Gender and Artificial Intelligence Readiness in Africa: Can new technological innovations address an unequal playing field?

- **Gender gaps occur in access to ICTs and the Internet, use, research, skills, leadership and equality. There are fewer women than men in computing and Artificial Intelligence (AI) related careers.**
- **Male students dominate admissions for computer science, computer engineering and software engineering. This number is affected by the number of female students taking science courses in secondary/high school.**
- **Low participation in AI leadership in start-ups, product development and policy development teams.**
- **Globally, 12% of machine learning researchers are women and the contribution of women in machine learning conferences is lower than in technology in general. 22% of AI professionals globally are female.**
- **Data being fed into algorithms sometimes affects the output and may also introduce bias by gender, skin tone and social-cultural norms.**
- **In terms of AI Policies and Strategies, only 2 (Kenya and Tunisia) out of 55 African Union (AU) member states, have announced their AI Strategies. Majority of the AU member states have cybersecurity and Information and Communication Technology (ICT) policies and strategies. Only 1 country has published its AI Strategy.**

Introduction

Africa is making strides in technological advancement[1], and the impact of Information and Communications Technologies (ICTs) is evident, even in low-income economies [2]. While the emergence of new digital technologies may create over-hyped, high expectations[3], their impacts and potentials need careful analysis

[1] UNCTAD, 'Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development.' Geneva. United Nations Conference on Trade and Development. https://unctad.org/en/PublicationsLibrary/tir2018overview_en.pdf.

[2] GSMA. 'The Mobile Economy Sub-Saharan Africa 2019. London. GSM Association. https://www.gsmaintelligence.com/research/?file=36b5ca079193fa82332d09063d3595b5&download.

[3] Gillwald, Alison. 'South Africa is caught in the global hype of the fourth industrial revolution.' *The Conversation*. 20 August 2019. http://theconversation.com/south-africa-is-caught-in-the-global-hype-of-the-fourthindustrial-revolution-121189.

and exploration. But, despite the fact that the Internet, and its associated technologies and applications, has always been premised on fairness and equality, inequalities in access and usage continue to exist, including those based on gender[4].

Unequal playing field: Women less unlikely to use ICTs and the Internet.

Unequal playing field

ICTs claim to be a power for social good, but social good cannot be achieved if there are segments of society who are marginalised from research, development and use of Internet and broadband technologies and applications. Gender, in particular, remains a particular axis or marginalisation: a number of studies show that women continue to be less likely to access or use ICTs and the Internet, and that this has an impact on the implementation and uptake of these technologies, and in the realisation of socio-economic benefits form their deployment. [5]

Artificial Intelligence (AI) and its associated algorithms, in particular, can be skewed by human bias, or through the unconscious prejudices of humans transferred into systems and their computational workings[6]. This further marginalises those already under-represented and widens the technology gap. Can new technological innovations address gendered digital inequalities, or will they make these gaps even wider?

Research scope and focus

This policy brief sets out to:

1. Analyse gender inclusion in the research, design and use of technologies, with a focus on gender and AI in Africa;
2. Assess the extent that gender considerations are included in AI policy-making;
3. Develop policy recommendations that ensure gender inclusivity and responsible design of algorithms, in order to help ensure algorithms that are fair, transparent and accountable.

Overall, the study seeks to understand if and how technological innovations address already- existing, gendered digital inequalities.

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[4] GSMA. 'Connected Women: The Mobile Gender Gap Report 2019'. London. GSM Association. 2019.https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/02/The-Mobile-Gender-Gap-Report-2019.pdf.

[5] See: RIA. 'Understanding the gender gap in the Global South.' Cape Town. Research ICT Africa. 2018. http://afteraccess.net/wp-content/uploads/2018-After-Access-Understanding-the-gender-gap-in-the-Global-South.pdf, & EQUALS. 'Data and Evidence on Gender Equality in Digital Access, Skills and Leadership.' Macau. EQUALSs Research Group. 2019. http://collections.unu.edu/eserv/UNU:7350/EQUALS-Research-Report-2019.pdf.

[6] Powles, J, & Nissenbaum, H, 'The Seductive Diversion of 'Solving' Bias in Artificial Intelligence', Medium, 7 December 2018, http://www.medium.com/s/story/the-seductive-diversion-of-solving-bias-in-artificial-intelligence-890df5e5ef53.

