RESPONSIBLE ARTIFICIAL INTELLIGENCE IN SUB-SAHARAN AFRICA: LANDSCAPE AND GENERAL STATE OF PLAY

ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

Responsible Artificial Intelligence in Sub-Saharan Africa: Landscape and general state of play

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1. Introduction

The state of artificial intelligence (AI) in Africa has revealed the uneven pace of its development and shown the need for African innovators, policy makers, social movements, and academic institutions to ramp up their engagement in the field of AI.

While AI presents an enormous opportunity to dramatically contribute to a broad range of sustainable development goals such as reducing poverty and hunger, quality of education for all, clean water and sanitation, affordable and clean energy, and peace justice and strong institutions[1], Africa is not able to take full advantage. When measured on government AI readiness, the African continent is among the lowest-scoring regions on average, in part due to few countries in the region having set out their vision for the implementation of AI.[2] A lack of preparedness to harness the tools that widespread adoption of AI would bring hampers the introduction of useful AI-based interventions that would solve many of Africa's most pressing social and economic problems. This reality could potentially entrench economic inequality and render obsolete already poor public services.

Notwithstanding this bleak picture, an AI ecosystem exists in Africa, with evidence of pockets of activity that could be prioritized, coordinated, and funded to result in an energized and productive AI infrastructure. Because Africa is lagging behind most of the world, its nascent, home-grown AI activities can often benefit from the support of international development partners and international technology firms, in addition to support from local government and African philanthropists. A diversified stream of funding to the ecosystem would go a long way to ensuring local leadership and ownership of AI innovation — in contrast to a narrative of external funding, which could open up the possibilities for an external agenda.

It is tempting to take a cookie cutter approach, by the wholesale adoption of AI technologies already in use in the Global North. However, this approach would not produce optimal results for reasons we present in Chapter 2. It is crucial for Africans to participate in the development of technologies that consider the socio-economic and infrastructural realities of Africa to craft AI solutions that serve Africa's priority needs. Premature and unquestioning use of existing technologies without key adaptation could harm local communities and their human rights, and fail to tackle the uniquely African problems that were not in scope for the original developers. Adopting these transplanted technologies could lead to minimal or even negative impacts, drain resources, and ultimately discourage African governments from prioritizing and investing in AI.

If Sub-Saharan Africa (SSA) is to harness the power of AI and its burgeoning machine-learning community, it is critical to support the development of a responsible AI ecosystem within which researchers, innovators, and innovations can flourish. Responsible AI "focuses on ensuring the ethical, transparent and accountable use of AI technologies in a manner consistent with user expectations, organisational values and societal laws and norms."[3] We suggest a focus on four core areas:

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[1] Vinuesa, R, Hossein A, Leite, I, Balaam, M, Dignum, V, Domisch, S, Fellander, A, Langhans, S, Tegmark, M, and Francesco N. (2020). "The Role of Artificial Intelligence in Achieving the Sustainable Development Goals." Nature Communications 11(1):233. doi: 10.1038/s41467-019-14108-y.

[2] Oxford Insights and the International Development Research Centre. (2020). Government Artificial Intelligence Readiness Index 2020. https://www.oxfordinsights.com/government-ai-readiness-index-2020

[3] Accenture Federal Services. (2018). Responsible AI: A Framework for Building Trust in Your AI Solutions. https://www.accenture.com/_acnmedia/PDF-92/Accenture-AFS-Responsible-AI.pdf

a. innovation
b. capacity building
c. policy
d. infrastructure

This paper examines these four areas from the perspective of responsible AI principles as outlined, for example, by the Organisation for Economic Co-operation and Development (OECD), which identifies five principles for responsible stewardship of AI.[4] The paper then addresses critical issues that cut across these dimensions, including political participation, scaling, and inclusion, particularly as it relates to gender.

In exploring these four areas, the paper provides a bird's-eye view of the state of AI in African settings and proposes a general roadmap of key activities required for Africa to position itself to better harness responsible AI technologies — and even become a leading voice on the subject.

As a high-level overview, the paper does not cover the application of AI in specific sectors such as healthcare, manufacturing, governance, nor does it exhaustively address all cross-cutting issues. However, it does pose questions relevant to setting domain-specific research agendas for Africa at its current stage of adopting AI.

4 Organisation for Economic Co-operation and Development (OECD). (2019). Artificial intelligence in society. OECD Publishing. https://www.oecd-ilibrary.org/science-and-technology/artificial-intelligence-in-society_eedfee77-en

2. The state of the AI ecosystem in Africa: Innovation, capacity, policy, and infrastructure

Despite AI in Africa ranking low on global indices and indicators for AI activities and formal policies — and still being in the early stages of adoption and use in business — a growing set of AI activities and communities is emerging across the continent. Coalesced around academic institutions, and usually in conjunction with industry and development partners, new interdisciplinary machine learning communities are providing opportunities to showcase skills, cascade opportunities for participation in projects, and gain a better understanding of developments in the field.

Meanwhile, some governments, with support from foreign investors, have been integrating AI and data-optimization technologies into politics, daily life, and electoral processes.[5] Although these multipurpose technologies are meant to enhance public services, the escalation in their use for political surveillance suggests that, in the not-too-distant future, AI and related dual-use technologies may be used in imperfect and unequal environments for undemocratic purposes. This would threaten basic human rights and civil liberties and further entrench existing inequality by marginalizing targeted populations. The benefits of AI policies that have at their heart the principle of responsible and inclusive AI are myriad, including the dilution of historical marginalization, maintenance of cultural values, diversity, and the optimisation of the solutions that AI is designed to achieve. A careful and consistent application of the principle of responsibility should therefore be foremost in the minds of developers, governments, researchers, and funders.

