimate that by 2016, medical images will account for at least 90% of all medical data. A titanic proportion that would make it the most

[67] Abder-Rahman Ali. “Deep Learning Applications in Medical Imaging”. (2019). Emerj Artificial Intelligence Research.
https://emerj.com/ai-sector-overviews/deep-learning-applications-in-medical-imaging.
[68] Ja Lee et Deepashri Varadharajan. “The future of clinical trials”. (2018). CB Insights.

important source of data in the health care sector.[69] A correlation seems to emerge when, as we saw earlier with the rise of big data, there is knowledge of the link between AI and data, especially when they are in large quantities. Scenarios where deep learning has already been deployed in this field include detection and monitoring of tumor development, quantification and visualization of blood flow; medical interpretation, and treatment of diabetic retinopathies. It must be noted that in each of the examples presented by Ali, the case of AI involved a company, including a start-up, but, above all, three technological giants: IBM, Google and the Samsung Group. The study of these scenarios was reminiscent of Argus, a project of SAP Labs China of the multinational company SAP, another big name in the technology world, which was contacted in this regard. A team there had developed the "Argus" solution, which can detect signs of lung cancer in CT scans, with the help of machine learning. Argus then allows a larger number of patients to be analyzed in a shorter period of time, this, while also improving the detection accuracy.[70] Here again, we find the elements encountered previously, namely: AI, the contribution to the SDGs, for "Food health and well-being", but above all, this by actors in the "business and industry" sector, as defined by the UN.

The SAP company is a concrete example of how a company can use AI sensibly for a possible sustainability impact. The Argus project, discussed earlier, is far from trivial. It was actually part, after its creation, of one of the company's many initiatives aimed at having a real beneficial societal impact, here "SAP One Billion Lives", which aims to solve the world's biggest problems through the incubation and promotion of internal projects. The different

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[69] Heather, Landi. “IBM Unveils Watson-Powered Imaging Solutions at RSNA”. (2016). Healthcare Innovation.
https://www.hcinnovationgroup.com/population-health-management/news/13027814/ibm-unveils-watsonp owered-imaging-solutions-at-rsna.

[70] John Hunt, Paul Baur et Joanne Chen. “How Machine Learning Is Helping Save the Lives of Cancer Patients in China”. (2019).
https://news.sap.com/2019/05/machine-learning-saving-lives-cancer-patients-china

The company's worldwide "Labs", such as SAP Labs China, frequently work on such projects, including the use of AI, of which SAP has its own instance, with its "SAP Leonardo" technology portfolio.

A similarly auspicious project, in which was developed a device to help a client company whose business is water and wastewater management for low-income communities. This was achieved by optimizing its processes by using the capabilities of SAP Leonardo, including *machine learning,* to create a "proactive decision engine that drives predictive analysis and automates the operation (or maintenance) of assets in the field" (see Annex 2). Basically, *machine learning* was used to be able to predict the resulting water pressure based on several variables. This allows the company to simulate how the change in pump capacity has affected water pressure in the communities served. The aim was to optimize pumping to avoid waste and damage, without underfeeding households. Thus, the company could follow the general state of the system in real time, and simulate the results of their actions. AI (*machine learning*) was also used to generate alerts based on consumer trends for appropriate response. Three months of historical data were used to feed a neural network on which the *machine learning was* operating.

This is also a very interesting scenario, not only in terms of using

promising for AI, but also for efforts towards SDGs, here for "Clean Water and Sanitation", and sustainable development more generally. Here, both companies are actors of this impact. The company supported for direct effective work, and SAP supporting this effort with its technological means, including AI.

Another interesting example with the same company is another project. For this topic, I was fortunate to have the return of Mr. S, Data Scientist in *machine learning at* SAP, and co-founder of the project. With this project,

S. and their team created a regression model (prediction of quantitative variables by *machine learning*) to analyze the key drivers of pay equity using the Human Capital Management solution *SAP SuccessFactors*. In addition, the implementation of this project allowed the creation of a pay equity report based on relevant data. The SAP AI has been applied here to explain the key drivers of pay equity and how it could be mitigated.

