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GFAR INSIGHTS NO. 1

Using Artificial Intelligence for Agricultural Research and Innovation: GFAR's Experience of Using ChatGPT for the Global NARS Consortium

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SUMMARY

GenAI is a game changer - especially in agriculture. It has the potential to transform agrifood systems not only by supporting small-scale producers with co-piloting and by improving precision agriculture, but also in other ways. This article showcases how GFAR used GenAI to support the establishment of a Global NARS Consortium (GNC) which will give National Agricultural Research Systems (NARS) a much more powerful role in international agricultural research and thus contribute to a greater impact of research on agrifood systems, ultimately catalysing efforts to achieve the Sustainable Development Goals (SDGs) on the ground.

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1. CONTEXT AND KEY CONCEPTS

Artificial Intelligence (AI) has emerged as one of the most significant technological advances in many years, but with the advent of Generative Artificial Intelligence (GenAI) in 2022 a revolution is unfolding with huge impacts on all sectors across the world.

To provide some historical context, applications of AI have been explored for decades, with the World War II period accelerating the process. The goal has always been to develop technologies that enable machines, computers, and robots to imitate the cognitive abilities of human beings: the possibility to think, learn, reason, problem-solve and – as we are currently seeing – exhibit creativity. It was not until about a decade ago that advances led to a new boom in the development and application of this innovative technology.

Lingnau (2023) summarizes the latest annual McKinsey Global Survey as confirming the "explosive growth of generative AI tools" (see Chui *et al.*, 2023): within one year of the release of ChatGPT in November 2022 one third of the respondents to the McKinsey survey reported that their organizations are using GenAI regularly and 40% of the respondents said that their organisations will increase their investment in AI.

With this growing interest and increasing investment "the generative AI market is poised to explode, growing to 1.3 trillion USD over the next 10 years from a market size of just 40 billion USD in 2022" (Bloomberg 2023). GenAI's impact on productivity is expected to contribute trillions of USD in value to the global economy. McKinsey estimates that GenAI could add 2.6 to 4.4 trillion USD annually (which is comparable to the entire GDP of the United Kingdom's 3.1 trillion USD in 2021) (Chui *et al*., 2023). The finance industry estimates that AI could contribute between 10 and 15 trillion USD to the global economy by 2030 (UN 2023).

GenAI will not only impact the economy, but will also create a more profound relationship between humans and technology (Lingnau, 2023; Srinivasan *et al.*, 2023, p2). Almost every government and every organisation will need to have an AI strategy and use AI effectively in the (very) near future. While technological innovations formerly took eight to 27 years from commercial availability to reach a plateau in adoption (Chui *et al.,* 2023, p39), the adoption of generative AI will most probably be much faster because of the ease of deploying them. McKinsey predicts little more than eight years for reaching a global plateau in adoption (Chui *et al.,* 2023, p39); in other words, by around 2030. In the meantime, there will be some ups and downs.

The GenAI revolution will change the way we work and live. It not only offers the ability to review and process vast amounts of different types of information, but can also generate texts, images and videos. GenAI has the potential to support and improve work done by humans in many regards. It has already been applied in many areas and its use and importance is growing rapidly. This is leading to a great transformation in ways of working, analysing, and creating knowledge and technology. This inaugural issue of *GFAR Insights* provides an overview of the use of GenAI, and specifically ChatGPT, by the Global Forum on Agricultural Research and Innovation (GFAR) in the construction of the Global NARS Consortium (GNC) (see GFAR, 2023).

It should be noted that **two categories of AI** stand out: conversational AI and generative AI. The first is trained on large datasets with human input, conversations, user queries and responses. Generative AI, on the other hand, is trained on different datasets to learn patterns and generate content independently with predictive capabilities. In other words, it is a subset of AI which trains a model on a certain data set and allows it to generate new, previously unseen data (Boston Consulting Group, 2023). With OpenAI developing ChatGPT and making it publicly available in late 2022, GenAI became widely accessible at no cost. Further definitions (from Lingnau, 2023) can be seen in Box 1.

Box 1: Key concepts and definitions

Artificial Intelligence (AI) is a broad category, encompassing the creation of algorithms that allow computers to perform tasks that typically require human intelligence.