Outside government, most African businesses are in the very early stages of adopting AI. They are investing in foundational activities such as building robust infrastructure and good data management practices, and fostering digital cultures to support their future AI initiatives.[6]

Despite numerous examples of AI adoption and use in business intelligence and analytics, healthcare, food and agriculture, and other areas[7] worldwide, Africa is still in the very early stages of exploring and implementing AI technologies. This lack of readiness to implement AI is a consequence of several factors, including Africa's low prioritisation of AI implementation, and sparse use cases to inspire businesses to invest with an assurance of a return. Of 32 countries in Africa that responded to a UNESCO 2020 survey, only 21 regarded the development and use of AI as a priority in their national development plans.[8]

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5 Pauwels, E. (2020). The Anatomy of Information Disorders in Africa. Konrad Adenauer Stiftung. https://www.kas.de/documents/273004/10032527/Report+-+The+Anatomy+of+Information+Disorders+in+Africa.pdf/787cfd74-db72-670e-29c0-415cd4c13936?version=1.0&t=1599674493990

6 University of Pretoria. [ND] Intelligence for Africa: An Opportunity for Growth, Development, and Democratisation. https://www.up.ac.za/media/shared/7/ZP_Files/ai-for-africa.zp165664.pdf

7 Ajadi, S, Sharma, A. (2020). Artificial Intelligence and Start-Ups in Low- and Middle-Income Countries: Progress, Promises and Perils. The GSMA Mobile for Development Foundation. https://www.gsma.com/mobilefordevelopment/blog/artificial-intelligence-and-start-ups-in-low-and-middle-income-countries-progress-promises-and-perils/

8 UNESCO. Artificial Intelligence needs assessment in Africa. https://en.unesco.org/news/unesco-launches-findings-artificial-intelligence-needs-assessment-survey-africa.

Major artificial intelligence readiness indices show that Sub-Saharan Africa (SSA) remains one of the lowest-scoring regions on average with respect to government AI readiness. This analysis is based on three key dimensions: government, the technology sector, and data and infrastructure.[9] Despite this low score, Mauritius (45th in the world), South Africa (59th), Seychelles (68th), Kenya (71st), and Rwanda (87th) are Africa's top five countries in the 2020 global Government AI Readiness Index.[10] South Africa is the only African country listed in Stanford's Global AI Vibrancy Tool, which compares countries' global activities, including a cross-country perspective as well as an intra-country drill down.[11]

Despite SSA's poor ranking on the above surveys, significant progress has taken place. For example, the Government AI Readiness Index showed the SSA region is rapidly catching up with middle-income economies, with South Africa, Rwanda, Ghana and Senegal ranking in the top 100. In the Responsible AI Readiness sub-index of the Government AI Readiness Index, Senegal was ranked ninth. The same report also notes recent government progress towards AI readiness in Tunisia and Egypt.[12]

Positive rankings seem to correlate with leading African economies such as Tunisia,[13] Ghana, Nigeria, Kenya, Mauritius, and South Africa, which have well-documented histories of strong technology development.[14] Nigeria and South Africa, for example, still have the highest level of innovation and uptake of AI in SSA, with 42 and 38 use cases, respectively, in a recent GSMA sample-based case study. In section 2.3 of this paper, we examine these countries, which have taken steps aimed at AI policy coordination by creating task forces.[15]

While global technology companies such as IBM in Kenya and South Africa possess the essential elements for AI R&D — namely the financial, human, data, and computational resources to deploy sophisticated algorithms — African governments and local start-ups face a deficit in these areas. Creating an efficient AI ecosystem that supports innovation requires successful collaboration, governance, investment, sound infrastructure, and skills. In African countries, this under-resourced ecosystem is attributable to governments' lack of vision and supporting policies to improve AI implementation, digital capacity, adaptability, technology sectors that are small and lacking in scale, human capital, and infrastructure and data availability.[16] In addition, a lack of access to sufficient computing power and unreliable internet limits access to cloud services.[17]

In the following section, we dive more deeply into the three areas of innovation, capacity building, policy, and infrastructure.

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[9] Oxford Insights. (2020). *Supra* note 2

[10] Oxford Insights. (2020). Supra note 2.

[11]The Stanford Institute for Human-Centered Artificial Intelligence. (2019). Global AI Vibrancy Tool. http://vibrancy.aiindex.org/

[12] Sey, A. (2020). Sub-Saharan Africa: Regional Analysis. In Oxford Insights, & International Development Research Centre (IDRC). Government artificial intelligence readiness index 2020. https://www.oxfordinsights.com/government-ai-readiness-index-2020

[13] Although Tunisia is not in Sub-Saharan Africa, it has been included here for comparative purposes.

[14] Government Artificial Intelligence Readiness Index 2020. supra note 2.

[15] Arthur Gwagwa Erika Kraemer-Mbula, Nagla Rizk, Isaac Rutenberg, and Jeremy de Beer Artificial Intelligence (AI) Deployments in Africa: Benefits, Challenges, and Policy Dimensions Africa Journals. Volume 2020, Issue 26 | Jan 2020. https://journals.co.za/doi/abs/10.23962/10539/30361

[16] Oxford Insights. (2020) *Supra* note 1.

17 Ajadi, S, Sharma, A. *Supra* note 7.

2.1. Innovation

The following section sets out the sectors in which AI innovation is being applied in Africa, encompassing a wide range of business services solutions, from accounting and decision-making to customer service.[18] The section also seeks to explore some major sources of funding for AI innovation.

While AI is well embedded in global technology-driven social and informational networks like Facebook and Google, its application in African businesses is taking root mainly in data-based innovations, and at a slow and cautious pace. Businesses that use informational networks models in consumer goods and services similar to social networks are also present in Africa, but the scale at which they use these technologies is limited.

Logistical, taxi, and temporary accommodation services that rely on business intelligence and analytics belong in this category, including international companies such as Amazon, Uber, and AirBnB. These companies are present in leading African economies such as Kenya and South Africa.

Some local start-ups servicing big financial institutions rely on artificial intelligence as a service (AIaaS) platforms such as Microsoft Cognitive Services and Google AI services.[19] AIaaS resembles the software as a service (SaaS) delivery and licensing model in which software is accessed on the web via a subscription rather than being installed on local computers.