Background

ICTs and the Internet

ICTs have become indispensable in different sectors in human life. They have been said to have the potential to change lives and give access to better healthcare, education, jobs, improve livelihoods and even achieve the United Nations Sustainable Development Goals (SDGs)[7] [8]. Sectors like engineering, education, healthcare, manufacturing, governance, agriculture, transport and others are increasingly becoming dependent on ICTs for operations and service provision. The Internet has made this experience better by supporting collaborative working, remotely and in multiple locations, thereby improving business processes for organisations/companies. On the other hand, there have also been some negative consequences of platform mediated work (like Uber, Taxify/Bolt, etc), though this debate is mainly about the developing world. Research ICT Africa's report on microwork shows limited uptake of online work with just 2% taking part in online work across the seven surveyed countries. [9] The report further notes the impact of the Internet in facilitating online work, highlighting low Internet penetration rates on the African continent.

The ICT Competitiveness in Africa report[10] indicates how the ICT sector has been a strong driver of Gross Domestic Product (GDP) growth globally, and how it has been socially and economically relevant to Africa's growth. The report further indicates that even if generally some countries have improved faster than others, access to ICTs has increased in a majority of African countries.

Gender Disparity

Access to ICTs and the Internet

Despite the general increase in access to ICTs and the Internet, some reports continue to show a disparity in access to ICTs and the Internet between men and women, rural and urban communities, and across different age groups. For

[7] International Telecommunications Union, 2017. How ICTs are accelerating the SDGs. https://www.itu.int/en/itunews/Documents/2017/2017-03/2017_ITUNews03-en.pdf
[8] Takayuki Ono, Kenichi Lida and Seiya Yamazaki, 2017. Achieving Sustainable Development Goals (SGDs) through ICT Services. https://www.fujitsu.com/global/documents/about/resources/publications/fstj/archives/vol53-6/paper03.pdf
[9] Onkokame Mothobi, Aude Schoentgen and Alison Gillwald, 2018. What is the state of microwork in Africa? A view from seven countries. https://researchictafrica.net/wp/wp-content/uploads/2018/10/After-Access_The-state-of-microwork-in-Africa.pdf
[10] World Bank and African Development Bank, 2012. ICT competitiveness in Africa. http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1346223280837/ICTCompetitiveness.pdf

example, the After Access Survey[11] shows gender disparity in mobile phone ownership. Out of the 16 countries surveyed in Africa, Asia and Latin America, men are more likely to own a mobile phone than women in majority of the countries, and in some of the countries, the difference is as high as 46%.

In terms of Internet usage, apart from one country, men have more access to the Internet compared to women, and the differences range from 1% to as high as 62% in countries whose Internet penetration percentages range between 9 and 53%. The Survey, further highlights that the digital gender gap mirrors offline gender inequality, with fewer women having access to the Internet than men. The compounding factors to this inequality are level of education and income of women in the same communities.

Such numbers are not unique to access to the Internet only, but have also been witnessed in access to technologies, developing solutions and in the technology workspace. The report further shows disparities in mobile money use, social media networking and others. The gap widens further for developing economies, many of which are African countries. The World Economic Forum[12] reported that many countries had achieved milestones towards gender parity across education, health, economic and political systems, though there is a possible emergence of new gender gaps in advanced technologies like Artificial Intelligence (AI)-related skills.

Gender Gaps and Intersectionality

Gender gaps are observed in most aspects of ICT access, skills and leadership and equality gaps are related to finances, aptitude, interest, infrastructure, safety, security, socio-cultural contexts among others. Through another lens, it is important to recognise intersections that exist in our societies. Social and political identities intersect and overlap; for example, women cannot be seen through one lens because they have different experiences and identities that intersect in different configurations. In her paper, Crenshaw[13] criticises work on discrimination in the way it treats race and gender as mutually exclusive categories of experience and analysis. She highlights that black women are multidimensional and placing them in a single axis distorts their experiences. Catherine Harnois argues that intersectional perspectives are important because measuring social phenomena through the lens

[11] After Access, 2017. Understanding the Gender Gap in the Global South. DIRSI, LIRNEasia and Research ICT Africa. http://afteraccess.net/wp-content/uploads/2018-After-Access-Understanding-the-gender-gap-in-the-Global-South.pdf
[12] World Economic Forum, 2018. The Global Gender Gap Report 2018. http://www3.weforum.org/docs/WEF_GGGR_2018.pdf
[13] Kimberlé Williams Crenshaw, 1989. Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. University of Chicago Legal Forum: Vol 1989: Iss. 1, Article 8. https://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=1052&context=uclf

of one variable can focus on certain gendered experiences whilst rendering others invisible.[14] Therefore, in understanding gender and AI from an African perspective, if these intersections are not taken into account, some women can further be marginalised or have their experiences ignored, overlooked or completely erased. If gender diversity and inclusion are not strongly considered, progress in terms of using ICTs for development will not be realised[15].

