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Artificial Intelligence, Sustainability and Climate Change

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Abstract

This paper presents a short introduction to the AI4S workshop aiming in painting a “big picture” of various interrelated aspects of Sustainability and Climate Change. The connections between energy, agriculture, water and technology, usually addressed separately, are vital to properly address the given challenges.

The concern about the sustainability and climate change weakly considers in the debates the pollution induced by technology and innovation. While technology produces twofold effect – benefits and waste, the capacity of available technology and in particular Artificial Intelligence for related complex problems solving is still underexplored.

The knowledge-based AI and connectionist approaches and techniques combined with adequate thinking may innovate the way of managing industry, administration and in other contexts and improve the effectiveness of efforts in sustaining the Planet. Knowledge-based AI help improving the explanation of the results got from Deep learning.

After the introduction aiming in connecting the “dots” between AI, sustainability and Climate actions, this paper presents shortly some contribution of AI to Climate actions and comments the conditions for minimizing the footprint.

Keywords: Artificial Intelligence, Digital Transformation, Method, Sustainability, Sustainable Development, Planet Crisis, Climate Change, Data Obesity.

1 Introduction – Sustainability and Climate Change

Sustainability is a broad concept and one of the least understood. There are many ways to define and address these issues depending on various perspectives and motivations. The concern is not new. Antoine de Saint Exupéry, the pioneering French aviator, journalist and writer emphasizes the beauty of our planet Earth (Terre des hommes) and necessity to protect it [1].

Since the early days of intensive industrialization, a number of authors have tried to warn of the consequences of such rapid development for our environment [2, 3, and 4]. Nobody paid attention to these voices. Globalization and the growing intensity of business, amplified by the internet, Covid pandemics and intensive agriculture accelerated the decline of our environment. Introduced by Google the advertisement-based business model as well as new practices of marketing amplified by AI are pushing people to buy

more and throw out. The business trends such as planned obsolescence [5] and shrinkflation [6] produces more waste. Many seems to ignore that recycling needs the energy and generates pollution affecting also our health [7, 8].

The second consciousness awakening have seen various approaches defined and introduced in companies and organizations. Among them Corporate Social Responsibility (CSR) defines sustainability as an intersection of social, economic and environmental aspects. Actually this initial definition evolved in various context, from company to for example community [9]. Another definition of CSR proposes “balancing people, profit and planet” [10]. However, some large companies still practice intensive business and preach “sustainable development”. Despite all these actions the planet decline accelerates [7, 11 and 12].

Following the debates on governmental levels that begun in 1992 in Rio, the UN defined 17 Sustainable Development goals [13] that many try to achieve with separate actions such as replacement of all cars by electric ones without considering the battery lifecycle, installing wind farm on the sea or on land, solar panels on the roofs and on lands that can be cultivated. Such actions in one area can have ripple effects across others [14].

Despite all these single actions the natural catastrophes as earthquakes, drought, flooding, melting ice, species extinction due to pollution or poachers are more and more frequent leading to planet decline.

The COP28 just ended. This event brought registered 97 372 registered participants [15]. Many come here just to be visible and to talk. The majority of sponsors called “climate innovators (!) is more concerned by sustainable business [16].

I wonder who among the advisory committee (mainly politicians) has a real practice in managing such a complex actions, what conclusion, how far technology is considered. At least the carbon emission of such event has to be evaluated.

The scientific works on various aspects such as climate modeling. Among them Caltech founded CLiMA, Climate Modeling Alliance [17]. They are developing a Climate Machine, probably the first Earth system model able to learn automatically from diverse data sources. Their model uses machine learning and data assimilation to learn from observations and from data generated on demand in targeted high-resolution simulations, for example, of clouds or ocean turbulence. They expect that this work will allow reducing and quantify uncertainties in climate predictions.

The modelling of such complex systems requires a huge amount of data and the use of this data for prediction with AI considers mostly linear approximation while there are not. How such models can lead to relevant actions?

French research center BRGM [18] works on various aspects related to water ecosystems.

Despite the adoption of the Paris Agreement on climate change and the establishment of the 2030 United Nations Sustainable Development Goals, significant gaps remain between the scientific and political communities when it comes to understanding how climate change risks cascade through environmental, social, and economic systems.

The World Meteorological Organization has established seven climate indicators shown in Figure 1.