Here, the application of AI is intended to correct pay equity and to ensure that everyone receives a fair salary in relation to the individual's function, performance and contributions. This application also has a preventive aspect, and allows pay equity to be monitored to prevent it from occurring in the first place. In this respect, SAP and AI can contribute to sustainable development through the achievement of the SDGs, particularly with regard to "Gender Equality". Asking S. if he thought AI could meet the challenges of today and tomorrow through large enterprise initiatives such as SAP, his answer was that "AI / machine *learning can be an* ideal tool to automate decision making where there is historical data capturing desired business practices" (see Appendix 3). The idea raised is interesting indeed, in the context-specific vision of the company the cornerstone remains the practices and strategies desired by the company. More generally, I would even suggest that it should not be forgotten that, by definition, and because of its capitalist and profit-making nature, the company, at least comparable to a multinational such as SAP, retains as its primary objective not only to create wealth, but also to make a profit.

This brings us to our latest case study, that of the non-governmental organization (NGO) *Elephants, Rhinos & People, which,* thanks to AI and the support of SAP and its software infrastructure, is conducting its "ERP Air Force" project, and its director David Allen, with whom I was able to speak. The NGO *Elephants, Rhinos & People* is itself interesting in that it belongs to a private group.

companies, *groupelephant.com*. This NGO is then the company's initiative to broaden its societal impact, going beyond "simple" financial participation. The ERP Air Force project consists of a complete ecosystem for Internet-based, multi-sensorial, object surveillance (connected objects and sensors), including aerial UAVs, and enhanced by AI, for the protection of animal reserves and anti-poaching measures in southern Africa. Here, the elements where AI, here free and open source, is involved are: the analysis of photographs of "camera traps" and the recognition of number plates. The greatest use of AI is in the analysis of photographs to identify human beings. The impact of this project and this initiative could lead one to believe, falsely, that it is limited to the protection and conservation of two animal species alone, yet it is much greater. ERP Air Force, and the NGO Elephants, Rhinos & People, are perfect examples of a strategic and effective sustainable development effort, which is all the more complex. Indeed, this initiative presents a number of challenges, particularly economic ones. If nothing is done now to conserve elephants and rhinos, opportunities for economic participation for these communities may disappear. In the regions concerned, tourism and ecotourism, including safaris, are an integral part of the local economy. These animals are then an important capital asset of these economic opportunities, and by protecting them, the integrity of these opportunities is also protected for present and future generations. In addition, elephants and rhinos have a very important religious value for different cultures in the communities concerned, and in Africa as a whole. They have a cultural, folkloric, artistic and even educational value. The disappearance of these animals would then be a disaster in these dimensions. And even in its limiting appearance, this initiative is not confined to these two important animal species. The real objective of the project is then the conservation of wild species, more generally, through the empowerment of local communities. By educating about the value of elephants and rhinos and enabling the conservation of all the habitat in which they live, or the habitats associated with them, not just the elephants and rhinos.

not only would they be preserved, but also the entire fauna and flora included. By protecting elephants, rhinos and the habitat at the summit, the connected fauna and flora would also be protected accordingly. In this, this apparently one-sided application of AI, shows in truth the great complexity of sustainable development and the interconnectedness of its different spectrums. Concretely, not only a case of preservation of life on earth, as framed by the SDGs, this scenario is also involved in the sustainability of communities, and poverty reduction, among others, all in a successful partnership.

Asking David Allen whether Artificial Intelligence could meet the challenges of today and tomorrow through initiatives of large companies such as SAP and its support for ERP Air Force, he replied that there is "a place for AI in all spheres" and "at all levels of society" and "of the company and the organization". It states that AI is certainly not "something that is only for large companies or large multi-million dollar companies" (see Annex 4). This is an opinion that may contrast with some of the rhetoric, including that in this brief, and is, however, totally commendable. In this sense, Allen seems to agree with the idea of Tom Mitchell, who defined *machine learning* earlier in this paper, and Erik Brynjolfsson, director of the MIT Initiative on the Digital Economy, who see AI, like electricity or the steam engine, as a general-purpose technology.

[71] Therefore not only would there be no strict predisposition to AI,

It would be free and, ideally, to a lesser extent, inclusive, for anyone to use and, most importantly, benefit from.

We have seen here how the different actors of the Enterprise, NGOs, and scientific and technological actors, can use, and are already using AI for Sustainable Development. This proves the AI's definite potential in this direction. East

[71] Brynjolfsson, Erik; Mitchell, Tom (2017). "What can machine learning do? Workforce implications". Science.