Generative AI (GenAI) is a type of AI. It is the umbrella for the groundbreaking form of creative AI that can produce original content on demand (such as text, images, 3D models, etc.). GenAI uses patterns it has learned by "training" on extensive data with Machine Learning techniques. GenAI is typically built using Foundation Models. Foundation Models (FM) are models trained on a large, diverse range of data on a massive scale that can be adapted (fine-tuned) to a wide range of downstream/specific tasks. They are called Foundation Models to highlight their critically central yet incomplete character (see Bommasani *et al*. 2021, p3).

Large Language Models (LLM): LLM "is a specialised type of artificial intelligence (AI) that has been trained on vast amounts of text to understand existing content and generate original content. More specifically, LLMs make up a class of Foundation Models that can process massive amounts of unstructured text and learn the relationships between words and portions of worlds, known as tokens. This enables LLMs to generate natural-language text, performing tasks such as summarization or knowledge extraction. ChatGPT and Bard use LLMs "(see Chui *et al*. 2023, p.6). Accenture's report (Daugherty *et al*. 2023, p3) is enthusiastic: "The LLMs ... mark a significant turning point and milestone in artificial intelligence. Two things make LLMs game changing. First, they've cracked the code on language complexity. Now, for the first time, machines can learn language, context and intent and be independently generative and creative. Second, after being pre-trained on vast quantities of data (text, images, or audio), these models can be adapted or fine-tuned for a wide range of tasks. ... The positive impact on human creativity and productivity will be massive".

In 2022 the Center for Research on Foundation Models of the Stanford Institute for Human Centered Artificial Intelligence published a report composed of 26 sections: "On the Opportunities and Risks of Foundation Models" (Bommasani *et al.* 2022). This introduced the term "foundation models" to "underscore their critically central yet incomplete character" (Bommasani *et al.* 2022:1). A foundation model is a type of machine learning (ML) model that is pretrained to perform a range of tasks. The report not only summarized the technical principles (model architecture, training procedures, data, systems, security, evaluation, etc.) and the "multi-modal" capabilities (language, vision, robotic manipulation, reasoning, human interaction), but also several areas of applications (education, healthcare, law, etc.) and societal impact (inequity, misuse, economic and environmental impact, legal and ethical considerations).

Thus, AI refers to a technology, which simulates human-like intelligence processes. With regard to agriculture and innovation, AI involves the development and application of these technologies to: analyse large databases; review the vast amount of information and analysis available across the Internet; predict outcomes; and adapt responses (policies and actions). This also applies to agrifood systems and promises to improve agricultural policies and practices – and ultimately productivity and sustainability.

ChatGPT, in particular, is an advanced GenAI tool developed by OpenAI[1]. Based on GPT-4, the most advanced system developed at time of writing (October 2023), this language model uses deep learning[2] to generate responses and have quasi-natural conversations with users. ChatGPT is able to understand and process human language in real time, providing consistent and accurate responses on a wide variety of questions and topics. Its versatility and ability to adapt to different topics and contexts makes it a powerful solution for chatbots[3], virtual assistance applications and more, transforming online interaction with users in a meaningful way.

[1] OpenAI is an American AI research and deployment company. Its mission is to ensure that AI, defined as "highly autonomous systems that outperform humans at most economically valuable work", benefits all of humanity.
[2] Deep learning is a subset of AI where computers learn and make decisions from data, similar to how humans learn from experience.
[3] A "chatbot" is a software program that engages in text or voice conversations with users, usually to answer questions or perform tasks.

The unfolding AI revolution will have a huge impact on the world at large. It should be used to tackle the challenges at hand. According to the latest projections, the global population is expected to reach nearly 10 billion by 2050, which will place immense pressure on agriculture and food production systems (United Nations, 2022). AI can help in different ways in tackling related challenges. For example, by utilizing AI, farmers and experts can gain better insights into factors such as soil quality, temperature, and crop health. This can ultimately lead to the more efficient use of resources. In this regard, CGIAR Alliance projects (Barangé, 2023) already provide illustrative examples of the application of AI in agriculture: *Tumaini* (a smartphone app assisting banana farmers in solving 90% of major diseases and pests); *Melisa* (a chatbot that estimates maize and wheat yields for Colombian farmers based on long-term weather predictions, soil and crop varieties, and sowing dates); and *Artemis* (computer vision technology systems enabling crop breeders to develop locally adapted, climate-resilient varieties).

