Appendix B:

RECOMMENDATIONS FROM EACH CHAPTER

Part II: SECTORS

Chapter 3 – Power System

1. *Utilities and independent power producers should use artificial intelligence (AI) tools for a wide range of purposes, including helping to plan renewables projects, monitor the condition of power equipment, integrate distributed energy resources into the grid, run demand response programs and optimize the use of energy storage systems. In doing so, utilities and independent power producers should prioritize rigorous testing, continuous monitoring and robust fail-safe mechanisms, setting benchmarks for the transparency of AI systems.*

2. *Electricity regulators should create clear regulatory frameworks to support using AI in energy management. These frameworks should include rates that provide cost recovery for AI-related investments, such as smart meters, sensors and open-source grid management software. The frameworks should address risks related to data privacy, safety and cybersecurity.*

3. *National governments, electricity regulators and utilities should work together to develop and enforce data standards for all aspects of grid operations. Regional governing bodies, such as the US independent system operators (ISOs) and regional transmission organizations (RTOs), should prioritize standardization of data to enable cross-regional analysis. These data should be available in industry standard formats in free and publicly available portals for use in AI modeling and research.*

4. *Utilities, regulatory agencies and academic experts should work together to develop AI-driven AC-OPF (alternating current-optimal power flow) models and permitting reforms. These models should be used to reduce delays in the interconnection process and accelerate deployment of new renewable generation sources to the grid.*

5. *Academic experts should emphasize geographic specificity in AI-driven weather models to increase the utility of weather forecasting for renewable energy production within specific boundaries (e.g., ISOs, climate zones). These experts should develop models that forecast within a smaller range than nearby weather station radii, focusing on wind direction, wind speed, solar radiation and cloud cover.*

6. *Utilities and electricity regulators should launch programs for training workers in the power sector to assess and use AI-driven technologies.*

7. *National governments should encourage and fund collaborative research and development (R&D) projects between academic institutions, industry and utilities focused on AI and related applications for renewable power, energy efficiency and emissions reduction, including AI-driven forecasting tools and grid management systems.*

Chapter 4 – Food Systems

Food systems are highly decentralized, with an estimated 570 million farms worldwide, each operating in specific agroecological and socioeconomic contexts, challenging the notion of one-size-fits-all AI solutions. To address the myriad unique issues associated with AI applications in food systems and to ensure their responsible and effective deployment across contexts, we recommend the following priorities targeted at a range of institutional structures (Table 4-3):

1. *National governments should expand public R&D funding to develop and study AI applications in remote sensing, agricultural systems modeling, crop breeding and other high impact application areas.*
2. *Researchers, industry associations and standards development organizations should collaborate to develop and share benchmark datasets, sample algorithms and standard performance metrics for AI applications.*
3. *National governments and businesses should invest in developing adaptive data collection technology, such as Internet of Things sensors and mobile apps, to enable continuous updating of AI models with relevant, accurate and timely data.*
4. *Academic institutions and research organizations should prioritize inclusive and participatory approaches to developing AI models and tools, such as engaging farmers, extension agents and community organizations, to ensure that AI solutions are context-specific, user-centered and aligned with local needs and priorities.*
5. *Professional societies, academic institutions and international organizations should develop and promote guidelines, best practices and training programs on the appropriate use of AI in food systems, covering issues such as data privacy, model transparency, potential biases, risks and limitations.*
6. *National governments, private companies and civil society organizations should establish collaborative data ecosystems for food systems that have clear frameworks for data sharing, ownership and access rights.*
7. *Research funding agencies and philanthropy should support interdisciplinary research on ethical, legal and social implications of AI in food systems, as well as development of responsible AI governance frameworks and accountability mechanisms.*
8. *Private companies and model developers should prioritize development of human-in-the-loop model improvement approaches, incorporating user feedback and local knowledge to iteratively refine AI solutions and ensure their adaptability to evolving climate challenges and food system dynamics.*
9. *International organizations and multi-stakeholder platforms should facilitate knowledge exchange, capacity building and coordination of AI R&D with a focus on promoting inclusive innovation and equitable access to AI technologies.*

A responsible AI information ecosystem is based on the principles of true multi-stakeholder collaboration, the incorporation of local knowledge and priorities, the prioritization of transparency and accountability, and an emphasis on continuous, adaptive improvement. A coordinated approach can support the critical transition to more sustainable, resilient and equitable food systems that are bolstered against the impending challenges of climate change.