However, local AI start-ups are still comparatively few and, where they exist, they generally leverage existing digital platforms offered by large, typically international technology companies, mostly in online retail. By relying on global platforms, these developers focus on developing, testing, and rolling out AI-based web platforms for e-commerce and data analytics solutions that benefit citizens and create local jobs.[20] While the relatively small number of start-ups is a concern, their contribution to job creation and the facilitation of easier online shopping is evidence of the development of responsible AI.

Although most AI applications are not yet fully integrated into the full range of economic activities, organizations are building the necessary infrastructure, including data architecture and expertise to achieve integration over the long term. The tyre manufacturer Bridgestone South Africa is an example of a business that is investing in its digital backbone by moving it into the cloud as a preliminary step to AI deployment.

Although still few in number, notable examples of AI adoption and use cases are emerging.21 For example:

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[18] Ajadi, S, Sharma, A. *Supra* note 7.

[19] Margaret Rouse. (2020). "AI in IT tools promises better, faster, stronger ops", *Tech Target Network*. Accessed Tuesday, September 01, 2020. https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence

[20] The Knowledge for All Foundation (K4A) *supra* note 2.

[21] Microsoft. (2019). Artificial Intelligence in Middle East and Africa: How 112 Major Companies Benefit from AI — Outlook for 2019 and Beyond. https://info.microsoft.com/rs/157-GQE-382/images/MicrosoftSouthAfricanreportSRGCM1070.pdf

- In healthcare, AI is used for disease diagnosis and treatment, hospital logistics and informatics, as well as lifestyle change recommendations and healthy eating habits.22
- In agriculture, AI is being used to identify crop diseases, and for farm logistics, such as linking farmers to markets more effectively and maximizing crop yields.
- Other innovations include government service delivery, wildlife conservation, water management, enterprise development,23 as well as natural language processing, and conflict management.

According to a UNESCO needs assessment,[24] priorities for the future must include encouraging economic growth through digital innovation and support to start-ups. Initiatives must address cross-cutting issues that include education, skills and training, facilitating R&D and data governance, and addressing gender-related bias and discrimination in the development and use of AI.

Corporate investment

The bulk of AI funding comes from corporate investment through private businesses and international organizations invested in AI for social good. A Microsoft white paper on AI highlighted the importance of AI research taking place in Africa itself.[25] The world's leading technology companies have been responsive to the logical and prudent desire for funding to be applied in Africa and infrastructure developed with Africans' participation.

The Vodafone[26] Foundation pioneered a program in Ghana that uses aggregated anonymized data to help the Ghanaian government track and control epidemics and prevent widespread outbreaks. An IBM research laboratory in Nairobi has produced significant research on technological developments and, more recently, Google in 2019 and Microsoft in 2020 established AI labs in Accra, Ghana and Nairobi, Kenya. At the same time, international organizations such as Omdena,[27] Bolesian, and Element AI[28] have been investing in 'AI for good' projects. This illustrates a desire to develop research and its funding in a responsible manner that is responsive to the pressing needs of significant proportions of the population.

Private corporations are allocating a large amount of digital spending to set up data and related architecture and adapt to the agile working culture of the future, including digitizing previously human-led business operations to increase efficiency and scale in selected industries. While the focus on prioritizing AI is encouraging, the proportionately

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[22] Ajadi, S, Sharma, A. *Supra* note 7.

[23] Smith, Matthew L., Neupan, Sujaya. (2018). Artificial Intelligence and Human Development: Toward a Research Agenda. IDRC. https://idl-bnc-idrc.dspacedirect.org/handle/10625/56949

[24] UNESCO. (2017). UNESCO moving forward the 2030 Agenda for Sustainable Development. https://en.unesco.org/creativity/sites/creativity/files/247785en.pdf

[25] Microsoft Report 2019, supra

[26] Vodafone Group Plc. (2018). Vodafone Foundation "Big Data for Good" Programme. https://markets.ft.com/data/announce/full?dockey=1323-13545319-187UGUMMBPSC2INVUICOB7Q822

[27] An organisation using AI-based crowdsourcing solutions to climate-related or climate-relevant challenges is Omdena, which sources ideas to respond to local challenges.

[28] The Canadian-based Element AI has African-focused projects that support the use of robots for humanitarian purposes. Their intention is to develop human-machine collaborations that build up a trusted relationship with AI products and services already available.

higher amounts spent on other digital projects show it is still not uppermost on the list of priorities.[29]

What is not clear is the extent to which small and medium-sized enterprises and other organizations are investing in foundational activities to create a solid platform for establishing and scaling AI technologies. Further research on this issue is key to understanding the funding being made available from all sources. Such understanding will enable planning and engagement with funders to create a roadmap for the development and implementation of AI that achieves the purposes highest on the priority needs of Africans.

Venture-capital investors

There are examples of non-GAFA[30]companies and international donor organisations providing AI start-ups with venture capital. The Airbus and GIZ Africa4Future Aerospace Acceleration Program funded Fastagger, a Kenyan start-up and one of 10 African start-ups chosen for the 2020 cohort of the Africa4Future aerospace acceleration program. Fastagger is developing satellite-based AI to map potential markets for photovoltaic infrastructure corporations.[31]

Other projects funded include management, aviation, fishing, energy, mining, construction, defence, and water resources. All projects have the goal of building capacity and eventual scaling to realize the change that AI can bring to productivity and solution building. GIZ and IBM also partnered with Ghana Tech Lab on an AI accelerator for African companies — a program structured to provide start-ups with technical product development and business development expertise. The first cohort supported 10 AI start-

[29] Microsoft. (2019). Artificial Intelligence in Middle East and Africa: How 112 Major Companies Benefit from AI — Outlook for 2019 and Beyond. https://info.microsoft.com/rs/157-GQE-382/images/MicrosoftSouthAfricanreportSRGCM1070.pdf

30 GAFA stands for Google, Apple, Facebook, and Amazon.

[31] Ibeh, J., Abdurrahman, A. (2020). Fastagger, a Kenya-based AI-as-a-service Startup, Sees Growth Opportunities in Geospatial Data. Accessed Tuesday, September 01, 2020. https://africanews.space/fastagger-a-kenya-based-ai-as-a-service-startup-sees-growth-opportunities-in-geospatial-data/

ups from Ghana, South Africa, Rwanda, and Uganda. Another example is Villgro Africa[32] (rebranded from Villgro Kenya), a social-impact investor not-for-profit that is increasingly funding artificial intelligence start-ups.