At the same time, the increasingly blurred and sometimes imperceptible boundaries between these actors were highlighted. If the scientific and technological sector is spearheading the advancement and opening up of AI opportunities, scientific and technological research and progress is also taking place today in abundance at the heart of companies, as we see with Google, IBM and SAP. The major players in the business world, at least in the technological world, seem to be becoming the major scientific research centers of today. In some cases, NGOs work in partnership with companies for a reason that is primary to them: to have a beneficial societal impact. Which seems to benefit everyone, or almost everyone. Some NGOs can also be part of a company themselves, as illustrated by *Elephants, Rhinos & People,* presented earlier. Finally, all these efforts are facilitated, sometimes simply possible, thanks to the policies and investments of the various local authorities, mainly state authorities, such as those studied earlier in this work which, like a cascade, water the lower strata to allocate and fuel this global development effort.

Conclusion

Through this report I have tried to study Artificial Intelligence as a unique opportunity for the world community to address the challenges that lie ahead for humanity, and which, I would suggest, are already well entrenched in the garden of Men. To do this, we have essentially paralleled AI, and its applications, with the Sustainable Development Goals of the United Nations. With the overall aim of feeding the European and global dialogue on the issue, by re-establishing relevant bases on the prevailing notions, an effort of definition and contextualization was necessary.

We have therefore first sketched AI in its plural and complex nature, and its multiple implications. We could then see that it is a technology as powerful as it is nebulous. Indeed, due to its nature, since what would be equivalent to its official birth in the 1950s, AI has been constantly evolving, whether technical or more philosophical. Therefore, although we have attempted to consider the definition of an AI in the current context in an inclusive definition, it is still impossible to reach unanimity on what absolutely defines AI. It is therefore in the way it works, like some cases of deep learning, that we have been able, in my opinion, to treat the case of AI honorably, although while not mastering the complexities of its being. We were able to report on the framework within which AI fits, and the implications that are unique to it. During these last ten or even twenty years, an AI impressive and courted for its prowess, which does not leave without reaction the public opinion, nor the informed audience, which generates many dynamics to seek, study, apply, finance, promote, politicize on, and praise AI. But it also represents controversies, nuances to be considered, and one must then think of AI, from a philosophical, existential, but also ethical point of view, when it integrates more and more the world of Man, and, moreover, resembles it. Finally, many people like to think of Man with AI, or transhumance with AI, with the design of this technology, not only to improve the life of humans, but to improve the human himself. It is this fascinating and sibylline entity that is AI that we believe is capable of meeting the challenges of our societies. Societies that make up our earthly world, and that we have to explain, thereby establishing the semantic web of "society". As our thinking evolves in a global context, and tends to want to be as universal as possible, we had to abandon ideological blinkers that could insidiously tarnish our good-faith elucubration. For while we show that AI was germinating and thriving from practiced regions of the world, it tends to cover its vast scope in the future. We therefore concede the polysocietal world in its diverse and complicated nature, and the challenges of it, just as it is. Challenges that the international community, in conjunction with the United Nations, has established the Sustainable Development Goals and all the enthusiasm

attached to them. For this, real efforts and provisions were born, and this common goal is then pragmatically evaluated, judged, followed, in particular by indexes and indicators, which show pleasing advances, while praising us for the efforts made, reminding us that total success is still a long way off. This in no way discourages the multiple actors contributing to this meritorious work. Among them, we had identified some players we had identified as being judiciously disposed to complete this duty of Sustainable Development, and, what is more, with the help of AI. This is what led us, after all, to intertwine these elements into a chapter showing an appreciation of the potential, exploited, and still exploitable, of AI in the participation in SDGs, and therefore of Sustainable Development. We were able to present AI and its applications as being able to meet the needs and problems related to each of the SDGs, even if certain objectives, through domains and then scenarios, were more solicited or accessible. More specifically, we explored specific cases of AI at the service of sustainable development through interviews with specialists in the field, exposing different aspects perceived through different prisms, reminding us once again of the complex plurality of AI, of today's challenges, as well as of the landscape of the actors of this development, especially when joined to this fascinating technology, blending together in preconceived roles today returning from obsolescence, but still giving us hope with the success of their feat.

