Preparing National Research Ecosystems for AI

SECOND EDITION (2025)

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SECOND EDITION (2025)

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Foreword

Dr Vanessa McBride
ISC Science Director and Acting Head of the ISC Centre for Science Futures

Welcome to the second edition of the ISC Centre for Science Futures' paper on AI for Science. This edition provides *six new country case studies*, primarily from the Global South, and *updates to four studies from the first edition*.

During 2024, we witnessed just how much and how quickly AI is already changing the scientific landscape: from copyright issues to assessment of research excellence to conducting research.

The aim of the working paper was to address a critical gap in discussions about AI policies: their implications for national science and research ecosystems. As was highlighted by Dr Mathieu Denis in the first edition, the project has a few different but overlapping audiences in mind when developing this work. If you are a STI policymaker involved in integrating new AI technologies in your country's research ecosystem, you will find in this paper first-hand evidence on the issues that are of importance for your work, as well as examples of the initiatives taken by other countries. It is likely that you will find examples of countries from your region, with research ecosystem of a similar size as that of your country. If you work with a granting council or a philanthropy, this paper will give you a sense of the priorities that countries have identified for the uptake of AI in science. If you work with an AI company and you are concerned with the specific technological and infrastructural needs of science and research institutions, this paper will give you a primer on the challenges identified by countries as they roll out their AI strategy for research. If you are a scientist or a science journalist, and your main interest is on the impact of AI on science in general, you will discover in this paper the extent to which countries are currently actively adapting their science system for AI.

Since the release of the first edition of this paper in March 2024, the ISC Centre for Science Futures has broadened its efforts to advance global discussions on the role of AI in science. We've hosted a regional workshop in Santiago de Chile, conducted individual consultations with local experts, and partnered with the International Development Research Centre in Canada to expand this work.

The Centre invites continued dialogue to shape the future of AI for science.

General introduction

The dominant notion communicated today on the influence of artificial intelligence (AI) is its capacity to change everything across all sectors, including science (Khalif et al., 2023; Nature, 2023; Van Noorden and Perkel, 2023; Miller, 2024). Beyond the promises of new advances in different fields of research, a set of critical questions is emerging about the impact of AI on the documentation, funding and reporting of science:

- How is the increasing use of AI going to influence research funding allocation?
- What research data standards will evolve? How will AI change the nature of scientific outputs?
- How will scientific careers evolve with the increasing use of AI in research?
- What investments in infrastructures are required for the successful uptake of AI by the science sector?
- What legal adjustments are needed to enable the use of AI in research while ensuring high standards in the responsible conduct of science?
- How is AI going to affect international research collaborations?

Discussions around these questions are critical for the future of science and research systems. Research institutions and ministries are beginning to tackle them, although with limited resources to guide them. As this study will show, there remains a notable absence of comprehensive literature regarding the impact of AI on the structural aspects of science and research.

Several countries have developed overall AI strategies to set out their plans and aspirations for AI development and implementation across different sectors. Despite the immediate and significant implications of these strategies for science and research, these documents mostly offer broad statements on the involvement of science and research institutions in delivering the national plans without looking further into the concrete implications.

This is not to suggest that countries are inactive. Quite the opposite: much is under way. Partnerships are being formed, training initiatives launched, infrastructures put in place and policies implemented. However, people in governmental ministries, universities and consultancy firms tasked with spearheading the preparation of the research environment for AI are largely working with speculation on the key challenges and have limited insight into the approaches being adopted by countries of similar size and capacity.

Frameworks outlining the key issues for countries to consider when planning the integration of AI into their research ecosystems can come a long way at this critical stage. This working paper offers one such framework derived from an analysis of the existing literature.

This second edition of the paper presents a total of 18 case studies from countries of different sizes and regions, authored by people directly engaged in these discussions in their respective countries. The paper is an expansion of the previous edition published in March 2024[1].

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1   https://council.science/publications/ai-science-systems/

It is important to consider the circumstances of countries of varying sizes, which are also major contributors to scientific advancements, rather than solely focusing on the AI powerhouses. We deliberately sought to gain insight into how small to medium-sized countries are preparing their research ecosystems for the uptake of AI.

This working paper therefore seeks to:

- gather the basic knowledge and information about the issues, and the current efforts to prepare science and research systems for AI;
- help countries as they develop roadmaps for the uptake of AI in their science systems;
- create regional and global networks of people involved in the reflections on adaptation and implementation of AI for science;
- raise awareness and help shape a critical discussion among the scientific and policy communities of the critical issues that AI raises for the organization of science and research.

The development of the working paper benefitted from a workshop convened in October 2023 in Kuala Lumpur, Malaysia, and a workshop in Santiago de Chile, Chile in April 2024 bringing together participants from around 12 countries in each region of the Asia and the Pacific and Latin America and the Carribean. Contributions from some countries who participated in the workshops have been incorporated into the second version of the paper. The coordination of the workshops was generously supported by the Australian Academy of Science and the Malaysian Academy of Sciences for the workshop in Malaysia and the Latin American Initiative for Open Data (ILDA) and the Colombian Academy of Exact, Physical and Natural Sciences (ACCEFYN) for the workshop in Chile.

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Literature Review

What are the critical issues for the integration of artificial intelligence in science systems? A bibliometric analysis.

This working paper seeks to take stock of how countries are approaching and planning the uptake of AI by their science and research ecosystems. A bibliometric study was undertaken (in September 2023) to identify publications from different parts of the world exploring the impact of AI on national science and research ecosystems. Note that the bibliometric study was done in September 2023. Since then, documents on national approach for Ai have been released as well as papers on AI for science. The literature review has been kept for the second edition as it stands relevant to the initial motivation to delve into the study and produce country case studies specific to AI for Science.

The study was done in partnership with Nature Research Intelligence in September 2023. It combines academic journal and book content, conference proceedings, policy documents and 'grey' literature. The search strategy encompassed three steps:

- A high-precision keyword search (with more than 30 search keywords) generated a base document set. Over 1,600 documents were thus identified using the Dimensions database.
- A review of that initial corpus of documents and selection of the most relevant ones (180 in total) created a training document set.
- The refined training document set was used to identify similar documents. Additional web searches were also made. The resulting dataset comprises 317 documents published between 2018 and 2023. They are the documents used in this review.

Classification of the 317 publications in the literature review

PUBLICATION TYPE	NUMBER
Journal articles	123
Book chapters	59
Preprints	51
Web pages	30
Conference proceedings	20
Policy documents	18
Books and monographs	16

While 317 publications dealing with national plans to integrate AI in science and research ecosystems may seem relatively low, there was a tenfold steady increase in numbers of publications published annually between 2018 and 2022 (from 9 to 88). This increase suggests a growing attention to the issues relating to the uptake of AI in national science and

research ecosystems. We can realistically expect the number of publications to continue growing in the coming years, as more experience is gathered on the progressive integration of AI in national science and research infrastructures.

Leading countries by publication volume across project dataset (2018–2023)

COUNTRY	PUBLICATIONS	% TOTAL PUBLICATIONS
United Kingdom	32	11.9%
United States	28	10.4%
Germany	13	4.8%
China	10	3.7%
Canada	9	3.3%
India	8	3.0%
Sweden	7	2.6%
Spain	7	2.6%
Switzerland	6	2.2%
Singapore	5	1.9%

The review of these publications allowed us to identify a core set of 45 issues and topics which experts and observers have posited as critical for the integration and uptake of AI in research and science systems.

We tried capturing these issues using a simplified version of OECD's framework for technology governance, with three broad themes:

- research and development agenda setting, technology assessment, foresight and science advice;
- public engagement, science communication and public accountability;
- regulation, standards, private sector governance and self-regulation.

Some of the issues listed here are not specific to science and research, such as those related to careers and employment, data quality and AI safety, and those having to do with the development and adoption of AI in general. We tried to limit the number of such issues in this exercise but included those with a particular significance for science (e.g. data quality) or that we expect to be increasingly discussed in relation to the uptake of AI in research (e.g. AI safety and employment).

Theme

› **AREAS**
  a. Topics
     – Issues

THEME 1: R&D agenda setting, technology assessment, foresight and science advice

› **PRIORITY SECTORS**

a. **Priority-setting**
   – We must find ways to identify strategic sectors for AI development and for its uptake by the scientific community. Mechanisms may include funding, infrastructure development and capacity building programmes.

› **FUNDING PRACTICES**

a. **Will AI capacity replace scientific merit in science funding decisions?**
   – AI intensity may become an inappropriate deciding factor in determining the allocation of resources and hence the trajectory of scientific discovery. Its salience could close off areas of research that do not use it.
   – Competition within research could become less a matter of merit and more a matter of access to AI. This risks poor decision-making and further concentration of research funding.

b. **Use of AI in resource allocation**
   – AI relies on machine learning from existing material. It may produce reviews that are inherently conservative and which reproduce old biases.

c. **Impact of AI on evaluation panels**
   – AI-driven science tends to be interdisciplinary because AIs do not know subject boundaries. Today's domain-led expert panels may be unable to review it adequately, despite the many recent calls for science to be more interdisciplinary.

› **CAPACITY BUILDING AND RETENTION**

a. **Growing AI skills in the scientific community**
   – There is a need for broad but differentiated AI skills development for learners and practitioners at all levels. Important aspects include education in AI, training in domain-specific use, ethics, and interdisciplinary competencies. Teaching will have to recognise that this is a fast-moving topic.

b. **Diversity in AI research**
   – There is a need to ensure the gender, ethnic and cultural diversity of the AI workforce, in the interest of equity and to improve the quality of research and other outcomes. Machine learning can reproduce existing inequity.
   – We have to develop the right incentives for disciplinary and interdisciplinary AI.

c. **Talent retention in the public science sector**
   – Public sector science, including universities and research centres, needs talent acquisition and retention, given the strong demand for AI skills from the private sector. Unusually, this is an area in which the private sector can offer interesting jobs as well as high salaries.

› INFRASTRUCTURE

a. **Development of cloud computing appropriate for science**
  – Uncertain funding for cloud computing and research data repositories constrains scientific advances. In the absence of public cloud capacity, wealthier research institutions are likely to contract private companies, limiting the sharing of their research data and leaving less wealthy institutions behind.

b. **The digital divide goes algorithmic**
  – We must determine how inequity in AI access between individuals, groups, academic disciplines, organisations and locations results in poorer research outcomes.

c. **Development of AI tools for science**
  – We must determine what kinds of partnerships will encourage the development of AI tools appropriate for specialized research institutions. How do we ensure that new AI technologies are not driven solely by the AI and machine-learning communities, but rather developed jointly with all research communities?

› INTERNATIONAL COLLABORATION

a. **Variation between legal systems**
  – We need to assess how jurisdictional variability in governance and data protection between countries impacts international research and research collaboration.

b. **Regional collaboration**
  – Countries must find out the extent to which they can cooperate to establish regional AI centres and research networks if they don't have the resources to do it on their own.

› JOBS, CAREERS AND EMPLOYMENT

a. **Impact on jobs in science and research**
  – There is a need to monitor how advances in AI affect the number and nature of jobs in science.

b. **Continuous AI training**
  – There is a need to develop ways for scientists and research staff to keep up to date with AI in order to produce better research and minimise job losses. There may need to be specialist AI trainers and teachers, for example to help users understand the ethical issues raised by AI.

› NETWORK AND REPOSITORY SECURITY

a. **AI effects on scientific cybersecurity**
  – Science institutions must ensure the best possible network hygiene, ensure the security of partner organisations, and control cybersecurity risks from individual people. How do they secure facilities against intellectual property theft, access to private and sensitive data, and ransom attacks?
  – The protection of data quality and integrity requires controls on access to repositories, as well as highly qualified personnel, strong partnerships and an appropriate built environment.

THEME 2: Public engagement, science communication and public accountability

› **SCIENTIFIC INTEGRITY IN THE CONDUCT OF RESEARCH**

   a. **Principles and values of current science**
- AI may generate tensions between some of the core principles and values that define today's science. Such contradictions might include openness vs. rigour; privacy and confidentiality vs. open science; massive data vs. high quality data; or explainability vs. "black box" results.

   b. **Reliability and explainability of results**
- Lack of trust in AI, within science and in other activities, may create challenges for its uptake in science. But uncritical trust will lead to a potentially dangerous overreliance on AI technology and the results it generates. AI tends to produce normative results rather than groundbreaking insights, because it is based in existing knowledge and existing opinion.

   c. **Reproducibility**
- Today's science already has severe reproducibility issues. How will AI worsen them or perhaps solve them? For AI to improve reproducibility it will need to be more transparent, providing more information about codes, underlying data and experiment design. This applies both to AI research and to research using AI.

   d. **Explainability of results**
- The scientific method requires scientific claims to be explainable and understandable. Some popular AI methods operate as a black box, making it impossible to say how they have reached their conclusions or to identify spurious correlations or causalities.

   e. **Ethical data use**
- The use of big data and AI complicates present-day notions of consent and of human research participants, as well as the ways in which data is collected and used.
- AI Ethics and Review Boards focus on human subjects. As well as carrying out their present vital role, they should be able to examine possible harms to wider society.

   f. **Accountability**
- We will have to determine who is responsible for fabrication, falsification, plagiarism and other bad practice when the faulty conduct can be traced back to an AI. The answer may be simple if the AI has an obvious owner, but in the future many may not.

   g. **Conflict of interest**
- We need to see whether new conflicts of interest arise as AI spreads. They may not be covered by current conflict-of-interest policies.

› **ENVIRONMENTAL IMPACT**
- AI development has to be made more sustainable (in relation to the use of computer chips and electricity in particular). More fundamentally, AIs may well not be attuned to environmental concerns if they have not learned from appropriate input materials.

› SCIENTIFIC PUBLISHING

a. **Acknowledgment of contributors and authors**
   – Researchers have to explain how AI was used in the production of research outputs.

b. **AI for policing science**
   – Publishers have to determine whether AI should be used to detect non-AI generated fabrication, falsification and plagiarism.

THEME 3: Regulation, standards, private sector governance and self-regulation

› DATA QUALITY

a. **Accuracy**
   – Larger datasets are better for training AIs, yet they are also more likely to produce responses based too closely on the data available to them (overfitting) or to contain inaccuracies and biases that could result in wrong or misleading results. Incorrectly sourced data, Frankenstein datasets and biased datasets already have dangerous implications for science. This problem needs to be addressed at every level, from considerations of governance and management to operational use.

b. **Bias and exclusion**
   – While AI, and large language models in particular, use 'biases' (statistical similarity) in data to produce results, it is important to curate training data to avoid further marginalization of particular groups and regions. Digital exclusion leads to gaps in data. Furthermore, how do we represent those who are offline?

c. **Subject orientation of data vs. the interdisciplinary nature of AI research**
   – Most scientific knowledge comes from a specific subject. We need to encode and use it, while enabling communication between domains and allowing for the growing generation of interdisciplinary knowledge.

d. **Data coding and annotation**
   – AIs, and large language models in particular, require humans to code and annotate the data they use. These individuals must be aware of the risk of embedding cultural differences in the data during the annotation process.

› DATA MANAGEMENT AND GOVERNANCE

a. **Open data vs. AI safety**
   – Access to high-quality data is crucial to the development of AI for science. But the public interest, as well as that of individuals, calls for governance structures to protect privacy and to guarantee the ethical use of data.

b. **Access vs. Advantage**
   – Much of the data required for the development of scientific AI will not fall within the scope of open data initiatives, for example data held by the private sector. The tension between enabling access and maintaining commercial advantage may result in high-quality data being kept confidential.

c. **Data infrastructures**
   – The development of AI for science will require harmonization of practices and the development of communities of practice. Current norms and practices for the

production and use of data differ between disciplines and institutions.

– As scientific organizations increase their data curation and storage capacity, they will need to increase interoperability between repositories.

› DATA STANDARDS

a. Data standards for provenance

– The sources of training data must be appropriately disclosed and evaluated. A specific concern is the ethical aspect of data and data sources, and its implications for bias in AI.

b. Data standards for quality (see also 'data quality' above)

– Technical standards, certification and compliance should be imposed to ensure that data used in science is properly curated and stored.

› LAW, REGULATION AND POLICY

a. Legal liability of research done with AI

– We have to reconcile traditional liability systems with AI processes and outputs, with their varying degrees of autonomy and transparency. At what point does an AI, rather than its maker, become responsible for its actions?

b. Copyright protection or patenting for machine-generated creations?

– Uncertainty about the eligibility and appropriateness of copyright protection for AI-generated creations may lead to the use of patenting or trade secrecy techniques to protect intellectual property. This would reduce public availability of the valuable results, positive and negative, of AI projects.

c. Protection and use of digital data

– Text and data mining risk infringing copyright through the creation of unauthorized copies, and may violate the terms and conditions of websites and databases. The United Kingdom is creating a copyright exception rule for text and data mining, and other jurisdictions may follow.

– Works mined for data can be protected by copyright, but data themselves are usually protected only if they were part of original datasets. This may lead to the use of trade secret to protect data. The European Union protects data extracted from protected databases for scientific research. But the borderless character of digital data exacerbates tensions between jurisdictions.

› REGULATIONS

a. The domestic regulatory environment

– Work towards domestic AI regulation will be a balancing act between different considerations and needs. In these arbitrations, countries must create beneficial conditions for their science and research sectors to thrive and work for the common good.

b. Impact of regulation in other jurisdictions

– Observation of other countries' actions can lead to leap-frogging and the alignment of provisions; or, uncertainty about regulation may lead some legal regimes to seek competitive advantage through less rigorous regulation, to the detriment of the country where the creation was generated.

It has become common sense to predict that AI will transform science and research. The encompassing set of considerations and issues identified through the literature review unpacks the many ways in which AI is influencing how science is made, organized and funded. They relate to conditions for good and responsible practices of science with AI. The list should therefore be of use to countries as they develop and implement roadmaps for the uptake of AI in their science and research systems. It reflects imperfectly, however, the considerations that are currently guiding countries. As will become clear in the case studies current plans for the uptake of AI in science are only partially driven by considerations such as those highlighted in the list. By and large, they are rather guided by a country's overall approach to AI and seek to support the ambitions (in terms of economic growth, better governance, digital infrastructures, etc.) attached to AI more generally. This partial disconnect and the pre-eminence of national strategies is understandable. However, insufficient attention to the specific conditions for a successful uptake of AI in science and research will affect the quality of science in these countries and everywhere. It will be measured in poor research data policies, strengthened epistemic biases, insufficient capacity and ineffective institutional and regulatory environments. It will lead, in other words, to bad science.

Introduction to the case studies

The following case studies were developed to help increase our collective knowledge and understanding of countries' approaches towards the integration of AI in research ecosystems. These short essays were authored by those individuals involved in the development and roll out of their country's AI strategy for science.

The countries were selected somewhat opportunistically, using ISC's networks and connections to identify willing contributors from diverse global regions. This second iteration of the papers includes new country case studies from Colombia, Dominican Republic, Pakistan, Palestine, Panama and South Africa. The case studies of Australia, Brazil, China and Malaysia from the previous edition have been revised by the authors to include new developments in the country.

Similar to the approach for the first edition, in our initial interactions with the authors, we introduced the project's goals and ambitions, and provided a set of guidelines. Case studies signed by authors reflect each author's perspective based on their experiences in their positions and what they deem most pertinent and current at the time of writing. In line with the ambition of expanding our knowledge basis and initiating a discussion, authors were encouraged to provide factual information and refer to key documents. An internal review process within the project's core team was conducted upon receipt of the first draft from each author. Comprehensive feedback was provided on the first drafts from the project team, followed by a secondary discussion to address the feedback and refine the draft further. Professional copy-editing was provided, but the tone and content vary across the case studies and reflect the author's contributions.

References to the key documents framing countries' approaches are included in each case study. The bulk of those documents are not available in the international publication databases and were therefore not included in the literature review discussed previously.

AUSTRALIA

Preparing for human-centric use of artificial intelligence

Emma Schleiger, Qinghua Lu, Stefan Harrer, Liming Zhu

Commonwealth Scientific and Industrial Research Organisation

Key takeaways

- Ethical principles and human-centric approaches to AI are informing Australia's emerging framework for AI governance. The number of tertiary education offerings for AI have increased in Australia and are complemented by an initiative to attract and train job ready AI specialists.
- While active programs to enhance diversity in Australia›s STEM workforce exist, they are not specifically tailored to address AI. Additionally, there is a recognized need to enhance ethical competence and raise awareness of human rights in AI-related scientific endeavours. However, more customized resources for the science sector are required.
- Other challenges remain to be addressed such as the high-performance and data computing infrastructure needed for AI and AI-enabled science and the implementation of FAIR and CARE data principles.

Australia's government, scientific organizations and universities are exploring the preparedness of the national science system to capture the opportunities and mitigate the risks of AI to accelerate scientific discovery. For example, the national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), released the report *Artificial Intelligence for Science – Adoption Trends and Future Development Pathways* (Hajkowicz et al., 2022). It examines the impact of AI on science and the imperative for research organizations to invest in mechanisms to harness the benefits and mitigate the risks of these technologies. The report outlines six future development pathways to enable the transition, including hardware and software upgrades, data capability uplift, improved education and training, the development of human-centred AI, improved workforce diversity and ethical capability. Organizations throughout Australia's national science system have begun expanding their capacity for AI uplift in these areas with recent research initiatives, activities, programs and guidelines. However, challenges remain to be addressed.

Hardware and software

Scientific organizations seeking to uplift their AI capability must make decisions about hardware, software and computational infrastructure upgrades. The Australian Academy of Science recently held a national roundtable to discuss the Australian science sector's future supercomputing needs. The group highlighted the need for a national strategy and an exascale computing facility to secure Australia's sovereign research capability and enable science to meet national and regional priorities into the future (Australian Academy of Sciences, 2023).

Data

Future AI capability uplift also requires investment in high-quality data which is fit for purpose, provenance assured, validated, up to date and ethically obtained. The Australian government is leading by example through its Data and Digital Government Strategy (Government of Australia, 2023). This initiative focuses on adopting best-practice approaches to data collection, management and use to become a data-driven organization.

In conjunction with the increasing use of AI, it is essential for Australia to better implement the FAIR (Findable, Accessible, Interpretable and Reusable) and CARE (Collective benefit, Authority to control, Responsibility and Ethics) data principles. These and other principles and practices from open science, the Indigenous Data Sovereignty movement and participatory data stewardship all provide critical guidance for the creation, use and management of the data that will underpin AI in Australia's science system.

Education, training and capability

There is an imperative for education, training and capability uplift across the science sector and into lifelong education. The number of tertiary AI courses offered in Australia almost doubled between 2020 and 2023, providing greater educational opportunities (37 offerings in 2020, 69 in 2023) (OECD, 2024).

 The Australian Human Rights Commission (2023) has recommended that 'professional development and training be provided to teachers' and 'schools should introduce comprehensive digital literacy programs to provide students with the skills needed to engage with generative AI tools in a responsible and ethical way'.

 In 2021, AUD 24.7 million was invested in establishing CSIRO's Next Generation AI Graduates Program to attract and train job-ready AI specialists in Australia (CSIRO, 2021). Currently, more than a thousand CSIRO researchers are working on a diverse range of AI and data science projects (CSIRO, a).

In December 2023, CSIRO' researchers published the world's first responsible AI book for practitioners (Lu, 2023a). The book introduces Responsible AI Pattern Catalogue, featuring over sixty best practices for different types of stakeholders. It also contains case studies from industry partners on how they have applied these best practices.