China's growing investment in AI R&D in Africa

In recent years, a new force in the funding and deployment of AI in African countries has gained prominence. China's domestic and foreign policy, laid out in 2017, outlines ambitions to become the "world's primary AI innovation centre" by 2030. The Chinese state-backed AI National Team, a group of leading Chinese technology firms, is investing in the development and export of new technologies.[33] Coupled with a sizable state investment in cyber technology development, this effort is indicative of China's aim to become an AI-centered "cyber-superpower".[34] China's continent-wide economic engagement with African governments and its strong foothold in Africa has also facilitated its export of AI technologies into the continent.

However, as pointed out above the unregulated export of multi-purpose AI technologies from China and liberal democracies comes at a cost. The export of intrusive and covert AI to African countries with poor human rights records is likely to reinforce existing systemic repression, as well as introduce new forms of repression. Although China legitimately seeks to expand its market share through such exports, the exploitation of African data goes beyond conventional trading parameters to constitute a form of economic exploitation that leans toward extractive dynamics, reminiscent of colonization.[35]

2.2 Capacity building

As described in section 2.1 on innovation, Africa is seeing an increasing number of local actors involved in AI knowledge creation, capacity building, and innovation processes. This is due to enhanced computational capacity[36] accompanied by an increase in funding[37] for AI as part of an increase in funding for start-ups more generally.[38] Despite this increase, businesses in Africa are struggling to identify appropriate and attractive use cases for investors to fund with a reasonable certainty of good returns.[39]

Furthermore, many countries still lack a steady pipeline of home-grown and skilled AI development talent and mentorship programs, despite increasing access to upskilling

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[32] Read more about Villgro Africa. https://villgroafrica.org/

[33] Kania, Elsa. (2018). China's AI Agenda Advances. The Diplomat. https://thediplomat.com/2018/02/chinas-ai-agenda-advances/

[34] Segal, Adam. (2018). When China Rules the Web. *Foreign Affairs.* https://www.foreignaffairs.com/articles/china/2018-08-13/when-china-rules-web

[35] https://foreignpolicy.com/2018/07/24/beijings-big-brother-tech-needs-african-faces/
https://www.cfr.org/blog/exporting-repression-chinas-artificial-intelligence-push-africa

[36] OECD. (2019). Artificial Intelligence in Society. https://doi.org/10.1787/eedfee77-en

[37] *Ibid.*

[38] Olingo, A. (2018). Google Takes African Start-ups under its Wings. *The East African.* https://www.theeastafrican.co.ke

[39] Microsoft. (2019). Supra note 28.

and training in AI.[40] In this section, the paper lays out some funding sources and capacity, including skills-building efforts.

Centres for higher education and training

When academic institutions partner with international technology companies and industry funders to establish and develop AI research and policy activities, they can benefit from the increased capacity that results. The resulting AI can improve teaching and research, and enable African academics to gain visibility for their work. Furthermore, independent academic research institutions in the region are best placed to pursue localized and innovative interdisciplinary research for the benefit of local peoples. This is a unique advantage for African universities and should be utilized to build capacity and increase public awareness of the benefits of AI. Local African universities would benefit immensely from government support through funding and collaboration on the development of national AI policies and roadmaps. A great example of this is South Africa's Centre for Artificial Intelligence Research, discussed below.

International donor agencies and industry are continuing their tradition of building technology R&D in partnership with universities. Most companies are looking to address their skills shortages by leveraging the ecosystem of internal and external resources and fostering close ties with academia.[41] Although funding structures are not always clear or accessible to researchers, university labs or semi-independent institutions linked to academic institutions are often used as conduits for channelling funds to AI projects. The challenges that academics and researchers at local universities face when they receive research funding should not be understated. Challenges include high administrative costs arising from hiring of researchers as consultants, bureaucracy, and sometimes corruption — all factors that diminish the final sum allocated to research. While alternative routes of funding — via university labs, and semi-independent institutions have supported research thus far, this will be difficult to replicate as funding needs for AI in Africa grows. Such routes may eventually lead to the skewing of funding towards institutions that are privileged enough to be affiliated with partners who can devise means of overcoming these difficulties.

Operating from universities, industrial representatives are building capacity at the lower academic levels by promoting science, technology, engineering, and mathematics (STEM) and highlighting opportunities in industry. Academic research teams are subsequently drawn from internal and external academics, including post-doctoral fellows. However, there seems to be limited interdisciplinary work — for example, computer science departments working with other departments within their universities. Most computer science departments in African universities, unlike their European counterparts, are still struggling to achieve interdisciplinary collaboration. Yet, Artificial Intelligence is highly interdisciplinary, therefore, should be approached in an interdisciplinary and holistic way Apart from computer science and data science capabilities, other skills, such as advanced analytics, social science, and design skills, are also needed. In addition, behavioural science and soft skills such as emotional intelligence are required to build solutions that understand, mimic, and interact with humans. Yet these skills are complicated for companies to understand.[42]

South Africa's Centre for Artificial Intelligence Research (CAIR) is a key national initiative building AI expertise. Established in 2011, it links nine research groups from six universities: University of Cape Town, University of KwaZulu-Natal, North-West University, University of Pretoria, Stellenbosch University, and the University of the

[40] Ajadi, S, Sharma, A. Supra note 6.

[41] Microsoft. Supra note 3.

[42] Microsoft. Supra note 3.

