A call for action for coupling Artificial Intelligence Research and Sustainable Development

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Abstract

Social and technology agendas project strategically to connect AI and SDGs in defining societal priorities and demands. We examined the alignment between STI and SDGs through an Artificial Intelligence (AI) lens through a scientiometrics analysis of the EEE Xplore database from 200 to 2019. We address these critical questions: 1. To what extent is AI related to SDGs? 2. Which core subjects of AI are connected to an emerging interest in SD? 3. To what extent does AI stimulate collaboration between regions of the world? We identify the dominant AI topics, visible production regions, and limited intercontinental collaboration.

Introduction

priorities between Science, Technology, and Innovation (STI) and Sustainable Development Goals (SDGs). Overall, they suggest that the alignment is poor, and there is ample room for policymaking to improve it (Ciarli et al., 2022, 2019; Yegros-Yegros et al., 2020). The warning message set by these works is that the disconnection between the 2030 agenda and the technological revolution could hinder the commitment to leave no one behind, augmenting the inequality between high-income and low-income countries.

The most recent developments in AI perform tasks associated with understanding, reasoning, and problem-solving (Mikalef & Gupta, 2021; Mou, 2019). This creates the expectation that AI could operate independently of human intervention. However, it is vital to remember that AI should ultimately serve and benefit human communities (Harari 2017) and non-humans as well. According to Vinuesa et al. (2020), AI technologies could positively impact 71 to 79% of the targets set in the SDGs, but they could also negatively impact 23 to 35% of these targets. Therefore, linking AI with sustainable development (SD) is crucial. To what extent is this link being pursued in AI engineering research?

Our study (Chavarro, Pérez-Taborda & Avila 2022) explored that link through 3 critical questions:

1. To what extent is AI engineering research related to the SDGs?
2. Which core subjects of AI are connected to an emerging interest in SD?
3. To what extent does AI stimulate collaboration between regions of the world?.

Methodology

We analyzed the *IEEE Xplore* database and identified publications related to AI and SDGs. A challenge to identifying these publications is finding a consensus on the definition of AI (Samoili et al. 2021). Instead of choosing one definition, we searched for AI-related works in the database and used the IEEE Thesaurus to explore AI research categories. We analyzed 220,127 documents from 2000 to 2020 and performed the following analyzes to answer our research questions:

1. Identification of AI papers that have a focus on SDG topics in their titles, abstracts, or keywords.
2. Identification of concentration of SDG-related publications in publication venues (journals, books, conferences). We present exploratory results for this policy brief.
3. Identify areas with a growing interest in SDGs using a composite indicator based on the number of documents produced, scientific impact, and innovative impact.
4. An exploration of the co-authorship networks at three levels, namely region, income group, and country, to analyze collaboration patterns within the identified areas of interest.

A challenge to performing our study was classifying documents into related and unrelated to SDGs. For this, we used two approaches and assessed them through different indicators. The first approach uses SDG-related keywords curated by experts and made available by Elsevier. The second approach used machine learning software to label documents based on tagged documents (OSDGs). We tested the two methods against the golden standard of human classification on one thousand random documents. Measures of recall, precision, accuracy, and inter-rater reliability were better for the keyword approach, which we used to identify SDG-related documents.

To measure the concentration of SDG-related publications in publication outlets, we identified the ISSNs, ISBNs, and other identification numbers of the journals, books, and other publication media for all the documents.

To identify emerging areas, we developed a composite indicator to detect IEEE categories with a critical growth rate in three aspects: the number of documents produced, document citation impact, and patent citation impact. We estimated each variable as the compound annual growth rate from the year 2000 to 2017. The average ranking of the three variables was our indicator for emergence.

Finally, we calculated the rate of inter-regional collaboration and the rate of cross-income collaboration based on co-authorship networks. Finally, we performed a social network analysis of countries to identify the most central nodes through co-authorships.

Main findings

Here we explore our findings, highlighting the main Here we explore our findings, highlighting the main messages.