Intersectional feminist perspectives are not only important to unpacking the relevance of AI in the context of intersections of gender, identity, and class but also important to a "proactive understanding on how to imagine, design and develop an emancipatory AI" that addresses structures of power and "undermines consumerist, misogynist, racist, gender binarial and heteropatriarchal societal norms."[16]

New gender gaps in advanced technologies like AI-related skills.

In assessing the digital gender divide, the World Wide Web Foundation[17] states that the digital gender gap extends beyond just divisions in access, noting that women and those living in poverty in the Global South are less likely to use the Internet to transform their lives. Spuy and Souter[18] emphasise that 12% of women are less likely to use the Internet globally than men, while in low and middle-income countries, the gap between women's use and that of men is 26%. Additionally, once online, women are less likely to use ICTs to increase economic opportunity, seek information or participate in civic life, even in urban areas where connectivity is more widely available. The World Economic Forum (WEF)[19] states that many countries had achieved milestones towards gender parity across education, health, economic and political systems. The report mentions that there are still 44 countries where 20% of women are illiterate. The report warns about new gender gaps in advanced technologies like AI-related skills.

[14] Catherine Harnois, *Feminist Measures in Survey Research* (SAGE 2012) cited in Ambika Tandon, Feminist Methodology in Technology Research: A literature review. Centre for Internet and Society 2018.
[15] EQUALS Global Partnership, 2019. Data and Evidence on Gender Equality in Digital Access, Skills and Leadership. Report of Equals Research Group, led by the United Nations University. Macau.
[16] Paz Peña and Joana Varon, "Decolonising AI: A transfeminist approach to data and social justice" in Global Information Society Watch 2019 – Artificial Intelligence: Human rights, social justice and development (Association for Progressive Communications, 2019).
[17] World Wide Web Foundation, 2018. A D VA N C I NG WOMEN'S RIGHTS ONLINE: Gaps and Opportunities in Policy and Research. pp.6 -7. http://webfoundation.org/docs/2018/08/Advancing-Womens-Rights-Online_Gaps-and-Opportunities-in-Policy-and-Research.pdf
[18] Anri van der Spuy and David Souter, 2018. Women's Digital Inclusion. Background Paper for the G20. https://www.apc.org/en/pubs/womens-digital-inclusion-background-paper-g20
[19] World Economic Forum, 2018. The Global Gender Gap Report 2018. http://www3.weforum.org/docs/WEF_GGGR_2018.pdf

Gender and AI

The AI Index[20] reported that women are severely underrepresented in university faculties as candidates for AI jobs. In addition, men made up 71% of the applicant pool for AI jobs in the United States of America. Leavy[21] highlights that the over-representation of men in the design of AI and technologies could quietly undo decades of advances in gender equality. There have been deliberate efforts to ensure reduce gender inequalities, from national to multinational efforts, including special focus by the United Nations and on the sustainable development goals (SDGs). With the biggest contributors in AI being male, these efforts are greatly undermined.

According to a Access Partnership [22], the rapid developing set of AI technologies has the potential to solve some of the world's most pressing challenges that impact Sub-Saharan Africa. The whitepaper mentions that many sectors including agriculture, healthcare, education, public services, finance, telecommunications and others will benefit from AI and algorithms. But, with the already existing gender gaps in education, access to finances, access to devices and the Internet - does AI have the capability to reduce the gender divide?

Computers, Algorithms and Bias

Facial recognition software error rates higher for darker-skinned women.