Human-centric artificial intelligence

Human−AI collaboration and human-centric AI is designed and implemented to ensure humans can work effectively with AI and benefit from the complementary strengths of humans and AI systems to carry out tasks to higher standards than either can achieve alone. In 2023, Australia signed the Bletchley Declaration affirming that AI should be designed, developed and deployed in a human-centric, responsible and trustworthy manner. Australia then signed the Seoul Declaration in May 2024, which builds upon the Bletchley Declaration. Signatories of the Seoul Declaration committed to a shared understanding of the opportunities and risks posed by AI.

CSIRO's collaborative intelligence (CINTEL) program of work is developing the science and technology to ensure AI systems support humans to solve scientific challenges, such as highly labour-intensive tasks like genome annotation (CSIRO, b). Annotation uses the genome sequence to create biological phenotypes critical for increasing crop yields through selective breeding. The group is developing a scalable approach involving collaboration between a domain expert and AI that will allow for accurate and timely annotation of genomes.

CSIRO's Science Digital – AI for Science program of work is developing an agentic AI platform that allows scientist users to integrate AI agents into scientific discovery workflows. AI agents will assist and leverage the work of human scientists from hypothesis generation to experimental design to outputs analysis. The AI agent platform will evolve into a user and developer ecosystem where scientists can build their own AI agents alongside AI agents built by others. Moreover, CSIRO has entered a strategic partnership with Google to promote the role of AI in Science, to educate and upskill scientists on safe and responsible use of AI, and to nurture a community of practice in AI for Science.

Gender, ethnic and cultural diversity

The AI workforce lacks gender, ethnic and cultural diversity, which limits the quality of outcomes. Improving this will contribute to an uplift in AI capability within research organizations.

The Government of Australia's (2020) *Advancing Women in STEM Strategy Action Plan 2020* provides a national, coordinated approach to achieving sustained increases in gender equity in science, technology, engineering and mathematics (STEM). Currently, only 20% of AI and computer science PhD students are female in Australia, however it is notable that 44% of the new AI talent entering the market in Australia are female, placing Australia amongst the highest gender diversity in the world for new talent (Randstad, 2024).

Programs such as Deadly Science (Deadly Science) and the Indigenous STEM Education Project (CSIRO, 2021) seek to support and engage Aboriginal and Torres Strait Islander students in science- and STEM-related careers. Between 2014 and 2021, the Indigenous STEM Education Project reached over 23,000 participants in 603 schools, and Deadly Science has delivered 7,500 boxes of science resources to over 800 schools.

CSIRO's Responsible AI Pattern Catalogue (Lu et al., 2023b) and Diversity and Inclusion (Zowghi and da Rimini, 2023) in AI Guidelines were highlighted in the National Framework for the Assurance of AI in Government. The same works are integrated into the digital pathway co-developed with the National AI Centre and will be accessible as interactive tools to all Australian businesses.

Ethical capability

Evolving standards and regulation of the design and implementation of AI require investment in ethical capability – including technology, skills and cultures. In support of responsible innovation, the Australian government has produced a framework of eight ethics principles to ensure AI is safe, secure and reliable (Dawson et al., 2019; DISR, a). This was followed by

the 2023 discussion paper *Safe and Responsible AI in Australia* (DISR, 2023) to support responsible AI practices and increase community trust and confidence through consultative government responses. The Australian government's January 2024 interim response to the consultation identified a range of legal, regulatory and governance measures that are needed to ensure AI is designed, developed and deployed safely and responsibly (DISR, 2024).

Following this work, the National AI Centre (NAIC) has developed the first iteration of the Voluntary AI Safety Standard, with 10 voluntary guardrails aimed to help organisations develop and deploy AI systems safely and reliably (DISR, 2024). The government is also considering options for mandatory approaches and released a set of ten mandatory guardrails for AI in high-risk settings for consultation in September 2024 (DISR, 2024). Within their proposal, the Australian Government has sought advice on the proposed guardrails themselves and the three different regulatory options available to the Australian Government to mandate the proposed guardrails, including the introduction of a cross-economy Australian AI act.

CSIRO's Responsible Innovation Future Science Platform is a program of research that systematically and scientifically assesses the risks, benefits and uncertainties of future science and technology. Meanwhile, the Australian Human Rights Commission (2021) recommends that 'professional accreditation bodies for [STEM] should introduce mandatory training on human rights by design as part of continuing professional development'. However, no framework or strategies are in place for such upskilling in the science sector, and very few professional accreditation bodies exist.

CSIRO Responsible AI Team collaborated with Alphinity Investment Company on the world's first Responsible AI Framework using the ESG lens (Alphinity and CSIRO, 2024), involving 26 ASX and internationally listed companies. The work was widely reported internationally, with many investor roundtables discussing their use of the framework and potential licensing for external use.

Other challenges

As well as impacting how science is done, AI may impact how science is administered, governed, funded and assessed. Australia's research councils, the Australian Research Council and the National Health and Medical Research Council, have created policies to account for the role of generative AI in their grant processes (ARC, 2023; NHMRC, 2023). The use of generative AI is prohibited in assessing applications to preserve the confidentiality and integrity of the process. For applicants, the policies note the potential benefits and need for caution in using AI but do not list any specific restrictions on the use of AI by applicants.

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BENIN

Anticipating the impacts of artificial intelligence on West Africa's aspiring digital services hub

Ministry of Digital Economy and Communications

Key Takeaways:
- Digital infrastructures and platforms have been put in place since 2016 as part of the Beninese vision as the hub for digital services of West Africa. Institutes in the country have initiated AI training and education programs for the young generation.
- Challenges around data collection, preparation, access, storage and governance need to be addressed for proper operation of AI systems. Data protection and fundamental rights as well as data governance also raise legal, regulatory and ethical challenges

The Government of Benin, with its vision to 'transform Benin into the digital services hub of West Africa for accelerating growth and social inclusion' (MDEC, 2016) has implemented several structural reforms and deployment projects of digital infrastructure and platforms since 2016. This vision has been articulated in the government's action programs, which focus on flagship projects, priority projects, and projects with rapid impacts for structural, economic, political and social transformation of the country.

The operationalization of its vision has enabled Benin to establish a digital code, a national data centre, a national portal for public services, a public key infrastructure, a national administration network integrating over 187 sites, and a network of over 2,500 kilometres of fibre-optic cables deployed throughout the national territory, among other projects. The use of Benin's new infrastructure and platforms will generate massive amounts of data that must be managed and valorised through the use of AI tools and technologies so that their value creation potential does not escape the Beninese economy.

National Artificial Intelligence and Big Data Strategy

It is within this framework that the Government of Benin adopted, in January 2023, a National Artificial Intelligence and Big Data Strategy (SNIAM 2023–2027). This strategy outlines a structured action plan around four programs, including one related to 'Support for training, research, innovation, the private sector, and cooperation' (MDEC, 2023). Through this program, Benin aims to support training and research by equipping universities and promoting partnerships in AI. It also aims to develop financing mechanisms by strengthening institutional support to the structures that are responsible for entrepreneurship and innovation as they mobilize and sustain resources allocated to startups. Lastly, it aims to strengthen sub-regional and international cooperation in this area.

The development of SNIAM 2023–2027 was carried out in two phases: a preliminary stage followed by the development of the document itself. It was during the preliminary stage that the government prepared by providing Benin with its digital code, connectivity infrastructure, data storage and platforms conducive to strengthening digital trust. However, many challenges remain to be addressed. There are data challenges concerning the collection, preparation, access, storage and governance of the data necessary for the operation of AI systems. There are also notable legal and regulatory challenges related to AI governance and regulation, and ethical challenges concerning data protection and fundamental rights.

At the same time, the opportunities for Benin are manifold and relate to supporting the development of priority sectors such as education, vocational training, health, the living environment and transportation.

The use of Benin's new infrastructure and platforms will generate massive amounts of data that must be managed and valorised through the use of AI tools and technologies so that their value creation potential does not escape the Beninese economy.

Financing and institutional arrangements

With an estimated cost equivalent to USD 7.7 million over a period of five years, the main actions of SNIAM 2023–2027 will be implemented through a public–private partnership, at the national level, targeting specific areas of development. Various sources of financing are proposed to mobilize the resources needed to implement the actions outlined in the strategy. These include calls for national funding from both the government and the private sector; appeals for bilateral and multilateral foreign aid; and appeals for foreign private capital within the framework of the public–private partnership.

The integration of AI in Benin will require the participation of all public bodies, the public sector and the population to achieve the desired effects. The effects in question include improving productivity and the quality of products and services in priority sectors and those presenting real opportunities for AI; a dynamic AI ecosystem driven by Beninese companies; technology and knowledge transfers between research laboratories and the private sector; and recognition of Benin in the field of AI.

Stakeholders shaping readiness in research

On one hand, AI readiness in research involves public innovation bodies, and on the other hand, it involves civil society organizations, academics, startups and the private sector in general. Several targeted skill development programs have been identified to help workers prepare for AI transitions. These programs are either directly envisaged by the government or in collaboration with partners. Thus, the Ministry of Digital Economy and Communications, as part of the operationalization of the AI strategy action plan, is collaborating with various digital ecosystem partners in Benin to implement awareness raising, networking, training activities, and more.

Basic AI awareness actions are also planned during the development of digital literacy modules. The Smart Africa Alliance has developed a capacity building reference document that has led to the implementation of several projects and initiatives, including the Smart Africa Digital Academy (SADA) project, which supports existing processes in various countries (SADA, no date). In Benin, a convention for the implementation of SADA was signed in 2022, and in 2023, actions began to support the Lever of Learning for Retraining in the Digital Sector (LeARN), focusing on three modules: training of 25 Data Steward experts, training of 25 Data Developers, and AI training (Government of Benin, 2021).

Furthermore, there are initiatives by some non-governmental actors in the Beninese digital and AI ecosystem that are worth highlighting. The Odon Vallet Foundation has held a Summer School on Artificial Intelligence since 2021, where around a hundred young people receive pragmatic and high-quality training on basic AI concepts such as programming, machine learning and embedded electronics (including robotics and home automation). Since 2020, the Francophone Agency for Artificial Intelligence has been organizing awareness conferences for young Beninese people, including women, on the challenges of AI, as well as online master's-level training in AI and big data in partnership with Francophone universities (AFRIA, 2020).

National scientific and research community

SNIAM 2023–2027 is the result of a synergy of actions stemming from both government sectoral departments and the private sector, as well as associations or academic organizations.

In its development process, the national strategy's aim was to have a consensus document that takes into account vital domains such as research, developments and innovations, applications, market placement and intersectoral dissemination, support, and guidance for deployment.

In terms of local research institutions, Benin has a training and research centre, the Institute of Mathematics and Physical Sciences (IMSP), established in 1988. With its specialized resources in AI, the IMSP constitutes a centre of competence at the national level in mathematics and AI computer science (at the PhD level), and it has a supercomputer with rare power for an institute in West Africa. The challenge for the IMSP today is to maintain computing power and strengthen the means to take advantage of this infrastructure. The Institute of Training and Research in Computer Science, the Abomey-Calavi Polytechnic School and its Doctoral School of Engineering Sciences, and the Laboratory of Biomathematics and Forest Estimations at the University of Abomey-Calavi are also working on several projects implementing AI technology as well as blockchain.

Furthermore, several capacity-building actions have been initiated and are ongoing to prepare human resources for the labour market transformations induced by AI and emerging technologies in general. In addition to teaching computer science (networking and engineering), the IMSP has been offering a data science master's program since 2020, having already trained about twenty graduates, with around forty students currently undergoing training in this field. About ten theses in AI or related fields have already been defended at the IMSP. Additionally, at the Institute of Training and Research in Computer

Science there is a bachelor's program in AI. Efforts are under way to create a master's program here to allow students to continue their studies in AI. The AI training provided in this field will address the various challenges in AI skills. Several universities and schools are also initiating training programs in AI within the private sector. For example, the Sèmè City Development Agency, in partnership with Sorbonne University, launched in 2022 a cohort of professionals who benefited from highly certified continuing education in AI.

Operational steps for the strategy

SNIAM 2023–2027 aims to make AI and big data a lever for Benin's development by 2027, with increased support for strategic sectors such as education, health, agriculture, the living environment and tourism in an opportunistic approach. Ongoing actions are distributed within the programs, and their implementation will be based on prioritization considering three factors. The first factor is business impact: the extent to which the proposed solution will benefit the primary beneficiary or address the original problem. The second factor is given complexity: the extent to which the data are available and exploitable right now. The third is technological complexity: the effort it will take to create, deploy or adapt an AI solution.

In operationalizing the strategy, initiatives are under way to identify and execute associated action plans. These include feasibility studies and project definition to operationalize SNIAM 2023–2027. They also extend to the development of application platforms for AI use cases. As part of this latter action, the Government of Benin has implemented GPT.BJ, an initiative to promote access to legal information in citizens' lives (Le Matinal, 2023). GPT.BJ is a chatbot developed by the Benin Agency for Information Systems and Digital and is designed to answer questions related to the general tax code, digital code, labour code and penal code of Benin. It was launched in 2023 during the second Digital Entrepreneurship and Artificial Intelligence Fair.

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BRAZIL

Reaping the benefits of artificial intelligence with some cautionary notes

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Key takeaways:
- The need to facilitate AI research and development has driven the Brazilian government to enact legislative reform and a key achievement is the partnership of the Ministry of Science with national funders and experts for the creation of AI Applied Research centres.
- Challenges in the country include a gap in AI literacy and education as well funding for AI research. There is also worry on the stagnation of the national AI strategy and bills of law that could hinder science and research priorities, foster uncertainty among researchers and limit international collaboration.

Brazil has a significant history in promoting long-term policies for digital development, beginning in the 1970s with improved digital infrastructure for data collection, storage, processing and sharing (for example, within the federal agencies SERPRO and DATAPREV). Since then, specific legislation has supported the creation of networks by bringing companies and universities together – for instance, IBM and the University of São Paulo, which have developed a joint initiative for long-term research projects on AI such as AI for sustainable agribusiness and food networks, climate decision-making with multiple criteria among other projects – and accelerating deployment of Internet usage, including by instituting an encompassing Civil Framework for the Internet (Government of Brazil, 2014).

However, according to a Berkman Klein Center research report (Fjeld et al., 2020) and the MIT Technology Review (Gupta and Heath, 2020), despite those important steps Brazil was not ranked well amongst Latin American countries, up until 2020, in terms of AI regulations and respective national strategies. It made some progress thereafter, with later initiatives positioning it on OECD's Policy Observatory map of AI regulation and national strategies, as well as in reports from private organizations such as the Global AI Index and others (IAPP, 2023).

Research centres

Brazil reached important milestones between 2018 and 2021, particularly with the enactment of new laws (Government of Brazil, 2018; 2019a) that removed bureaucratic barriers to digital transformation driven by AI research and development. That was the scenario when, in 2019, the Ministry of Science, Technology, Innovation and Communications (MCTIC) partnered with the Foundation for Research in the State of São Paulo (FAPESP) and the Brazilian Internet Steering Committee to launch a call for creation of eight AI Applied Research Centres.

The targeted beneficiary sectors were health, industry, cities, agriculture (formally prioritized in the Science, Technology and Innovation national policy), information security (including the investigation and design of algorithms and mechanisms) and cyber defence systems. Six of these centres were selected in May 2021 (one for AI in smart cities, one for agriculture, two for industry and two for healthcare) and four in 2023 (two for AI in industry 4.0, one for renewable energy and one for cybersecurity). Each centre involves dozens of senior researchers and dozens of students, and each centre receives around USD 200,000 a year for up to ten years from FAPESP.

The EBIA aimed at designing an AI development plan for the country by providing guidelines for the federal Executive Branch to encourage research, innovation and development of AI solutions as well as on ethical and reliability concerns.

National strategy

In April 2021, MCTIC presented the Brazilian National Strategy for Artificial Intelligence (EBIA), which was linked to the AI Applied Research Centres as another MCTIC structuring action to prepare the Brazilian science and innovation system for AI (MCTI, 2021). The EBIA aimed at designing an AI development plan for the country by providing guidelines for the federal Executive Branch to encourage research, innovation and development of AI solutions as well as on ethical and reliability concerns. Although the EBIA is a general and macro-level national strategy, and has not specified particular fields for research on AI, it has indicated strategic actions where references to research are made, especially regarding research aimed at developing ethical AI solutions. These directions were addressed in the 2024-2028 Brazilian National Plan for Artificial Intelligence (PBIA), published in 2024, aiming at ensuring proper infrastructure of high-performance computing (HPC) capable of processing large volumes of data and of developing advanced algorithms. The 2024 Brazil National Plan also highlight's the establishment of an AI Institute (IIA) at the National Laboratory for Scientific Computing (LNCC) in charge of coordinating applied research, promoting innovation, and seeking cooperation from international institutions. The 2024 Brazil Nation Plan plans for a significant budget and the improvements in the HPC infrastructure where the Brazilian government is calling on researchers to develop a "Brazilian AI". While the research needed for developing this goal of a national AI remains unclear, one of the major goals is to develop advanced language models in Portuguese, trained with national data that encompasses the cultural, social and linguistic characteristics of the country.

Bills of law

In parallel to the structuring of an overall administrative strategy, the legislative attempts to legitimize the national plan were followed, from 2019 through 2021, by the introduction of three AI bills of law in Congress (Government of Brazil, 2019b; 2020; 2021), which particularly envisaged the fostering of innovation and the safeguarding of harm minimization. None of those bills of law were approved. In 2023, therefore, the Senate invited a group of 40 jurists to conceive of a fourth bill (Government of Brazil, 2023; Hilliard, 2023). Its contents were inspired by the European Union's AI Act – then considered as international standard of good practice on the matter – and included the aim of sustaining a risk-based approach to AI regulation. Such a long sequence is indicative of concentrated efforts on legislative action so far. Finally, since the last quarter of 2023, Congress has debated on all bills of law in an attempt to consolidate them, and has drafted a replacing text, which is expected to be voted after the Country-wide municipal elections to take place in November, 2024.

Strategic goals and action

At the other end, in the administrative sphere, EBIA purports to be driving the Brazilian government to stimulate research, innovation and development of AI solutions in accordance with multiple considerations, including the assurance of reliable and ethical development and usage (Government of Brazil, 2022). Such goals have drawn on Organisation for Economic Co-operation and Development (OECD) concepts and principles as source of reference for key issues to be addressed, and inspired EBIA's structure with regards to areas of concern – for instance, inclusive growth. In practice, EBIA is split into six primary goals, namely: education, training and workforce; research development and innovation; application in productive sectors; application in public administration; and public security. However, although such EBIA axes point to strategic actions, they have been vaguely worded, so there is lack of clarity on concrete ways to set proper public policies. The goals do not get into prescribed instrumental actions (Filgueiras and Junquilho, 2023).

For example, in the education axis the development of digital literacy programs is generically advocated for all areas and levels of education, irrespective of the natural specificities of each such as the particularities for the teaching of AI in the context of fundamental schooling, or of academic advanced studies. Paradoxically, the Latin American AI Index has interpreted these generic terms as a strength, making the assumption that Brazil has effectively incorporated AI elements into its national school curriculum. The Common National Curriculum Base has indeed been recently updated to add computational thinking and computer programming items, but the reality is that AI literacy has not been properly introduced, as there are neither qualified teachers nor a defined strategy.

Research guidelines

Mirroring such a scenario, in November 2023 the Brazilian Academy of Sciences published a set of recommended guidelines for the use and scientific advancement of AI in Brazil (ABC, 2023). The recommendations stress the existing gap in AI literacy and education throughout civil society, especially for minors, and in fundamental action to prepare the national system for AI in the long term. Alongside these and other issues, the group of researchers from the Academy highlights the need for an immediate increase in funding from the government for

public research (as public universities lead AI research in Brazil), the creation of mechanisms for the private sector to also increase investments in this technology, and the need for a regulatory environment safe for teachers and researchers (ABC, 2023).

In essence, the development of a national science system for AI necessitates the implementation of public policies designed to coordinate the various enabling factors involved. Consequently, it is expected that the examination of the current legislative and administrative landscape in Brazil, coupled with an analysis of select studies from both scientific and grey literature, will afford insight into Brazil's efforts to establish its national science system for AI and the resultant impact on the national science and research framework.

EBIA and AI bills of law serve as the principal instruments guiding scientific research priorities and fostering a targeted innovation ecosystem in Brazil. Failure to contemporaneously advance these instruments may engender negative impacts by creating an uncertain regulatory environment for researchers and professors. Moreover, such stagnation could restrict international collaboration and funding.

Missing implementation

However, generally speaking, other Latin American countries' national AI strategies (Chiarini and Silveira, 2022) propose circa a decade to be implemented, while Brazil has attempted to do it within a relatively short period from 2020 to 2022. There should be little surprise, then, that no specific goals have been substantially achieved so far, despite the magnitude they may represent in the context of a country with a continental size and population. EBIA's missing cascade of detailed indications of opportunities and challenges to implementation (Chiarini and Silveira, 2022) is therefore a serious and urgent problem for Brazil, and for everyone who would likely benefit from AI research for accelerated solutioning.

Given all of the above, the fact that AI is quoted in the Brazilian Digital Transformation Strategy 2018 nine times, but very generically and disconnected from any effective action or concrete objective, seems like one more sign that Brazil has not properly set EBIA's goals and has struggled for too long to approve a legislative platform. Brazil's insufficient preparation for AI and machine learning makes its national science system inconsistent with international good practices. Its national challenges and possibilities, and regional prominence, demand prompt action and support.

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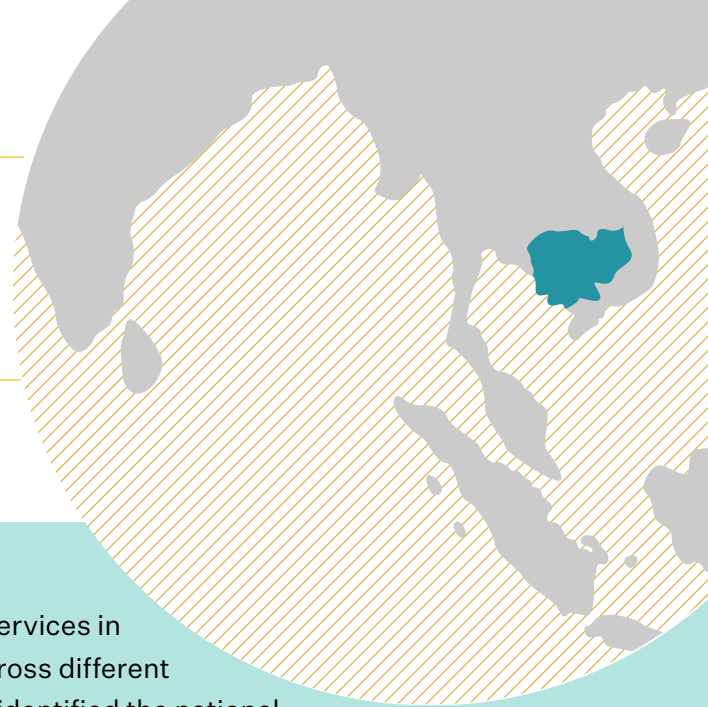
CAMBODIA

Seeking artificial intelligence approaches to national research missions

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Key takeaways

- The collective efforts in developing cloud-based services in the country has been supported by local actors across different sectors. The National Research Agenda 2025 has identified the national challenges and has put a plan to address these challenges.
- There is limited funding and capacity for research in Cambodia as well as weak alignment between research work and national challenges. Cultural caution around uncertain technologies makes a part of why education is predominantly prioritized for engineering and accounting.
- Among the immediate priorities are strengthening of the infrastructure for data and computing power as well as upskilling and expansion of AI practitioners.