Table 4-3. *Recommendations*

GOVERNMENTS	CIVIL SOCIETY	INTERNATIONAL ORGANIZATIONS	BUSINESS	SCIENCE
Convene consortia exchanging food system data Ensure equitable access to AI tools in food systems Establish oversight and accountability mechanisms Create forums for stakeholder feedback on AI policies Support participatory collection initiatives for agricultural data Invest in rural connectivity infrastructure	Monitor data use and privacy issues Advocate for inclusive and transparent data governance Provide training in digital literacy to marginalized groups Create resources on ethics in AI for food systems Monitor AI adoption and impacts	Coordinate global data-sharing efforts in food systems Develop privacy and security frameworks for data in food systems Promote inclusive AI development Facilitate technology transfer and capacity building Identify and fill data gaps Share pre-competitive research and data	Participate in industry data consortia and standards bodies Ensure diversity in AI teams and training data Invest in Internet of Things and mobile data collection Develop scalable, accessible data architecture Co-develop tools that help identify barriers and limits to adaptation Develop open-source libraries, platforms, models and tools	Study the ethical, legal and social elements of AI in food systems Advance explainable, interpretable AI techniques Establish model evaluation protocols using open benchmark datasets Standardize data formats for ease of interoperability Identify and fill data gaps

Chapter 5 – Manufacturing Sector

1. *Private companies should engage with governments, non-profits and academia to develop, release and maintain AI-ready datasets that pertain to industrial operations. This effort should leverage best practices for data sharing and hosting. Private companies should encourage those interested in leveraging their data to explore high-impact AI applications.*
2. *Private companies should develop clear processes to accelerate the adoption of digitalization within their organizations, from streamlining vendor evaluation to incentivizing internal adoption of AI in high impact use cases.*
3. *Technical societies should develop educational assets and programs to increase digital and AI literacy within industrial workforces. These initiatives should scale across the workforce, from*

operators up to executives. Emphasis should be on developing a foundational skill set that will enable the manufacturing sector to adopt AI-based solutions.

4. *Governments and standards organizations should incentivize market demand for AI-optimized products that exhibit increased material circularity and lower carbon footprints. Governments should offer financial incentives to adopt such goods.*
5. *Governments and academia should develop and deploy education opportunities at the intersection of AI and manufacturing as part of computer science and engineering programs.*
6. *Governments should incentivize the market of recycled feed and fuel stock to increase their supply and reduce their costs. This reduces a barrier for adopting AI to increase material circularity.*

Chapter 6 – Road Transport

A. Vehicle Electrification

1. *Local governments should promote development and deployment of AI-optimized electric vehicle (EV) charging stations, update building codes that require incorporating such systems in new installations, and run public awareness campaigns to educate residents and businesses about the benefits of intelligent EV infrastructure.*
2. *Industry and academia should form partnerships to drive innovation in AI-enhanced EV technologies. These collaborations should focus on developing AI-driven solutions to improve battery lifespan, efficiency and recycling methods.*
3. *National governments, industry and academia should invest in AI research for battery and motor advancements, leveraging high-performance computing (HPC) for materials discovery; integrating AI methods to enhance performance, safety and lifespan; and promoting collaborations such as the US Joint Center for Energy Storage Research and the European Battery 2030+ Initiative.*
4. *National governments should establish comprehensive regulations for AI applications in EV technology on topics including data privacy, usage and storage. These regulations should align with global standards to facilitate international cooperation and ensure responsible and ethical use of AI tools.*
5. *Industry and standards development organizations should work together to develop standards for AI applications in EVs, covering topics such as battery monitoring, charging optimization and communication protocols.*

B. Alternative Fuels

1. *National governments should implement incentive programs such as subsidies and grants, to encourage AI-driven research and development of alternative fuels. They should also increase simulation capabilities to evaluate the life-cycle and infrastructure impact of innovative fuels.*
2. *Industry and academia should increase collaborative research efforts to enhance efficiency and reduce the environmental impact of alternative fuels based on AI methods, for example by*

establishing innovation hubs and providing funding and support for startups working on AI-driven technologies in these fields.