Even with the positive contribution, AI is not without fault. Some studies have shown negative implications of algorithms based on many issues including quality of data, training data sets, inclusion and unconscious bias. Computers and algorithms are developed by humans, and these algorithms can be unconsciously biased because metadata (a set of data that describes data) can be exploited by our imported unconscious bias. According to a study by Buolamwini[23] on algorithmic bias, the error rate on facial recognition software of three commercial facial recognition systems, Microsoft Azure Face API, IBM i2 facial recognition software and China-based Megvii (Face++), is higher when recognising females compared to when recognising males, and even higher when recognizing darker females as compared to lighter males. In a related paper on gender shades, Buolamwini and Gebru[24]

[20] AI Index, 2018. 2018 Annual Report. http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf
[21] Susan Leavy, 2018. Gender Bias in Artificial Intelligence: The Need for Diversity and Gender Theory in Machine Learning. History Studies International Journal of History, 10(7), pp.241-264
[22] Access Partnership, Artificial Intelligence for Africa: An Opportunity for Growth, Development, and Democratisation, 2019. https://pic.strathmore.edu/wp-content/uploads/2019/03/PIC_AI_for_Africa_Whitepaper.pdf
[23] Joy Buolamwini, 2018. Project Overview: Gender Shades – MIT Media Lab. https://www.media.mit.edu/projects/gender-shades/overview/
[24] Joy Buolamwini and Timnit Gebru, 2018. 'Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification'. Conference on Fairness, Accountability and Transparency: Proceedings of Machine Learning Research, 81, 2018.

highlight that machine learning algorithms can discriminate based on classes like race and gender. From their data which is balanced by gender and skin type, the study shows that darker-skinned females are the most misclassified group with error rates of up to 34.7%, while that of lighter-skinned males is 0.8%, calling for urgent attention of commercial companies to build systems that are fair, transparent and accountable.

Self-driving cars more likely to knock darker-skinned people.

When looking at self-driving cars, a study claims that the technology used in self-driving cars has a racial bias that makes autonomous vehicles more likely to drive into black people[25]. Sensors and cameras used in the cars are better at detecting people with lighter skin tones, making it less likely to spot black people and stopping before crashing into them. This is worrying for a population in Africa where majority of the people have darker skin tones.

If algorithms make prediction errors, there are costs involved, as well as potentially significant effects on people's lives. In some fields like the nuclear space, algorithmic errors may cause major outages that could destroy property or even lives. For example, a robot surgeon killed 144 patients and hurt 1,391, and was reported to have malfunctioned 8,061 times[26]. This shows the importance of ensuring accuracy and correctness of algorithms, to avoid such effects.

Quality of Data

Beyond bias, the quality of data fed into algorithms shapes negative outputs of AI. In a paper on improving data quality, Cong et al.[27] mention that real-world data is often "dirty" (badly captured, classified and organized) and contains inconsistencies, conflicts and errors. The paper also mentions that error rates of approximately 1 - 5% are expected and the consequences may be severe. Fan[28] explains how the quantity/volume of data and techniques to store, manage and query data are often emphasised more than the quality. He adds that more than 25% of critical data in the world's top companies is flawed. Such issues negatively affect the output of an algorithm.

The critique around artificial intelligence stems from the approach of the knowledge that is considered valid within the development of AI. Because a lot of the decisions

[25] Anthony Cuthbertson, 2019, 'Self-driving cars more likely to drive into black people, study claims', Independent, Indy/Life. https://www.independent.co.uk/life-style/gadgets-and-tech/news/self-driving-car-crash-racial-bias-black-people-study-a8810031.html.
[26] Iain Thomson, 2015. Robot surgeons kill 144 patients, hurt 1,391, malfunction 8,061 times. The Register. https://www.theregister.co.uk/2015/07/21/robot_surgery_kills_americans/
[27] Gao Cong, Wenfei Fan, Floris Geerts, Xibei Jia and Shuai Ma, 2007. Improving Data Quality: Consistency and Accuracy. http://homepages.inf.ed.ac.uk/wenfei/papers/vldb07-b.pdf
[28] Wenfei Fan, 2015. Data Quality: From Theory to Practice. http://homepages.inf.ed.ac.uk/wenfei/papers/sigmodRecord15.pdf

are made by machines, based on the available data, it is assumed that the data is valid. Some measures need to be put in place to ensure that data is of very high quality to improve the output of an algorithm.