In the rapidly developing landscape of technological advancement, Cambodia stands poised to integrate machine learning and AI into its national science systems. We delve into the strategic approach taken by Cambodia, exploring various facets ranging from the government's perspective on AI's impact to the institutional arrangements and stakeholder involvement essential for fostering innovation and economic growth.

Human-centred policies

At the heart of Cambodia's strategy lies a keen awareness of the transformative power of AI across diverse sectors. With a vision aligned with global AI trends, the Government of Cambodia is crafting human-centred policies aimed at driving responsible AI research and development (R&D). The Ministry of Industry, Science, Technology and Innovation (MISTI) has published the report *AI Landscape in Cambodia: Current Status and Future Trends* (MISTI, 2023a). This forward-thinking approach underscores Cambodia's commitment to leveraging technological innovations to enhance its socio-economic development, as the Supreme National Economic Council outlined in its *Cambodia Digital Economy and Society Policy Framework 2021–2035* (SNEC, 2021).

Institutional framework

Institutional arrangements play a crucial role in facilitating Cambodia's AI agenda, with the government spearheading initiatives to initiate and integrate changes. Collaborative frameworks and knowledge-sharing platforms are instrumental in fostering collaboration among multidisciplinary research and innovation sectors, paving the way for holistic development. *Cambodia's Science, Technology & Innovation Roadmap 2030* (MISTI, 2021)

emphasizes that the National STI Policy prioritizes five pillars: governance, human capital, R&D, collaboration and ecosystem building. In addition, MISTI (2023b) developed the *Digital Tech Roadmap*, pinpointing machine learning and AI as key technologies for national digital technology development. According to the MISTI (2023c) *Science, Technology & Innovation Report 2022*, MISTI has the mandate as a government entity to oversee the STI sector, and is responsible for promoting the network of AI, robotics and automation in Cambodia.

National research missions

The *National Research Agenda 2025* detailed by MISTI (2022) identified eight national research missions: 1) local food; 2) reliable energy supply; 3) quality education; 4) electronic and mechanical spare parts; 5) cloud-based services; 6) electricity and potable water; 7) carbon neutrality; and 8) digitally-enhanced health. The key research areas to support mission 5 on cloud-based services are infrastructure, software, cybersecurity and accessibility. These services would be provided to businesses in Cambodia to develop their digital capacities and store their data locally. MISTI, the Ministry of Education, Youth and Sport and the Ministry of Post and Telecommunications are all leading institutions in implementing policy instruments – ranging from legal and policy frameworks to human resources, infrastructure and collaboration – in accomplishing the cloud-based services research mission, with the National Council of Science, Technology and Innovation as the guiding body. Currently, universities and research institutions such as the CamTech University, Royal University of Phnom Penh, Institute of Technology of Cambodia, Cambodia Academy of Digital Technology and Kirirom Institute of Technology, as well as broadband networks and service companies, software producers and cybersecurity companies, have been producing research to accomplish the cloud-based services research mission.

Challenges and pathways to research and innovation in Cambodia

The National Research Agenda (MISTI, 2022) highlighted five challenges facing the national research and innovation system, all of which are relevant to AI research:

- There is national underinvestment in R&D and limited policy support to promote research.
- There is limited alignment between research activities and national challenges, and insufficient contribution of academic research to private sector innovation activities and policy-making.
- There is limited research capacity in the public and the private sectors.
- Research institutions need strengthening and resources.
- There is need for stronger university–industry linkages and sustainable international collaborations.

In response, the National Research Agenda developed four pathways to achieve the country's national research missions:

1. Invest in research to support the eight research missions.
2. Strengthen the role and capacities of public research institutions.
3. Support research careers.
4. Incentivize research activities and collaboration.

Missing pieces

One urgent area of concern for Cambodia is the significant data and computing power required for effective machine learning algorithms. Infrastructure limitations and a shortage of skilled practitioners in the AI field present immediate barriers for Cambodia. The lack of available talent and financing hampers AI research and experimentation, hindering the country's ability to fully capitalize on AI's potential benefits. Additional support in the form of public–private partnership and international collaboration will be required to address these challenges.

Cultural challenges also loom large as Cambodia delves deeper into AI adoption. A cautious yet experimental mindset is essential to navigate the uncertainties and errors inherent in AI implementation. Furthermore, fostering innovation, critical thinking, and science, technology, engineering, arts and math education is crucial to equip the workforce with the skills necessary for successful AI development and deployment. Cambodia's current education landscape is skewed towards the context of a developing country, with civil engineering and accounting as predominant majors. Without a strong foundation and culture of scientific reasoning, the impact of AI research and applications will be limited.

Opportunities ahead

MISTI collaborated with the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2022) in developing the report *Mapping Research and Innovation in the Kingdom of Cambodia*. UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments survey conducted in 2021 conveyed that R&D expenditure and human capital in Cambodia were both limited. On the positive side, Cambodia is taking steps to integrate AI effectively into its science systems. 'Networking, matchmaking and/or partner search for R&D/innovation activities' and 'support for infrastructure' were the two highest-ranked types of R&D and innovation-related support or services provided, at 50 percent and 40 percent consensus respectively.

In conclusion, Cambodia offers a compelling narrative of a nation poised to harness the transformative potential of machine learning and AI for sustainable socio-economic development. The median age of Cambodia is 27 years, with a large majority of the population integrating social media, e-commerce and mobile banking applications into their daily lives. With the unique combination of a young, tech-savvy population and a lack of legacy technologies, Cambodia has the unique characteristics to leapfrog conventional technological and industrial revolutions. Although late to the game, the timing is opportune for Cambodia to adopt AI at the national level, in an era where the power of AI is now more accessible than ever. Through strategic planning, stakeholder engagement and a commitment to inclusivity, Cambodia is charting a path towards a future where technological innovation drives progress and prosperity for all.

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CHILE

Finding possibilities to apply artificial intelligence in an existing research financing ecosystem

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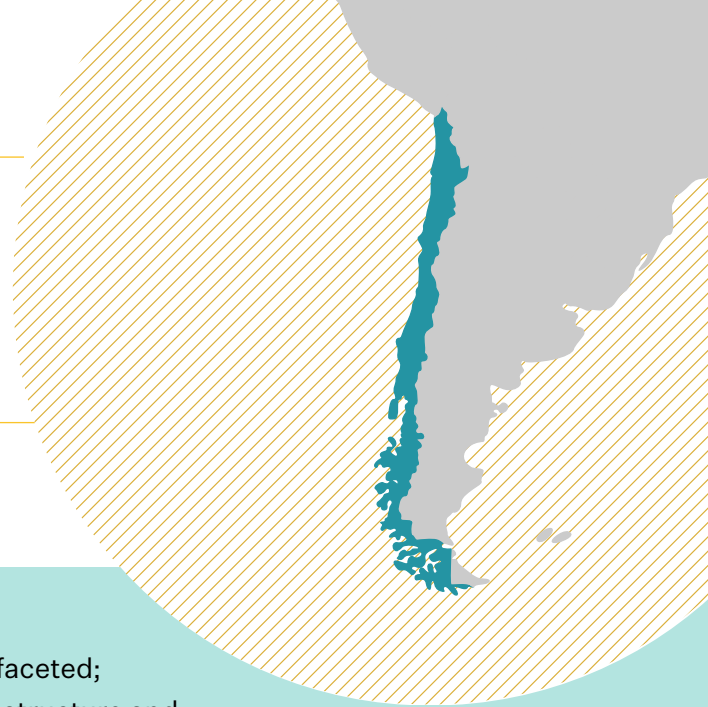
Key takeaways:
- Challenges in Chile around AI for science are multifaceted; primarily there is a lack of funding, resources, infrastructure and capacity and skills for AI.
- Priorities for AI have not been identified at the national scale and universities may be working in silos. Whether a unified vision for AI for science will exist in the near future in Chile is not yet clear.

Chile gained a National Artificial Intelligence Policy in 2021, after a two-year formulation process in which more than 1,300 people participated (MinCiencia, 2021). The policy is formulated in three pillars: enabling factors, R&D, and governance and ethics. The proposed guidelines have a ten-year scope and involve several public and private agencies, which are coordinated by the Ministry of Science for these purposes.

It must be noted, however, that the policy is not a binding instrument; the guidelines are not explicit mandates but proposed courses of action, which implies certain enforcement difficulties. In this sense, the policy also does not define priorities in the area of R&D project financing in any significant way.

The larger research financing ecosystem

The Chilean research and development (R&D) ecosystem is relatively small compared to the average in the Organisation for Economic Co-operation and Development (OECD, no date). The percentage of Chile's gross domestic product allocated to R&D amounts to 0.36 percent, while in the OECD it is 2.68 percent, meaning the relative investment in Chile is seven times lower. At the same time, the system is highly dependent on public funding, which represents 57 percent of total investment (MinCiencia, no date a). In nominal terms, in 2021 total investment reached USD 1.138 billion, USD 648 million of which was public investment.

These amounts represent the total investment in R&D, including talent training, basic and applied research and technology transfer. Forty-one percent of public investment is managed through the National R&D Agency (ANID), which reports to the Ministry of Science and Technology, while 15.5 percent is resources invested by the universities and comes from the national budget through fiscal contributions or undergraduate university

tuition subsidies (DIPRES, 2023). The remaining 30 percent depends on various agencies with specific mandates, such as the Development Corporation or Public Technological Institutes in specific areas such as fisheries, agriculture or aerospace research. International contributions, for example from observatories, are included in the ANID amount.

Public funding to research

The Chilean public funding system covers the whole researcher career, starting at the formation of advanced human capital, its insertion into industry or academia, the development of long-term individual and associative research projects, as well as infrastructure for centres and universities (MinCiencia, no date b). All of the above is financed through competitive calls, with award rates that vary between 8 percent and 30 percent depending on the instrument (ANID, 2022). The evaluation of the projects is carried out by national academic peers, grouped in 'study groups' that are nominated by collegiate scientific committees representative of the different sectors that participate in the ecosystem (universities, research centres, scientific societies and academia). Currently about 1,500 national researchers participate in 52 study groups, and 120 international peer reviewers evaluate the largest competitions (over USD 1 million) (ANID, no date).

Local research, however, lacks significant targeting and prioritization mechanisms as well as mandates to prioritize. A full 87 percent of public investment in R&D – USD 564 million – is allocated to 'open skies' projects, whether for the formation of advanced human capital or for individual or group research (MinCiencia, no date a). The remaining 13 percent of public R&D investment is mainly housed in the Public Technological Institutes, which have specific mandates from the government. This freedom of research transcends public funding and is also a differentiating element of the university ecosystem, composed of 56 universities, where more than 80 percent of the national knowledge-generating community is concentrated (MinCiencia, no date b).

In summary, the Chilean R&D ecosystem is small compared with the OECD average, with little prioritization in the allocation of resources and high dependence on public funding. Nevertheless, it has solid and transparent mechanisms for the evaluation of highly competitive projects for the entire trajectory of researchers' development, oriented mainly to individual research projects. The impact of Chilean publications measures close to the OECD average, and thus the impact achieved per dollar of investment goes well beyond the average.

The arrival of artificial intelligence

In terms of prioritization of sectors and funding practices, the Chilean R&D ecosystem faces challenges from AI. Being a highly atomized system in terms of project evaluation, many evaluators are not trained to properly assess the impact that the use of AI or machine learning tools can have on research, so more orthodox approaches outside of the science, technology, engineering and mathematics (STEM) disciplines are likely to be prioritized. On the other hand, in the absence of prioritization or targeting mechanisms in specific sectors, the development of these competencies in the academic community depends profoundly on what the host institutions – mainly universities – do. However, the lack of

base funds for universities in this area means they need to prioritize other policies rather than the continuous training of their academic staff. There is no mandate for universities to move in this direction, nor are there any competitive mechanisms to encourage work along these lines.

In this sense, the integration of AI tools in interdisciplinary research depends on the ability and possibility of researchers to articulate around specific projects for particular funding calls – which must be evaluated by peers who do not have the tools to understand their impact – or else focus on particular STEM study groups. This phenomenon means that interdisciplinary projects using AI compete for funds with AI-focused R&D projects, which ultimately may discourage the AI community from collaborating with other disciplines. Addressing AI governance issues has led to more international collaboration which has encouraged academic collaboration.

Training and talent

In terms of training and retention of talent, since 2019 there has been a relative increase of 15 percent in funding for the training of advanced human capital at the local level, with a decrease of 12 percent in funding for master's and doctoral degrees abroad (ANID, no date). This is consistent with the maturation process of the local university system in general. However, in disciplines such as AI it represents a challenge, since the community is less mature and therefore there is less quality supply than in disciplines like astronomy or biochemistry. This means that the speed at which the community has been growing is decreasing, which limits the possibilities for interdisciplinary research. Similarly, the growing interest of the private and public sector in the adoption of AI tools at the international level has generated a significant increase in the demand for advanced human capital, which means that the salaries offered by academic research careers are less competitive than five years previously. Consequently there is a shortage due to better working conditions outside the academy. Although the talent gap that will be faced in the future seems evident, there are no concrete efforts on the part of the private sector to significantly promote talent development on a national scale.

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Infrastructure and data

In terms of infrastructure, Chile lacks national laboratories or 'big facilities' with open access to the academic community. The development of AI models requires access to computing infrastructure, either physical or cloud, which is increasingly expensive due to the generalized increase in demand. This lack can be a significant impediment to the adoption of AI tools in an interdisciplinary manner, or a concentration of tools in university institutions with the resources to fund them.

Data access and governance for AI systems is also a structural weakness of the local system. A policy of open access to state-funded research data started in 2022, but the academic community is still reluctant to embrace this openness. There is no culture of standardization of data formats, which means that in many disciplines curatorial work is required prior to their availability. This lack of standards is also reflected in privacy and access policies, which depend on what is established by each university or even faculty within the university. All of the above translates into a substantive challenge for the adoption of AI in an interdisciplinary manner.

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CHINA

Promoting the Artificial Intelligence for Science approach

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Key takeaways:
- The government in China is supporting the integration of AI across different fields of science through programs and infrastructure.
- China is active on the international front regarding AI technologies and has achieved the development of platforms and software supporting AI.

Artificial Intelligence for Science (AI4S) is an emerging mode that integrates AI and scientific research. It refers to the use of AI technologies and methods to learn about, simulate, predict and optimize various phenomena and laws in nature and human society. This case study focuses on the example of AI4S in China, exploring the impact of machine learning and AI on the scientific system.

The Chinese government attaches great importance to AI4S, promoting innovations in AI algorithms and models oriented towards major scientific problems. They have established open platforms in typical research areas of AI4S, encouraged academic institutions to open their data resources and set norms for ethical conduct with AI4S. At the national and local government levels in China, policy initiatives in the field of AI4S are mainly as follows.

Special research programs and infrastructure
In March 2023, the Ministry of Science and Technology, in collaboration with the National Natural Science Foundation of China, launched a special initiative called the Implementation Plan for Scientific Research Driven by Artificial Intelligence (2022–2025) to support the adoption of AI tools in basic sciences such as mathematics, physics, chemistry and astronomy. The intention is to address major challenges such as climate change, the energy transition, drug development, genetic research, biological breeding and new materials. The projects include cross integration of AI and materials science, cross integration of AI and basic mathematics, cross integration of AI and information technology, cross integration of AI and life sciences, and cross integration of AI and ethical and social issues (Ministry of Science and Technology, 2023a).

Meanwhile, the Ministry of Science and Technology is leveraging the national project Science and Technology Innovation 2030 – Next Generation of Artificial Intelligence (Ministry of Science and Technology, 2021) as a driver to build open intelligent computing power infrastructure, facilitate the active opening of data resources from various sectors, and generate policy synergy to advance AI4S. In April 2023, the Shanghai government supported Shanghai Jiao Tong University in launching the Open Platform of AI4S with Open-Sourced Models and Scientific Data (Jiefang Daily, 2023).

Ethics governance and regulations

In 2017, the Chinese national plan for developing AI was released (State Council, 2017), in which it is pointed out that AI has both technical and social features. Two committees were established by the Chinese government to implement the plan: a technical committee and a governance committee. The governance committee is composed of relevant experts from universities, research institutes and enterprises. It has released documents such as *Governance Principles of the Next Generation of AI – Developing Responsible AI* (National Next Generation AI Governance Professional Committee, 2019) and *Next Generation Artificial Intelligence Ethics Standards* (National Next Generation AI Governance Professional Committee, 2021).

In 2021, the Chinese government also established the National Science and Technology Ethics Committee, which has released a list of high-risk AI research and development areas (Ministry of Science and Technology, 2023b). This ethics committee has a subcommittee dedicated to AI, consisting of experts from relevant sectors and providing professional consultations to the State Council for the formulation of China's technology ethics policies. Finally, in 2023, after a month-long online open consultation, the State Cyberspace Administration of China along with multiple departments jointly issued *Interim Measures for the Management of Generative Artificial Intelligence Services*, marking the first regulatory policy for China's AI-generated content industry (The Cyberspace Administration of China, 2023a).

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Brain computer interface (BCI) technology has also been included in the scope of AI ethical governance in China. In February 2024, the Artificial Intelligence Ethics Subcommittee under the National Science and Technology Ethics Committee, developed the "Ethical Guidelines for Brain Computer Interface Research". It emphasizes that research on brain computer interfaces should be conducted in accordance with relevant Chinese laws and regulations, internationally recognized ethical standards, as well as professional consensus and technical specifications reached by the scientific communities (National Science and Technology Ethics Committee, 2023).

In September 2024, the Research Ethics Committee of China Academy of Science released a document entitled 'Reminder on Integrity in the Standardized Use of Artificial Intelligence Technology in Scientific Research', which clearly states that the committee opposes the implicit use of AI for the following: the generation of unverified research reports, references lists, research proposals, literature review papers, peer review comments etc.; the use of AI generated data, audio, video and graphics as experimentally observed ones; the abuse of AI technology that endangers data security, infringes on intellectual property rights, and leaks personal privacy. The committee prohibits uploading review information to AI platforms that have not been approved by the review organizers. Additionally, wherever AI is used in scientific research, it is required that the name, version, date and usage process of the AI tool be declared [10].

The international perspective

China has an open and proactive attitude towards international cooperation in AI. It supports the United Nations' irreplaceable role in international AI governance, and actively participates in activities organized by bodies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), International Telecommunication Union (ITU), World Health Organization (WHO), United Nations Industrial Development Organization (UNIDO) and United Nations Development Programme (UNDP). China has invited United Nations bodies' representatives to join relevant AI conferences and forums in the country.

In November 2023, the Chinese government launched the Global Initiative on AI Governance, outlining eleven proposals that prioritize a people-centric approach and respect for the sovereignty of other countries. It was emphasized that China is willing to engage in communication, exchange and cooperation with all parties on global AI governance, promote the benefits of AI technology to all mankind, and propose constructive solutions to the development and governance issues of AI that are of wide concern to all parties in the new era (The Cyberspace Administration of China, 2023b).

China's promotion of non-governmental exchanges and cooperation is exemplified in the August 2023 International Young Scientist Salon 'AI for Science – Taking Place in the Current Scientific and Technological Revolution', organized by the China Association for Science and Technology in Shanghai. Young scientists from eight countries including the United Kingdom, Greece and Germany participated in the discussion and exchange (CAST, 2023) . Shanghai also hosted the January 2024 World Digital Education Conference, jointly organized by the Chinese Ministry of Education, the National Committee of UNESCO and the Shanghai Government. This conference focused on the theme of 'Digital Education: Application, Sharing, and Innovation', with subthemes of enhancing teacher digital literacy and competence; digitizing education and building a learning society; evaluating global trends and indices in digital education development; AI and digital ethics; challenges and opportunities of digital transformation for basic education; and digital governance in education (Ministry of Education, 2024).

Overall development trend

Based on relevant research reports and literature review (AI for Science Institute of Beijing, 2023), the overall trend in the field of AI4S in China can be summarized as follows.

Chinese academic institutions, universities and leading AI enterprises are proactive in the AI4S field, with internationally influential achievements such as MEGA-Protein, Pengcheng Shen Nong, Shanghai AI Lab's FengWu and PanGu Weather (Fang, X., et al., 2022) (K. Bi,et al., 2023) . Abundant open scientific research data resources have accumulated for AI4S, with open-source data found in meteorology, astronomy and high-energy physics (Tan, S. *et al.,* 2023).

A considerable number of AI4S algorithms and foundational software have also emerged, including Huawei's MindSpore Science, Baidu's PaddleScience, DP Technology's DeePMD and Zhipuai's GLM, providing rich datasets, foundational models and specialized tools for AI4S research (Huawei, 2017). AI4S applications are being explored in various fields including life science, material science, energy science, electronic engineering and computer science, earth and environmental science, and industrial simulation. In particular, institutions represented by the likes of Baidu and Huawei are actively promoting the development of AI4S industrial practice.

Foundational Artificial Intelligence for Science software

Baidu's PaddlePaddle began planning technical forms and product routes in the AI4S field as early as 2019. It has since released the biological computing platform PaddleHelix, the quantum computing platform PaddleQuantum, and the scientific computing platform PaddleScience. Baidu has collaborated on exemplary projects with multiple universities and research institutions and launched the PaddlePaddle AI4S CoCreation Program to build an ecological business opportunity. In May 2023, Baidu published a paper in the journal Nature opening up numerous possibilities for the integration of AI into fields such as biology and healthcare (Fang, X., et al., 2022).

Huawei, meanwhile, has launched PanGu large models for drug molecules, meteorology and ocean waves. Among them, the PanGu drug molecule large model can improve the screening speed of small molecule compounds, greatly improve research and development efficiency, and explore more possible combinations of molecular elements at lower costs. In July 2023, the research results of the PanGu meteorological large model of Huawei Cloud were published in the journal Nature, and it is the first AI model to surpass traditional numerical forecasting methods in accuracy (K. Bi,et al., 2023).

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COLOMBIA

Scientific ecosystems and enablers of artificial intelligence

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Key takeaways
- Colombia is a regional leader in AI in Latin America, but faces significant challenges in developing appropriate infrastructure, data availability and digital skills.
- The Government of Colombia envisions AI as a key tool in tackling the country's most pressing challenges.
- Multiple programmes and initiatives are underway to expand connectivity, improve digital literacy and advance the development of AI with a social impact.

In Latin America, Colombia is gaining prominence in the field of artificial intelligence (AI) through its efforts to establish governance and regulations for AI systems and implement programmes that prepare its citizens and the public and private sectors to harness the benefits of AI. Colombia sees AI as a crucial tool for driving socio-economic development, placing a strong emphasis on ensuring responsible, sustainable and ethical use in line with the principles set by the OECD (OECD, 2024) and UNESCO (UNESCO, n.d.). Despite its progress, Colombia faces significant challenges in developing its AI systems, particularly in the areas of infrastructure, data availability and digital skills.

Strengthening Colombia's science and research sector
With approximately 4,500 science, technology, engineering and mathematics (STEM) researchers, Colombia lags behind other nations in terms of research and development (R&D). By comparison, Chile has nearly 10,000 researchers, Argentina over 56,000 and the United States 1.6 million. Moreover, while Colombia has the third-largest R&D budget in Latin America (after Brazil and Argentina), it allocates the lowest percentage of GDP to it (0.29 percent), trailing behind Brazil (1.21 percent), Uruguay (0.48 percent), Argentina (0.46 percent) and Chile (0.34 percent) (Tortoise Media, 2024). This lack of a robust R&D ecosystem hinders Colombia's ability to fully leverage AI for societal and economic growth. The Colombian government has therefore introduced programmes aimed at fostering the necessary skills to strengthen its science and research ecosystems.