2. GENERATIVE AI AND AGRIFOOD SYSTEMS (AFS)

Agriculture is one of the sectors in which AI has been applied and is increasingly being used: as a weather forecaster; as a plant pathologist (identification and treatment of diseases); as a marketing consultant (when, where and at what price can products be sold); as an extension/rural advisory worker; as an instrument of precision agriculture (how much water, how many inputs – if at all – are needed) and thus also as a powerful agent of agroecology. The results are breathtaking: the accessibility (especially for small-scale producers) and quality of extension services (on demand, localized, personalized) have dramatically improved, the price of extension services has been reduced to almost nothing, as long as there is access to a computer and electricity and with this the potential for agroecological approaches is dramatically enhanced.

But GenAI is not only a good co-pilot, it is also a good "pilot" in precision agriculture. It measures water requirements, recognizes potential problems and can reduce the use of inputs (fertilizers, pesticides) to a minimum. Huge farms (especially in so-called urban agriculture or aquaponic/hydroponic farms) can be automated and largely operated by robots.

The selection and multiplication of seeds can also be greatly accelerated by AI. While humans need a lot of time for this, AI can carry out the corresponding screenings in no time.

GFAR however has used AI for a completely different purpose: to support the improvement of the global governance of agricultural research.

The Secretary-General of the United Nations has understood the challenge and the potential and has convened a multi-stakeholder High-Level Advisory Board for Artificial Intelligence that will provide a report with options by the end of the year in order "to develop AI for good: to develop AI that is reliable and safe and that can end poverty, banish hunger, cure cancer and supercharge climate action and an AI that propels us towards the SDGs" (UN 2023).

Other global actors such as the Food and Agriculture Organization of the United Nations (FAO) have recognized the potential of AI and actively collaborated with tech giants, including IBM and Microsoft. In September 2020, they reaffirmed their commitment to harnessing AI technologies that can ensure sustainable food and nutrition security (FAO, 2020). In parallel, the World Food Programme is also leveraging AI to tackle food security challenges resulting from conflict and natural disasters. The *ImpactAI* initiative seamlessly integrates ML and AI into Geographic Information Systems (GIS), significantly strengthening the organization's ability to respond effectively to natural disasters and their subsequent shocks.

This perspective is also echoed by other international organizations, such as the European Union, which has noted that a well-coordinated application of AI could yield significant societal benefits, from contributing significantly to achieving climate and sustainability goals to innovating in sectors such as healthcare, education, and transportation. As a result, the role of AI in agriculture is set to expand, as its use extends rapidly in other areas of society and the economy, offering solutions to combat climate change while ensuring food security and the conservation of natural resources. Given its importance, it is crucial that AI technologies are made accessible to all stakeholders in the agrifood sector, including small-scale producers and their organizations, and that it is used to explore solutions to the challenges they face in making a living from agriculture. The increased use of AI could strengthen the resilience of small-scale producers to the effects of climate change and contribute to the reduction of poverty, triggering faster and more equitable socio-economic development of rural areas. Furthermore, AI is also driving advances in agricultural research and innovation initiatives, for example through its application in constructing GFAR's GNC.

3. CREATING A GLOBAL NARS CONSORTIUM: A COLLABORATIVE ENDEAVOUR

GFAR Regional Fora (RF) agreed to establish the Global NARS Consortium (GNC) based on the recognition that National Agricultural Research Systems (NARS) play vital roles in driving innovation and sustainable practices at the national level, yet their collective voice at the global level remains fragmented and dispersed. The lack of a unified platform hampers their ability to address global challenges, share knowledge and advocate for their priorities on the international stage. The creation of a GNC within GFAR has been based on a recognition of an urgent need for a more cohesive and empowered NARS community.