Social-cultural factors

Socio-cultural norms often come to play - society has often categorised some roles as for women and for men. A study by KPMG[29] shows that women are more receptive to self-driving cars, citing the freedom to focus on children in the back seat and other issues while men preferred less restriction by the self-driving cars to stay in a lane or follow speed limits. Smith and Neupane[30] highlight the need to evaluate the impact of some applications like women's health, cycle monitoring and body scanners, on the rights of the people in order to avoid algorithmic discrimination. Getting representative data is a challenge depending on who is included in developing solutions. Humans are biased by nature, many times unconsciously, and some of this bias and socio-economic issues that are faced in society can easily be transferred to algorithms and the training data sets that are used.

Smith et al[31] talk about both positive and negative implications of AI applications to both low- and middle-income countries, especially those in the Global South. In assessing whose lives will be improved or harmed by new technologies like AI, the paper asserts that if countries continue to blindly go forward, increased inequalities should be expected, alongside economic disruption, social unrest and political instability, with the technologically disadvantaged and underrepresented fairing the worst. It is important to implement and use AI applications with an understanding of what would work or not, for whom and in what contexts. It is also important to emphasise exploring the differential impacts on various groups, particularly those resulting from gender, social and economic status, race and others.

It is important to develop responsible AI best practices to make algorithms and their implementation fair, transparent and more accountable. Specifically related to gender, algorithmic bias reflects the bias existent in our social and cultural spaces therefore highlighting the "imperfectness of the perfect" machine[32]. This simply means that even though machines and algorithms are perceived to be unbiased, on many occasions, our social and cultural norms are carried into algorithms and the

[29] KPMG, 2013. Self-Driving Cars: Are We Ready?, p. 21
https://home.kpmg/content/dam/kpmg/pdf/2013/10/self-driving-cars-are-we-ready.pdf
[30] Matthew L. Smith and Sujaya Neupane, 2018. Artificial intelligence and human development. Toward a research agenda. International Development Research Centre. https://idl-bnc-idrc.dspacedirect.org/handle/10625/56949
[31] Matthew L. Smith and Sujaya Neupane, 2018. Artificial intelligence and human development. Toward a research agenda. International Development Research Centre. https://idl-bnc-idrc.dspacedirect.org/handle/10625/56949
[32] Katrin Caspar. (2010). Time is Somewhere, but Not Here. Time is Somewhere, but Not Here.
https://gupea.ub.gu.se/bitstream/2077/24718/1/gupea_2077_24718_1.pdf

programs written for machines, therefore importing unconscious bias.

AI Policies and Regulations

Just like in other continents, the fourth industrial revolution (4IR) is a subject of discussion by many governments in Africa. The benefits for 4IR technologies, which include Artificial Intelligence (AI), Internet of Things (IoT), Virtual Reality (VR) and robotics cannot be ignored have often been said to have the potential to change lives and revolutionise public service delivery. The Elsevier AI Report[33] highlights that the capacity for AI research, technology and application is seen as vital to national competitiveness, security, and economic strength. For example, Nyoni[34] discusses how AI can be used to predict Africa's next migration crisis, while Maritz[35] highlights solutions that have played important roles to individuals and organisations in Africa, including mobile-lending platforms, season fashion predictions and driver's performance in Nigeria, South Africa and Kenya respectively.

Besaw and Filitz[36] highlight the demographic boom in Africa that is largely young and urban, with a median age of 19.5. The article also references the 2018 Ibrahim Index of African Governance which states that Africa is improving but not keeping pace with expectations of the young and urban population, causing pressure to deliver services to growing towns. AI and machine learning in specific have been highlighted as a means to support the fourth industrial revolution and improve governance. Start-ups in countries like Ghana, Nigeria and Kenya have developed AI applications to solve problems in education, medical access, agricultural planning, and finance.

Governments have started realising the potential of technologies and AI for their economies and public service provision. In the past few years, there has been an increase in government mentions of AI in developed countries, from almost no mention at all a few years ago[37]. Governments and policy makers need to adapt to

[33] Elsevier, 2018. Artificial Intelligence: How knowledge is created, transferred, and used. https://p.widencdn.net/jj2lej/ACAD-RL-AS-RE-ai-report-WEB
[34] Babusi Nyoni, 2019. How artificial intelligence can be used to predict Africa's next migration crisis - UNHCR Innovation. https://www.unhcr.org/innovation/how-artificial-intelligence-can-be-used-to-predict-africas-next-migration-crisis/
[35] Jaco Maritz, 2019. 3 lessons from running an AI-powered start-up in Africa. World Economic Forum, 2019. https://www.weforum.org/agenda/2019/08/artificial-intelligence-africa-venture-capital-investment/
[36] Clayton Besaw and John Filitz, 2019. AI & Global Governance: AI in Africa is a Double-Edged Sword. [online] Center for Policy Research, United Nations University. Available at: https://cpr.unu.edu/ai-in-africa-is-a-double-edged-sword.html
[37] AI Index, 2018. 2018 Annual Report. http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf

the advances in technology. With this in mind, how many countries are actually ready for AI?