Building on existing foundations to strengthen R&D
Between 2009 and 2011, Foros Semana, the knowledge unit of Colombia's leading political magazine, played a key role in consolidating the elements of an innovation ecosystem. It

fostered trust and established relationships between scientists, academics and the public and private sectors. This project began with Colombia's National Planning Department (DNP) and subsequently included the university and business ecosystem in Bogotá. As a result, institutions such as Connect Bogotá and Ruta N were established, working to apply science for the country's economic development. Through Ruta N, the World Economic Forum's Centre for the Fourth Industrial Revolution has been set up in Medellín (World Economic Forum, 2024).

In August 2024, Colombia hosted both a national summit and the Latin American and Caribbean Ministerial Summit on Artificial Intelligence – ColombIA in Cartagena (ColombIA, 2024), which was attended by more than 22 ministers of education, science and technology from Latin America (MinTIC, 2024a). A declaration was adopted promoting digital education, innovation ecosystems and shared AI infrastructure in the region.

Also, in recent years, Colombia has trained and welcomed professionals who have studied and researched AI topics globally, building a network of international cooperation and positioning the country as a regional leader in Latin America.

These intellectual capabilities are continually being refined, becoming a crucial factor in Colombia's technological development. For instance, during the COVID-19 pandemic, Colombia developed a vulnerability interactive geographical viewer (Espinosa et al., 2021). This tool facilitated the identification of vulnerable populations that could benefit from state programmes, including cash transfers and other forms of support. Additionally, the initiative helped energize Colombia's research ecosystem as it created a unique database that was accessible for other developments.

Another example is Project Guacamaya, a joint effort between several Colombian research institutions and Planet Labs PBC and Microsoft AI for Good to monitor deforestation and protect biodiversity in the Amazon rainforest through satellite imagery, camera traps and bioacoustics (Smith, 2023).

R&D for innovation through AI

The Colombian Ministry of Science, Technology and Innovation (MinCiencias), in collaboration with the DNP and the Ministry of Information and Communication Technologies (MinTIC), is leading efforts to promote R&D that better understands how AI can support local government agendas and businesses, while enhancing social and economic development with sustainability at the core. The primary focus is currently on solutions for food security, agriculture and climate change.

In response, discussions with the United States government have identified a need to prioritize USAID resources to fund AI-based projects addressing agriculture and climate change issues in Colombia. Additionally, as president of the Executive Committee of the Inter-American Telecommunication Commission, Colombia took the lead in two key decisions approved by the 13 member countries, one of which emphasizes moving towards interoperability and supranational infrastructure for open data, focusing on climate and agriculture as common global challenges. This initiative will be supported by three

Colombian universities: Los Andes, Externado and the National University. Colombia also played a key role in the World Telecommunication Standardization Assembly in India in October 2024, pushing for the creation of a framework supporting states to report how they impact biodiversity and develop standards around energy and electromagnetic impact within the AI value chain (Government of Colombia, 2024a).

Moreover, in early 2024, MinTIC launched the ColombIA Inteligente programme, which supports applied research, technological development and innovation projects in AI and aerospace technologies to contribute to the social, economic and environmental development of different regions across the country (Innovamos, 2024). With a budget of COP 9,400 million (approximately USD 2.4 million), the programme addresses critical areas such as food security, energy transition, healthcare sovereignty and science for peace (MinCiencias, 2023). This demonstrates how the government envisions AI as a tool to tackle Colombia's most pressing challenges.

Challenges in enhancing AI systems in Colombia

Despite these initiatives, Colombia faces significant challenges in building the infrastructure and digital skills needed for robust, sustainable and autonomous AI systems. According to the World Bank, less than 13 percent of Colombia's rural population has Internet access (Blanco and Román, 2023), and there is a 40 percent national digital divide, primarily due to a lack of digital skills and Internet access (MinTIC, 2023). This digital divide has been attributed to economic factors, with many households unable to afford Internet, and digital illiteracy, with many people believing they do not need or would not use the Internet at home (Universidad Externado de Colombia, 2024). Furthermore, in 2021, 37.1 percent of households with Internet access had speeds below 10 Mbps (DANE, 2022).

As explained by Oxford Insights in its Government AI Readiness Index for 2023, one of the pillars underpinning AI systems is 'Data and infrastructure'. AI tools and systems require large amounts of high-quality data (data availability), which, to avoid bias, should reflect the diversity of the population (data representativeness). The full potential of this data can only be unlocked with the right infrastructure to support and deliver AI tools to the public. Colombia's score of 63.3 in the data and infrastructure pillar of the AI Readiness Index underscores the need to improve connectivity, broadband quality, access to supercomputers, and data availability and governance (Oxford Insights, 2023).

As such, the government has announced plans to expand connectivity in 2024, aiming to ensure 85 percent of the population has Internet access (MinTIC, 2024b). Additionally, Colombia recently accessed BELLA II, a transcontinental fibreoptic cable between Portugal and Brazil that connects Latin America with the European Union, thus helping to increase computing capacity in Colombia and activate AI projects through cooperation between academia, industry and the state.

On the digital skills front, the Colombian government has prioritized programmes aimed at improving digital literacy. MinTIC is setting up 75 Centros PotencIA across the country – public centres offering high-speed Internet access; gaming and virtual reality spaces; co-working spaces; and free courses in AI, cybersecurity and data analytics, both online and

in-person (MinTIC, 2024c). This initiative is backed by a COP 200,000 million investment (approximately USD 47.4 million) and is supported by local universities across the different regions. Other programmes, such as Avanza Tech, Talento Tech and SENATIC, seek to build digital skills among professionals and entrepreneurs (Universidad Externado de Colombia, 2024). Colombia's National Development Plan sets a goal of enhancing the digital skills of 1 million citizens between 2022 and 2026 (Government of Colombia, 2023).

The role of the private sector in enhancing AI

With the support of FEDESOFT, the national software development union, the Digital Economy Directorate at MinTIC has established working groups to collaborate with companies that have Large Language Model prototypes. These efforts aim to ensure that university scientists and PhD students can work with local public officials and business associations through the public procurement office to capitalize on AI tools like ChatGPT and Gemini. FEDESOFT and the National Spectrum Agency have also worked intensively to secure national AI software for the government's Colombia Compra Eficiente (Colombia Buys Efficiently) initiative, which aims to link the national software industry with the public office to facilitate the purchase of technology for the public sector through AI.

Additionally, through the Center for Innovation, Research and Technology (CENISOFT), the national software and IT sector works to strengthen the national technology industry through programmes and projects to promote digital transformation of the private sector.

Internationally, Colombia, as president of the International Telecommunication Union's Study Group 5, has launched an initiative for Latin American technology companies, researchers and countries to create AI-based solutions to tackle the climate crisis (Government of Colombia, 2024b). Colombia is also leading research on the impact of AI on the environment and biodiversity, contributing to the framework for COP16, which the country hosted in October 2024.

Final remarks

Colombia has laid the groundwork to advance the development of AI with a social impact and is seeking to strengthen the enabling factors needed to maximize the potential of AI. As such, the government aims to create a positive feedback loop, where advancements in science reinforce AI development and vice versa. While the Colombian AI ecosystem is consolidating, with talent, knowledge networks and political will in place, digital skills, scientific research and financial investments must continue to grow, with the private sector playing a crucial role.

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DOMINICAN REPUBLIC

ENIA: a roadmap for creating a knowledge economy based on AI

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Key takeaways

- The *National Artificial Intelligence Strategy* (ENIA) of the Dominican Republic is a driver of national development – facilitating the creation of AI infrastructure that works in the public interest, and promoting business growth to generate more opportunities and prosperity for citizens.
- The ENIA covers everything from human talent and technology development to regional collaboration and ethical governance of AI, ensuring effective and responsible implementation.
- The Dominican Republic is emerging as a leader in the adoption and development of AI in Latin America and the Caribbean, promoting regional collaboration and establishing ethical standards.

The Dominican Republic, aware of the rapid advance of AI, is implementing comprehensive policies, fostering human capital, building robust infrastructure and leveraging regional collaborations. A key component of this is the ENIA, launched in October 2023 as part of the National Innovation Policy 2030 (ENIA, 2023). The strategy aims to integrate AI ethically and responsibly across various sectors, thus promoting the sustainable development in the country.

The ENIA has been developed and implemented by the Government Office of Information and Communication Technologies (OGTIC), in collaboration with the Cabinet of Innovation and Digital Development (OGTIC, 2023). Additionally, the Ministry of Higher Education, Science and Technology has played a significant role in advancing AI initiatives – such as partnering with OGTIC and academic institutions to launch the country's first Master's degree in Applied Artificial Intelligence (Dominican Today, 2024).

Infrastructure: the backbone

Building a strong technological infrastructure is essential for the future of the AI ecosystem in the Dominican Republic. In Latin America, the digital divide remains a significant challenge; in 2022, over 64% of the rural population lacked internet access, and 40% of urban

households in the lowest income quintile were without connectivity (CAF, 2024). Tackling this 'digital divide' by improving access to high-quality internet connections and increasing the number of local data centres is crucial to ensuring connectivity, secure data storage and digital sovereignty.

The Dominican Republic is therefore working to create a regional supercomputer centre, in collaboration with the Development Bank of Latin America and the Caribbean, and to enhance its national data centre. The vision is to contribute to an interconnected network of data centres across Latin America that supports the exponential growth of AI and other emerging technologies, driving innovation and technological development in the region (CAF 2023).

Another key initiative set out in the ENIA is a data hub, which will host decentralized digital architecture to enable collaborative development of AI models – ensuring integrity and secure access to large volumes of data. The strategy also includes a plan to develop a national standard for AI systems, based on open-source code, with the goal of strengthening the country's cybersecurity.

The ENIA underscores the importance of fostering industry–university collaboration to drive the national development of AI. This approach promotes research and innovation, leveraging the expertise and resources of academic institutions to advance the country's AI capabilities. Furthermore, the Ministry of Higher Education, Science and Technology plays a pivotal role – establishing research centres, developing new academic programmes and promoting innovation and entrepreneurship, all of which contribute to the development of AI in the Dominican Republic.

Human talent: the heart of the system

Human talent is at the core of digital transformation. In Latin America, there is a significant shortage of professionals skilled in advanced technologies – a gap that is expected to widen in the coming years, according to the World Economic Forum. This limits the potential for innovation and affects the competitiveness of industries. However, this gap also represents an opportunity to train and develop technological talent, especially in the Dominican Republic.

The World Economic Forum's "Future of Jobs Report 2023" projects that nearly a quarter of jobs globally (23%) are expected to change by 2027, with 69 million new roles created and 83 million eliminated, resulting in a net decrease of 14 million jobs, or 2% of current employment (WEF, 2023). This transformation is driven by technological advancements, including artificial intelligence (AI), and the green transition. The report highlights that AI adoption is anticipated to lead to significant job creation, particularly in roles such as AI and machine learning specialists, sustainability experts, and business intelligence analysts. However, it also notes that certain positions, especially those involving routine tasks, may face displacement due to automation. To navigate this evolving landscape, the report emphasizes the importance of reskilling and upskilling initiatives to prepare the workforce for emerging opportunities.

The Global Entrepreneurship Monitor report highlights the region's entrepreneurial potential alongside the growing demand for software developers globally, particularly in the United States – underscoring the economic value of investing in the development of technological talent (GEM, 2023). In addition, according to a report by PwC, in Latin America, the projected contribution of AI to the GDP is estimated at 5.4% by 2030, which equates to approximately US$500 billion. (PwC, 2017).

To seize this opportunity, the Dominican Republic has launched programmes such as INCUBO and INTRO. INCUBO (OGTIC, 2023), the first AI-focused digital incubator in the country, aims to transform university students into tech leaders by equipping them with advanced skills and preparing them to drive innovation in key sectors. INTRO, on the other hand, focuses on training young people in the fields of science, technology, engineering and mathematics, providing not only technical skills but also the soft skills necessary to thrive in the workforce.

These programmes aim to graduate 10,000 new developers annually, promising a significant impact on the country's economic and technological development. They are part of the #YoSoyFuturoRD human talent and innovation hub, which brings together various stakeholders to develop the workforce and strengthen the AI ecosystem. Investing in the development of human talent in this way will not only meet the country's technological needs but also allow for the export of talent and services globally, thus positioning the Dominican Republic as a key player in the regional and global digital economy.

The ENIA also promotes the inclusion of AI in the education system – from primary to higher education – through educational modules, teacher training and the creation of specialized academic programmes. These programmes include a Bachelor's degree in Data Science and a Master's degree in Artificial Intelligence at the Autonomous University of Santo Domingo, and a Master's degree in Applied Artificial Intelligence at the Caribbean University, developed in partnership with Tecnológico de Monterrey.

Additionally, AI certification programmes aim to strengthen diversity and inclusion in this field – with a particular focus on women. For these programmes, the Dominican government is providing funding and strategic direction, while universities and private sector organizations lead on design and implementation. Likewise, upskilling and reskilling programmes like the DocencIA diploma are preparing the workforce for future challenges.

Governance: the brain of the system
Governance is essential for guiding and coordinating efforts to build a robust and sustainable AI ecosystem – particularly in the form of 'glocal' governance, which combines local policies with international standards. One of the most significant challenges for governance is developing a strong and autonomous tech industry. In most countries of Latin America, investment in research and development (R&D) is low, averaging less than 0.67 percent of GDP. In the case of the Dominican Republic, this figure is even lower: less than 0.03 percent of GDP.

To aid the governance of AI development, the ENIA includes the creation of frameworks such

as 'regulatory sandboxes', which enable supervised but live testing of AI innovations. It also promotes an ethical code for AI, to ensure that development is responsible and ethical. The strategy seeks to avoid a 'techno-fetishist' perspective, addressing risks associated with AI, including its impact on global conflicts and the labour market, and the potential for 'digital colonization'.

Additionally, the Dominican Republic advocates for a 'multi-regulatory convergence' approach, recognizing that developing countries need to build their own AI industry rather than simply regulating one that does not yet exist. The ENIA aims to foster the development of local capacity and the creation of homegrown models and algorithms – to avoid technological dependency and ensure that AI reflects the identities and cultures of the region.

This approach has significant implications for the science sector. By prioritizing local talent and knowledge, the Dominican Republic can reduce its reliance on external resources and technologies, empowering local scientists and researchers, and promoting their active involvement in shaping the future of AI. The approach also increases the likelihood that AI applications are relevant and beneficial to the Dominican population – as they are developed with a deep understanding of local needs and challenges.

Furthermore, this strategy promotes innovation and creativity. By encouraging the development of unique AI models and algorithms, it fosters a culture of discovery and exploration, allowing the Dominican Republic to contribute original solutions to the global AI landscape. This gives the Dominican Republic greater control over its technological trajectory – reducing dependence on foreign entities, promoting self-determination in the development of AI, and enabling it to participate actively in the global market and drive its own economic growth.

The TAINA project: an example of an AI system adapted to Latin America

The TAINA project, an AI system under development to modernize and digitize public services, shows how new technology can be adapted to local needs. The project has the potential to enhance various public services in the Dominican Republic including:

- healthcare, where it can improve diagnostics, personalize treatment plans and accelerate medical research;
- education, where it can be used to develop personalized learning platforms, automate assessments, and provide intelligent tutoring systems;
- transportation, where it can manage traffic flow, optimize routes and improve road safety;
- the justice sector, where it has the potential to automate judicial processes, analyse legal data, and assist in legal decision-making – and can also be used to detect threats, analyse patterns, and prevent crime;
- other government services, where it can improve efficiency and accessibility, such as in applying for permits or licenses.

To ensure that TAINA truly represents Dominican identity, Project CiudadanIA, an AI-based citizen-interaction system, is being implemented to collect data in Dominican Spanish. This is crucial for addressing the risks of algorithmic bias and ensuring that AI systems do not perpetuate social or cultural inequalities.

Regional networks: the nervous system

Regional networks function like a nervous system that connects and coordinates the different components of the AI ecosystem, ensuring effective integration and collaboration at the regional level. This kind of a shared vision and joint action are essential for AI to flourish in Latin America.

LATAM 4.0 is the core of Latin America's regional vision. Focused on developing a robust Latin American AI ecosystem by capitalizing on human talent and promoting R&D, this platform aims to build the world's first regional AI project. A concrete step toward this vision is an agreement between the Dominican Republic and Honduras to establish the first #YoSoyFuturo hubs in the region, with the goal of training 1,000 young people in AI (500 in each country), in collaboration with the AI company GENIA and the Latin American Artificial Intelligence Academy (GENIA, 2023)(SENACIT, 2023).

At the Latin American and Caribbean Ministerial Summit on Artificial Intelligence, ColombIA, all countries in the region were invited to join LATAM 4.0 (ColombIA, 2024) – in order to leverage economies of scale, reduce costs and share technologies to address common needs. This regional approach will strengthen competitiveness, attract international investments and collaborations, and position Latin America as a leader in innovation and technology. At the summit, the Dominican Republic was one of 17 countries to adopt the Cartagena Declaration for AI governance in Latin America (Martinez, 2023).

Additionally, a project to form a Regional Artificial Intelligence Council for Latin America and the Caribbean us taking place in collaboration with UNESCO and the Development Bank of Latin America and the Caribbean, (UNESCO, 2022). Using UNESCO's Readiness Assessment Methodology, the Dominican Republic has evaluated its AI ecosystem, which has invited other countries in the region to do the same – as part of advancing towards a joint regional strategy (UNESCO, 2023).

Other developments include regional data repositories and interoperability frameworks, to facilitate collaboration and shared access to data and technological resources – now and in the future. Such joint action is particularly important in the anticipated transition toward artificial general intelligence and superintelligence. By investing in R&D for AI at a regional level, Latin America can ensure it not only participates but also leads the development of ethical and safe AI technologies, thus preparing the region for future challenges and opportunities.

Financing: the drive for development

Various funding mechanisms support the development of human talent and technological infrastructure – key factors for the ENIA's success. Specifically, the National Innovation Policy 2030 sets a goal for increasing investment in R&D to 1 percent of GDP by 2030, including through an Innovation Support Fund (InnovaciónRD, 2022).

This fund's main objective will be providing finance and support to innovative projects across various sectors of the economy – to promote research, technological development and knowledge transfer, and generate impact and added value for Dominican society. Supported

projects will include AI solutions to improve the efficiency of public services, and those to enhance sustainability and efficiency in the agricultural sector.

Learning from international indexes

Two global indexes give some insight into the Dominican Republic's progress with regard to artificial intelligence R&D. Firstly, the Global Index on Responsible AI provides an overview of how nations are addressing the ethical, social and regulatory challenges posed by AI technologies – highlighting the need for comprehensive policies and a human-centred approach (GIRAI, 2024). Following the launch of the ENIA, the index gave the Dominican Republic a score of 23.18 out of 100. This places the country in 50th place out of 138 countries evaluated, in first place out of the nine Caribbean countries indexed, and in 6th place out of Latin American countries.

Secondly, the AI Investment Potential Index evaluates 193 countries on their readiness and potential for AI investment (AFD, 2024). This index considers multiple factors, including digital infrastructure, human capital, macroeconomic conditions and social inclusion, to provide a comprehensive analysis of AI investment opportunities globally. With a score of 67.69, the Dominican Republic ranks third for this index in the Americas, surpassed only by Canada and the United States. This reflects the country's growing capacity and potential to attract AI-driven investments.

As recognized by the two global indexes on national AI standards, the Dominican Republic's *National Artificial Intelligence Strategy* represents a bold step toward digital transformation and sustainable development. Through a comprehensive and collaborative approach, ENIA seeks to harness the potential of AI to improve the lives of Dominicans and position the country as a regional leader in innovation and technology. The ENIA aims not only to drive economic growth and enhance quality of life, but also to establish the country as a model for the ethical and responsible adoption of AI.

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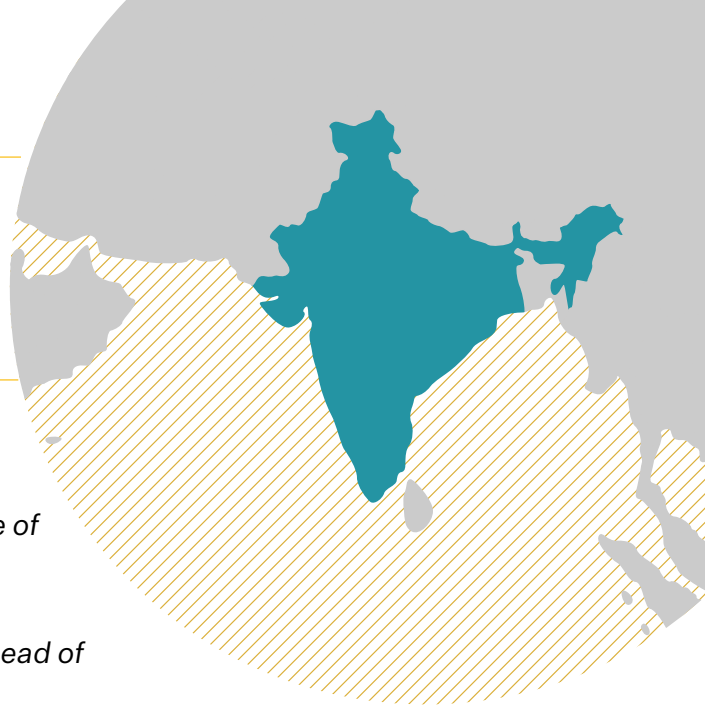
INDIA

Gaining insights into transformative technologies and their social integration

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Key takeaways:

- Development of online platforms and AI supporting software tools in India are part of its vision to become the hub for software in the Global South. Achievements in the country include the establishment of Centres of Excellence and upskilling initiatives to advance capacity for AI.
- Streamlining and coordinating the work of the newly established Centres of Excellence as well as the lack of private-public partnerships are challenges in the country which are currently being addressed.

AI is pivotal to India's strategy of harnessing transformative technologies. Driven by the Ministry of Electronics and Information Technology (MeitY), AI missions are designed to foster inclusivity, steer innovation and ensure AI's wide acceptance across diverse sectors. The aim is to yield significant societal benefits and economic growth.

First applications

A primary focus is on extending the advantages of AI to every segment of society, aligning with the broader vision of comprehensive and sustainable development (TEC, 2020). With current rapid developments in data and AI infrastructure in the country, India aims to become the hub for the Global South for software tools. A prime example of AI's societal contribution in India on the national level is the Bhasini platform, empowered by AI and other advanced technologies and dedicated to local language translation (Bhasini, no date). The National Data and Analytics Platform is another government initiative that streamlines access to governmental data in India: it offers a user-friendly environment for individuals to search, amalgamate, visualize and retrieve datasets easily (NDAP, no date). Moreover, AIRAWAT (AI Research, Analytics and Knowledge Assimilation), a specialized AI-centric cloud computing infrastructure for India, is set to debut soon (AIRAWAT, 2023).