Western Cape. CAIR is funded by the Department of Science and Innovation and coordinated by the Council for Scientific and Industrial Research. One of the CAIR member institutions, the University of Pretoria, is also involved in a national AI policy engagement exercise. The university's Data Science for Social Impact Research Group participates in the the Policy Action Network (PAN), convened by South Africa's Human Sciences Research Council. Published in 2020, the AI and data series developed by PAN provides brief guides and discussions on AI's interfaces with equity, crime prevention, education, cities and towns, migration management, and health. These initiatives demonstrate the importance that the South African government places on establishing structures to expedite the development of policy that underpins the implementation and eventual scaling of AI in South Africa.

Machine learning professional communities

Although most AI R&D across Africa is being carried out by academic institutions in conjunction with industry and development partners, machine learning (ML) communities akin to social movements are also springing up organically. These developed to address bottlenecks in academic institutions and industry. ML communities provide forums and networks for sharing skills, collaborating on projects, or gaining better understanding of developments in the field. The vibrancy of these communities is exemplified by groups such as the Deep Learning Indaba,[43] and Data Science Africa,[44] the natural language community, Masakhane,[45] and the Machine Intelligence Institute of Africa.[46] ML communities are key channels building Africa's capacity by pooling opportunities and sharing knowledge and resources.

Several ML communities have mandates to build national AI expertise and, by extension, policy capacity. For instance, to further close the skills gap, the Deep Learning Indaba

[43] Deep Learning Indaba. https://deeplearningindaba.com/2020/

[44] Data Science Africa. http://www.datascienceafrica.org/

[45] Masakhane. https://www.masakhane.io/

[46] Machine Intelligence Institute of Africa. https://miiafrica.org/about/

launched the IndabaX program, which funds and strengthens AI research communities at the national level by giving them autonomy to design and host events suitable for their diverse local contexts. In 2019, 26 countries hosted IndabaX events. The development and scaling of such programs in collaboration with their respective government and academic ecosystems would go a long way towards achieving the critical mass of human capital needed to bring about effective AI capacity in Africa.

Research capacity

The academic institutions establishing and developing AI research and policy activities are few and located in only a handful of countries. According to current surveys on the state of play on AI-related activities, there is a lack of enrolment data from academic institutions. Such data is critical to monitor the success of AI-related academic opportunities at universities and measure how these opportunities relate to the broader institutional and national goals of promoting AI-related activities.[47] Despite an increase in AI courses and institutions offering them, greater capacity is still needed — in particular, an increase in the number and technical expertise of lecturers, as well as collaboration between universities.

With regard to AI R&D, although most of the UNESCO needs assessment participants interviewed indicated that AI research and development is a priority for their institutions, most reported that their institutions did not have mechanisms available solely to fund AI research and development. Many noted, however, that general funding mechanisms could be used. Partnerships with government and industry could raise additional funding.

In addition to universities, not-for-profits, governmental agencies, and intergovernmental organizations are active in research on responsible AI. Examples include Research ICT Africa[48] and South Africa's Human Science Research Council. Grassroots communities and organisations are also working to support the development of AI capacity at universities by gaining access to training and compute resources, and providing mentorship to students — particularly students whose universities do not have formal AI programs or faculty capacity.

Funding for AI research

Industry, international development partners, and governments are collaborating with academic institutions using diverse forms of funding. The funding can be general — i.e., not sector-specific — where researchers are given the flexibility to choose areas of interest in innovation and AI governance, and examine several cross-sectoral policy issues.

Canada's International Development Research Centre (IDRC) and the Swedish International Development Agency launched the CA$20 million AI4D Africa program (ai4d.ai). These initiatives stemmed from consultations, including a workshop in Nairobi in April 2019 and a second workshop later that year in Abidjan, Cote D'Ivoire. At IDRC's workshop in Nairobi,[49] the African community committed to advance AI innovations that

[47] International Journal of Educational Technology in Higher Education. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators. https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-019-0171-0

[48] Research ICT Africa. https://researchictafrica.net/

[49] Artificial Intelligence for Development. (2019). Toward a Network of Excellence in Artificial Intelligence for Development (AI4D) in sub-Saharan Africa – April 3-5, 2019 Nairobi, Kenya. https://ai4d.ai/blog-africa-roadmap

would aid Africa's sustainable development agenda, and outlined a roadmap to achieve this. The roadmap included recommendations for capacity building, governance, and innovation for ethical and locally relevant AI research. A core idea discussed by participants was how to mobilize networks of African companies, universities, research centres, and public institutions to collaborate on advancing the AI4D agenda.

The Norwegian Agency for Development Cooperation is funding WIMEA-ICT,[50] a combined research and capacity building project between Makerere University in Uganda, Dar es Salaam Institute of Technology (DIT) in Tanzania, the University of Juba in South Sudan, and the Geophysical Institute of the University of Bergen. African governments have also collaborated to set up the Partnership for Applied Sciences, Engineering, and Technology's (PASET) Regional Scholarship and Innovation Fund, which includes a doctoral training scholarship that comprises an AI theme.[51]

2.3. Responsible AI policy

Promoting responsible AI innovation in Africa also requires appropriate policy responses from governments and regulators. A small number of countries have already initiated measures to guide the development and use of AI through the launch of AI strategies and policies, enactment of legislation, including data protection laws, establishment of centres of excellence for AI, and development of ethical guidelines for AI. For example, the top five African countries in the 2020 global Government AI Readiness Index are Mauritius (45th in the world), South Africa (59th), Seychelles (68th), Kenya (71st), and Rwanda (87th). That same report cites recent government progress toward AI readiness in Tunisia and Egypt.[52] Only 17 of the 55 African Union member states had enacted "comprehensive data protection and privacy legislation".[53] However, emerging policy discussions are slow and somewhat cautious.[54]

At national levels, leading African economies Tunisia,[55] Ghana, Nigeria, Kenya, Mauritius, and South Africa have well-documented histories of strong development in their technology sectors.[56] Mauritius launched its Artificial Intelligence Strategy, along with the Digital Government Transformation Strategy 2018–2022, and the Digital Mauritius 2030

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[50] WIMEA-ICT focuses on weather prediction and meteorological observation to provide accessibility to reliable weather information, which is vital for planning and decision-making in agriculture and disaster mitigation in various sectors.