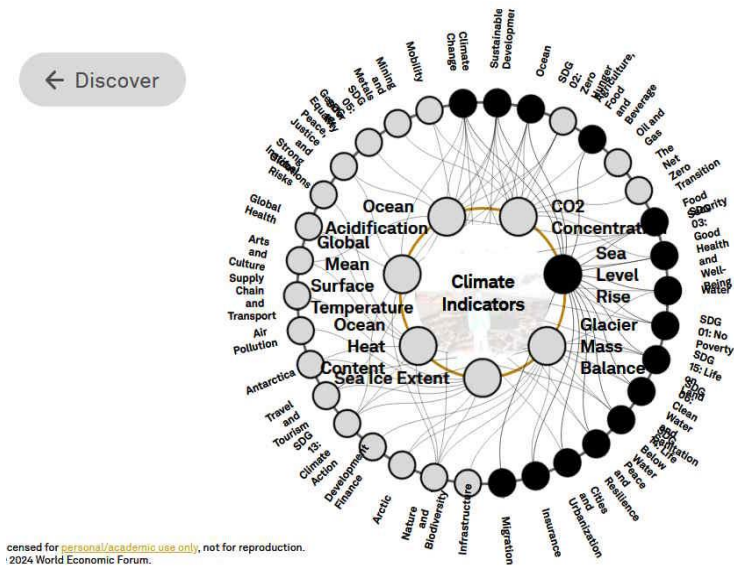


Fig. 1. WEF Climate indicators [19], credit <https://intelligence.weforum.org>

Among them the CO₂ concentration, sea level rise, glacier mass balance, sea ice extend, ocean heat content, global mean surface temperature and ocean acidification. This interactive representation helps understanding partially some connections between items, for example clicking on “sea level rise” displays the connections shown in black.

Among the last trends is the “zero net transition”. Achieving this objective seems rather utopic. Some elements and their impacts are also represented on interactive drawing [20]. We find here advanced manufacturing but not IT, neither AI.

The AI impact is represented in another graphic but does not include environmental impact [21].

All representations available on weforum.org website are very useful in elaborating a “big picture” with a system view.

The organizations involved in various aspects of Sustainability and Climate Change still did not elaborated an adequate assessment to measure the progress.

Our recent article [22] proposes an assessment to evaluate the progress in Planet protection. The small surface represents the current situation and the external curve represents the objectives. Of course the axes can be defined in function of a given context. Such assessment should be conducted on regular basis to see the progress.

Hoping more interest for it.

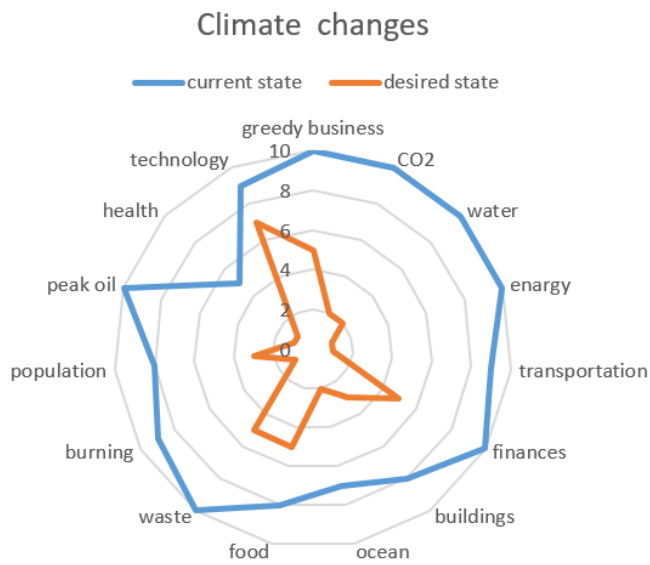


Fig. 2. Initial assessment for Climate Change, own drawing [22]

Artificial Intelligence (both Knowledge-based and connectionist) has a great potential in effective addressing of those challenges. Some examples how are mentioned in [23].

2 Contribution of AI to Climate action

Climate actions shown in another weforum drawing [24] do not include smarting and greening IT and AI, neither data sliming, the raw material for connectionist Machine Learning and Deep Learning.

Actually, many collect data, but nobody manage them at the global level. Among the recent initiatives those of <https://handprint.tech/calculator/> a smart way of collecting data by evaluation of a company alignment with Paris Agreement goals. The quality and relevance of the results obtained from ML or DL systems strongly depends on the quality of data used for training.