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Establishing Centres of Excellence

MeitY is leading the AI initiatives in India. It has formed seven expert groups to focus on various aspects of AI integration, from establishing national missions to skilling the workforce and addressing cybersecurity. These committees are shaping India's AI strategy. The expert groups' recent report (Expert Group to MeitY, 2023) brought out the operational aspects of establishing the Centres of Research Excellence, which now as they are being implemented are referred to as Centres of Excellence (CoEs). The functions of CoEs may include but are not limited to foundational research, technology development, promoting innovation and entrepreneurship, and AI skill development. Institutional structures of CoEs vary from partnerships between national or local government with companies, such as the CoE for Internet of Things and AI, a partnership between MeitY and the trade association Nasscom, as well as the CoE for Data Science and AI, a partnership between the Government of Karnataka and Nasscom. Some CoEs are within universities.

Skill development initiatives

The Ministry of Skill Development and Entrepreneurship has launched a free online training programme on AI available in various Indian languages. This course is jointly developed by Skill India and GUVI (Grab Ur Vernacular Imprint), an ed-tech company incubated at the Indian Institute of Technology, Madras, and Indian Institute of Management, Ahmedabad. The private sector is also stepping up in AI skill development. For example, Infosys has launched a free AI certification training program that is available on the Infosys Springboard virtual learning platform. Intel, in partnership with the Central Board of Secondary Education under the Ministry of Education, has announced the 'AI For All' initiative to foster a fundamental understanding of AI for everyone in India. Many Indian educational institutions have meanwhile developed their own programs and certification courses in AI and machine learning. One such example is the postgraduate-level advanced certification program in Deep Learning (TalentSprint, 2024) offered by the Indian Institute of Science, Bangalore.

Strategic direction

The National Institution for Transforming India (NITI) Aayog serves as the apex public policy think tank of the Government of India. NITI Aayog published a discussion paper in 2018 titled *National Strategy for Artificial Intelligence #AIForAll* (NITI Aayog, 2018). This is a guiding document for understanding India's vision to integrate AI across all sections of society, ensuring its benefits reach everyone. The document highlights NITI Aayog's recommendations for five sectors that are envisioned to benefit the most from AI in solving societal needs: healthcare; agriculture; education; smart cities and infrastructure; and smart mobility and transportation. MeitY drives India's AI missions within these sectors.

Acknowledging that AI research in India is at a relatively early stage, NITI Aayog has put a strong emphasis on enhancing research capacity and infrastructure. The strategy involves setting up CoEs for in-depth AI research and International Centres of Transformational AI for developing practical AI applications. This dual approach aspires to bring together more collaboration among academia, industry and government. Integrating AI into society also requires addressing ethical, legal and socio-economic issues. Recognizing the need for

appropriate handling of data to ensure privacy and security, NITI Aayog recommends setting up Ethics Councils within CoEs. There is also a recommendation for creating a National AI Marketplace to democratize data access, which is essential for AI innovations.

Roles for Centres of Excellence

In acknowledgment of AI's transformative potential, the finance minister, in her 2023–2024 budget speech, emphasized the need to expand India's comprehensive AI capabilities, which led to the inception of three CoEs in premier educational institutions, adopting a hub-and-spoke model.

These CoEs are integral to the 'INDIAai' initiative, positioning the country at the forefront of global AI advancements. The critical areas identified for the CoEs to promote research and development include governance, healthcare, agriculture, manufacturing and financial technology, as a reflection of their significance in promoting inclusive socio-economic growth. The CoE initiative aims to foster an AI ecosystem, driving innovation through collaboration with industry, academic entities and startups domestically and globally. The CoEs are to lead foundational and practical AI research, targeting sector-specific challenges and aiding the commercialization of existing AI solutions. They are mandated to outline sector-specific AI strategies, identify primary challenges and recognize opportunities.

India's global position

The *AI Index Report 2023* by the Stanford Institute for Human-Centred Artificial Intelligence highlighted India's growing contribution to AI research and development, with steady growth in AI-related publications (Stanly, 2023). India is also making contributions in the global AI ecosystem and Indian tech giants are promoting open-source AI contributions to democratize the technology. India served as the chair of the Global Partnership on Artificial Intelligence, an international initiative aiming to promote the responsible development and use of AI, for 2022–2023. The Indian government has meanwhile taken various steps in developing its own roadmap for AI governance. Towards this, INDIAai organized a roundtable in February 2023 to discuss the generative AI developmental trajectory, ethics and intellectual property rights, involving experts from institutions like the Indian Institute of Science, Bangalore, the Global AI Ethics Institute and IBM Research India (INDIAai, 2023).

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MALAYSIA

Advancing with AI at the fore

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Key takeaways:

- Malaysia aims to become a high-tech nation by 2030 through the strategic integration of AI, as set out in key policies including the National Science, Technology and Innovation Policy 2030–2021 and the National Artificial Intelligence Roadmap –2021 2025. These policies promote the adoption of AI in sectors like health care, education, agriculture and finance, to boost economic development and societal well-being.
- Major global technology companies like Oracle, Google, Microsoft, NVIDIA and Amazon Web Services have invested billions of dollars in Malaysia to enhance AI and cloud computing infrastructure, underscoring Malaysia's role in the global AI landscape.
- A National AI Office, newly established in 2024, aims to position Malaysia as a key AI player in the Association of Southeast Asian Nations (ASEAN) and globally, and demonstrates Malaysia's commitment to AI innovation.

As Malaysia strides boldly into the Fourth Industrial Revolution (4IR), the convergence of science, technology and innovation becomes paramount for sustainable growth. At the heart of this transformation lies the strategic integration of AI, propelling Malaysia towards its vision of becoming a high-tech nation by 2030. Guided by pivotal policy frameworks, Malaysia's journey unfolds as a testament to the nation's commitment to leveraging AI for scientific advancement and economic prosperity.

Enabling policies

In 2021, the Government of Malaysia introduced its *National Science, Technology and Innovation Policy 2021–2030* (MoSTI, 2020) to intensify the development of local technology. As part of this initiative, the Academy of Sciences Malaysia (ASM) developed the *Malaysian Science, Technology, Innovation and Economy (10-10 MySTIE) Framework* (ASM, 2020), specifically to boost economic development and enhance levels of innovation, wealth generation, inclusion and well-being in society.

At the same time, the Economic Planning Unit of the Prime Minister's Department developed a *National Fourth Industrial Revolution Policy* (EPU, 2021a) to serve as a comprehensive national strategy for the 4IR. Aligned with the *National Science, Technology and Innovation Policy 2021–2030,* it provides guiding principles and strategic direction to ministries and

agencies, aiming to optimize resource allocation and manage emerging risks. The policy supports national development policies such as the *Twelfth Malaysia Plan and Shared Prosperity Vision 2030*, and complements the *Malaysia Digital Economy Blueprint* (EPU, 2021b) in driving the growth of the digital economy and bridging the digital gap.

In line with these policies, Malaysia's *National AI Roadmap 2021–2025* (MoSTI, 2021) aims to kickstart a thriving AI innovation ecosystem in Malaysia, and encourage industry leaders and academicians to develop and implement AI solutions. To coordinate and monitor implementation of this roadmap, the Ministry of Science, Technology and Innovation (MoSTI) established a National Blockchain and Artificial Intelligence Committee (Ministry of Communications, 2022). This committee aims to accelerate the adoption of AI adoption, using the roadmap to identify national cases of AI use in supply chains, health care, education, agriculture and finance.

Malaysia's national roadmap also recommends embarking on fundamental and applied research and development (R&D) in relevant entities within the AI innovation ecosystem, and encouraging AI adoption for all fields of R&D. Accordingly, each state in Malaysia has a digital transformation strategy, with Selangor, Sarawak, Terengganu, Penang and Melaka showing robust adoption of AI, through for example increasing digital labour and growing awareness of R&D.

To support this work, and provide national AI standards, Malaysia's Department of Standards formed an AI technical committee with representatives from various sectors (DSM, 2023). Malaysia is also actively participating in the development of International Organization for Standardization (ISO) AI standards (ISO/IEC42000).

Government of Malaysia principles for AI
In line with national and ISO standards, and aligning with principles established by organizations including the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organisation for Economic Co-operation and Development, and the European Commission, the Government of Malaysian government has proposed seven principles for the development of trusted and responsible AI. These principles relate to:
- fairness
- reliability
- safety and control
- privacy and security
- inclusiveness
- transparency
- accountability
- pursuit of human benefit and happiness

New ministry, AI office and guidelines
To further strengthen the AI agenda, Malaysia established in 2024 a new Ministry of Digital. Under this ministry, the country approved a National AI Office, with the aim of positioning Malaysia as a key player in AI within ASEAN and the global landscape. This office focuses

on enhancing AI capabilities, promoting cross-sector collaboration, and supporting the integration of AI into various framework. It will spearhead initiatives that leverage AI to strengthen the digital economy, improve public services and contribute to sustainable development goals.

In September 2024, MoSTI released *National Guidelines on AI Governance and Ethics* (MoSTI, 2024), so that policy-makers and practitioners can develop and deploy AI in a safe, trustworthy and ethical manner. The guidelines provide consumer protection principles in AI, and 'Dos and don'ts' for adopting AI technology. According to the guidelines, key factors in effective AI governance are: awareness on AI and ethics; a centre for sustainability and AI ethics; institutional support and regulations; ownership and data sharing; buy-in from stakeholders; funding and infrastructure; and champions consisting of certified and trained professionals and a skilled workforce.

Malaysia has not enacted specific legislations on the governance of AI. However, the new national guidelines have emphasized that AI must be adopted in a way that promotes accountability and transparency, protects data privacy and security, mitigates risks, and builds public trust in parallel with Malaysia's existing laws.

Research budgets

The 2025 budget unveiled by the Malaysian Prime Minister expands funding for AI initiatives at research universities to MYR 50 million (more than USD 11 million) – up from MYR 20 million (around USD 4.5 million) in 2024. This represents a significant leap forward for AI education and research, and demonstrates the government's commitment to positioning Malaysia as a leader in AI innovation.

Each university is tasked with a unique focus area for AI research, aligned with national priorities. Universiti Malaya will focus on AI applications in medicine, specifically targeting the fight against cancer and other deadly diseases. Universiti Putra Malaysia, in collaboration with the National Cyber Security Agency, will establish a Malaysian cryptology technology and management centre, advancing quantum computing AI to strengthen cybersecurity against emerging threats.

Meanwhile, Universiti Sains Malaysia will align its AI research with the nation's growing role as a global hub for semiconductors, working closely with industry leaders like Intel and Infineon. And Universiti Kebangsaan Malaysia will take on the challenge of AI-driven translation to elevate the status of the Malay language in scientific research and communication.

The budget also strengthens R&D efforts within government, increasing funding to MYR 600 million (nearly USD 135 million) for the Ministry of Higher Education and the Ministry of Science, Technology and Innovation. Additionally, the Malaysia Science Endowment will provide MYR 170 million (more than USD 38 million) in matching grants to encourage private sector investment in R&D. And to cultivate local talent and foster youth expertise in robotics and AI, the Malaysia Techlympics programme will receive MYR 10 million (around USD 2.25 million).

The 2025 budget allocates an additional MYR 20 million (around USD 4.5 million) to Universiti Teknologi Mara – to increase the number of Bumiputera engineers in the high-growth electronics and electrical sector, crucial for Malaysia's semiconductor industry. The budget also provides for the digital transformation of public institutions. Most notably, the Malaysian Communication and Multimedia Commission will receive MYR 120 million (nearly USD 27 million) to enhance internet connectivity across public higher education institutions and RM100 million is dedicated for the Fixed Line Broadband Infrastructure Connectivity Programme for rural schools supporting the growing need for digital infrastructure in education and beyond.

To further drive innovation in education, the Government of Malaysia will offer tax breaks to private universities that develop new programmes in digital technology, including AI, robotics, the 'internet of things', data science and financial technology. These initiatives are expected to create high-income jobs, attract students, and position Malaysia at the forefront of digital transformation.

Research streams

To facilitate the provision of end-to-end online services, the Malaysian Government Central Data Exchange provides data integration services across agencies. This platform is led by the National Digital Department under the Ministry of Digital. Services are also informed by a main database platform developed by the Ministry of Economy in 2024 to centralize socio-economic data for targeted subsidies, enhanced data security and consolidated management. In addition, the Malaysia Open Science Platform championed by ASM is a national research asset facilitating open science and data sharing.

Alongside the provision of open data, the Malaysia AI Consortium plays a crucial role in fostering collaboration, promoting AI research and development, and driving the commercialization of AI technologies. It also supports talent development and contributes to the creation of frameworks for AI governance.

MoSTI is another ministry supporting AI transformation for academic development and research. One of its flagship programmes focuses on digitalization and the internet of things, with a pilot project at the Pasoh Reserve Forest spearheaded by ASM. This project introduces robots, systems for managing the internet of things, AI- and machine learning-based systems for species digitalization, profiling and analysis, and an ecology simulator for facilitating AI-infused forest management (ASM, 2023).

MoSTI's National Technology and Innovation Sandbox is also driving the development of AI, providing support and financial assistance amounting to MYR 115 million (nearly USD 26 million) to 202 projects since 2020. Nearly a fifth of the projects supported were in agriculture and forestry, which benefits from AI in areas such as analytical data and image processing to determine quality classifications for fruit and vegetables.

The agricultural sector also benefits from a *Smart Agriculture Directory* developed by the Ministry of Agriculture and Food Safety as an online resource pioneering technological solutions developed through public–private partnerships; for example, a hydroponic

controller which integrates AI, the internet of things and cloud technology to manage, monitor and control pH, electrical conductivity, water temperature and humidity through a mobile phone.

Education and services

Academic research into AI is supported by the Ministry of Higher Education and the Malaysia Qualifications Agency, which release advisory notes and guidelines on the responsible use of generative AI. Higher education institutions provide additional support, through 'smart campus' and other digital initiatives. Institutions including Universiti Putra Malaysia, Universiti Teknologi Malaysia and Universiti Malaysia Pahang Al-Sultan Abdullah have developed guidelines for teachers, students and postgraduate researchers, while others such as Sunway University are drafting guiding principles for the integration of AI.

These institutional and national initiatives combined have led to a significant shift in demand, readiness and motivation among participants. Compared to earlier university cohorts, tutors and lecturers in 2024 demonstrate higher enthusiasm for AI and clearer goals, driven largely by the growing global influence of AI and data science. As these educators become more familiar with generative AI, they also develop new prompting skills, enabling them to unlock the full potential of the new tools.

A key educational development of 2024 is the Faculty of Artificial Intelligence at Universiti Teknologi Malaysia, funded by the Government of Malaysia as the first university faculty dedicated solely to AI. Launched in May 2024, this leading centre offers undergraduate, Master's and PhD programmes, focusing on cutting-edge research, practical learning and industry collaborations to prepare students for successful AI careers. It aims to position Malaysia as a leader in AI within ASEAN and globally, contributing to the country's robust AI research ecosystem. Other educational developments include the new Malaysia Centre 4IR, established by the Ministry of Economy under the MyDIGITAL initiative, and the 'AI untuk Rakyat' (AI for People) programme (MyDIGITAL, 2024).

To guide all educational endeavours relating to AI in Malaysia, ASM has prepared a white paper entitled *A New Horizon for Science, Technology and Innovation* (UPM, 2023), which contains recommendations to the Ministry of Higher Education on how to manage technological disruptions in teaching and learning and the governance of higher education. This paper is in line with the *Malaysia Higher Education Blueprint 2015–2025* (JPT, 2013) and the new blueprint which will be released soon, which promotes accessible online learning while tailoring experiences to each student's needs.

Across Malaysia and online, various conferences, talks, hackathons, forums, exhibitions and digital channels have been identifying educational opportunities for AI, addressing challenges such as talent gaps, and communicating best practice for implementation. The AI for Citizen by MyDigital in collaboration with Intel, and the MCMC Microsoft AI TEACH Programme aims to enhance AI skills and awareness among the public, ensuring that underserved groups, including the B40 community, Persons with Disabilities (PWD), women, and the unemployed be trained with AI tool proficiency. One example for the public workforce AI readiness is a symposium held by the National Institute of Public Administration (INTAN)

in October 2024. INTAN has also taken the lead on talent development in the government workforce, offering several AI-related courses for example in the area of precision agriculture, digital and e-commerce using Microsoft Azure.

Investment and the future

Recently, Malaysia has attracted significant AI investments from major global companies. Oracle has committed over USD 6.5 billion to enhance AI and cloud computing infrastructure in the country. Google is investing USD 3 billion to boost AI capabilities and establish new data centres in Malaysia and Thailand. Additionally, Microsoft is channelling USD 2.2 billion into advancing cloud and AI infrastructure, creating AI skilling opportunities, and setting up a national AI centre of excellence in Malaysia.

Nvidia and Amazon Web Services have also made significant AI investments. Nvidia has partnered with YTL Power International, committing USD 4.3 billion (MYR 20 billion) to build an AI data centre in Johor, which will use advanced AI chips to power supercomputers. And Amazon Web Services announced a USD 6.2 billion investment to expand its cloud infrastructure and AI capabilities. These substantial investments underscore Malaysia's growing role as a key player in the global AI landscape.

In conclusion, Malaysia stands at the forefront of a paradigm shift in scientific inquiry, driven by the strategic deployment of AI across various sectors. Through the concerted efforts outlined in its comprehensive policy frameworks, Malaysia has laid a robust foundation for fostering AI innovation, talent development and responsible governance. As the nation continues to chart its course towards the 4IR, Malaysia is poised to harness the full potential of AI for the betterment of its people and the advancement of science on a global scale.

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MEXICO

Creating a national lead agency for artificial intelligence

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Key Takeaways:

- The setting up of a national AI strategy in Mexico has been mandated through the creation of a Mexican Agency for the Development of Artificial Intelligence in 2023. Concurrently, previous multisectoral initiatives in the country are convening discussions on and development of AI technologies with an important role of universities.
- Challenges in Mexico lay in spearheading the next steps of the newly founded agency and focusing on local AI technology development rather than relying on foreign technology.

In October 2023, an initiative to issue a *Law for the Mexican Agency for the Development of Artificial Intelligence* was presented in the Parliamentary Gazette of the Chamber of Deputies (Government of Mexico, 2023a). The AI agency proposed in this legislative initiative would be the creation of a decentralized public body with technical and managerial autonomy. Its main objectives would include formulating a national strategy on AI, implementing a national AI policy, promoting the development of AI in various areas (education, industry, science, technology), fostering international cooperation in AI, and overseeing the responsible use of this technology. The assets of the AI agency would consist of resources, amounts allocated in the Budget of Expenditures, income from services and donations.

The AI agency would have a Governing Board composed of 14 members, including the Head of the Executive as president and representatives from various ministries and organizations. The Board would have responsibilities such as formulating the AI development policy, approving programs and projects of the agency and issuing recommendations. Additionally, experts, stakeholders and the general public would be involved in discussions and decision-making to ensure that any regulation is fair, effective and adaptable to the changing circumstances in the field of AI (Government of Mexico, 2023b). The Governing Board would organize and convene permanent forums and work tables within its first six months.

Next steps for a new agency

This proposed Mexican Agency for the Development of Artificial Intelligence represents a significant step towards the regulation and responsible promotion of AI in Mexico, but it is essential to remember that there are still more stages in the legislative process to go through.

The implications of these changes on science and research involve a series of fundamental actions. These include formulating and proposing a national strategy on AI; implementing a national AI policy in Mexico; and promoting the effective development of AI activities to expand the country's capabilities in educational, industrial, scientific and technological areas. If established, the AI agency will achieve these aims by developing the country's scientific and technological capacity, fostering international cooperation and serving as an instrument of state leadership to strengthen sovereignty and national security. Additionally, the AI agency will seek to facilitate the incorporation of related sectors, especially the productive sector, to enhance competitiveness in markets. It will also promote ongoing dialogue on studies and implications of AI, ensuring public interest and population protection. Finally, public, private and social entities will be encouraged to submit proposals and observations in the field of AI for study and consideration, aiming to advance development, security and peace in Mexico.

IA2030Mx

Since 2018, another ongoing initiative called IA2030Mx has emerged as a multisectoral coalition composed of practitioners, academic institutions, companies, startups, public agencies, organizations, media and other key players in Mexico's digital and AI ecosystem (IA2030Mx, no date). Among its objectives are to facilitate a deeper debate on present and future opportunities and challenges related to AI, translate this debate into actions, make AI knowledge accessible to everyone, advance the use and application of AI for the benefit of Mexicans, and localize the Organisation for Economic Co-operation and Development AI Principles in the Mexican context.

The IA2023Mx initiative has marked significant achievements in catalysing research, fostering innovation and advancing Mexico's presence in the global AI landscape. Through the initiative, universities have spearheaded groundbreaking research endeavours, contributing to the development of cutting-edge AI technologies across various academic disciplines. Moreover, IA2023Mx has facilitated international collaboration, enabling knowledge exchange and positioning Mexico as a key player in the AI domain. Additionally, the initiative has played a crucial role in nurturing AI talent by providing educational programs, scholarships and training opportunities, thereby bolstering the country's pool of skilled professionals.

The role of universities

Despite its successes, IA2023Mx also faces several challenges that universities must address to sustain momentum and maximize impact. These challenges include securing adequate infrastructure and resources to support AI research and education effectively; addressing the skills gap through comprehensive training initiatives; and ensuring that

AI developments adhere to ethical standards and societal values. Furthermore, promoting interdisciplinary collaboration and securing sustainable funding sources remain persistent challenges for academic institutions involved in the initiative.

Universities play a pivotal role in driving the IA2023Mx initiative forward by leveraging their research excellence, educational expertise and innovation capabilities. As hubs of knowledge creation and dissemination, universities lead AI research endeavours, educate the next generation of AI professionals and serve as platforms for collaboration between academia, industry and government. Additionally, universities contribute to shaping AI policies, advocating for responsible AI deployment and engaging with communities to address societal concerns and promote digital literacy. Through their multifaceted role, universities are instrumental in realizing the vision of IA2023Mx and positioning Mexico as a global leader in AI innovation and development.

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National research entities

A National Laboratory of Artificial Intelligence was founded in Mexico as early as 1990, but it later changed its name to the National Laboratory of Advanced Informatics (LANIA), since an understanding had not yet emerged about what AI would actually be. As a national laboratory, LANIA typically receives funding from various government agencies and entities to support its research activities, infrastructure and operations, including the Mexican government. This funding is often allocated through grants, contracts and other mechanisms to support LANIA's mission of advancing informatics research, innovation, and education in Mexico (LANIA, no date).

Another of the main initiatives in this field is the Artificial Intelligence Centre of the Technological Institute of Monterrey (ITESM), which focuses on the development of AI-based technologies to improve processes in areas such as medicine, transportation, agriculture and security. ITESM currently has a research project called Advanced Artificial Intelligence, which is composed of a group of researchers developing different research lines such as machine learning, computational intelligence and hyper-heuristics, data science and applied mathematics, and biomedical engineering Tecnológico de Monterrey, no date).

Finally, one of the challenges in Mexico for implementing various initiatives related to AI is the country's austerity policy. The constraints of this policy keep Mexico locked in as a user of foreign technology. The goal should rather be for Mexico to become a producer of its own technology and, in the medium term, to export AI solutions.

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OMAN

Fostering innovation through an Executive Program

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Key Takeaways:
- The Ministry of Transport Communications and Information Technology is leading the national AI strategy and its implementation in Oman. Economic objectives through Oman Vision 2040 are the predominant drivers for AI technology developments.
- Partnerships between the ministry and universities and other sectors have been created for AI training programs and initiatives.