This work seems to confirm the hypothesis of actors, then, of some more favorable than others to AI for Sustainable Development, for the good, achieving, and being able to achieve more, beneficial results with this AI, unfortunately not providential, and disarmed to cure the evils of Man, and more widely of his world, of his Earth, but fortunately not providential because reminding Man of his duties, and not granting him the miracle of absolution of the problems he has.

Probably in part self-generated, and of challenges which he may well have imposed on himself at will, and thus foreshadowing a much more frightening dysfunction and original evil. Yet this exercise, in an unexpected way, made me consider the free nature of AI, and the waste that it would be if it were limited to elites or decision-makers allowing them to use or abuse this unique opportunity. Like the fire of Prometheus, AI presents itself to Men with the greatest promise. Yet, one would not wish, as the latter, incur the wrath of Zeus.

If Artificial Intelligence ever reached or surpassed the level of Man, would it have the same considerations?

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Pamela McCorduck (2004, pp. 424) writes of "the rough shattering of AI in subfields—vision, natural language, decision theory, genetic algorithms, robotics ... and these with own sub-subfield—that would hardly have anything to say to each other."

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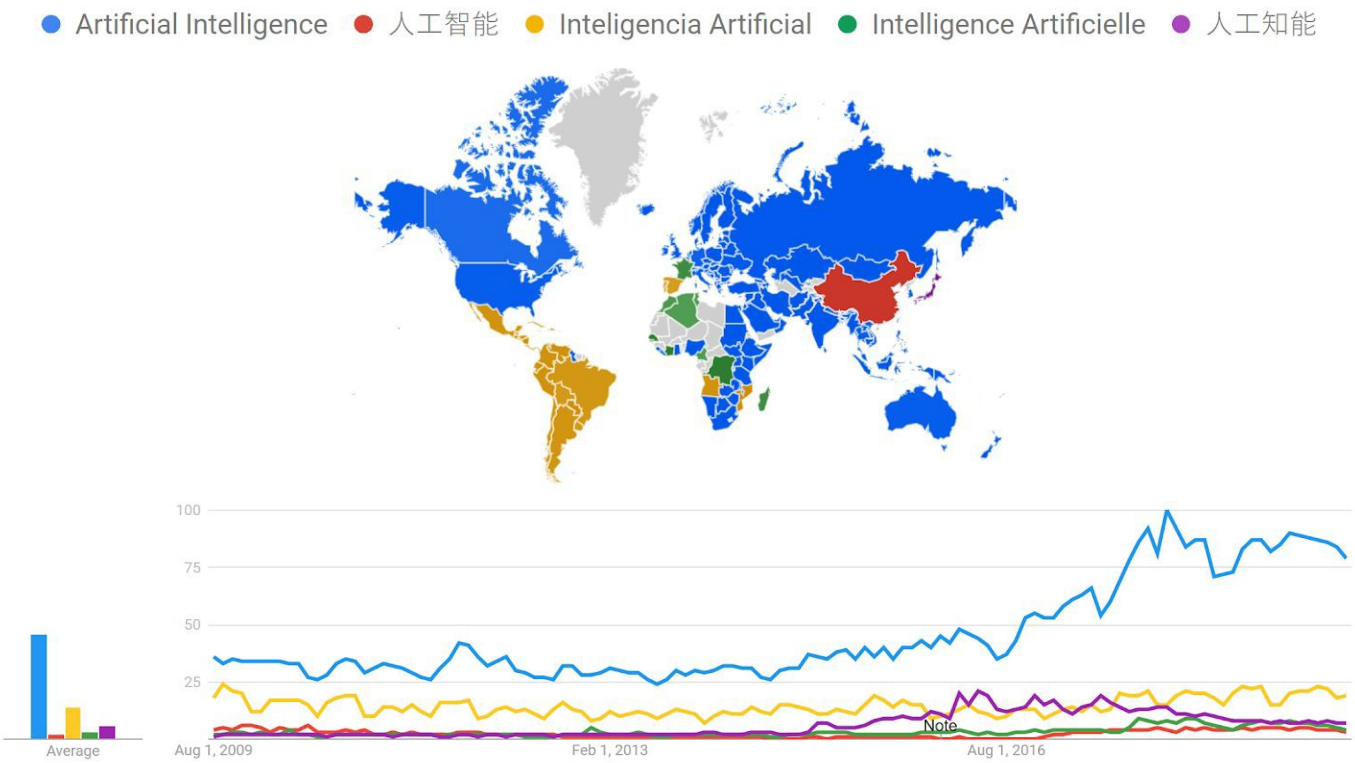
Appendix 1