3. *Governments, academia and industry should develop centralized data-sharing platforms where researchers can access and share datasets related to alternative fuels to facilitate data exchange, enhance research quality and speed up discoveries.*

C. Intelligent Transportation Systems (ITSs)

1. *National governments and intergovernmental organizations should establish comprehensive data privacy regulations for AI applications in transportation following examples such as the United Nations' global AI resolution. These regulations should ensure clear guidelines to safeguard human rights, protect personal data and support AI use to mitigate climate impact in road transport.*
2. *Local governments should invest in smart infrastructure and develop long-term strategic plans, implementing procurement policies, conducting public awareness campaigns and investing in sensor-driven infrastructure for AI-based real-time decision making.*
3. *Industry and standards development organizations should collaborate to establish standards for smart transportation technologies, including V2X ("vehicle-to-everything") communication, data security, EV charging connectors and harmonized communication networks leveraging 5G and satellite technology to ensure integration and distributed interoperability.*
4. *National governments, industry, and academia should increase research and data collection for intelligent transportation systems to support AI in mitigating climate impact in road transport, enabling complex simulations using HPC, and launching large-scale collaborations and pilot projects for smart infrastructure development.*

D. Modal Shift

1. *National governments should allocate funding for AI projects that optimize multi-modal transit routes, predict demand and improve shared mobility services, ensuring a streamlined and transparent application process for research institutions and private companies to access these funds.*
2. *Governments, industry, and academia should form consortia to develop AI-driven mobility platforms in major cities, integrate pilot projects to test strategies like dynamic pricing and optimized public transit schedules, and publish findings for wider implementation.*

E. Autonomous Vehicles (AVs)

1. *Local and national governments should collect and share data on the greenhouse gas (GHG) impacts of AVs, including data on supply chain emissions.*
2. *Local governments should develop regulations and run pilot projects to facilitate integration of AI-driven autonomous mobility solutions that reduce carbon dioxide (CO_2) emissions.*

3. *Industry and academia should expand research efforts and develop improved simulation capacities to help develop AI-based methods that offer a safe test bed for evolving autonomous driving capabilities, focusing in particular on ensuring that AVs help reduce CO_2 emissions.*

Chapter 7 – Aviation

1. *National governments should expand public R&D funding for applying AI/machine learning (ML) methods to aircraft design, engine design and aircraft operations, with a focus on improving fuel efficiency, enabling the use of sustainable aviation fuel (SAF), and reducing non-CO_2 impacts (including contrails). To ensure this funding targets priority areas, the relevant funding ministries should enhance the AI/ML expertise of program management staff through training and/or hiring.*
2. *Aviation technical societies, associations and standards development organizations should expand technical resources available for AI/ML-enabled aircraft design and operations, including developing benchmark datasets, releasing sample algorithms and publishing standard performance metrics.*
3. *National governments should increase the coverage and quality of publicly available meteorological data (temperature, pressure, humidity) in commonly traveled air spaces to enable improved modeling of the non-CO_2 climate impacts of aviation, including contrail formation.*
4. *National governments, philanthropy and private companies should collaborate to improve the state of the art on digital modeling of atmospheric contrail formation by aircraft, including use of advanced AI/ML techniques. High-quality models should be made publicly available.*
5. *National governments should require all commercial and private aircraft to track and report non-CO_2 impacts, including contrail formation. This should be through public-facing data portals or similar methods that minimize the burden of data collection and computation on the private actors covered by these requirements. Aggregated results should be publicly released.*
6. *Carbon accounting bodies should update accounting rules to include the full set of climate impacts of aviation, including contrails. Private companies with aviation-based supply chains should adopt the use of these updated rules in measuring supply chain greenhouse gas (GHG) emissions.*
7. *National governments should ensure that the regulatory frameworks for approving novel aircraft and engine design are compatible with using AI/ML methods and should update them accordingly if necessary. Aviation regulatory bodies should collaborate directly on these topics to ensure that regulations are harmonized as much as possible across national borders.*

Chapter 8 – Buildings Sector

1. *Governments at all levels working with the private sector should identify and pilot AI-supported technological improvements in design, materials, construction and demolition that reduce the embedded carbon in buildings.*
2. *National governments should develop research and development programs for AI improvements in emissions efficiency of building operations (including HVAC systems, lighting, elevators and other*

mechanical systems). Municipalities should explore more restrictive commercial-building energy use and emissions standards (including for Scope 2 emissions) that become attainable through AI. These efforts should combine a "pull" strategy of government support paired with a "push" effort of more restrictive norms.