Oman is proactively engaging with the impact of AI on its science system, seeking inspiration and collaboration beyond its borders. The country's multifaceted approach to AI involves substantial investment, policy development and international cooperation. In line with Oman Vision 2040, the Sultanate has endorsed the National Program for the Digital Economy (MTCIT, 2021), a cornerstone in Oman's strategy to foster a robust digital economy and significantly increase the digital economy's contribution to the gross domestic product from 2 percent in 2021 to an anticipated 10 percent by 2040. This program, a progression of Oman's digitization efforts, aims to elevate Oman's global standing across various digital economy indices.

The Executive Program

In alignment with these strategic directives, the Ministry of Transport, Communications and Information Technology (MTCIT) has launched the Executive Program for Artificial Intelligence and Advanced Technologies (MTCIT, 2022). This program is a strategic endeavour aimed at spearheading the adoption and localization of AI and advanced technologies within the Sultanate and it draws insights from international reports and benchmarks. It also involves extensive collaboration with stakeholders from the public and private sectors, academia, and entrepreneurs specializing in these cutting-edge domains. Through the program, MTCIT is supervising the preparation and implementation of an integrated national action plan for AI and advanced technologies.

The Executive Program specifically targets sectors earmarked for economic diversification as per the Tenth Five-Year Development Plan and Oman Vision 2040. MTCIT is committed to identifying and investing in priority technologies and vital information and communications technology infrastructures that align with national capabilities and sectoral needs. This

approach not only aims to establish a competitive edge for Oman in these technological arenas, it also ensures the transfer and localization of knowledge and technology in concert with public and private sector partners, educational institutions and local startups.

Other initiatives and ventures

In addition to the Executive Program, the Ministry of Economy launched the National Initiative to Empower the National Economy Enhanced with AI (ONA, 2023) to integrate AI into economic diversification projects and programs. In recognizing data as the cornerstone of AI, the Sultanate initiated an open data policy, encouraging government units to make their data accessible and establishing a legal framework for open data sharing. A National Data Strategy (NCSI, 2022) through the National Center for Statistics and Information, an independent entity, was also adopted, establishing a comprehensive framework to coordinate national data management, promote data exchange and develop mechanisms to enhance the productivity of government entities. This procedure is currently taking place for each ministry. Upon its completion across all ministries, a similar process will be extended across the public sector (including universities and other academic institutions), followed by the private sector.

A multitude of AI-related projects have been successfully executed across diverse sectors in Oman, reflecting a strategic commitment to integrating AI into various facets of the national economy. In the logistics domain, the Muscat Delivery Project (ONA, 2022) exemplifies this integration by employing drones for parcel delivery between Al Bustan and Muscat Bay. The health sector witnessed a notable application of AI in breast cancer detection (MOH, 2019), achieving a remarkable 96 percent success rate. Additionally, the agricultural sector has adopted drones for pesticide application and palm tree pollination (WIPO, 2021), alongside AI techniques for early detection of pests like the dubas bug and the red palm weevil (Muscat Daily, 2023a). In the oil and gas industry, AI-enhanced drones are being deployed for monitoring pipelines and detecting leaks (CCED, 2021), crucial for preventing security incidents. These drones are also instrumental in inspecting burners at oil refining sites. The transportation sector has seen the digitization of road-related documents (maps, contracts, etc.) using AI, facilitating enhanced decision-making in road maintenance and development.

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The agenda of Oman's Executive Program

The Executive Program recognizes the transformative potential of AI in the science and research sector and aims explicitly at enhancing its uptake in that sector. The approach focuses on the following areas:

1. Collaborations with higher education and research institutions to bolster research and develop academic programs in AI and data science.
2. Awareness and knowledge dissemination, elevating the understanding and appreciation of AI technologies through organizing specialized workshops, events and conferences.
3. Innovation and entrepreneurship support, nurturing innovation in AI through government–private sector collaborations, offering essential support to fund and develop startups in this burgeoning field.

To realize these objectives, the program encompasses several initiatives and projects:

- Development of core AI personnel, focusing on cultivating experts in AI and data science who are capable of spearheading industry advancements.
- Support for skill acquisition, seeking to bolster skills in data science and AI through accelerators, higher education grants and reskilling incentives for employees, and aligning these efforts with industry needs.
- Research and development in core technologies, representing a significant thrust towards accelerating research in key AI technologies such as machine learning, vision, natural language processing, smart sensors and intelligent decision support systems.
- Education centred on problem-solving and critical thinking.
- Localization of AI innovation and entrepreneurship.

Training programs

To achieve the objectives of the Executive Program, the government is working closely with academic institutions and other sectors. In 2023, MTCIT signed a memorandum of understanding with the University of Technology and Applied Science (Muscat Daily, 2023b) with intended impact in the realm of AI and advanced technology. This includes provisions for scientific chairs, research centres and laboratories in these fields. Joint AI programs will further qualify academic staff of the university. The memorandum of understanding also extends to enhancing academic programs via specialized AI courses, collaborating with local and international tech firms for joint research, and enabling faculty to augment their skills through training programs, workshops and conferences. To further AI and tech awareness, the agreement includes holding public lectures, competitions and seminars.

Other AI and advanced technology training programs have been launched under the Makeen Initiative, overseen by the MTCIT. These include partnerships with Sultan Qaboos University and collaborations with local and international companies for virtual training programs in AI. A total of 48 qualification and training programs have trained 1,880 people, working towards a target of 10,000 by 2025.

Infrastructural enhancement

The ambitious integration of AI into various sectors necessitates a robust and adaptable infrastructure. Recognizing this, MTCIT has been actively collaborating with key infrastructure providers, including telecom companies and cloud service providers, to ensure the necessary technological support and enhancements are in place. This collaboration focuses on upgrading the existing cloud computing infrastructure to efficiently process AI applications, a critical step in accommodating the growing demands of AI research and application.

A significant milestone in this endeavour was the introduction of cloud AI services by Oman Data Park (Arabian Daily, 2021). This development came about through a strategic partnership with Nvidia, a global leader in AI and graphics processing. This collaboration is not just a technological advancement but is poised to significantly improve the productivity of various economic sectors and propel the national economy towards a digital transformation.

The telecom sector as well has played a pivotal role in this infrastructural enhancement. A testament to their efforts is the widespread access to mobile broadband networks, which now extend to 97.3 percent of the population. This expanded network access is crucial for facilitating seamless AI research and applications across the nation.

Ethics and commitment

In conjunction with these infrastructural developments, there has been a focused initiative to support research in the field of AI ethics. A notable step in this direction is the establishment of a research chair dedicated to AI ethics, in collaboration with the Islamic World Educational, Scientific and Cultural Organization (Oman Daily Observer, 2024). This initiative underscores the importance of ensuring that AI development and application align with ethical standards and contribute positively to society.

Oman has released a policy on AI systems. Through this policy, the MTCIT seeks to establish ethical principles and controls that in turn promote the optimal use of these regulations and reduce potential risks. MTCIT aims to emphasize the need for all units of the state administrative apparatus to abide by the terms of this policy. Additionally, the Open Government Data Policy is a policy used to define the overall governance for the ICT services continuity within the government administrative units ensuring the continuity of the services during disruptive events.

Oman's commitment to AI is evident in its successful implementation across various sectors, the Ministry of Economy's initiative to integrate AI in the national economy, the comprehensive National Data Strategy, and the focus on AI competency development. Collaborations between governmental institutions and educational entities, infrastructure development through strategic partnerships, and a sustainable and ethically grounded approach to AI research and application further bolster this commitment. Oman's strategic embrace of AI reflects a broader vision of sustainable development, economic diversification and global competitiveness, setting a benchmark for innovation in the region and beyond.

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Pakistan

Building a robust, resilient digital ecosystem

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Key takeaways
- Pakistan is actively developing its use of AI in multiple sectors and has instituted many initiatives to facilitate progress.
- Programmes are prioritizing development of the necessary policies, research, skills and infrastructure to disseminate AI throughout the country.
- Challenges to the widespread adoption of AI technologies remain, particularly in the areas of data quality and availability, and responsible and ethical use.

Pakistan, like many low- and middle-income countries, faces four significant development challenges – meeting basic human needs, achieving rapid economic growth, enhancing quality of life and improving governance (Ministry of Science and Technology, 2022). Advances in emerging digital technologies such as artificial intelligence (AI) and machine learning (ML) can help address these challenges. Pakistan began adopting AI in various disciplines in 2010, with academia and research leading the way. The startup sector followed in 2015 and AI began to be promoted by the government in 2016. However, Pakistan's overall technological progress remains slow when compared with similar countries (Nazeer and Gil, 2023) and government commitment is needed to develop digital governance, digital infrastructure, innovation, integration and human capital, all of which are crucial for harnessing the potential of AI (Government of Pakistan, 2023). Without this, sectors heavily reliant on manual and traditional roles may miss out on the benefits of AI, leading to further economic divergence.

Science, technology and innovation and AI adoption
The Pakistan Council of Science and Technology (PCST) advises the government on the country's National Research Agenda (NRA) and policies for building a robust, resilient and sustainable science and technology system. Fifteen priority areas, including information and communication, and robotics, were identified in the 2017 NRA (PCST, 2017), in line with

Pakistan Vision 2025, under which Pakistan aims to be among the top 25 global economies by 2025 (Ministry of Planning, Development & Reform, 2014). The 2017 NRA highlighted that Pakistan's efforts towards adopting Industry 4.0 at the national level were unsatisfactory and that the country needed to expedite its endeavours in industrial automation and increase Internet penetration through the development of information and communication technology (ICT) infrastructure. However, it acknowledged that research institutes, academia and the private sector were helping Pakistan embrace the fourth industrial revolution through teaching and research activities in robotics, AI, ML and e-governance.

Also in 2017, the PCST conducted Technology Foresight Exercises to identify emerging trends in robotics, AI and ML, and their potential impact on society (PCST Newsletter, 2017). It made valuable recommendations for the diffusion and adoption of AI, including increasing research efforts in e-health, e-commerce, e-education and e-governance, and establishing robotics research and design laboratories, incubation centres, public ICT and technology parks, and centres of excellence in robotics and AI research at universities across Pakistan. It also recommended a specific budget allocation to support training and specialization in robotics and AI.

Pakistan's national Science, Technology and Innovation (STI) Policy places AI at the top of the NRA alongside other emerging and future technologies (Ministry of Science and Technology, 2022). It paints a comprehensive picture of the actors, activities and institutions involved in the national innovation system and presents 61 policies for strengthening the innovation ecosystem and improving Pakistan's global competitiveness through target-oriented research funding and skill development programmes.

The STI Policy acknowledges that digital infrastructure development, regulations and policies must be integrated into national policy. Such strategic interventions can shape the future of technology and the economy, focusing on developing digital infrastructure and skills, and incentivizing research and development (R&D) across all economic sectors (Government of Pakistan, 2023). Consequently, efforts have been made to rapidly advance AI and digital technologies in line with the Pakistan Vision 2025, Digital Pakistan Policy 2018 and STI Policy 2022. To further strengthen the digital innovation ecosystem and enhance the digital landscape, the Ministry of Information Technology & Telecommunication (MoITT) and the Ministry of Planning, Development and Special Initiatives are drafting an updated Digital Pakistan Policy (MoITT, 2023). Alongside this, multiple policies for facilitating the adoption of AI and digital technologies have been instrumental in structuring a cohesive national AI framework. Further, to ensure digitization of the economy and promote e-governance, the Digital Nation Pakistan Act 2024 was recently approved (Dawn, 2024).

The Digital Pakistan Policy 2018 emphasizes the establishment of innovation centres for modern technologies to promote homegrown talent in the Internet of Things (IoT), financial technology, AI and robotics. It seeks to encourage a highly integrated startup ecosystem through collaboration with public and private sector entrepreneurship support organizations, financial institutions, universities, government departments, industry consultants and associations (MoITT, 2018). Key features of the forthcoming Digital Pakistan Policy 2024 are expected to include strategies for the widespread adoption of AI and ML, the

implementation of blockchain for secure and transparent transactions, and the deployment of 5G networks to boost connectivity and support the IoT. The policy will also focus on digital skills development, cybersecurity measures and the promotion of digital entrepreneurship (ProPakistani, 2024).

In addition, Pakistan's draft AI Policy 2023 provides a holistic structure for addressing societal challenges around AI adoption by establishing the necessary ecosystem with specialized initiatives and organizational responsibilities. It also proposes a national AI fund to support the interventions (MoITT, 2023). A National Task Force (NTF) of experts in AI from academia, business and the government is now reviewing the AI Policy, which aims to harness the power of AI for transformative change, leading to economic development and growth while ensuring societal benefits. The NTF's key objective is to develop a ten-year roadmap for accelerated adoption of AI in the business, development, governance, education and healthcare sectors (Butt, 2023).

Infrastructure, stakeholders and research community
A number of initiatives have been introduced by public service organizations in Pakistan to enhance digitalization capabilities. The Special Technology Zones Authority was created in 2020 to develop the IT sector and establish Special Technology Zones in the country (Pirzada, 2024; Nazeer and Gil, 2023). Under the Pakistan Vision 2025, the government has developed 17 software technology parks; twelve are fully operational (with six predominantly focusing on AI, IT and IT-enabled services), and the remaining five will become operational soon (STZA, 2024).

To promote R&D and human resource development in AI and related technologies, Pakistan's Higher Education Commission (HEC) has established six national centres under the Public Sector Development Program (PSDP) 2018-19. These centres aim primarily to build national capacity to conduct R&D in modern technologies, solve local problems, provide high-value shared services to academia and industrial partners, and develop an advanced workforce through training and applied work. They will also provide technology and consultation to help businesses embrace Industry 4.0 (HEC Pakistan, 2024).

Additionally, two dedicated AI research centres have been established under the Pakistan Vision 2025. The National Centre of Artificial Intelligence (NCAI) offers services to local industry, the HEC and other government departments in the fields of AI, ML, deep learning, image recognition and automatic speech recognition, equipping them with the latest technology. Headquartered at the National University of Sciences and Technology (NUST) in Islamabad, the NCAI operates nine research laboratories in six major universities across Pakistan. The second dedicated centre is the Sino-Pak Center for Artificial Intelligence, which offers solutions in intelligent biomedical applications, smart city urban planning, smart agriculture, applied neural interfaces, computer vision, robotics, deep learning, system designs, natural disaster management and the IoT. These efforts have enhanced research output by Pakistani scholars, who published around 18,365 research contributions between 2000 and 2024, including almost 11,000 papers in the field of computer science, more than 2,200 considering telecommunications and almost 750 on robotics (Web of Science database).

Strategic actions, activities and capacity-building initiatives

The Digital Pakistan Policy 2018 emphasizes active collaboration between the HEC, IT industry and other relevant institutions to modernize the education curriculum to meet industry's emerging technologies and requirements. The policy also highlights the importance of capacity-building measures such as awareness campaigns, trainings, seminars and workshops to digitize key socio-economic sectors (MoITT, 2018).

Curriculum development

The curriculum for postgraduate programmes in AI was first developed by the NCAI and approved by the HEC in 2019 (NCAI, 2019). Since then, the HEC has approved 38 universities in Pakistan to offer AI programmes (Nazeer and Gul, 2023).

PhD scholarships

Understanding that industry in Pakistan lacks highly qualified professionals in emerging technologies, the HEC supports advanced skills development through international scholarships to equip participants with up-to-date, hands-on knowledge of AI and related technologies. As well as reducing the workforce skills gap, these trained scholars will also help raise the educational standards and rankings of universities in Pakistan (HEC Pakistan, 2024a).

Research grants

The HEC is also pivotal in promoting the research culture in higher education institutes (HEIs) through its grant programmes.

- **The Innovative & Collaborative Research Grant** supports partnerships between Pakistani and UK universities, research bodies and centres of excellence that focus on energy, climate change, AI, robotics, big data and cloud computing. The three-year grant is worth up to Rs. 50 million.
- **The Technology Development Fund** finances proposals from interdisciplinary applied research for prototype development and industrial value addition for tech-based product or process development. It has already funded 200 joint academia-industry projects and over 160 have been licensed to industry for mass scaling and commercialization.
- **The RAPID Technology Transfer Grant** is a fast-track funding mechanism to support time-sensitive technology transfer projects at an advanced stage of development. It encourages industry-academia collaborations to promote homegrown technologies (HEC Pakistan, 2024b).

Skills development

Some initiatives include the following:

- **Exam resources and certifications**. Introduced by the HEC in partnership with Microsoft, these free resources cover foundational skills and additional topics, including Azure, AI, data analytics and cybersecurity (HEC Pakistan, 2024).
- **Conferences and competitions.** HEIs in Pakistan regularly organize conferences and competitions to foster AI development and adoption. The annual National Engineering and

Robotics Contest organized by NUST highlights cutting-edge AI and robotic technology and encourages collaboration and creativity among Pakistan's budding engineers. Pakistani students and academics also participate in international competitions such as the ROBOCUP and Organisation of Islamic Cooperation-funded robotics and AI contests.

- **Mentorship.** Google for Startups has launched an AI Academy to support AI startups in Pakistan and the Asia Pacific region. It is designed to fast-track startups to market by enabling them to rapidly validate and enhance AI innovations through tailored mentorship and up to 350,000$ in Google Cloud credits (The News, 2024).
- **Leadership training.** The NCAI at NUST offers a two-day 'AI for leaders' workshop that aims to equip participants with skills to help their organizations act with agility and purpose and explores how AI technology can amplify leadership practices to improve individual, team and organizational capabilities (NCAI, 2024).

Product development

In Pakistan, the private sector and academia are leading the way in developing AI-enabled products and services. Some AI-based private sector firms are providing services to the global market. The NCAI has been particularly productive, establishing 37 spin-offs and developing more than 220 AI-based products and design solutions across multiple sectors.

Way forward

Despite improvements in its AI infrastructure, Pakistan faces particular challenges to widespread adoption of the technology. One critical challenge is the availability and quality of data to train and operate AI algorithms effectively. Ethical concerns surrounding AI adoption are also crucial. Although no national AI ethics framework currently exists, public and private stakeholders have been setting guidelines, rules and regulations to ensure the responsible and ethical use of AI technologies. These highlight the need to understand global best practices, emphasize responsible use of AI, safeguard user data, uphold privacy rights and address concerns related to AI biases and data security. Another challenge is the shortage of expertise in AI technologies. However, universities and research centres are introducing AI-focused courses to develop a talented cohort of AI specialists (Ahmed, 2023).

The recent economic survey of Pakistan highlights the implications of AI for productivity and growth in various sectors. The NTF's roadmap and implementation plan for the adoption of AI in Pakistan should be published by the end of 2024 (Butt, 2023); however, the country needs strategic large-scale policy interventions to shape digital infrastructure development, innovation, integration, research incentivization and human capital development and harness the potential of this global change (Government of Pakistan, 2023). To unlock the full potential of AI for economic growth, efficient products and services, and improved quality of life, continued government investment and collaboration with international organizations and the private sector are required in research, development and education.

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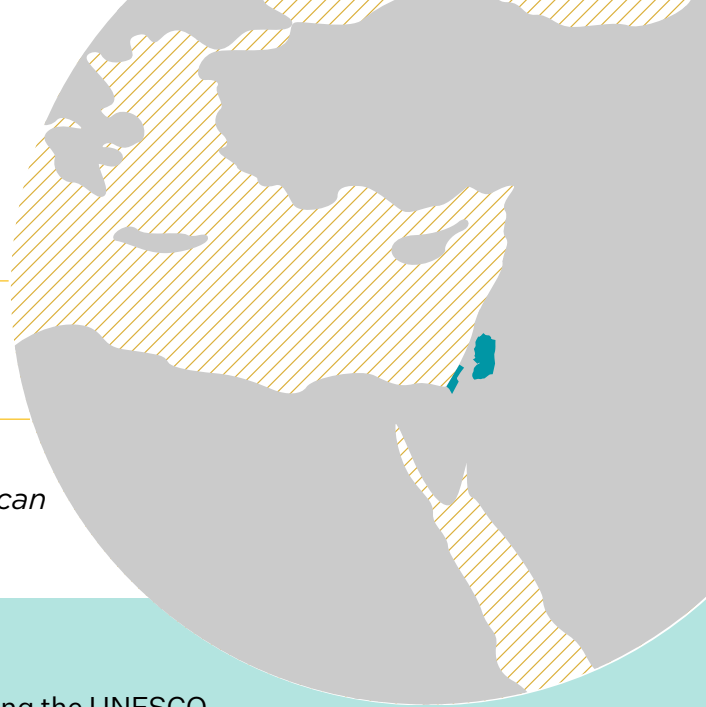Web of Science. 2024. https://www.webofscience.com/

Palestine

Adapting the science landscape for artificial intelligence

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Key takeaways

- The introduction of an AI National Strategy and using the UNESCO Readiness Assessment Methodology tool mark significant achievements for Palestine.
- Capacity-building programmes and infrastructure development are underway, aiming to develop local expertise and create a supportive environment for AI research and applications.
- There is a pressing need to develop policies and frameworks to support and expand AI research and development in Palestine.

As an emerging nation, Palestine faces unique opportunities and challenges in integrating AI into its national research ecosystem. Palestine's AI National Strategy (Ministry of Telecommunications and Digital Economy, 2024a; Demaidi, 2023; Palestinian AI National Strategy, 2023) encourages a comprehensive and collaborative approach, and the country has used the UNESCO Readiness Assessment Methodology (RAM) tool (UNESCO, 2023a, 2023b) to understand its preparedness to implement AI ethically and responsibly. Using insights from both the AI National Strategy and the RAM findings, this case study explores the integration of AI in Palestine and outlines opportunities, challenges and strategic actions aimed at enhancing national preparedness and adaptation for AI in the scientific ecosystem.

Institutional arrangements

The Palestinian Council of Ministers established an Artificial Intelligence National Team, headed by the Ministry of Telecommunications and Digital Economy (MTDE), in September 2021. The team includes representatives from government ministries, authorities and councils, and from the academic and private sectors. This ensures that AI initiatives align with national development goals, such as enhancing economic growth, fostering innovation and addressing societal needs.

Universities and research centres play a crucial role in AI research and talent development. However, Palestine's expenditure on research and development (R&D) is approximately 0.01% of its GDP, significantly below the global average of 2.62% (World Bank Open Data 2021) and the overall research output from Palestinian universities is far lower than that of leading global institutions. By 2023, Palestine had produced 1,867 AI-related publications, a modest number when compared with other countries. The proportion of female authors of AI

publications in Palestine (16.03% in 2023) also lags behind countries such as India (52.03%), the USA (48.43%) and France (41.70%) (OECD.AI Policy Observatory 2024).

There remains a pressing need for increased research output and the Palestinian AI National Strategy calls for more investment to bridge this gap and foster innovation.

Role of the private sector

The private sector is a critical component of the AI National Strategy, with key institutions playing pivotal roles. The Bank of Palestine, by supporting technology-based start-ups, including AI-driven ventures, is helping build a resilient ecosystem for innovation. Its RISE-Palestine and SAFE-Palestine initiatives offer technology-based start-ups essential financial resources, mentorship and networking opportunities (RISE-PALESTINE, 2024).

By integrating private sector participation and fostering a strong start-up ecosystem, Palestine can accelerate the development and adoption of AI technologies, driving economic growth and innovation across various industries.

Building a robust foundation for AI development

Developing the necessary infrastructure is crucial for scaling AI development and implementing AI-based solutions across Palestine. Establishing dedicated AI research centres and enhancing existing facilities will promote advanced AI research. Palestine currently has five data centres, which help support AI and data-intensive applications (Data Center Platform, 2024). However, the country lacks a policy for AI-driven cloud computing, something that is vital for scalable AI solutions. Developing such policies and ensuring a legal framework for consistent data management and publication are essential to advance AI infrastructure.