In March 2023, GFAR was tasked with creating a GNC based on the Declaration signed in Bangkok by the Regional Fora (APAARI - Asia-Pacific Association of Agricultural Research Institutions, FORAGRO- Forum for the Americas on Agricultural Research and Technology Development, AARINENA- The Association of Agricultural Research Institutions in the Near East and North Africa, CACAARI Central Asia and The Caucasus Association of Agricultural Research Institution, FARA - Forum for Agricultural Research in Africa and EFARD - The European Forum on Agricultural Research for Development). The main objective of the GNC is to unite, strengthen and amplify the voice of NARS in the global development context. An inclusive definition of NARS has been developed that includes "all public and semi-public stakeholders involved in research and development in a country, including national agricultural research institutes, universities and government laboratories" (GFAR, 2023). Through the establishment and operationalization of the GNC, the Secretariat of GFAR, its members and partners aim to strengthen and revitalize NARS, ensuring its global representation and influence in the evolving field of agricultural research and development.

Initially, the GFAR Secretariat set itself the goal of identifying as many NARS in each region as possible. This identification process began by building on the rich knowledge and database accumulated by GFAR and the six RF. However, while the collection of data provided a solid basis for establishing the process of contacting and inviting these NARS to join the GNC, it was not adequate to generate a sufficiently reliable and complete list to initiate that process.

4. GenAI-POWERED PROCESS TO IDENTIFY NARS

To complement the latter effort, the Secretariat therefore decided to use GenAI, specifically ChatGPT4. The initial focus was on actors and institutions that were part of NARS gathered by GFAR and the RFs from their memberships. An extensive search was conducted to identify potential NARS classified by country. The resulting list was organised by region, and further refined criteria (nature of the institution, research focus and resource allocation) were used to narrow down and improve the results. This approach yielded a considerable number of findings, which facilitated the subsequent development and refinement of the criteria for selecting a precise list of NARS to be invited to participate in the GNC. The status of the organizations identified through AI was cross-checked systematically by humans (*HiL* or "humans in the loop") by contrasting them with other sources of information, ensuring the reliability of the results. This approach was instrumental to resolving specific cases where countries had more than one institution recognized as an official NARS.

The process enabled the creation of a comprehensive and reliable list of potential NARS in each country. By leveraging the capabilities of ChatGPT4, the Secretariat improved the thoroughness and depth of the NARS identification process. In this regard, the generation of a second list that included potential NARS in each country represented a significant improvement in the identification process, as it brought a new level of completeness and accuracy. It should be noted that the application of ChatGPT4 was always guided by GFAR Secretariat staff, who meticulously entered the regional data into the tool. This approach ensured that the data generated by ChatGPT4 were consistent with the overall objectives of the exercise and the desired results. In summary, ChatGPT4 demonstrated its utility in its capacity to generate an extensive list of relevant organizations that contained enough information to serve as a critical initial basis for further exploration and validation by GFAR and its RF. This work involved both the use of AI and the mobilization of human analytical expertise to analyse and understand the results it generated. This undertaking serves as a basis for further efforts to connect with these institutions, while assessing and verifying their current status.

The use of GenAI to generate information in supporting the establishment of a GNC can therefore constitute a significant boost in the modalities for collaboration, management, and coordination of global agricultural research.

5. ETHICAL LANDSCAPES AND REGULATORY HORIZONS

Despite the advantages and the potential of AI for the purpose revealed in this analysis, there remain ethical considerations in the use of AI for such tasks. To ensure that the use of AI contributes to the objectives of inclusive agricultural development, principles of transparency, inclusion, partnership, participation, and fairness must be built into the systems and analytical process.

As the European Parliamentary Research Service was able to identify (EPRS, 2023a), there are certain risks that will require extraordinary measures or policy actions to ensure that all stakeholders in agriculture have access to a fair and equitable share of the benefits of AI. These risks span concerns related to fairness, transparency, accountability, sustainability, privacy, and robustness. Furthermore, three distinct categories of potential concerns with the use of AI in agriculture have been identified: data-related risks (including issues related to collection, access, quality, and trust), optimization risks, and disparities in technology adoption, as well as deployment challenges at scale for machine learning platforms.