3. *Public and private construction organizations should engage government research agencies, academia and the nonprofit community in providing support for developing and deploying AI. Sharing data, encouraging the development of standards and best practices, and creating venues for dissemination and discussion of these results can help accelerate development and deployment of AI in this sector. In particular, using AI to build more sophisticated life-cycle analytic tools can help optimize AI's impact and reduce the possibility of its misapplication.*
4. *Governments, the private sector and professional associations should develop a platform to disseminate best practices regarding improving digitalization and other data collection to support the deployment of AI to reduce building energy use and emissions (including Scope 2). This platform should be tied into the areas of action for AI identified under recommendations 1, 2 and 3. These groups should also work with suppliers to increase the availability and improve the affordability of related sensors and other equipment.*
5. *Multilateral development banks, national/bilateral organizations and other donor agencies should develop a program of technical assistance and funding to increase the capacity of stakeholders both (1) to develop domestic AI innovation programs for the buildings sector in urban areas and (2) to implement AI-enhancements, whether designed locally or abroad. AI in the buildings sector should be adapted to the opportunities and constraints presented by developing economies, including designing and deploying technology-appropriate solutions (such as low-tech approaches where country conditions present constraints), as well as encouraging data gathering in those geographies.*
6. *Governments, in association with city associations and academia, and supported by international development agencies, should identify and develop one or more urban development pilot programs to explore using AI to lower embedded carbon and operational emissions. The new cities being built in emerging economies (such as Indonesia's new capital, Nusantara) provide a possible opportunity for targeted cooperation between donor agencies, such as the World Bank and Japan's JBIC, together with developing-country national and municipal authorities (e.g., Egypt's new administrative capital).*

Chapter 9 – Carbon Capture

1. *National governments and private companies should expand current research, development and demonstration (RD&D) programs in carbon capture to include AI methodologies, with commensurate increased funding.*

a. *Specific use-inspired research topics would include material discovery (especially sorbents and solvents for carbon capture), functionalization of materials, and novel reactor design (including catalysts for CO_2-to-products). They should consider prioritizing efforts beyond simple material discovery and focus on more applied and operational aspects of CO_2 capture. Near-Medium term*

b. *Applied research topics could include optimizing systems (including heat integration, use of digital twins, minimization of heat and electricity demands) and designing key infrastructure pathways (including location, size and operation for CO_2 transportation and storage design), operation and MMRV (measurement, monitoring, reporting and verification)). Near and medium term, with near term emphasis.*

c. *Government granting entities must hire and/or train personnel that are sufficiently trained and knowledgeable to be able to review AI-related proposals well. Near and medium term.*

2. *Asset owners, utility owners and operators, industrial manufacturers and key state-owned enterprises should use AI tools and methodologies to accelerate assessment of carbon capture, utilization and storage (CCUS) pathways for existing and planned assets. This should include cost-benefit determinations in comparison with other decarbonization options, with the goal of establishing a ranking of opportunities. Near term.*

3. *National governments should use AI, including large language models (LLMs) and other generative AI platforms, to streamline permitting processes for carbon capture in all forms. This includes permitting wells for CO_2 injection and processing pipeline rights of way, power electronic designs, and processing revisions to air permits for facility retrofits. Near term.*

4. *National governments and private companies should use AI to improve resource characterization for carbon capture, with emphasis on characterizing geological storage resources. AI-enabled resource characterization should extend beyond bulk storage terms and volume estimates to include understanding of injectivity, permeability fields and risks posed by pre-existing wells. Where possible, national and state governments and some private companies should make data available for training, either through voluntary sharing and federation or mandates. Near term.*