The Palestine Emerging initiative emphasizes the critical need for a robust digital infrastructure to support AI development and overall economic growth. A key element of this infrastructure is the implementation of 5G technology throughout Palestine (Palestine Emerging, 2024). The adoption of 5G will be transformative, enabling enhanced Internet connectivity, supporting advanced AI applications and providing the foundation for innovations in sectors such as healthcare, education and smart cities.

However, during the recent war on Gaza, Internet connectivity has declined significantly, with many areas experiencing up to an 80% reduction in access, and some regions facing complete shutdowns. Power outages are frequent and prolonged (Access Now, 2023). These issues have been devastating for Gaza's universities and technology start-ups. Most universities have been severely damaged or destroyed, affecting the studies and career opportunities of thousands of students (Le Monde, 2024; Reuters, 2024) and removing an important source of research and innovation, which are vital for developing Gaza's tech sector. For technology start-ups, the challenges are just as serious. With regular power and Internet interruptions, many companies cannot continue their work, connect with global clients or meet deadlines. These problems make it much harder for Gaza to close the digital gap and restrict the technology sector's ability to support future growth and recovery.

Data sharing and accessibility

Data sharing and accessibility are essential for using machine learning and AI in scientific research, with high-quality, accessible datasets enabling researchers to train and validate AI models effectively. The Open Data Inventory (ODIN) examines the coverage (how much data is available) and openness (how accessible the data is) of official statistics, with an ODIN score representing how well a country provides important statistics and whether the data is easy to access and use (Open Data Inventory, 2024). Palestine's ODIN score of 71/100 indicates a good start in making important data available for AI research, but more work is needed to improve its open data policy.

Making high-quality datasets more accessible with better metadata, more download options and clear open licensing will strengthen Palestine's infrastructure for AI research, helping to drive innovation. Its open government data policy aims to create additional datasets representing different sectors in the country. Notably, the data policy mentions making datasets available and accessible for research. Currently, 40 datasets are available on a portal which focuses on education, finance and agriculture (Open Data Palestine, 2024). The MTDE is working on an open data 'hackathon' to enhance the existing datasets and encourage their use for research and innovation (MTDE, 2024b).

Developing a national data-sharing framework will help ensure structured data management and accessibility and facilitate the integration of data from various sectors, thus enhancing the ability to apply AI effectively. The formation of a national committee tasked with expanding the availability of datasets and supporting AI research and applications reflects Palestine's commitment to institutionalizing open data practices.

Capacity building for AI in Palestine

Capacity building is a cornerstone of Palestine's AI National Strategy. Developing the ability to identify the information to collect, the technical knowledge to gather, store and present data, and the expertise to interpret it are essential for cultivating a robust science ecosystem that can leverage the full potential of AI. The AI National Strategy emphasizes several key areas to ensure a knowledgeable and skilled workforce, fostering a culture of innovation and ethical responsibility.

 Awareness of AI-related laws and regulations is critical for the ethical and responsible implementation of AI technologies. The AI National Strategy highlights the need for education on legal frameworks to ensure stakeholders are well-informed and compliant. Building this awareness lays the groundwork for responsible AI deployment, fostering trust and adherence to ethical standards.

The AI National Strategy also sets clear goals for educational integration, aiming for 300 AI graduates and the incorporation of AI into four educational programmes within three to five years. Key initiatives include launching an AI R&D centre, integrating AI into school curricula, developing hands-on AI courses at universities and initiating AI programmes across all higher education institutions.

As part of the Palestine Emerging initiative, the Gaza Technical University of Reconstruction

(GTUR) will integrate programmes for researchers focused on post-conflict reconstruction and economic development with a strong emphasis on AI and related technologies. GTUR will also offer a vocational programme, training local workforces to address post-conflict challenges, ensuring that students are equipped with the necessary AI skills to contribute to Palestine's reconstruction and economic growth.

Within GTUR, the Data4Palestine initiative will serve as a central data hub for collecting, analysing and disseminating real-time information on the impact of conflict and reconstruction efforts across Palestine. This initiative will aggregate and leverage crowdsourced data, satellite imagery, social media analysis and other data sources to provide comprehensive insights to guide reconstruction and development efforts. It will also develop interactive dashboards for decision-makers.

GTUR students and faculty will be actively involved in research, fieldwork and data analysis projects, ensuring that the data reflects the lived experiences of those most affected by conflict. The curriculum will incorporate courses on data collection and analysis, geospatial analysis and AI. By fostering collaboration with international partners and creating opportunities for practical application, GTUR and Data4Palestine will strengthen Palestine's AI and data infrastructure, driving innovation and informed decision-making in the reconstruction process.

Additionally, the Palestinian Information Technology Association of Companies has started a programme to upskill 40 mid-level engineers in technology companies, ensuring that professionals in the industry are equipped with advanced AI skills. This fosters innovation and enhances research capabilities within their companies, contributing to the overall scientific and technological development in Palestine.

The Arab American University is playing a leading role in advancing AI research and offers robust AI educational programmes, contributing to the cultivation of local talent. Fostering partnerships with international AI research institutions also brings global best practices to regions like Palestine, where AI has the potential to address significant local and regional challenges. Such international collaborations can amplify research outputs, foster innovation and develop AI solutions that are directly relevant to the unique challenges of these areas.

Next steps
Despite its achievements, limited resources and funding for AI projects hinder further progress in Palestine. There is a need for a robust legal framework to support AI development, and expanding AI research is crucial, with an emphasis on increasing the number of AI research projects and publications. Strengthening partnerships between government, academia and the private sector can foster collaborations and drive innovation, while developing and refining laws and regulations for AI will address emerging ethical and societal issues. Finally, integrating AI education into all levels of the educational system will prepare the next generation for an AI-driven world.

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PANAMA

Assessing the AI ecosystem

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Key takeaways
- Panama faces multifaceted challenges to the successful adoption of AI across a range of industries and sectors.
- A draft Bill to regulate the use, development and application of AI in Panama, and a new national strategic plan for science and technology for 2029–2025 are aiming to address some of these challenges.
- A national project, INDICATIC, is focusing on data processing, with AI as a critical component, and encompasses research, innovation and training.

According to the Latin American Artificial Intelligence (AI) Index, which assesses a country's readiness for and performance in AI in five areas (see box), Panama ranked ninth among the 12 countries studied in 2023, with an average score of 24.66 (out of 100), below the regional average of 42.6 (Centro Nacional de Inteligencia Artificial, 2023). This ranking highlights several gaps: Panama lacks AI-skilled talent, higher education opportunities in AI, a national strategic plan to promote advanced technology, and supportive AI laws and regulations (Hernandez, 2023). In talent development specifically, Panama ranks among the lowest in the region, with a score of 16.12, just above Paraguay and Bolivia. The index further notes the absence of open AI courses, scarce professional training, a lack of advanced postgraduate AI programmes and a shortage of workers with sufficient knowledge to leverage AI for innovation in their roles.

Dimensions assessed by the Latin American Artificial Intelligence Index
- Enabling factors for developing a robust AI system
- Research, development and adoption of the technology
- Governance and legal frameworks
- Societal perception in social networks and digital media
- Academic trends and expert views on social impact

These issues must be overcome to ensure the successful adoption of AI across multiple sectors in Panama.

Legislation and strategy

In July 2023, a draft Bill (Bill Draft No. 014) was presented to the National Assembly of Panama. The Bill aims to regulate the use, development and application of AI in the country (National Assembly of Panama, 2023). Presented through Citizen Participation, the Bill applies to any person within Panama who develops, uses or commercializes AI systems, and prohibits the use of AI for illicit purposes, including the creation of digital forgeries, such as deepfakes, videofakes and audiofakes. Responsibility for such misuse falls on the person employing AI, even in cases where outcomes are unintentional or unforeseen. Additionally, individuals or companies using AI must inform affected individuals about any automated decisions made and the impact on their personal data.

Although Panama does not yet have an official AI strategy, it will shortly introduce its Plan Estratégico Nacional de Ciencia y Tecnología (PENCYT) 2025–2029. PENCYT is a broad initiative for science and technology that aims to support and coordinate research efforts (CECOM, 2025). The PENCYT of 2025-2029 will focus on six key areas, one of which is 'Digitalization', within which AI will be addressed.

AI penetration and adoption

Manufacturing is currently the only sector in Panama that is significantly leveraging AI; however, there is a trend towards expanding AI use across other sectors, including agriculture, urban development, environmental management, education, finance and health. This expansion remains in its early stages, and no specific policies or initiatives are yet actively supporting AI adoption in these sectors. Nor are there measurable goals or benchmarks in place to track AI penetration or its sectoral impact over time.

Adoption indicators reveal notable differences in technology transfer between Panama's private and public sectors, with government indicators for AI promotion surpassing those of private companies – a trend that mirrors patterns observed in many other countries in Latin America. There is limited information on collaboration between local businesses and government agencies regarding the implementation of AI, and it is unclear if there are incentives for organizations that choose to adopt AI technologies.

Several factors are impacting the adoption of AI in Panama, primarily a lack of knowledge on how it can be applied within various domains and what benefits it could offer. Another significant barrier is reluctance to invest in this new technology due to uncertainties surrounding its adoption. Additionally, there is a workforce skills gap, with limited access to the expertise required for AI implementation.

Increasing demand for AI skills

According to McKinsey's workforce skills model, technological skills are increasingly valuable and are projected to have the greatest impact on working hours. This trend is observed globally, and affects all sectors, although the degree of technological advancement varies by country. In its report on the future of employment, the World Economic Forum predicts that specialists in AI, big data and digital transformation will be among the roles most in demand in the next few years (WEF, 2025).

New job opportunities requiring AI skills are anticipated to emerge in Panama, including in government, academia and private industry. While high demand for AI-related jobs is expected across all sectors, there is limited data on the specific sectors in Panama currently experiencing the highest demand, and no formal tracking of the skills required in these sectors. Sector-specific strategies to foster AI job growth are also lacking, even in areas where Panama may have unique strengths or high growth potential. Panama's strategic plan, PENCYT, emphasizes sectors such as agriculture, logistics, health, finance and tourism, but there are no targeted initiatives to directly support job creation in these areas, meaning that workforce readiness for AI may develop more organically or rely on broader digitalization efforts under PENCYT's objectives.

Coordination and collaboration in AI research

Panama currently lacks dedicated AI research centres, although some AI research groups exist within universities. Resources and funding to support these groups are limited, with no specific emphasis on either applied or theoretical AI research. Individual university initiatives occasionally involve collaboration with companies but there are no formal structures to coordinate these efforts.

Through PENCYT, the government intends to coordinate AI research groups within universities, particularly by facilitating collaboration on large-scale projects; however, specific projects have yet to be identified. Formal channels or structures to increase collaboration between academic AI research groups and the private sector are also lacking, which could hinder cross-sector innovation and the application of AI insights in diverse industries.

In terms of data infrastructure, Panama is collaborating with the European Union on the Copernicus Data Centre project to store imagery of the region from the Copernicus satellite system (CopernicusLAC Panama Centre). This data will support climate change research and analysis, and is currently accessible, representing a significant step in making resources available to Panamanian researchers and institutions. However, this project remains focused on climate change, with limited efforts directed towards expanding AI research to other sectors. Panama currently has no detailed plan to expand AI research across additional sectors where AI data and infrastructure might play a critical role.

Addressing the skills gap

While the skills gap in AI is acknowledged, Panama does not currently benchmark its AI skills progress against similar countries in Latin America, nor does it have measurable goals or a defined timeline to reduce this gap. As such, Panama's approach to building AI skills is in the early stages, with limited structured strategies or metrics to evaluate progress.

Historically, academic training programmes have been slow to adapt to evolving industry requirements. Given the predicted increase in demand for specialists in big data and AI (WEF, 2025), training in these areas is becoming a significant necessity for the professional population in Panama but there appears to be a gap in AI training programmes specifically aligned with industry needs. Panama has no national initiatives dedicated to building

disruptive skills; only small, localized programmes are in place, and no substantial partnerships have yet emerged to address these needs. There is an urgent requirement to develop more professional training programmes alongside traditional Bachelor's and Master's degree tracks, to cater to broader audiences beyond university students.

Advancing Panama's technological capabilities

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The INDICATIC project

The INDICATIC project, an initiative of the National Secretariat of Science, Technology and Innovation (SENACYT) under the national 'Panama Digital Hub' project, is funded by the Panamanian government but also seeks other resources via grants, projects with international banks and private contracts.

Focused on data processing, with AI as a critical component, INDICATIC's mission encompasses research, innovation and training, with a strategy for international collaboration. It specializes in developing AI-driven 'smart systems' and mathematical tools to process big data across sectors such as the environment, agriculture, urban development and education. This work centres on transforming raw data into valuable information and knowledge through a value-added chain, facilitating decision-making, predictions, process optimization and simulations. In addition to data processing, INDICATIC emphasizes data preprocessing (e.g. integration, cleaning and anonymization) and post-processing (e.g. visualization and augmented reality). Beyond research, INDICATIC prioritizes innovation, ensuring rapid socio-economic impact through technology transfer and valorization, and training, with opportunities for undergraduate and postgraduate interns and advanced technical training in AI, big data, blockchain and cybersecurity. While primarily national in scope, INDICATIC actively pursues international collaborations with partners in the United States, Europe (notably France) and Colombia, which are essential for its expansion and growth.

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Achieving a high level of technological integration in Panama presents a significant challenge. To help address it, the INDICATIC initiative, started in June 2022, is playing a crucial role in advancing the nation's technological capabilities, particularly in AI (see box). One of INDICATIC's primary goals is to design and implement smart systems that incorporate AI within an innovation-driven framework, promoting technology transfer from research to productive sectors. To support this, INDICATIC also offers internships to students, allowing them to gain hands-on experience with AI through involvement in ongoing projects. INDICATIC is also supporting the development of the new legislation to govern AI in Panama and is playing a role in strategic planning.

The new PENCYT (2025-2029) which is being finalized, especially the vector "Digitalization", will include AI as a key issue for future plans and goals of Panama. This vector is articulated with sectors such as Logistics, Agro, Tourism, Health, Education, FinTech, very important for the country development. The issue of AI regulation is also tackled with a law project.

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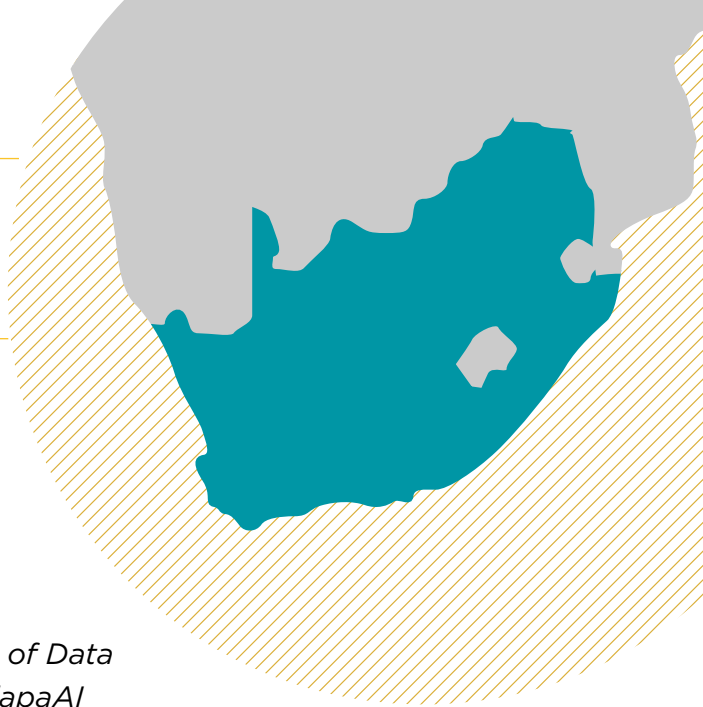
Adopting artificial intelligence for all citizens

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Key takeaways

- South Africa has embraced AI by establishing: the Presidential Commission on the Fourth Industrial Revolution; the Artificial Intelligence for Africa Blueprint and other regional frameworks; a digital and future skills training programme for 500,000 participants; the Centre for Artificial Intelligence Research, and the Artificial Intelligence Institute of South Africa; and initiatives to reduce data costs and improve internet penetration, so that all South Africans can benefit from the AI revolution.
- The Department of Science and Innovation's National Integrated Cyber Infrastructure System, together with supercomputer research into AI, means that South Africa is poised to harness big data and drive future scientific and industrial growth.
- A key challenge is the need for a comprehensive national AI strategy to guide and coordinate efforts across various sectors in South Africa.

AI is a rapidly growing technology in South Africa. Research publications in the country increased from 262 in 2000 to 4,000 in 2023 (OECD, 2024), while venture capital investments in AI grew from USD 1.5 million to USD 213 million in 2021. The economic potential of AI for South Africa is significant, with Access Partnership estimating that AI could contribute up to USD 52.2 billion in economic gains by 2030 (Access Partnership, 2023).

Government strategy

South Africa's commitment to integrating AI into its science system is rooted in its national development plan, also known as Vision 2030 (Government of South Africa, 2011). In 2019, the newly established Presidential Commission on the Fourth Industrial Revolution (PC4IR), reiterated this commitment (Presidential Commission on the 4th Industrial Revolution, 2020).

The Commission advises on strategies for skills development and research and development (R&D) programmes to advance technologies including AI. Comprising leaders from academia, business and civil society, the PC4IR has recommended that R&D and implementation

capabilities for AI must be embedded within the state. As such, the Department of Science and Innovation (DSI) promotes a whole-of-government approach to research, implemented through a decadal plan (Department of Science and Innovation, 2019).

The DSI decadal plan (Department of Science and Innovation, 2024b) prioritizes six digital domains for focused resource allocation over the next ten years: the internet of things (physical network); cloud computing; modelling and simulation; AI, robotics and cybernetics; blockchain recording and cybersecurity; and quantum computing. To support these domains, the DSI launched in 2021 a ten-year Foundational Digital Capabilities Research programme, in collaboration with the Council for Scientific and Industrial Research (CSIR).

On the international front, South Africa has actively contributed to pan-African initiatives. Most notably, during its African Union Presidency, the country was instrumental in developing the *Artificial Intelligence for Africa Blueprint* as part of the Smart Africa initiative, supported by the German Development Cooperation (GIZ) and the Smart Africa Secretariat (Smart Africa, 2021). The Blueprint assists member states in crafting policies, strategies, and plans to foster growth and prosperity within the context of the 'Fourth Industrial Revolution' (4IR). Additionally, South Africa has led efforts to develop a Southern African Development Community big data framework (Department of Communications and Digital Technologies, 2023).

To gain a global perspective, the PC4IR analysed 4IR strategies from countries including India, the UK, the USA, China, Japan, Singapore, Mexico, Malaysia, Kenya, Australia, Canada, Russia, and Tunisia, extracting critical lessons. Such insights informed the development of South Africa's decadal plan, which aligns with international approaches such as the EU's Horizon 2020 research, development and innovation programme.

Priority sectors for artificial intelligence
By focusing on the following sectors, South Africa aims to harness the transformative potential of AI to drive sustainable and inclusive growth.

- Manufacturing, agriculture and mining
- Digital and circular economies
- Health innovation
- Energy innovation
- Building of a capable state
- Social progress
- Societal grand challenges such as climate change

Opportunities and challenges
Artificial intelligence can substantially improve many sectors of the South African economy. In healthcare, it can lead to more accurate diagnoses, personalized treatment plans, and improved patient outcomes. In agriculture, it can optimize crop yields, enhance resource management, and reduce waste. In education, it can personalize learning experiences and improve outcomes. And in manufacturing, it can streamline production processes, reduce costs, and increase efficiency. Moreover, AI can act as a lever for the South African Government to improve service delivery, and consequently the quality of life of its citizens.

But alongside these numerous opportunities also lie critical challenges – such as the digital divide, which creates disparities in access to digital technologies and services, particularly in rural areas. The DSI's *White Paper on Science, Technology and Innovation* acknowledges additional challenges, including the need for high-level skills, sufficient funding, and robust infrastructure to support AI research and applications. And the Department of Communications and Digital Technologies, in its strategic plan, highlights as critical hurdles policy uncertainty, high data costs and outdated policies on information and communication technology.

In addition, the PC4IR has noted the need for substantial investment in digital infrastructure, including data centres and broadband connectivity. It has also identified a pressing shortage of professionals skilled in AI, which hampers South Africa's ability to fully leverage AI technologies. And it acknowledges that addressing data privacy, algorithmic transparency and ethical concerns in the deployment of AI is essential for building public trust and using AI in a responsible manner.

An overriding challenge is the lack of a comprehensive national strategy outlining goals, initiatives and investments for developing and implementing AI. The South African National Advisory Council on Innovation is therefore spearheading an initiative, led by the CSIR, to develop recommendations for a national AI strategy.

Institutional structures and initiatives

South Africa has established a robust governance structure to oversee the implementation of AI and other 4IR technologies. At the top is the biennial Presidential Science, Technology and Innovation Plenary (Department of Science and Innovation, 2023), which brings together all innovation actors, including government, academia, industry and civil society. This is complemented by an Interministerial Committee on Science, Technology and Innovation, which ensures government alignment on scientific and technological innovation; the PC4IR; and the DSI, which plays a pivotal role in steering AI-related initiatives.

Other key government institutions include the National Research Foundation, which funds and supports AI research projects (National Research Foundation, 2024a); the Technology Innovation Agency, which focuses on the development and exploitation of discoveries, inventions and innovations to improve quality of life for all South Africans (Technology Innovation Agency, 2024); and the National Intellectual Property Management Office, which ensures that intellectual property resulting from publicly financed research and development is identified, protected, utilized and commercialized (The Innovation Hub, 2024).

AI initiatives also involve the national science and research community, including the CSIR; the Centre for Artificial Intelligence Research, a network across eight universities conducting research in cybersecurity, machine learning and ethics and other aspects of AI (CAIR, 2024);

the Artificial Intelligence Institute of South Africa, established in 2022 at four universities in Tshwane, Johannesburg, and Free State and Western Cape provinces; and the Medical Research Council, which has launched a new initiative, in partnership with the Bill & Melinda Gates Foundation and Grand Challenges, using models like GPT-4 to address health challenges (SAMRC, 2023).

Public–private partnerships, based on a multi-stakeholder approach, play a key role in implementing AI in South Africa. For example, a partnership between IBM South Africa and the Department of Trade, Industry and Competition launched one of South Africa's largest equity equivalent investment programmes (Department of Trade, Industry and Competition, 2022), which includes an IBM Research Africa lab that fosters local innovation, and creates new models for partnerships with industry, academia, government, non-profit organizations and start-ups (IBM Research, 2024).

To support AI and other emerging technologies, specific budgets and grants are allocated through various channels including the National Research Foundation and the Department of Trade, Industry and Competition, which implements the Technology and Human Resources for Industry Programme to leverage collaboration between government and industry (Department of Trade, Industry and Competition, 2024). Additionally, the South African Government offers an R&D tax incentive designed to promote private sector investment in R&D activities within the country (Department of Science and Innovation, 2024a).

Transparency and ethics

South Africa has made significant strides towards data protection and cybersecurity, which are crucial for the successful deployment of AI. This includes enacting several key laws to safeguard personal data and ensure secure digital interactions. In addition, the DSI *White Paper on Science, Technology and Innovation* highlights the importance of responsible research and innovation (RRI) – which can help South African researchers collaborate and compete with their international counterparts in an increasingly ethics-driven global research environment. The country plans to develop RRI indicators and a comprehensive monitoring, evaluation and learning framework to ensure that AI systems are transparent and ethically sound.