Only 2 out of 55 African Union member states have announced AI Strategies.

The Government AI readiness Index[38], which shows preparedness of governments to implement AI in public service delivery reports mostly developed economies on the list of top 35 ready countries. The rankings capture metrics like digital skills, innovation, infrastructure, and economy and skills. Outside North America, Europe and Asia, the other continents either show low or no preparedness. In terms of AI policies and strategies, in 2018, about 10 countries had publicly announced AI strategies[39]. In Africa, only 2 countries: Kenya and Tunisia, have announced their National AI Strategies[40], yet most African countries have ICT and Cybersecurity Policies and Strategies. The African Union Convention on Cyber Security and Personal Data Protection that was set up in June 2014 imposes obligations on member states to establish legal, policy and regulatory measures to promote cybersecurity governance and cybercrime[41]. Kenya constituted a blockchain and AI national strategy that was released in January 2018 and Tunisia created a Taskforce to develop a National AI Strategy and conducted a workshop in April 2018 to build capacity of different stakeholders.

Perhaps a similar arrangement for the AI space would be useful to ensure that the issues raised, including those of gender and bias, are emphasised across member states. The African Union may support member states by extending the principles of the Cyber Security and Personal Data Protection convention to cover AI and other disruptive technologies like Internet of Things (IoT), robotics, Virtual Reality and others. This way, member states can continue to establish frameworks and guidelines for establishing legal, policy and regulatory measures to promote AI.

The number of countries with strategies on start-ups that develop AI applications is small on the continent. In addition, there are few AI applications and innovations developed by Africans that focus on AI that can be tested. It is worth noting that without good policies, AI may not be useful.

[38] Richard Stirling, Hannah Miller and Emma Martinho-Truswell, 2018. GOVERNMENT AI READINESS INDEX. Oxford Insights. https://www.oxfordinsights.com/government-ai-readiness-index
[39] Hannah Miller, André Petheram and Emma Martinho-Truswell, 2018. Want to get serious about artificial intelligence? You'll need an AI strategy. Oxford Insights. https://www.oxfordinsights.com/insights/2018/1/23/aistrategies
[40] Tim Dutton, 2018. An Overview of National AI Strategies. https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd
[41] Uchenna Jerome Orji, 2018. The African Union Convention on Cybersecurity: A Regional Response Towards Cyber Stability?. Masaryk University Journal of Law and Technology, 12(2), p.91. https://www.researchgate.net/publication/327986841_The_African_Union_Convention_on_Cybersecurity_A_Regional_Response_Towards_Cyber_Stability

Methodology / Research Approach

This study sought to understand the African debate on gender and AI and how new innovations can address the already existing gender gaps in the technology space. The research analysed gender inclusion in the research, development and use of new innovations like AI applications in Africa, assessed policy frameworks whether gender is considered in policy formulation and developed policy recommendations to ensure that AI applications and algorithms are fair, transparent and accountable. This included looking at teams and who is involved in the discussion and development of AI applications. As a case study, results of the Uganda National Examination Board (UNEB) results were compared with students admitted for computing-related courses at Makerere University in Uganda.

Research Findings

Computing Courses and AI Workforce

A study done to determine who eventually joins the general technology workspace shows that more men than women opt for sciences in general and computing related courses.

Case Study: Uganda

A further study shows that such numbers are affected from science/mathematics related courses at advanced level (popularly known as A-Level).