AI engineering research addresses, to a small extent, the SDGs

We found that out of 220,127 AI engineering articles indexed, only 8% to 30% -depending on the specific engineering field- address SD-related issues in their contributions. Figure 1 shows the specific subjects within the domain of AI engineering that address the SDGs and the percentage of papers found. Our analysis indicates that several AI subcategories address SDGs from 20 to 25%. However, in the case of subcategories in Neural Networks, Computational Intelligence, and Logic, most of them do not even reach the threshold of 20%.

The growth of AI engineering research related to the SDGs is higher than average.

Despite the relatively small percentage of AI documents addressing the SDGs, we found that the overall growth rate of SDG-related documents and citations is higher than the growth of documents unrelated to the SDGs and only 1% lower than patent citations (Table 1). This suggests an emerging interest in SDG-related research.

Specifically, we identified the following top 5 emerging subjects within the category of Computational and Artificial Intelligence: Prediction methods, Computation theory, Machine learning, Learning (artificial intelligence), and Biological neural networks (Table 2).

SDG-related engineering research is highly concentrated in specific venues

The vast majority of publication venues in the database have published ten or fewer SDG-related papers, indicating that most SDG-related production is scattered across a range of different journals and conferences. A small number of journals concentrate most of the production of SDGs, with only one journal, IEEE Access, publishing more than 500 SDG-related papers.

Unequal geographical distribution and collaboration in AI Research and SDGs

The production of AI papers is primarily concentrated in high-income countries from regions such as East Asia & Pacific, Europe & Central Asia, and North America (Table 4). However, the percentage of SDG (Sustainable Development Goals)-related papers is higher in the lower middle- and low-income countries, indicating a negative relationship between income and the share of SDG-related papers (Table 5). Inter-regional collaboration on AI research is low, with most papers involving collaboration only within their region. Despite high-income countries dominating the top 15 countries in terms of betweenness centrality, there are some emerging countries in AI research, like India (Figure 2)..

Policy suggestions

Our study highlights the need for funding to support AI engineering research for sustainable development, as the percentage of SDG-related papers is relatively low (finding 1). The perception that engineering research should focus solely on technical aspects may contribute to this trend. However, increasing interest in SDG-related research within AI (finding 2) indicates a shift toward considering societal impacts. This interest is spread across different journals (finding 3), indicating the need for more specialized platforms for engineers to reflect on social impact. The authors suggest creating specialized journals and other media for engineers to anticipate and evaluate societal impact, which could be supported by the UN.

Given the lack of cross-collaboration and the concentration of power on high-income economies (finding 4), we see the need for the support of intercontinental and regional networks for AI research impacting the SDGs, with the representation of emerging and consolidated economies, diverse disciplines, industry, and civil society to produce a participative global AI research agenda for the SDGs and establish governance mechanisms centered around ethics, inclusivity, and sustainability. Key goals of these networks include:

-Monitoring the progress of AI engineering research in incorporating the SDG priorities in their design and innovations -such as green AI patents.

-Supporting current efforts aiming to promote ethics for public policies on AI (EthicaLIA)

-Including the contexts, needs, and concerns of marginalized regions.

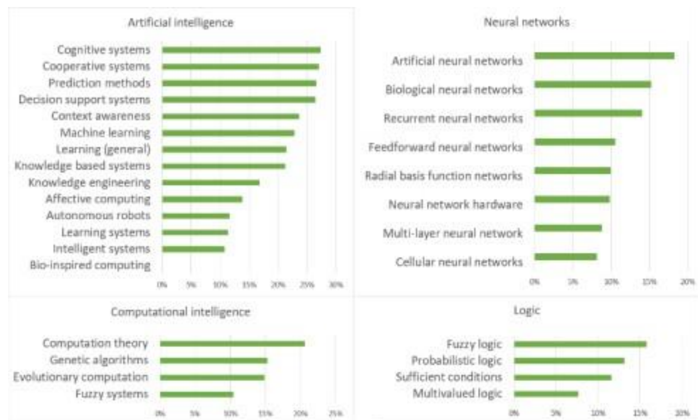
-Propelling for the development of the research workforce in those marginalized regions.