[51] ICIPE. http://www.icipe.org/content/rsif-phd-scholarships

[52] Sey, A. (2020). Supra note 12.

[53] Onuoha, R. (2019). AI in Africa: Regional data protection and privacy policy harmonisation. In Association for Progressive Communications (APC), Article 19, & Swedish International Development Cooperation Agency (Sida). (Eds.). Global information society watch 2019: Artificial intelligence: Human rights, social justice and development. https://giswatch.org/2019-artificial-intelligence-human-rights-social-justice-and-development

Artificial Intelligence in Middle East and Africa. South Africa: Outlook for 2019 and Beyond. https://info.microsoft.com/rs/157-GQE-382/images/MicrosoftSouthAfricanreportSRGCM1070.pdf

[54] Yasodara Cordova. Artificial Intelligence and the need for data fairness in the global south. Medium, March 21, 2018 https://thelivinglib.org/artificial-intelligence-and-the-need-for-data-fairness-in-the-global-south/

[55] Future of Life Institute. (2019). AI Policy – Tunisia. https://futureoflife.org/ai-policy-tunisia/?cn-reloaded=1

[56] Eugene, J. (2019). Government Artificial Intelligence Readiness Index 2019. https://frontiermarketnews.org/2019/06/04/government-artificial-intelligence-readiness-index-2019/

Strategic Plan in December 2018[57] and is the only country with a fully formalized national AI strategy. Its government has also announced that it will establish the Mauritius Artificial Intelligence Council.[58]

Of the leading African countries in AI policy development, Senegal, Ghana, Nigeria, Kenya, and South Africa have all demonstrated supportive but cautious approaches to AI development.[59] The approaches have included offering monetary support for AI research and development alongside the promotion of STEM education, which in some cases has taken priority over AI integration within government agencies.[60] Some of these countries have created task forces for co-ordinating AI policy — for example, Tunisia's National AI Strategy,[61] Uganda's Expert National Task Force on Emerging Technologies,[62] and Kenya's Distributed Ledgers Technology and Artificial Intelligence Task Force.

In addition to governmental initiatives, intra-governmental organisations are also playing a role in supporting responsible AI policies. For example, the African Union Development Agency is supporting the African Union Panel on Emerging technologies.[63] In addition, apart from doing work on AI ethics, UNESCO has carried out an AI needs assessment to identify AI priority areas for countries.[64] One example is the UNESCO Forum on Artificial Intelligence in Africa, which took place in Morocco in December 2018. In its outcome statement, the forum called for "the African Union, in partnership with the RECs [regional economic communities], to develop a continental strategy for AI, which includes digital data management, and that is based on a multi-stakeholder approach and underpinned by [the AU] Agenda 2063" (UNESCO, 2018).[65]

2.4 Infrastructure: internet, cloud services, and data

AI has come to the fore due to exponential growth in computing capacity, the development of more sophisticated algorithms, and increasing datafication. These advances depend on infrastructure availability as well as human and institutional capacity.[66]

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[57] Eugene, J. (2019). Government Artificial Intelligence Readiness Index 2019. https://frontiermarketnews.org/2019/06/04/government-artificial-intelligence-readiness-index-2019/

[58] Sey, 2020. Supra note 12.

[59] Ibid.

[60] Besaw, C., FilitZ, J. (2019). AI & Global Governance. AI in Africa is a Double-Edged Sword. United Nations University – Centre for Policy Research. https://cpr.unu.edu/ai-in-africa-is-a-double-edged-sword.html

[61] Future of Life Institute. (2019). AI Policy – Tunisia. https://futureoflife.org/ai-policy-tunisia/?cn-reloaded=1

[62] Xinhuanet. (2019). Uganda Prepares to Harness Opportunities of 4th Industrial Revolution. http://www.xinhuanet.com/english/2019-04/09/c_137963317.htm

[63] African Union Panel on Emerging Technologies. https://www.nepad.org/programme/african-union-high-level-panel-emerging-technologies-apet

[64] UNESCO. Artificial Intelligence needs assessment in Africa. https://en.unesco.org/news/unesco-launches-findings-artificial-intelligence-needs-assessment-survey-africa

[65] UNESCO. (2018). Outcome Statement of the Forum on Artificial Intelligence in Africa. https://en.unesco.org/sites/default/files/ai_outcome-statement_africa-forum_en.pdf

[66] *Ibid.*

Poor internet connectivity hinders consistent use of mobile apps and consumer adoption of AI-based services. The high cost of mobile internet data or home-based broadband connections also limits the market size and uptake of services.[67]

Most businesses do not have solid platforms for AI technologies that include potential for future scaling, building on open-data architectures, digitizing operations, and fostering an agile culture.

Despite an increase in mobile technology, which has given rise to new data-driven business models,[68] smartphone penetration is still relatively low. In 2018, only 45% of Sub-Saharan Africans had mobile phones, and many devices were older models unable to support high-tech apps.[69] This is coupled with a lack of access to sufficient computing. Further, while cloud computing is a significant step towards overcoming the smartphone barrier, unreliable internet in many locations limits the impact of the cloud.[70]

Improving access to cloud computing would place Africa at par with other regions. For example, it would give Africa open interoperable digital platforms that address the whole research data cycle, on par with the European Open Science Cloud. With only a handful of supercomputers on the African continent, access to the cloud through mobile phones could be the way forward. Additionally, work in machine learning (ML) on the edge, which can be summarized as AI on microcontrollers or on end-user devices, should be considered a key research direction in Africa given the challenge of access to compute resources. This work enables cheaper, lower-power, and smaller edge devices to carry out some of the compute needed for ML models. It reduces latency, conserves bandwidth, can be designed to improve privacy, and enables smarter application. To this end, Google Ghana is exploring reducing reliance on high computing power and data farms by encouraging compressed versions of algorithms that can run on the computing power of mobile phones.[71]

Like computing infrastructure, data is also foundational. AI R&D advances more quickly in areas with complementary datasets.[72] Across all sectors, the number of ML models directly corresponds to companies with high volumes of well-managed data and strong foundational infrastructure, and where AI takes its place alongside their other top digital priorities.[73]

There are multiple issues in relation to the access and availability of relevant, unbiased data (particularly labelled data), most of which are beyond this paper's remit. At the heart of the issue, however, is that African organizations do not have sufficient infrastructure, resources, and data-management protocols in place to operationalize the creation of adequate data sets. In less digitized environments, comparatively less data is available,

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[67] Ajadi, S; Sharma, A. Supra note 7.