In line with these concerns, the European Commission is the first institution to start regulating the use of AI (in early December 2023) as part of its digital strategy. This pioneering regulatory framework, now adopted as the AI Act, represents the world's first global regulation governing AI applications. Not only does the AI Act establish a regulatory framework that classifies AI systems based on their risk levels, but it also aims to address challenges such as cognitive behavioral manipulation, social scoring and real-time biometric identification. These developments reflect a growing awareness of the complexities associated with AI, underlining the increasing need for proactive regulatory measures to maintain ethical and responsible AI practices that extend beyond agriculture to encompass a variety of sectors (EPRS, 2023b).

Some countries and international bodies point to the need for enhanced regulation in the face of the rapid development of AI. While also recognizing the great opportunity for development and improvements with respect to the future of humanity, AI also presents risks and threats recognized by experts and governments around the world, in addition to those threats that have yet to be discovered (Dowden, 2023). All parties interested in the safe and controlled development of AI must agree to establish limits that enable the responsible and secure use of this revolutionary technology. On the one hand, international collaboration, and participation in AI-related events by governments and national authorities will be necessary, so that issues of mutual interest or concern can be addressed, and so that regulations can be developed and agreed in a consultative way to enable its good use and development. This will be particularly necessary if AI is to benefit and be accessible to small-scale producers to enhance their livelihoods and incomes. On the other hand, it is necessary to collaborate with the private sector and the companies that develop this technology, so that it serves the expectations of human beings, countries, and regions – particularly in the Global South.

Over recent years, some countries, such as China, have already established certain regulations on the development and use of AI, aiming to address concerns about this technology in the country. These regulations address complex issues such as deepfakes and information control, including an algorithm registry and requirements for labelling AI-generated content (Sheehan, 2023). It remains to be seen how far-reaching these measures will be and whether other governments are willing to introduce similar regulations as they seek to maximize the development of the technologies with a view to achieving economic, and indeed socio-political, gains.

At the level of international organizations, the Organization for Economic Cooperation and Development (OECD) has also intensified its efforts in this domain and has established a series of standards to guide the development and deployment of AI technologies. In May 2019, the OECD adopted a legal instrument on AI (OECD, 2019). This recommendation of the OECD Council on AI, which was amended in November 2023 (OECD, 2023), calls on AI actors to promote the responsible and ethical use of AI for the benefit of society, while upholding fundamental values and respecting individual rights.

6. CONCLUSIONS

GenAI comes with opportunities and challenges. Taking both into consideration, there is no doubt that GenAI has huge potential to grow the economy and change society for good. The key question will be how to handle GenAI. A carefully thought-out development of GenAI could have a very positive impact not only on agriculture (and specifically for small-scale producers), but also on transformation of the AFS at large.

First, AI-based tools and technologies can be useful and effective on the ground, empowering smallholder farmers by generating and providing valuable information and knowledge – if they have the necessary access to the technologies and other essential factors, such as electricity and modern energy sources.

Second, while AI may advance considerably under private sector initiatives, its true impact is contingent upon accessibility and affordability. Without adequate infrastructure, small-scale farmers remain excluded from the benefits of AI. National governments must adopt proactive strategies that prioritize the inclusion of small-scale farmers and marginalized communities to ensure accessibility and ease of use of these technologies. This approach not only addresses the digital divide, but also contributes significantly to poverty reduction and improves food security, while protecting the rights and knowledge of small-scale producers.

Third, potential risks and concerns must be acknowledged, including the opacity of chatbot responses, which is attributed to the challenge of identifying reliable sources and navigating diverse contexts. It must be noted that current iterations of chatbots show a bias towards international sources, which may diminish confidence in local knowledge repositories in developing countries, highlighting the crucial need for more diverse and comprehensive data, especially from the Global South. Additionally, there are also legitimate concerns regarding the transparency of research processes and the ethical use of content, especially when dealing with copyrighted information from private entities, among others (CGIAR Initiative on National Policies and Strategies, 2023).

There are already several initiatives, such as Google's 7 principles for responsible AI (Google AI, n.d.) or the Gates Foundation's "First AI principles" (Suzman, 2023), which aim to guide the use of AI. This has also been requested by the Secretary General of the United Nations. He asked the governments of the world to ensure transparency, accountability and oversight in July 2023 and convened a multi-stakeholder High-Level Advisory Board for Artificial Intelligence that will provide a report with options in order "to develop AI for good: to develop AI that is reliable and safe and that can end poverty, banish hunger, cure cancer and supercharge climate action and an AI that propels us towards the Sustainable Development Goals" (United Nations, 2023).