The DSI decadal plan further underscores the importance of open science and open data policies to ensure that AI technologies are transparent and accessible. In line with these principles, it calls for the development of a comprehensive artificial intelligence strategy and ethics framework – to address critical issues such as data privacy, algorithmic bias and the ethical use of AI technologies. By establishing clear guidelines and standards, the framework aims to mitigate risks associated with AI, and ensure that its deployment aligns with societal values and ethical norms.

Capacity building and skills development

South Africa is committed to enhancing and future-proofing human capabilities to ensure a competitive and adaptable workforce in the rapidly evolving landscape of the 4IR. To achieve this, the Department of Higher Education and Training has launched several initiatives including investment in skills forecasting and overseeing a national skills fund.

Complementing these efforts, the DSI is collaborating with the Department of Basic Education to integrate essential 4IR skills, such as robotics, coding, and using augmented reality, into the school curriculum. By introducing these skills at an early stage, South Africa aims to build a solid foundation for the digital future. The DSI is also engaging with education

and training authorities, and state-owned enterprises, to build intermediate-level R&D skills in areas aligned with its decadal plan. Alongside this, the Department of Communications and Digital Technologies aims to train 500,000 people in a new digital and future skills training programme.

The National Research Foundation plays a crucial role in advancing research and innovation through its South African Research Chairs Initiative in public universities (National Research Foundation, 2024b): two of the research chairs awarded focus on artificial intelligence. Other educational initiatives include the Machine Learning and Data Science Africa Network and the AI Africa Consortium, led by the University of the Witwatersrand (AI Africa Consortium, 2024). In addition, non-governmental organizations like Deep Learning Indaba aim to strengthen machine learning and AI in Africa.

South Africa's leading universities offer undergraduate and postgraduate specializations in AI, with the number of tertiary AI courses increasing from just two in 2017 to 54 in 2023 (OECD, 2024). For example, the African Institute for Mathematical Sciences, a partnership between universities including Cambridge, Oxford, Cape Town and Stellenbosch, now offers a Master's degree in Mathematical Science which includes an 'AI for Science' module (AIMS, 2024). And in 2019, the University of Johannesburg introduced a free, online course entitled Artificial Intelligence in the Fourth Industrial Revolution.

National Integrated Cyber Infrastructure System

South Africa's commitment to advancing scientific and industrial development is exemplified by the National Integrated Cyber Infrastructure System (NICIS). This initiative, spearheaded by the DSI and implemented by the CSIR, aims to provide a robust and integrated cyber infrastructure to support research and education communities across the country. It is designed to promote scientific and industrial growth through the provision of high-performance computing capabilities, high-speed network capacity, and a comprehensive national research data (NICIS, 2024). These components are hierarchically integrated into both globally connected and local systems, providing seamless access for researchers and educators.

One of the three pillars of NCIS is the Centre for High Performance Computing, which offers massive capabilities and services to researchers in both industry and academia, enabling them to tackle complex computational problems that require significant processing power (CHPC, 2024). The second pillar, the South African National Research Network, provides high-speed connectivity and advanced networking services, ensuring that researchers have access to adequate bandwidth and network performance in order to collaborate effectively, share real-time data, and access global research resources.

The third pillar, the Data Intensive Research Initiative of South Africa, addresses the growing need for managing very large datasets, focusing on issues such as data curation, provenance, trust, digital preservation and analytical techniques. These services are critical for ensuring that data-intensive research can be conducted effectively, and that valuable data is preserved for future use. A related initiative is South Africa's new National Big Data Strategy (Department of Science and Innovation, 2024b).

Next steps

Recognizing the need for a strategic approach to solidify its position as a global leader in AI, South Africa is working on several plans for the future. Firstly, it is developing a national AI strategy and government policy – providing the framework necessary to harness the potential of AI, promote innovation and drive economic growth. Secondly, building on the progress of the digital and future skills training programme, South Africa will further invest in creating a skilled workforce for a digital future.

Thirdly, the country will continue to enhance data infrastructure and internet connectivity, ensuring that all South Africans have access to the digital tools and resources they need. Finally, through continued support for institutions like the Centre for Artificial Intelligence Research and initiatives like Deep Learning Indaba, South Africa will advance research into AI research and foster a vibrant AI community throughout the country. Such a multi-faceted and coordinated approach is both ambitious and necessary – for paving the way towards sustainable and inclusive growth, and ensuring ethical adoption of AI that benefits all sectors of society.

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URUGUAY

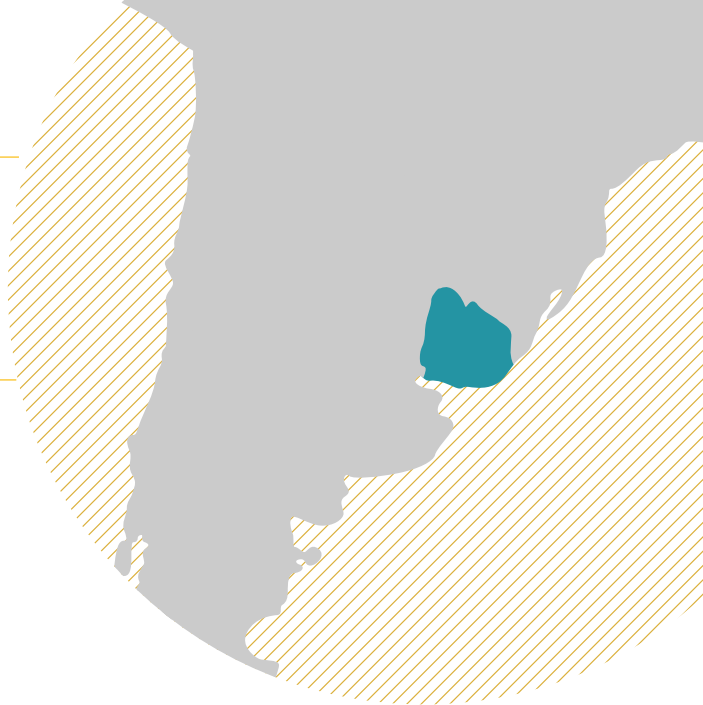**Following a roadmap to prepare national science systems for artificial intelligence**

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Instituto de Computación, Facultad de Ingeniería, Universidad de la República

Key takeaways:
- The Roadmap for Data Science and Machine Learning developed in Uruguay in 2019 highlights the role of universities, public-private partnerships and civil society. National and international investment have supported AI projects in the country since 2017.
- Uruguay is leading regional events and initiatives on AI placing it as a leader in the region.
- Among the immediate next steps in the country are capacity building and upskilling and AI education.

Nearly a decade ago, Uruguay initiated a strategic effort to integrate data science and AI into various aspects of its societal fabric. The resultant Data Science and Machine Learning Roadmap, published in 2019, is a testament to Uruguay's commitment (TransformaUruguay, 2019). Aligned with the National Development Strategy 2050 (Isabella, 2019), the roadmap envisioned Uruguay as a leader in AI solutions application by 2030. It delineated two main dimensions: creating an enabling environment and exploring opportunities in national strategic sectors. The roadmap underscored critical elements essential for fostering AI development in Uruguay, including enhancing education and training in data science and machine learning, attracting talent, improving research and innovation capabilities, updating regulations and fostering international collaboration. The document also identified capacities and opportunities for applying AI in crucial national sectors.

As part of the roadmap, Uruguay conducted a review to identify international experiences conducive to local AI development. The compiled report showcased successful global and regional initiatives, highlighting common characteristics that attract talent and cultivate thriving research and development ecosystems (Etcheverry and Fariello, 2020). After this review, the change in government in 2020 and the onset of the COVID-19 pandemic prompted the suspension or postponement of some roadmap actions. Yet despite these challenges, Uruguay has demonstrated resilience by resuming and continuing key actions and lines of work (AGESIC, 2023).

A regional snapshot

The Latin American AI Index (CENIA, 2023) offers an insightful analysis of AI landscapes across twelve Latin American countries, including Uruguay. This index, structured into three axes – enabling factors; research, development and adoption; and governance – provides a comprehensive perspective on the maturity of the region's research, development and adoption ecosystems. Uruguay stands out for having high scores in several dimensions assessed in the index, ranking third in the region (55 percent) after Chile (73 percent) and Brazil (65 percent).

There are still opportunities for improvement in many areas to further strengthen the ecosystem's development across Latin America. As Uruguay already leads regional initiatives and partnerships on AI, thus understanding the needs and differences across the region, it is well placed to lead effective and cohesive interactions towards common AI goals.

Artificial intelligence infrastructure

Uruguay boasts a robust connectivity infrastructure, surpassing the Latin American average in Internet usage and download speed (CENIA, 2023). The country excels in device accessibility, with high indicators – particularly in households owning computers and mobile device subscriptions – exceeding regional averages.

More local computing infrastructure is needed, however. A computing platform called the National Supercomputing Centre (ClusterUY) was created for use by scientists and researchers in the country by the National Agency for Research and Innovation and the Sectoral Commission for Scientific Research. Accessibility and use of ClusterUY is however limited to experienced coders. Universidad de la República (UdelaR) is working on facilitating access to the platform but this remains an ongoing challenge. A large part of cloud computing services comes from the private sector. Google, for example, is set to establish a Google Data Centre in Uruguay with the aim of serving the whole region.

Academic initiatives

Within the academic sphere, UdelaR, the country's leading research institution, plays a pivotal role. Several initiatives, notably Centro Interdisciplinario en Ciencia de Datos y Aprendizaje Automático (CICADA), aim to develop research, innovation capabilities and multidisciplinary education in AI-related fields (CICADA, no date). Several research lines at UdelaR explore diverse domains, such as genomics, bioinformatics, medical image processing, epidemiology, ecology, neurosciences and education, using AI methods and tools.

The Data Science and Machine Learning Roadmap highlights the role of universities in AI teaching and training as well as for development and research, even though the role of universities is not necessarily distinguished. The research and science ecosystem in Uruguay is limited, with only three main universities creating a tight community. Partnerships between the private sector and public sector are happening naturally or de facto depending on cases and needs.

The roadmap also outlines institutional arrangements involving collaboration between the government, national academic institutions like UdelaR, and the private sector. The national science and research community actively contributes to developing and implementing the response. In collaboration with other local organizations, CICADA actively engages with civil society, fostering discussions on ethical considerations in data science and AI (ANEP, 2023). This initiative is a platform for building knowledge and exchange between researchers, students, professionals and the broader community.

Talent and research challenges

The Latin American AI Index (CENIA, 2023) recognizes Uruguay's data capabilities and governance excellence. However, challenges persist in talent development, with a noted gap in professional AI training and a scarcity of relevant programs in regional QS-ranked universities. Improving data literacy and upskilling students and educators are integral to Uruguay's plans (Ceibal, no date). Building on the country's prominent position in AI research and innovation, the next steps will involve addressing challenges, particularly in formal AI education, to ensure a sustainable and comprehensive approach to AI adoption in the scientific sector.

Building on the country's prominent position in AI research and innovation, the next steps will involve addressing challenges, particularly in formal AI education, to ensure a sustainable and comprehensive approach to AI adoption in the scientific sector.

Uruguay emerges as a regional leader in research and development, showcasing high productivity and quality in open-source development. While patent registration remains low, the Latin American AI Index suggests aligning Uruguay's innovation landscape with its impressive open-source achievements (CENIA, 2023).

Investment and innovation

Uruguay boasts the highest normalized averages of inward investment and total estimated investment value in Latin America (CENIA, 2023). Although research on AI topics receives support from institutions like the National Agency for Research and Innovation and UdelaR, there's a noticeable absence of specific AI-oriented funding initiatives. Some exceptions are the Sectoral Fund for Open Data Research (ANII, 2018), which was discontinued, and the Call for R&D Projects in Artificial Intelligence (ANII, 2022), carried out jointly with the International Development Research Centre (IDRC). The two calls for the Sectoral Fund in 2017 and 2018 totalled USD 1 million, which was distributed among 38 projects (approximately USD 26,000 per project). With the specific calls for AI projects funded by IDRC, seven projects were supported with approximately USD 30,000 per project.

Alongside active investment, Uruguay also emphasizes algorithmic governance (AGESIC, 2023). Transparency in algorithmic systems is a cornerstone of this approach, aligning with global best practices and ensuring ethical considerations in the adoption of AI technology (Rahim, 2023).

Building bridges

The potential role of Uruguay in bridging academic and enterprise efforts in AI research is exemplified by the KHIPU events (KHIPU, no date). These meetings in Montevideo in 2019 and 2023 brought together top AI researchers from around the world with a strong presence of researchers from UdelaR in the KHIPU committee, and sponsored by international entities. The events culminated in the Montevideo Declaration on Artificial Intelligence and its Impact on Latin America, signed by almost 500 researchers (various authors, 2023).

Uruguay's approach to AI within its scientific system is characterized by a strategic approach under the 2019 roadmap; active collaboration between government, academia and the private sector; and a commitment to ethical and responsible AI practices. Ongoing initiatives and achievements position Uruguay as a regional leader in AI research, development and application, and the country is now focusing on building capacity, fostering transparency and addressing challenges for a sustainable future in AI development.

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UZBEKISTAN

Building the right conditions and skills for artificial intelligence

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Key takeaways:

- Presidential resolution enabling policy frameworks and strategies for AI in Uzbekistan have been put in place since 2020. Among the country's strategic goals is training the young generation, it has therefore set a goal to train one million Uzbeks through an online training platform.
- A new agency for Ai development has been founded to monitor and implement AI technologies across all sectors.
- The recruitment of the newly trained generation in coding and the infrastructure to support AI work are next steps for the country.

Uzbekistan's activity in recent years in the structural development of AI and the creation of the necessary conditions for its formation has been identified as one of the country's priority areas. Its reforms are based on the adoption of regulatory documents that structure the system to create the necessary conditions for the accelerated implementation of AI in the economy (Ministry of Digital Technologies, no date).

Policy foundations

Three documents in particular serve as a solid basis for AI development in Uzbekistan. The first is the 2020 Decree of the President of the Republic of Uzbekistan 'On approval of the strategy "Digital Uzbekistan – 2030" and measures for its effective implementation' (Government of Uzbekistan, 2020). This document defines tasks for the development of teacher technological competences.

This was followed in 2021 by the Presidential Resolution 'On measures to create conditions for the accelerated introduction of artificial intelligence technologies' (Government of Uzbekistan, 2021a). Under this resolution, a program of measures for the study and introduction of AI technologies in 2021–2022 was approved, which provides for the main priority areas of development for the State Program including an AI Development Strategy, a regulatory framework, the widespread use of AI technologies, domestic innovative ecosystem for AI and international cooperation.

Lastly, 2021 also brought the Presidential Resolution 'On measures to create a special regime for the use of artificial intelligence technologies' (Government of Uzbekistan, 2021b). Within the framework underneath this resolution, the introduction of a special regime for the use of AI technologies within the framework of experimental and innovative research was approved.

Strategic tasks

As described above, the 2020 Decree of the President led to the adoption of the strategy Digital Uzbekistan – 2030. One of the main achievements under this strategy so far has been the organization of training 587,000 people in the basics of computer programming, including by attracting 500,000 young people within the framework of the project One Million Uzbek Coders. This large-scale project is a result of a partnership with the Dubai Future Foundation in the United Arab Emirates and was launched at the end of 2019 (Inha University in Tashkent, 2019). One Million Uzbek Coders is a free distance-learning platform for the general public, especially targeted at young people with students starting from age 13. This training program is currently running, and in 2021 had already reached around 500,000 students (ITPARK, 2021).

Digital Uzbekistan – 2030 has also achieved the implementation of over 280 information systems and software products for automation of management, production and logistics processes in enterprises of the economic sector. The country has meanwhile consolidated relevant higher educational institutions in its regions to improve the digital literacy and skills of khokims (heads of regions) and employees of state bodies and organizations, training 12,000 employees in information technology and information security.

One Million Uzbek Coders is a free distance-learning platform for the general public, especially targeted at young people with students starting from age 13. This training program is currently running, and in 2021 had already reached around 500,000 students

Infrastructure for development

Particular attention is being paid to the creation of the necessary integrated infrastructure for the development of AI. In the Joint Alliance for the Development of AI, the Ministry for Development of Information Technologies and Communications acts as a working body in partnership with the Ministry of Innovative Development, other government agencies, commercial banks and the private sector. The Alliance, in partnership with the Tashkent University of Information Technologies, will direct a doctoral program as well as organize training and teaching programs for students.

Comprehensive infrastructure for artificial intelligence development in Uzbekistan

Comprehensive infrastructure for AI developmentt

→ Creation of a Department for the Introduction and Development of AI technologies on the basis of the Ministry for the Development of Information Technologies and Communications.

→ Creation of an AI Development Alliance in cooperation with the Ministry for the Development of Information Technologies and Communications, the Ministry of Innovative Development, government agencies, commercial banks and large industrial enterprises.

→ Creation of the Research Institute for the Development of Digital Technologies and Artificial Intelligence under the Ministry for the Development of Information Technologies and Communications.

→ Creation of a doctoral program in the specialty 'Digital technologies and artificial intelligence' in the systems of higher educational institutions.

The complexity of the infrastructure being created should make it possible to cover all areas of AI development in the country. Thus, state policy in the field of AI will be coordinated by the Department for the Introduction and Development of AI Technologies under the Ministry for Development of Information Technologies and Communication. The Alliance will promote the joint implementation of priority projects for the introduction of AI technologies in the economic and social sectors and the public administration system, the optimization of costs for their development, and dissemination of best practices in this area among government agencies and organizations. The doctoral program will produce highly qualified specialists in the field of AI.

A new research institute

An important part of this infrastructure is the Research Institute for the Development of Digital Technologies and Artificial Intelligence under the Ministry for the Development of Information Technologies and Communications. Among its main tasks is the organization of scientific research aimed at the widespread implementation of the strategy Digital Uzbekistan – 2030 and the introduction of AI technologies in different sectors of the economy, the social sphere and the public administration system. The Research Institute will also conduct fundamental and applied scientific research in the field of AI, forming a scientific ecosystem for the development of digital technologies. It will further develop innovative products for automation of management and production processes based on AI technologies, as well as their models, algorithms and software. Lastly, it is tasked with

the establishment of cooperation and implementation of joint projects with leading foreign innovative and scientific institutions for the development of AI technologies.

One project, currently in its initiation phase, in the field of scientific activity at the Research Institute is the creation of an electronic platform containing a national citation index of scientific articles and a bibliographic database of scientific publications. This project is notable as one of the first to create AI in research activities in Uzbekistan. In this regard, as part of the ongoing reforms, it is important to step up the implementation of AI in the entire scientific field.

Putting a million coders to work

Thanks to the active efforts of the government over the past few years, the institutional framework of AI in Uzbekistan is being strengthened. In particular, favourable conditions are being created for scientific research in the field of AI. But in parallel with the conditions created, it is important to accelerate the number of scientific projects in the field of AI, which, in our opinion, is not enough today.

In this regard, it is important to take into account the recommendation from the *Innovation for Sustainable Development Review of Uzbekistan* conducted by the United Nations, where it is noted that 'the creation of a large pool of programmers will require a significant restructuring of the higher education system and closer integration of IT with local and foreign IT companies' (UNECE, 2022). This recommendation serves as an important signal for the activation of targeted measures to attract foreign investment projects for the development of AI in all spheres of socio-economic life and especially in the scientific sphere.

At the initial stage of the formation of AI in the scientific sphere of Uzbekistan, it is important that the government's efforts are aimed at creating conditions for attracting foreign scientific and applied projects in the field of AI. These actions will strengthen the practical skills of trained specialists in the field of AI. On the other hand, these measures will help to stop an outflow of specialists in this field to more attractive projects carried out in foreign countries.

The government continues to develop and approve mechanisms to increase the attractiveness of the research field of AI. This is important, since the fastest possible transition of the scientific sphere to AI will accelerate this transition in other industries and spheres of the economy.

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Key learnings

The country case studies highlight several key learnings, including varying levels of readiness for AI across nations, the practice of observing and adapting approaches from neighbours or comparably sized (GDP and/or research ecosystem) countries, and the potential for leapfrogging in AI development.

Some countries have taken a leading role by leveraging their strengths, such as India's advancements in software development and its ability to use and address language diversity, or China's development of AI applications across sectors, supported by vertical policies to guide usage. In Latin America and the Caribbean, shared challenges and goals have fostered a strong motivation for regional collaboration that is unparalleled by other regions. Additionally, countries like Uzbekistan, Benin and the Dominican Republic have demonstrated significant ambition in their AI strategies.

Almost in each case study, priority industries included agriculture, healthcare and education, although the variety of sectors mentioned by authors – from governance to the justice sector and smart cities – signals country-specificity and versatility of AI for science. These case studies have also revealed that many nations focus their AI efforts on a few specific areas, such as computing and data infrastructure or workforce upskilling. This underscores the challenges of addressing all the dimensions required for holistic AI development. Many case studies indicate the development of a skilled AI workforce as a prominent challenge. Given the persistent obstacle of low digital literacy and digital divide highlighted in some of the case studies, the rise of AI has been presented both as a pressing hurdle for countries and an opportunity to invest in a more tech-literate population.

The discussions and consultations accompanying this work brought forward critical issues, particularly on the implications of AI on science related challenges. A prominent focus emerged on understanding data needs and addressing significant gaps, such as the necessity for regional and transnational initiatives and a stronger emphasis on sustainability in AI adoption. To deepen understanding of these challenges, the Centre is preparing three clarification papers that will explore some of these topics in greater detail to serve as tools that can support science policy around AI for Science.

Since the paper's publication, the Centre has received interest from various organizations seeking to understand the methodology and engage with the case studies. Iterative updates have facilitated meaningful exchanges with both previous collaborators and new contributors from diverse regions, enriching the network of experts and bringing fresh perspectives. These updates have offered valuable insights into emerging trends and enabled new connections with countries aiming to leverage AI for science and research. A major aim of this process is to build a network with the experts and collaborators, allowing peer-to-peer learning and sharing of best practices in addition to creating the space for new ideas. The nurturing of these groups is therefore of major value to the work of the Centre around this project.

Next steps

Recognizing the value of the iterative approach of producing versions of the paper, we plan to release a third version of the paper by mid-2025. Preparations are also underway for a series of clarification papers addressing key issues raised during discussions and consultations on AI for science. These papers will focus on:

1. Types of AI for science
2. AI and sustainability
3. Data for AI in science

We aim to collaborate closely with our established network of experts and our partners to develop these papers, further enriching the ongoing discourse on AI's integration into science systems.

Here is a rough timeline for the project:

- Regional workshop in Muscat, Oman – January 2025
- Publication of version 2 of the paper – February 2025
- Consultations for version 3 of the paper – February 2025
- Development of clarification papers – February 2025
- Publication of the third version of the paper – June 2025
- Publication of clarification papers on AI for Science – July 2025

The working paper is available for feedback via an online form on the publication page: www.futures/publications/ai-science-systems.

We welcome your feedback and encourage you to reach out to the Centre directly for further inquiries.

About the Centre for Science Futures:
The ISC established the Centre for Science Futures in 2023 to improve our understanding of emerging trends in science and research systems and to provide options and tools for impact and action.
council.science/our-work/centre-for-science-futures/

About the International Science Council:
The International Science Council (ISC) works at the global level to catalyse change by convening scientific expertise, advice and influence on issues of major importance to both science and society.

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