[68] Frost & Sullivan report on. Mega Trends in Africa. https://store.frost.com/mega-trends-in-africa-19897.html

[69] Ajadi, S, Sharma, A. *Supra note* 7.

[70] Ajadi, S; Sharma, A. *Supra note* 7.

[71] Adeoye, A. (2019). Google has opened its first Africa artificial intelligence lab in Ghana. CNN. https://edition.cnn.com/2019/04/14/africa/google-ai-center-accra-intl/index.html

[72] Garcia, J.M. (2020). A Speech-To-Text Practitioner's Criticisms of Industry and Academia. The Gradient. https://thegradient.pub/the-economics-of-ai-today/

[73] Microsoft. (2019). Supra note 29.

and less effective data practices can mean data held by companies and other organisations is uneven and inaccessible.[74]

At a macro level, not only is quality (unbiased and fully representative) data often unavailable in emerging economies, but the relevant stakeholders may also lack the capacity to make use of it.[75] In addition, the available data may not fully reflect African cultural and linguistic diversity, as African languages are still marginalized in the digital realm. This is because there are insufficient examples online of how the languages are used, which makes it challenging to train natural language processing (NLP) applications. These languages are marginalized by technology deployments developed in the Global North. Vukosi Marivate, a professor of Data Science at University of Pretoria estimates that 17% of the world's languages, many of them in Africa, are "low resource languages" in the digital realm.[76]

Emerging initiatives address this issue — for example, Samasource and the Lacuna Fund, guided by the motto "Our voice on data." The Lacuna Fund is the world's first collaborative effort to directly address the problem of the lack of unbiased, labelled data. Guided by local professionals, the Lacuna Fund "will provide data scientists, researchers, and social entrepreneurs with the resources they need to either produce new labelled datasets to address an underserved population or problem, augment existing datasets to be more representative, or update old datasets to be more sustainable".[77] The above approach will aid in scaling as applications of AI developed in other regions will likely lack contextual relevance, particularly regarding cultural and infrastructure factors, and will not be wholly fit-for-purpose in Africa.[78]

Cultural and linguistic diversity is a particularly critical area that is receiving increased attention from development partners, local ML communities, and inter-governmental initiatives. UNESCO highlighted linguistic diversity as one of the three domains of African AI benefits and challenges alongside gender and labour.[79]

To address this gap, the Masakhane community, which has more than 140 contributors from 17 African countries, focuses on the preservation of African languages. Despite the complexity of training NLP systems in low-resource African languages,[80] Masakhane members had developed and published 35 translation results for more than 29 African languages online in an open access GitHub repository by February 2020.[81] More such initiatives and more funding would ensure that African languages are preserved and indigenous people can access education in local languages using AI.

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[74] Ajadi, S, Sharma, A. Supra note 7.

[75] Verhulst, Stefaan. (2019). Data Collaboratives as an enabling infrastructure for AI for Good. Medium. https://medium.com/data-stewards-network/data-collaboratives-as-an-enabling-infrastructure-for-ai-for-good-99aeb1192c10

[76] Marivate, V., Sefara, T., Chabalala, V., Makhaya, K., Mokgonyane, T., Mokoena, R., Modupe, A. (2020). Investigating an approach for low resource language dataset creation, curation and classification: Setswana and Sepedi. https://arxiv.org/abs/2003.04986

[77] Lacuna Fund. https://lacunafund.org/

[78] Oxford Insights. . Supra note 2.

79 Gwagwa, Kraemer-Mbula, Rizk, Rutenberg, De Beer. (Forthcoming). Artificial Intelligence (AI) Deployments in Africa: Benefits, Challenges and Policy Dimensions. The African Journal of Information and Communication (AJIC).

[80] Orife, I. F. O., Kreutzer, J., Sibanda, B., Whitenack, D., Siminyu, K., Martinus, L. ... Bashir, A. (2020). Masakhane: Machine translation for Africa. https://arxiv.org/pdf/2003.11529.pdf

[81] GitHub. https://github.com/masakhane-io/masakhane-mt

3. Critical issues

Responsible AI development and deployment on the African continent must address complex challenges and questions that cut across the AI ecosystem. A number of cross-cutting issues are related to AI, such as future of work, environmental impact, bias, the inclusion of marginalized populations, and algorithmic/digital colonialism. In this section, we briefly consider the state of knowledge on two major issues: AI and human rights, and AI and gender.

3.1 Risks of AI technologies undermining human rights

In countries such as China, AI is being used as a tool for surveillance and control — for instance, in Xinjiang state. As China is now exporting dual-use, AI-based technologies to Africa, there are fears the technologies could be used for mass surveillance that targets particular social groups, such as ethnic minorities, the historically marginalized, and those who are perceived as political threats to governments.[82] Currently, it is unclear to what extent this is happening, and more research is needed. However, according to a recent report, South Africa, Nigeria, Kenya, Uganda, and Zimbabwe are already using AI in combination with data capturing technologies to centralize populations' sensitive data with the opportunity to provide access to essential public services. However, given a lack of accountability and oversight mechanisms, such systems may pose risks by undermining the right to privacy and restricting political agency in civic and electoral processes.

Across the world, there are already calls to develop a responsible governance approach to harness AI and converging technologies responsibly, such as for social empowerment.[83] This could include building collaborations to support civil society organisations, digital rights labs and young innovators in Africa in their effort to build governance accountability models that meet the ethical needs of African democracies. The United Nations Office of the Human Rights High Commissioner provides recommendations on how human rights considerations can be backed into the development and deployment of AI.[84] These include the development of human rights impact assessments on AI technologies[85] and the need to adopt responsible policies to prevent the violation of human rights.