5. *Professional societies, academic experts and carbon accounting bodies should launch training programs on the potential for AI in carbon capture. This could include use of AI for life-cycle assessments of carbon capture systems, as well as the RD&D topics stated above. Near and medium term.*

6. *National governments, private companies and academic researchers should immediately commence with identifying key data requirements for enabling AI in carbon capture. Once identified, these three groups should work to gather, federate and share these data while providing fair, judicious access. Near term.*

Chapter 10 – Nuclear Power

1. *Nuclear regulators should be open to AI playing a role in reactor design, safety analyses and recommendations for operating procedures. The operative question is the quality of the work product, not the identity of the designer. All designs, analyses and procedures, whatever their origin, should be run through rigorous reviews. Additional oversight, checks and security hardening may be part of this work.*
2. *Plant owners and regulators should assure that AI will be used only in advisory and alerting roles. Nuclear plant operators should play the same role in a plant that uses AI as in a plant that does not. The operator should not become like a car driver who plays video games while driving; humans must remain in the loop, engaged and active, despite the routine work performed by AI. Nuclear plant owners should look at the experience in aviation, power and other relevant industries.*
3. *The civilian nuclear industry should scrutinize AI technologies funded by government dollars through science R&D agencies for applicability to their operations.*
4. *Nuclear regulatory bodies should be preparing for license requests from microreactor companies that include a role for AI in remote control.*
5. *Regulators should consider employing the UK Office for Nuclear Regulation's (ONR's) initiative to test different AI technologies in a controlled environment to understand AI's potential to enhance various aspects of nuclear operation and regulation ("sandboxing"). Through sandboxing, regulators can test, refine and evaluate the algorithms within the context of nuclear safety.*
6. *Government innovation agencies should integrate AI into their RD&D plans. Key foci of innovation investments should include sustaining the existing fleet, advanced reactors, and non-electric applications of nuclear energy*
7. *Plant owners should engage with the scientific community to provide access to high-quality data that can drive AI development and deployment. Professional societies should support development and dissemination of best practices in gathering, annotating, hosting and sharing such data.*
8. *Professional societies should offer educational resources and training to attract the attention of the AI community to the nuclear sector. These societies should also reach out to computer science academic departments, professional computer science societies and government agencies to encourage development of AI skills within the nuclear sector.*
9. *Nuclear regulatory agencies should hire staff with AI expertise to efficiently evaluate and recommend adoption of high value-add AI applications in nuclear power.*

Part III: CROSS-CUTTING ISSUES

Chapter 11 – Large Language Models

1. *Private companies and academic researchers should continue to develop LLMs specifically trained on climate data and ensure they are openly available so the public can both improve them and benefit from them.*

2. *National governments, private companies, academic researchers and standards development organizations should cooperate on developing further benchmarks for evaluating LLMs' knowledge in the climate domain, thus extending the existing ecosystem for evaluating LLMs' knowledge in general.*

3. *Professional societies and academic experts should develop training programs on the proper use and limits of LLMs in mitigating climate change to help the public better understand the benefits and risks of using LLMs in the climate domain.*

4. *National governments, private companies and academic researchers should cooperate on developing public challenge competitions on proposed climate mitigation use cases of LLMs to advance their development.*

5. *National governments and private companies should expand current R&D programs in addressing known issues with LLMs, so the public can place greater trust in LLMs, especially when applied to climate change.*

6. *LLM developers and users should publish fine-grained measurements of LLMs' carbon footprint by adopting tools to track and report the GHGs emitted by their compute time.*

7. *National governments should fund R&D for public-facing prototypes to advance the use of LLMs for accelerating permitting of renewable energy.*

Chapter 12 – Greenhouse Gas Emissions Monitoring

Several measures could help address the barriers and overcome the risks described above, promoting the use of AI tools for GHG emissions monitoring.