Analysis of queries on the Google search engine for the keyword "Artificial Intelligence" in English, Chinese, Spanish/Portuguese, French and Japanese between August 2009 and August 2019 via the Google Trends tool.*

These numbers represent the research interest over time relative to the highest point on the graph for the given region and time. A value of 100 is the peak of popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means that there was not enough data for this term.

**Spanish (#3) and Portuguese (#5) merged due to the similarity of the word. Bahasa melayu/indonesia (#6) and Arabic (#4) replaced due to lack of data. Chinese (#2) not representative due to the very low use of Google in the Sinophone world.*

Appendix 2

Transcript of an interview with Mr. M., Program Ambassador at SAP

- **What did you actually build for Company X?**

"A conceptual prototype aiming to help Company X to optimize their business processes by using SAP Leonardo capabilities including IoT, SAP Cloud Platform, and Machine Learning to create a proactive decision-engine that drives predictive analysis to automate assets operation (or maintenance) in the field.
In the specific case of Company X, the customer's team, SAP Specialists and university students (different institutions) worked together to solve the challenge presented by the customer. [...] As in this specific case, we had 4 weeks to present a concept to the customer, we prioritized the core of the concept: the proactive engine (ML)."

- **Where was Machine Learning involved?**

"We basically used ML to be able to predict the resulting water pressure based on several influencing variables such as time of the day, booster/pump engine power, reservoirs levels. This allowed the customer to be able to simulate (via our prototype) how increasing/decreasing the pump power affected the resulting water pressure downstream the channel (that would get to households). The customer's purpose was to operate in optimal levels of pump power to avoid providing too much pressure (in order not to waste energy nor break pipes) and not too low either in order to avoid the lack of water on households. So, using our prototype, they were be able to monitor in real time (based on their IoT data) the overall system state and to simulate the results of their actions. We also used ML to generate proactive alerts based on consumption trends – let's say a spike in consumption was detected (based on ML), the system would then raise an alert suggesting to increase the pump power to avoid lack of supply.
More specifically, for the simulation part we have used around 3 months of their historical sensors data as input to feed a neural network on Hana PAL.
The input variables were time of the day, pump power, reservoirs' levels, water flow metrics and output variables (to predict) were water pressure on 2 downstream channels. We were really satisfied with the predictions afterwards (with limited test data).
For the trend analysis to generate proactive alerts, we have used ARIMA time series forecast – I don't recall the variables used, most likely time of the day and resulting pressure)."

- **How does your solution help improve Company X operational efficiency (thus its social impact)?**

"As portrayed in the public communications, and precedently (managing water and waste water for low-income communities with IoT and machine learning). Plus, our central focus was on operational and energy efficiency, as well as process standardization (security)."

Appendix 3

Transcript of an interview with Mr. S., Data Scientist in Machine Learning at SAP.

- **What did you actually build with Project X?**

"We have created a regression model to analyze key factors for pay parity. We have also created pay equity report based on relevant data."

- **Where and how was Artificial Intelligence involved, in more details?**

"Regression modeling, a key technique in AI / ML, has been applied to explain key factors of where pay parity occurred and how it might be mitigated."

- **How does your solution have a social impact and helps within our societies' Sustainable Development (Goals)?**

"Our solution attempts to correct pay parity and make sure everyone gets a fair pay with respect to things like job function, performance and contributions. It can also monitor pay equity for preventing it from happening in the first place."

- **Do you think Artificial Intelligence can answer today's and tomorrow's issues through large corporations' initiatives like this one from SAP?**

"AI / ML can be an ideal tool for automating decision making where there is historical data capturing desired business practices."

Appendix 4 (1/2)

Transcript of interview with David Allen, Air Force ERP Project Manager at Elephants, Rhinos & People

- **In your own words, what solution did you actually build with ERP Air Force?**

"A full multi-sensor IoT monitoring ecosystem boosted by AI for reserve protection and anti-poaching measures."