The data-wore Chat GPT in answer to “How AI helps addressing the sustainability challenges” provides the list of traditional items:

“Artificial Intelligence (AI) plays a crucial role in addressing sustainability challenges across various sectors. However, such way of considering it is not effective. This extremely complex and full of contradictions topic requires a different approach.

Here are several ways in which AI is contributing to sustainability efforts:

- **Energy Efficiency:**
 - **Smart Grids:** AI helps in optimizing energy distribution in smart grids, reducing energy waste, and enhancing overall grid efficiency.
 - **Predictive Maintenance:** AI algorithms can predict equipment failures, allowing for timely maintenance and preventing energy inefficiencies.
- **Renewable Energy:**
 - **Optimized Resource Allocation:** AI is used to optimize the placement and operation of renewable energy sources like solar panels and wind turbines, maximizing energy production.
 - **Energy Forecasting:** AI models can predict energy production from renewable sources, aiding in better grid management.
- **Climate Modeling and Prediction:**
 - **Data Analysis:** AI processes vast amounts of data for climate modeling, helping scientists understand and predict climate patterns and changes.
 - **Risk Assessment:** AI is used for risk assessment related to natural disasters, allowing for better preparedness and response planning.
- **Supply Chain Optimization:**
 - **Reducing Waste:** AI helps optimize supply chain processes, reducing waste and improving efficiency in manufacturing and distribution.
 - **Predictive Analytics:** AI enables better forecasting, reducing overproduction and minimizing environmental impact.
- **Conservation and Biodiversity:**
 - **Monitoring Ecosystems:** AI assists in monitoring and analyzing ecosystems, helping in the conservation of biodiversity.
 - **Wildlife Protection:** AI-powered cameras and sensors are used for wildlife monitoring and protection against poaching.
- **Waste Management:**
 - **Sorting and Recycling:** AI is used in automated sorting systems for recycling, improving the efficiency of waste management processes.
 - **Optimizing Collection Routes:** AI helps optimize waste collection routes, reducing fuel consumption and emissions.
- **Water Management:**
 - **Leak Detection:** AI can identify water leaks in real-time, helping in the efficient management of water resources.
 - **Water Quality Monitoring:** AI is used for analyzing water quality data, ensuring safe and sustainable water sources.

- Smart Cities:
 - Traffic Management: AI optimizes traffic flow, reducing congestion and emissions in urban areas.
 - Public Transportation Optimization: AI can improve the efficiency and sustainability of public transportation systems.
- Agriculture:
 - Precision Farming: AI helps optimize farming practices, reducing resource use and environmental impact.
 - Crop Monitoring: AI assists in monitoring crop health and predicting potential issues.
- Carbon Footprint Reduction:
 - Green Computing: AI contributes to energy-efficient computing, reducing the carbon footprint of data centers.
 - Optimizing Industrial Processes: AI helps industries optimize processes to reduce energy consumption and emissions.

Asked on interconnections between the items Chat GPT answers: “In conclusion, AI has the potential to drive significant positive impacts on sustainability by optimizing resource use, improving efficiency, and contributing to informed decision-making in various sectors. However, it’s essential to consider ethical and responsible AI practices to ensure that AI solutions align with sustainable development goals.” This answer demonstrates a lack of reasoning.

In the initial answer we notice some important keywords such as “optimization, forecasting, preventive, prediction and risk assessment” without mentioning the adequate AI technics to effectively address the related challenges. Very important keyword “knowledge” is missing as well as a comment on combination of knowledge (human and AI with connectionist AI implemented in hybrid systems).

The implementation and acceptance of some mentioned items requires the radical change in human behaviors.

Some of the cited items were discussed in the workshop, however, we also exchanged on interinfluences between them and carbon footprint of generative AI. Only one paper presented the impact of hardware and data centers on sustainability.

2.1 Environmental impact of generative AI

The recent Stanford study published by the Human-Centered AI lab [26] confirms that that “AI is both helping and harming the environment”. According to Luccioni et al., 2022, BLOOM’s training run emitted 25 times more carbon than a single air traveler on a one-way trip from New York to San Francisco [27]. Still, new reinforcement learning models like BCOOLER show that AI systems can be used to optimize energy usage.

The Figure 3 presents the studied impacts.