1. *National governments should encourage the United Nations Framework Convention on Climate Change (UNFCCC) to update guidance on preparing national emissions inventories to explicitly allow the use of AI-enabled data rather than primarily emissions factor–based assessments. This would provide for more accurate baselines and thus make it easier to optimize climate policies and to better tailor them to specific national conditions, while also better recognizing the progress of countries in reducing their climate footprint.*

2. *Carbon accounting bodies, such as the GHG Protocol of the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) or the Science Based Targets*

Initiative (SBTI), should develop rules for including AI-enabled data as part of corporate carbon footprints, supply chain emissions estimates and related emissions-tracking efforts. When feasible, they should encourage or prioritize the use of validated AI-enabled emissions data over generic emissions factors. In tandem with this, other relevant multilateral institutions, such as the World Trade Organization (WTO) and International Energy Agency (IEA), should continue[1] explicitly addressing the topic of using AI-enabled emissions data and should identify roles they can productively play in advancing its use in a scientifically robust manner.

3. *National governments and appropriate international bodies should consider how best to set up the housing and governance regime of AI-enabled emissions data, including such questions as whether one or several national or international organizations or private entities should function as de facto or de jure central data repositories or clearinghouses. Clear options should be defined and decisions made in the short-term. To the extent that the market or regulations require information on GHG emissions in supply chains, the quality of emissions data will be of paramount importance. To be effective, emissions data will need buy-in from as many stakeholders as possible and must be independently replicable. Governments and multilateral organizations should consider the role of existing institutions, such as the International Methane Emissions Observatory (IMEO), the World Meteorological Organization and the Food and Agriculture Organization, as well as major philanthropic organizations and for-profit companies, in providing repository and clearinghouse services for AI-enabled GHG emissions data.*

4. *National governments and appropriate international bodies should continue ongoing efforts toward standardizing AI-enabled emissions data and should consider whether to set up formal processes to certify AI-assisted emissions data and data providers. In the last two years, National Institute of Standards and Technology (NIST) at the US Department of Commerce and the UK Space Agency have spearheaded a series of brainstorming workshops and consultations with leading scientists and industry participants from around the world, with the goal of achieving greater standardization and consistency in AI-assisted measurements of methane and other GHG emissions and of preempting the risk of future conflicting data.[2] These efforts are highly worthwhile and ought to be continued so as to guarantee the scientific integrity and comparability of emissions data and to build public trust. To the extent possible, participation should be broadened to include more representatives from emerging and newly developed economies and major exporters of commodities and manufactured goods.*

5. *National governments, philanthropic organizations and private-sector companies should support ongoing "ground truthing" efforts by research universities and scientific organizations that aim to independently assess the performance of AI-assisted GHG monitoring technologies. Because AI-enabled GHG monitoring technologies often detect and measure emissions that cannot be otherwise detected or measured, proving their accuracy can be challenging. Hence, there is a need to support public research to develop ways of independently replicating and corroborating AI-enabled data and verifying their accuracy based on well-calibrated ground-truth experiments.*

6. *National governments and private-sector organizations should enhance their in-house AI proficiency, whether by requiring minimum AI literacy standards from a broad cross-section of employees or by building up dedicated AI-focused units and data-science centers within their organizations. Minimum AI literacy may be essential for these organizations to deploy AI-enabled GHG emissions data and to integrate those data into public and proprietary databases and operational systems. Professional standards bodies should update accreditation requirements for professions, such as public accounting and civil engineering, to require demonstration of minimal AI proficiency and the ability to use basic AI technologies. This would serve as a step to support adoption and implementation of emissions abatement targets by industry and carbon accounting by corporations. Trade and professional organizations, such as the Society of Petroleum Engineers (SPE) or the International Association for Energy Economics (IAEE), should support AI literacy among their members and the adoption of AI-enabled GHG monitoring, including through training programs in countries where these technologies are not widely available.*

7. *Banks, asset managers and other private-sector actors should use AI-enabled methane emissions data to quantify the embedded emissions of fossil fuel shipments, following the lead of some financial institutions who have already begun this practice.*

1) International Energy Agency (IEA). Progress on data and lingering uncertainties in *Global Menthane Tracker 2024* (Paris, France, 2024, https://www.iea.org/reports/global-methane-tracker-2024/progress-on-data-and-lingering-uncertainties).
2) Committee on Earth Observation Satellites (CEOS). *International Methane Standards Workshop;* UK Space Agency and US National Institute of Standards and Technology (NIST), London, UK, https://ceos.org/meetings/uksa-methane-workshop/ (2024).