3.2 Gender and inclusion

There is evidence to suggest that African nations are experiencing a transformative "feminization" of technology entrepreneurship.[86] This is despite the fact that gender

[82] Hawkins, Amy. (2018). Beijing's Big Brother Tech Needs African Faces. https://foreignpolicy.com/2018/07/24/beijings-big-brother-tech-needs-african-faces/

[83] Pauwels E., 2019. The New Geopolitics of Converging Risks. United Nations University. https://collections.unu.edu/eserv/UNU:7308/PauwelsAIGeopolitics.pdf

[84] United Nations Human Rights Office of the High Commissioner. (2018). Artificial Intelligence Technologies and Freedom of Expression. https://www.ohchr.org/Documents/Issues/Expression/Factsheet_3.pdf

[85] Methodologies to assess are emerging and are increasingly applied. For example, see: https://www.sciencedirect.com/science/article/pii/S0267364918302012

[86] Monehin, D. (2017). How youth and women are driving entrepreneurship in Africa. [Press Release]. Mastercard. https://newsroom.mastercard.com/mea/press-releases/how-youth-and-women-are-driving-entrepreneurship-in-africa/

inequality, among other multi-dimensional inequalities, remains an entrenched reality for women in many African settings. For example, in Kenya, Nigeria, and South Africa, and within North Africa, emerging AI start-up ecosystems support Africa's women. The African countries listed above, and others, including Ghana and Rwanda, are adopting proactive policies to increase the number of girls taking up STEM subjects and computer science and this stance has gained support from technology companies. Other initiatives mainstreaming youths and girls include the introduction of coding in South Africa, and information and communications technology and coding for girls in Ghana. Code4CapeTown in South Africa invests in women coders and programmers, and also runs a coding program for high school girls.[87]

African women are increasingly engaging with code. When the African Girls Can Code Initiative was launched in August 2018, 80 girls from 34 African countries signed up within the first 10 days to attend coding camp in Addis Ababa, Ethiopia.[88] SingularityNET, the startup that had the robot Sophia as one of its first use cases, is at the forefront of hiring and promoting African female engineers.[89]

Also, some advocates of gender-based inclusion are helping to address issues around how data and algorithms disfavour non-white women. This includes the work of Joy Buolamwini, Timnit Gebru, and Deb Raji, which revealed intersectional disparities in accuracies across facial recognition systems (the systems were far less accurate on Black female faces than white male ones).[90]

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[87] Dishman, L. (2018). These African women coders are changing the face of tech industry. *Fast Company*. https://www.fastcompany.com/90254209/meet-the-african-women-who-are-changing-the-ratio-in-tech

[88] UN Women. (2018). Meet the African girls who are coding to make a difference. https://www.unwomen.org/en/news/stories/2018/10/feature-african-girls-coding-to-make-a-difference

[89] Dishman, L. (2018). *Supra* note 86.

[90] Karen Hao. (2020). The true dangers of AI are closer than we think. https://www.technologyreview.com/2020/10/21/1009492/william-isaac-deepmind-dangers-of-ai/amp

4. Conclusion

Despite its massive potential benefits, AI is accompanied by risks and challenges. A global review of AI research found that AI is likely to have "markedly different social impacts depending upon geographic setting" where "low- and middle-income countries may be more vulnerable to the negative social impacts of AI and less likely to benefit from the attendant gains".[91] Unless AI technologies are developed and deployed in an equitable and ethical manner, there is reason to believe that they will further entrench these divides, both within Africa and globally.[92]

Despite African countries' unique peculiarities, Africa would benefit from adopting a collective approach to rulemaking around emerging technology akin to the collective policy response of European countries, which have cultural disparities similar to African ones. African countries are diverse but also share broad similarities, such as a common history and a broadly similar cultural value system. This makes it possible for countries to collaborate for appropriate ethical and governance frameworks and to strengthen their own values. Europe has demonstrated a willingness to collaborate to support the development of AI in this manner, exemplified by the European Commission's EU-wide strategy to make the region a global centre of excellence in AI.[93] Africa could, for example, adopt its own tech doctrine based on the African principle of Ubuntu (big society) to forge a unique and ground-breaking approach.

Governments also need to support the development of a responsible AI ecosystem through, among other things:

- being willing to adopt AI, and being able to adapt and innovate to do so;
- promoting a good supply of AI tools from the technology sector; and
- ensuring these tools are built and trained on high-quality and representative data, and building the appropriate infrastructure to be delivered to and used by citizens.[94]

Delivery of these work streams to achieve government AI readiness can create the impetus for AI to be designed and hopefully cascade into industry and communities.

Finally, the authors recommend a sector-by-sector roadmap for research and development of responsible AI, focussing on innovation, capacity, and governance. The proposed series of papers would highlight cross-cutting issues peculiar to each sector and explore the ways in which responsible AI would not only design digital solutions to perennial problems faced by Africans on the continent, but also assess and anticipate the effect of the technology on inclusion, human rights, and the maintenance of cultural integrity.

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[91] Hagerty, A., Rubinov, L. Global AI Ethics: A Review of the Social Impacts and Ethical Implications of Artificial Intelligence. Dovetail Labs; Princeton University. https://arxiv.org/ftp/arxiv/papers/1907/1907.07892.pdf

[92] Smith, Matthew L., Neupan, Sujaya. (2018). Artificial Intelligence and Human Development: Toward a Research Agenda. IDRC. https://idl-bnc-idrc.dspacedirect.org/handle/10625/56949.

[93] https://diginomica.com/us-and-uk-governments-are-ai-ready-are-not-being-responsible

[94] Recommendations adopted from Oxford Insights and the International Development Research Centre. (2020). Government Artificial Intelligence Readiness Index 2020. https://www.oxfordinsights.com/government-ai-readiness-index-2020