In summary, with a well regulated and equitable approach, where small-scale producers can access AI at an affordable cost, the use of AI can support the preservation and sharing of local agricultural knowledge, breaking the digital divide so that more small-scale producers gain easier access to knowledge and innovation. As noted in this article, this could have a direct impact in their work, for example by improving crop management, pest control, weather forecasting, and thereby contributing to improving the economic well-being of small-scale producers, optimizing farmer productivity and crop yields, and reducing food waste and losses.

Through the research exercise conducted by the GFAR Secretariat to identify NARS institutions using the GenAI tool ChatGPT4, it is evident that the primary advantages of its application lie in swiftly examining a vast amount of data to address specific research queries. In this regard, the questions posed to obtain relevant results must be carefully designed and the data obtained through GenAI tools cross-checked and verified. Additionally, further investigation is required to tackle some unresolved issues. The data generated by the GenAI tool contains inherent potential inaccuracies and the reliability of the information collected hinges on human review, emphasizing the broader issue of keeping "humans in the loop" and the need to scrutinize and regulate the use of GenAI.

Looking to the future, GFAR is exploring a number of possibilities to position itself within the evolving landscape of GenAI in agricultural research and innovation.

First, the more than 900 members of GFAR would benefit greatly from the Forum providing opportunities for training and support on how to use AI effectively. This would empower small-scale producers and researchers – among other stakeholders – to discover the full potential of AI.

Second, GFAR could foster international collaboration to share experiences and good practices on AI application in agricultural research and innovation. This could be done through partnerships with relevant like-minded initiatives, workshops, international conferences, and online platforms, such as the recently launched GFAR Hub (https://opensocial.gfar.net).

Last, but not least, this paper seeks to raise awareness of the potential benefits – and risks – of using AI in agriculture. It is hoped that it will inform advocacy and discussions on ethical concerns around AI in agriculture, such as data privacy, transparency, and fairness. This paper has sought to raise awareness, contribute to an informed debate on ways to ensure a responsible and sustainable use of this revolutionary technology.

REFERENCES

Barangé, L. (2023). Artificial Intelligence: How could it transform agriculture? In: *The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)*, 9 August 2023. Cited 12 December 2023. https://alliancebioversityciat.org/stories/artificial-intelligence-agriculture

Bloomberg (2023). Generative AI to become a USD 1.3 trillion market by 2023. *Bloomberg.com*, published 1 June 2023. Cited 12 December 2023. https://www.bloomberg.com/company/press/generative-ai-to-become-a-1-3-trillion-market-by-2032-research-finds

Bommasani, R., *et al.* (2021). On the opportunities and risks of foundation models. *arXiv:2108.07258*. (submitted 16 August 2021; last revision 12 July 2022). Doi.org/10.48550/arXiv.2108.07258

Boston Consulting Group. (2023). Generative AI. bcg.com. Cited 12 December 2023.https://www.bcg.com/capabilities/artificial-intelligence/generative-ai

CGIAR Initiative on National Policies and Strategies. (2023). How can artificial intelligence-powered chatbots help policymakers? A roadmap for Kenya. *CGIAR Initiative on National Policies and Strategies.* 1 June 2023. CGIAR. Cited 12 December 2023. https://www.cgiar.org/news-events/news/how-can-artificial-intelligence-powered-chatbots-help-policymakers-a-roadmap-for-kenya/

Chui, M., *et al.* (2023). *The economic potential of Generative AI: the next productivity frontier*, McKinsey & Company, published June 2023. Cited 12 December 2023. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-AI-the-next-productivity-frontier

Daugherty, P., *et al.* (2023): *A new era of generative AI for everyone,* Accenture www.accenture.com/content/dam/accenture/final/accenture-com/document/Accenture-A-New-Era-of-Generative-AI-for-Everyone.pdf