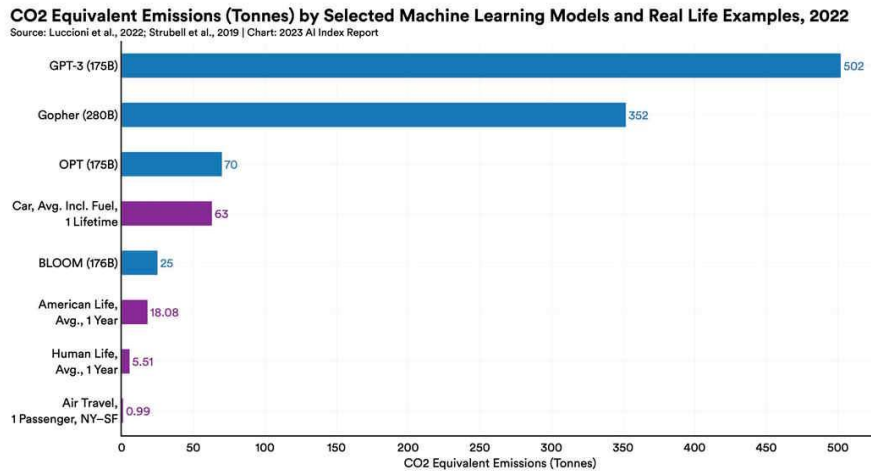


Fig. 3. Carbon footprint of selected genAI compared with plane travel, source <https://ai-index.stanford.edu/report/>

The European Union emphasis is also on innovation in digital transformation [28] as well as on “twin digital and green transition” [29]. While the role of AI is considered here, the carbon footprint of AI is not.

Since years the AI researchers and practitioners have been invented and practiced various AI techniques. We can consider them as AI toolbox to use in function of problem to solve with the aim of selecting “smarter and greener”. The art of using the available AI approaches (problem solving, modularity, genericity, reusability) and techniques must be shared and taught.

The fields AI can help us are among others:

- Education (with Chat GPT)
- Deep-understanding of complex problems to solve them “smart & green”
- Decision Support Systems
- Resource allocation
- Simulation before doing, evaluation of impacts
- Eco-design [31]
- Optimization using for ex. constraint programming for scheduling, resource allocation, frequency, networks, timetable, transportation, logistics...
- Industry 5.0 at the condition “human in the loop” [30]
- Natural resources management
- Agriculture (agroecology)
- Health – diagnosis and prevention

- Short term challenges :
 - Detection of fakes
 - Prevention of crimes - Cybersecurity and global security (TC12.13)
 - Personal intelligent assistant learning RT with its user
 - Twin transformation – digital & green [29]
 - Understanding the climate change for impactful actions

The whole life-cycle of IT should use eco-design and reusable components, be free of planned obsolescence, smartly manufactured, easy to update and recycling [31].

The future depends on how we use adequate AI combined with human knowledge to balance the system components presented in Figure 4.



Fig. 4. A condition for sustainable Future, own drawing

Preserving our Planet requires the global awakening about the current situation that should be assessed to facilitate the progress, the global “wisening” and the art of combining human knowledge and adequate AI systems.

3 Conclusion and future work

In the context of Planet Emergency, sustainability is still a big challenge for humanity. Before applying the various AI techniques to solve separate problems, the understanding of the overall picture is required. It comes with the awareness about our impact and evolution of individual and companies behaviors, radical change of focus from having more to living better in harmony with nature.

To remain sustainable, the IT development requires a smart use of available AI techniques, not only trendy ones but also those effective for a given case. Combined with intensive use of available knowledge – individual and collective, from related domains, from the past and currently gained from experience such systems can really help minimizing the impact of human activity.

AI can help managing many aspects when used appropriately, but we still need to define the right metrics for correct evaluation of the effects of our actions – individual and collective. Simulators can help understanding the impacts, evaluating the situation, testing effect of influencing factors and consequence of decisions to take before doing. It applies in industry, city and in our lives.

The balance between the use of technology and human capacity should be preserved. Technology producers have tendency to produce software and devices that think instead of the human and take decisions for him/her. This kind of applications may replace human at the long run and reduce his cognitive capacity. That is why we have to design applications able to enhance human intelligence without switching it off.

Technology alone cannot save Planet, but can help us to be smarter. It is a lot to do and it is the reason we will continue to run this workshop hoping including more concerned fields and also influence more human-AI synergy.

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