- **Where and how was Artificial Intelligence involved, in more details?**

"The pieces where we've got AI involved are in the analytics of our camera-traps' photos, and in our license plates recognition, also leveraging OCR (Optical Character Recognition). And then, the biggest use of AI is in our photographs' stalls analytics [...] to look for humans."
We use a combination of OpenCV and Darknet YOLO."

- **How do you think your solution has a social impact and helps within our societies' Sustainable Development (Goals)?**

Goal 1 (No poverty); Goal 4 (Quality education); Goal 5 (Gender equality); Goal 8 (Decent work and economic growth); Goal 10 (Reduced inequalities); Goal 11 (Sustainable cities and communities); Goal 15 (Life on land); Goal 17 (Partnerships for the goals)

Economic participation opportunity: *"If we don't do something with ERP Air Force now, to conserve elephants and rhinos, there won't be economic participation opportunities for these communities in ten years' time. Nobody will want to go on safari if there's no animals. Bottom line. People go on safari, they believe in ecotourism, to see wonderful trees and forests and animals. We're certainly protecting the integrity of these opportunities for the next wave of people in probably ten years' time."*

Quality education: *"We kicked off a lot of programs, with especially schoolkids, on the back of the big ERP Air Force story. Science, technology, engineering, and math are a real problem here in terms of education in Africa. We invite students to see what we do, we show them how we fly the drones and we do demonstrations at high schools. And we've actually started sponsoring through one of our other ERP initiatives, "We Code" challenge, where there are smaller drones and we teach kids how to do basic coding and fly these drones. "*

Cultural heritage conservation: *"Those animals (elephants) have very significant religious value to different cultures in Africa. They have cultural value, they are part of people's folklore, they are part of people's learning, their songs, their dances. So if those elephants are gone, that is a huge part of Africa that's missing. "*

Annex 4 (2/2)

Environment and life on land preservation: *“The actual goal is conservation of wild species through the empowerment of local communities. If we can show people the value of elephants and rhinos and they’ll conserve that whole habitat that they are living in, or living next to, suddenly that habitat is conserved, with all the other less glamorous fauna and flora. No one talks about all the antelopes, no one talks about all the birds, the rats, the different types of bushes, the flowers. But that’s just as important for that whole ecosystem. Because without them, well, there probably won’t be elephants or rhinos for too much longer anyway [...]. If we can protect the elephants and rhinos and the habitat at the top, it’s gonna fall to the rest of the fauna and flora too.”*

- **Do you think Artificial Intelligence can answer today’s and tomorrow’s issues through large corporations’ initiatives like this one?**

“I honestly think there’s a space for AI in all spectrums of society and all levels of business and organization. We all kind of operate on different levels. So, we found a way to take what we’re good at there, and mix it with some passion, and we’re conserving elephants and rhinos through the ERP Air Force, great. But there’ll be other people in education capacity who have other capabilities, and if someone can help them with AI a bit, suddenly they’ll have a solution to maybe help school kids with remote learning or distance learning. I think AI can make a difference at all levels of society. It is definitely not something that is just for big businesses or just for elite forecasting, or just for huge multi-million corporation, It should be at all levels of society. And I think, slowly but surely, you’re gonna see more and more of that coming through. I think AI is nicely positioned to make a difference to all levels of society.”

Appendix 5

List of entities contacted during these researches, sorted alphabetically*.

- AI for Good Foundation
- Berkman Center for Internet & Society at Harvard University
- Computer Science and Artificial Intelligence Laboratory of the Massachusetts Institute of Technology
- Deloitte Tohmatsu Key
- Department of Mathematics "Tullio Levi-Civita" of the University of Padua
- Department of Computer Science at Umeå University
- Elephants, Rhinos & People
- Emerj Artificial Intelligence Research
- Institute for Medical Engineering & Science of Harvard University
- International Telecommunication Union of the United Nations
- Next Generation Artificial Intelligence Research Center of the University of Tokyo
- SAP
- Stanford Institute for Human-Centered AI at Leland Stanford Junior University
- Sustainability and Artificial Intelligence Lab at Leland Stanford Junior University
- The AI Initiative at the John F. Kennedy School of Government at Harvard University
- The Future Society

**For reasons of personal data protection, only the entities contacted, and not the individuals (except in the case of interviews conducted) or their contact details, are apparent.*