Chapter 13 – Materials Innovation

1. *National governments should increase R&D budgets for AI-enabled materials discovery, with a focus on holistic design considerations that include full life-cycle GHG emissions. Support should also be made available for creating new automated and partly autonomous materials-testing laboratories in a variety of locations around the world. By combining AI and robotics, these facilities could unlock broad global access to rapid iterations in materials design and testing, reducing the challenges of participating in advanced materials development for researchers in resource-limited countries.*[1]

2. *Private companies should engage directly with AI-guided materials-discovery efforts by clarifying manufacturability constraints and offering embedded emissions guidelines. This could also include articulating specific materials classes of interest for commercially relevant low-carbon technologies and issuing benchmarks and/or targets for key performance thresholds.*

3. *National governments, academia and private companies should collaborate to develop and release (or expand existing) AI-ready datasets of material properties that can be used by other research teams to train high-performance models. This effort should use standard data formats and be at least loosely coupled to materials-synthesis and -testing facilities to validate results.*

4. *National governments and academia should support increased education in AI techniques as part of materials-science and related degree programs.*

5. *Scientific publishers should ensure that research publications are fully compatible with AI-guided research synthesis methods, including retroactively converting historical publications.*

1) Nature Synthesis Editorial. Automate and digitize. *Nature Synthesis* 2, 459-459 (2023). 10.1038/s44160-023-00354-y.

Chapter 14 – Extreme Weather Response

1. *National governments, international organizations, and the private sector should invest in AI models that increase accuracy, improve the timeliness and reduce the cost of extreme weather event forecasts. They should also collaborate on ways to evaluate accuracy and to develop frameworks that promote long-term sustainability.*

2. *National governments should:*

   - *continue collecting and publishing weather data as a foundational public service;*
   - *provide a base level of access for poorer communities and countries;*
   - *explore innovative programs to attract the necessary talent to lead public AI systems (this could include government-sponsored fellowships, additional compensation and opportunities for continued education);*
   - *integrate AI training into professional development programs for meteorologists and climate scientists working in public sector weather agencies;*
   - *ensure robust understanding of the limitations and opportunities of AI-assisted forecasting and early warning; and*
   - *promote and construct necessary infrastructure to disseminate forecasts and warnings effectively.*

3. *National governments and international organizations should develop the capacity to build and use cutting-edge AI-based weather models as those models improve in the years ahead. Public-private partnerships are important for equity. National governments and international organizations should also support the expansion of AI-based early warning systems for extreme weather to underserved regions, ensuring equitable access and bridging the gap in global forecasting capabilities.*

4. *National governments, international organizations, and the private sector should prioritize collection and integration of weather and climate data from the global south and provide technical support for adopting AI-based forecasting models to countries that have previously lacked advanced forecasting capabilities due to resource constraints.*

5. *Research institutions and AI developers should prioritize creating AI models that are transparent and interpretable to help meteorologists and emergency responders gain trust in AI-generated weather predictions.*

6. *Emergency management and humanitarian aid agencies should implement AI-driven decision support systems to optimize response strategies during extreme weather events, such as evacuations or resource allocation, based on real-time data and predictions.*

Chapter 15 – Greenhouse Gas Emissions from AI

1. *AI developers, data center owners, energy experts, GHG emissions experts and standards organizations should establish robust methodologies and standards for reporting energy use and GHG emissions across the AI value chain.*
2. *AI developers and data center owners should report energy use and GHG emissions associated with their AI workloads.*
3. *Governments should adopt regulations that require AI developers and data centers owners to report their energy use and GHG emissions.*
4. *AI developers should take steps to reduce the carbon intensity of their models, using the International Standards Organization's (ISO's) methodology for evaluating their models' Software Carbon Intensity (SCI).*[1]
5. *Data center owners should prioritize adoption of energy-efficient hardware for AI operations and optimize AI workloads based on carbon-aware computing strategies.*
6. *Governments should promote and support policies that enable and incentivize data center owners to purchase low-carbon energy, including supporting new low-carbon power generation and grid expansion in regions with high concentrations of AI-driven data center growth.*
7. *National governments, AI developers, data center owners and philanthropies should fund researchers to develop a set of scenarios to quantify the effects that AI could have on greenhouse gas emissions under a range of assumptions. These scenarios should combine quantitative models with expert consultations, rigorously exploring a range of possible futures. The Intergovernmental Panel on Climate Change (IPCC) should include these scenarios in a special report on AI to be released within two years.*[2]
8. *All stakeholders should review and consider the dozens of other recommendations throughout this Roadmap to help reduce GHG emissions using AI tools.*