Dowden, O. (2023). The Strength of UK–Italy Relations (Keynote address from the Deputy Prime Minister, Rt Hon. Oliver Dowden CBE MP at 31st UK–Italy Pontignano Conference, Siena, Italy, 14 September 2023). Published by UK Cabinet Office, 15 September 2023. Cited 12 December 2023. www.gov.uk/government/speeches/the-strength-of-uk-italy-relations

EPRS (European Parliamentary Research Service. (2023a). *Artificial intelligence in the agri-food sector (PE734.711).* ISBN 978-92-848-0190-9, doi:10.2861./516636

EPRS (European Parliamentary Research Service. (2023b). *Artificial Intelligence Act – EPRS Briefing (PE698.792).* Cited 12 December 2023. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698792/EPRS_BRI(2021)698792_EN.pdf

European Commission. (n.d.). Artificial intelligence (AI) in science. *European Commission – Research and Innovation*. Cited 12 December 2023. https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/artificial-intelligence-ai_en

FAO. (2020). Artificial Intelligence best-practices in agriculture can help bridge the digital divide while tackling food insecurity. *FAO Newsroom*, published 24 September 2020. Cited 12 December 2023. www.fao.org/newsroom/detail/Artificial-Intelligence-best-practices-in-agriculture-can-help-bridge-the-digital-divide-while-tackling-food-insecurity/en

Gates, B. (2023). The risks of AI are real but manageable. GatesNotes. Published 11 July 2023. Cited 12 December 2023. www.gatesnotes.com/The-risks-of-AI-are-real-but-manageable

GFAR. (2023). *Declaration of GFAR Regional Fora on the Establishment of a Global NARS Consortium*. 17 March, Bangkok, Thailand. Cited 12 December 2023. www.gfar.net/documents/gnc-declaration

Google AI (n.d.) Our principles. Cited 12 December 2023. https://ai.google/responsibility/principles

Lingnau, L. S. (2023). Leveraging transformer models to enhance the value proposition of digital consulting firms, MSc Thesis, ESCP, Paris 2023

Mills, S. (2023). ChatGPT: why it will probably remain just a tool that does inefficient work more efficiently. *The Conversation*, 14 March 2023. Cited 12 December 2023. https://theconversation.com/chatgpt-why-it-will-probably-remain-just-a-tool-that-does-inefficient-work-more-efficiently-201315

OECD. (2019). OECD AI Principles overview. Cited 12 December 2023. https://oecd.ai/en/ai-principles

OECD. (2023). *Recommendation of the Council on Artificial Intelligence 8*, OECD/LEGAL/0449 Cited 12 December 2023. https://legalinstruments.oecd.org/api/print

Sheehan, M. (2023). What the US can learn from China about regulating AI. *Foreign Policy,* 12 September 2023. Cited 12 December 2023. https://foreignpolicy.com/2023/09/12/ai-artificial-intelligence-regulation-law-china-us-schumer-congress/

Srinivasan, G, *et al.* (2023): *Generative Artificial Intelligence: The implications of Generative AI for businesses*, Deloitte US. Cited 12 December 2023. https://www2.deloitte.com/us/en/pages/consulting/articles/generative-artificial-intelligence.html

Suzman, M. (2023) The first principles guiding our work with AI. *Gatesfoundation.org*. Published 21 May 2023. Cited 12 December 2023. https://www.gatesfoundation.org/ideas/articles/artificial-intelligence-ai-development-principles

Tzachor, A. *et al.* (2022). Responsible artificial intelligence in agriculture requires systemic understanding of risks and externalities. *Nature Machine Intelligence* 4:104¬–9. https://doi.org/10.1038/s42256-022-00440-4

United Nations. (2022). 2022 *Revision of World Population Prospects*. Cited 12 December 2023. https://population.un.org/wpp/?_gl=1*1j3eev2*_ga*MTg5NzczODc1OC4xNjk0MzUzOTcx*_ga TK9BQL5X7Z*MTY5NDM1Mzk3MS4xLjEuMTY5NDM1NDU4NC4wLjAuMA

United Nations. (2023) Secretary General urges Security Council to ensure transparency and accountability, oversight, in first debate on Artificial Intelligence, *UN Press Release*, issued 18 July 2023. Cited 12 December 2023. https://press.un.org/en/2023/sgsm21880.doc.htm

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