The above reflections are intended to mobilize our collective intelligence through the development of an AI that works for the sustainable development of humans and non-humans. Strategic partnerships between regions, such as the recent European Union's digital alliance with Latin America and the Caribbean, can be a step into that direction if all parties work for the same objective. Bottom-up networks, such as the emerging EticalIA, which aims to be a space to contribute to the ethics of AI from a Latin American perspective, can help to ensure the coordination of such alliance for the benefit of the planet.

By supporting actions such as those proposed here, we expect that the UN will lead a change in the traditional relationships between powerful and marginalized countries while also incentivizing the transdisciplinary spaces for engineers to reflect on the impact of their research on society.

Tables and figures

Figure 1. Percentage of papers within the computational and artificial intelligence category that address SDGs, classified into artificial intelligence, neural networks, computational intelligence, and logic



Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 10)

Table 1. Percentage growth of documents, bibliographic citations, and patent citations

	Production (CAGR) (%)	Scientific Impact (CAGR) (%)	Inventive impact (CAGR) (%)
All docs	25	25	18.3
SD docs	31	32	17.5
Non-SD docs	24	24	18.4

All docs refer to the totality of AI documents; SD docs point to AI. Documents related to sustainable development; non-SD docs relate to AI documents not classified as related to sustainable development.

Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 10)

Table 2. Top 5 emerging subjects addressing sustainable development in AI papers within the category of computational and artificial intelligence

IEEE SUBJECT	CAGR PROD (%)	CAGR CIT (%)}	CAGR PAT CIT (%)	RAN K PROD	RAN K CIT	RANK PAT CIT	AVG RAN K
Prediction methods	36.4	55.6	34.9	2	1	1	1.3
Computation theory	36.3	38.5	27.4	3	5	5	4.3
Machine learning	39.3	31.3	31.9	1	11	3	5.0
Learning (artificial intelligence)	35.2	43.7	21.9	4	3	9	5.3
Biological neural networks	28.9	34.8	21.7	10	9	10	9.7

Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 12)

Table 3. Top 5 emerging subjects addressing sustainable development in AI papers

IEEE subject	CAGR prod (%)	CAGR Cit. (%)	CAGR Pat Cit. (%)	Rank prod	Rank cit	Rank pat	Avg rank
Ultrasonics, ferroelectrics, and frequency control	34.2	36.1	29.1	2	7	3	4
Education	38.3	59.8	27.3	1	2	11	4.7
Consumer electronics	33.2	43.6	27.6	4	3	9	5.3
Electrical engineering	33.3	40.7	23.0	3	4	17	8
Electromagnetic compatibility and interference	27.8	65.0	36.4	29	1	2	10.7

Notes: CAGR stands for cumulative aggregate growth rate, Prod documents, Cit stands for the sum of citations, and Patind refers to patent citations per paper. Rankings with lower values must be understood as being at the top of the list. Each ranking refers to the ordering of the values of CAGR and Patind. The average ranking is the mean of the three rankings in the columns.

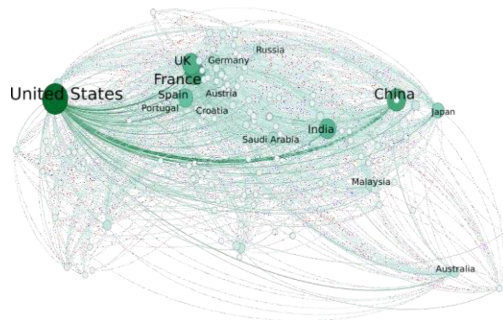
Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 10)

Table 4. Number of AI documents by region

Income group	Docs	Docs—SD	Docs—non-SD
High income	119,397	24,263	95,134
Upper middle income	95,163	18,355	76,808
Lower middle income	21,173	6077	15,096
Low income	203	64	139

Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 13)

Figure 2. Co-authorship network



Notes: Nodes positions attempt to preserve the location of countries in the Mercator projection of the world map. Size and color indicate betweenness centrality; only countries in the top 10 percentile by betweenness centrality are shown for visualization.

Source: Chavarro, Pérez-Taborda, & Avila (2022, p. 14)

Acknowledgments

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