1) International Organization for Standardization (ISO). *ISO/IEC 21031:2024 Information technology — Software Carbon Intensity (SCI) specification;* Geneva, Switzerland, https://www.iso.org/standard/86612.html (2024).
2) Amy Luers *et al.* Will AI accelerate or delay the race to net-zero emissions? *Nature* 628(8009), 718–720 (2024). https://doi.org/10.1038/d41586-024-01137-x.

Text Box: Data Center Water Use

1. *Data center operators and governments should collect and share data on water consumption to understand potential issues and determine risk. More and better data are needed to identify potential risks in terms of the magnitude and acuteness of community or environmental stresses.*

2. *Data center operators should explore potential pathways to reduce water consumption and mitigate risks. There are many promising, practical ways to manage water use and reduce total water consumption. The economic and technical viability of these options will vary by region. Especially in water stressed areas, data center operators should begin to track, review and explore options to responsibly and reasonably mitigate water consumption stresses and concerns.*
3. *National and local governments should consider policy options, including mandatory water usage reporting, water efficiency standards, incentives for sustainable practices, water pricing mechanisms and water recycling mandates.*

Chapter 16 – Government Policy

1. *Governments should prioritize development of a climate-relevant data ecosystem. This should include the following:*
    a. *Governments should invest significant funds in data collection, curation and standardization. The climate-relevant data collected by governments should be easily accessible by all stakeholders. In developing climate-relevant data, governments should particularly focus on data-gathering from underrepresented regions and sectors, as well as on data types that have previously been unavailable or insufficient.*
    b. *Governments should adopt and promote data interoperability standards and invest in secure, scalable infrastructure for storing and disseminating climate-relevant data. Governments should also adopt clear data governance frameworks to ensure data privacy, security and ethical use.*
    c. *Governments should employ a combination of direct funding, low-interest loans, tax incentives, advanced market commitments and regulatory frameworks to help.*
2. *Governments should help fund large-scale open-source foundational models tailored to addressing climate challenges. These models, in domains such as climate science, energy systems, food security and oceanography, could serve as the bedrock for a new generation of climate mitigation applications. By using existing open-source models and investing in new open-source models, governments can accelerate innovation, foster public-private partnerships and help develop solutions to pressing climate issues. International collaboration in funding and research will be essential to maximizing the impact of these models.*
3. *Governments should incentivize AI applications that contribute to climate mitigation with (1) regulatory frameworks that prioritize climate-friendly AI; (2) financial incentives, such as grants, tax breaks and procurement preferences and (3) public recognition programs. In connection with these programs, governments should establish clear evaluation criteria to assess the climate impact of AI systems to help ensure that incentives are targeted effectively.*

4. *Governments should invest in education and training programs to develop a skilled AI workforce. This should include supporting AI research, curriculum development and upskilling programs for both students and professionals.*
5. *In shaping policies and programs on AI and climate change, governments should seek input from and work closely with a wide range of stakeholders, including technology companies, energy companies, academia and civil society.*
6. *Governments should facilitate knowledge-sharing and collaboration between experts in climate mitigation and experts in AI. Governments should use their convening power (by organizing roundtables, task forces, advisory bodies and hackathons) and other tools for this purpose.*
7. *Governments should establish ethical guidelines for developing and deploying AI applications to help foster the trust and confidence in AI that will be important for using AI in climate change mitigation. These guidelines should address issues such as data privacy, bias, transparency, truthfulness and accountability. Governments should develop these guidelines in collaboration with industry, civil society and academia.*

DISCLAIMER

Ruben Glatt contributed to the technical evaluations but not the policy recommendations in this document.