As shown below, there were more male than female candidates in the Uganda National Examination Board (UNEB) Uganda Advanced Certificate of Education (UACE), which is the final examinations that students write before joining college/university. For example, in 2018, out of a total of 99,672 number of candidates who wrote the examinations, 41,313 were female, while in 2010, out of a total of 99,904, 40,856 were female. The years between 2010 and 2018 show similar results with more male than female students. These numbers do not match the population statistics that show a higher female to male gender ratio in Uganda. In addition, male students are shown to excel in physics, chemistry, biology, economics and fine art, while female students are shown to excel in Christian/Islamic education, entrepreneurship, literature in English and history. In fact, in the release

of the 2010 examination results, one of Uganda's top news agency published an article with the title "2010 UACE results released, boys continue dominance". The following comment was made by the then Education Minister:

"Boys dominate performance over girls in science. Girls should "pull up socks""[42].

S/N	UNEB Year	Total candidates (who sat)	Number of female	%Female	Number of male
1	2010	99,904	40,856	40.90	59,048
2	2011	102,296	42,341	41.39	59,955
3	2014	108,000	43,944	40.69	64,056
4	2017	62,082	41,932	67.54	20,150
5	2018	99,672	41,313	41.45	53,329

Table 1: Summary of select UNEB results; Source: Open Data Uganda[43]

Male students dominate admissions for computer science, computer engineering and software engineering.

For most science courses at Ugandan universities, a student needs to have excelled in science courses. For computer science or computer engineering for Makerere University, the essential subjects are any two best done subjects among mathematics, physics, chemistry, biology and technical drawing. According to the draft published 2019 admission lists for computer science and computer engineering at Makerere University, the biggest public university in Uganda, there is a big difference between male and female students admitted. For example, for the afternoon class of BSc Computer Engineering, out of 11 admitted students, 1 is female, while for the day class, out of 40 admitted students, 9 are female. For BSc Computer Science (day), 29 out of 100 are female. In 2018, for BSc Computer Engineering, 8 out of 35 were female for the day class, all 4 students were male for the evening class and 1 international student was also male. In 2017, for BSc Computer Engineering, 4 out of 36 were female in the day class and all 11 were male for the evening class, while for BSc Computer Science, 18 out of 81 were female for the day class and 3 out of 23 were female for the evening class. In 2013, for BSc Computer Engineering (day class), 7 out of 24 were female, while 2 out of 25 were female for the same course in the evening class.

Other computing related courses show similar results. For example, for the 2019 BSc Software Engineering day and evening admitted cohorts, 21 out of 98 were female in group 1, while 30 out of 107 were female in group 2.

Year	Course	Total Admitted	Female	% Female

[42] The Daily Monitor, 2010. 2010 UACE results released, boys continue dominance https://www.monitor.co.ug/News/National/688334-1121596-ap5kf4z/index.html

[43] Open Data Uganda, 2019. UNEB Results. http://catalog.data.ug/organization/uganda-national-examination-board-uneb

2019	BSc Computer Engineering (Afternoon)	11	1	9%
2019	BSc Computer Engineering	40	9	22.5%
2019	BSc Computer Science	100	29	29%
2019	BSc Computer Science (Jinja)	4	2	50&
2019	BSc Software Engineering – group 1	98	21	21.4%
2019	BSc Software Engineering – group 2	107	30	28%
2018	BSc Computer Engineering	4	0	0%
2018	BSc Computer Engineering	35	8	22.9%
2018	BSc Computer Engineering (International)	1	0	0%
2018	BSc Computer Science (International)	1	0	0%
2017	BSc Computer Engineering	11	0	0%
2017	BSc Computer Engineering	36	4	11.1%
2017	BSc Computer Science	81	18	22.2%
2017	BSc Computer Science (Evening)	23	3	13%
2013	BSc Computer Engineering	24	7	29.2%
2013	BSc Computer Engineering (Evening)	25	1	4%
Total		**601**	**133**	**22,1%**

Table 2: Summary of select Makerere University admission numbers; Source: Makerere University website[44]

Note: Gender considered is as listed on the admission/graduation lists

Further study shows similar results for postgraduate courses, and that the admission rates determine graduation ratios, hence who finally takes on Science, Technology, Engineering and Mathematics (STEM) and AI careers.

Year	Course	No of Graduates	No of Female	% Female
2019	MSc Computer Science	8	1	12.5%
2019	MSc Data Communication and Software Engineering	8	2	25
2019	MSc Information Science	6	5	83%
2019	Bachelor of Information Systems	60	19	31.7%
2019	Bachelor of Information Technology	93	33	35.5%
2019	BSc Computer Science	143	35	24.5%
2019	BSc Software Engineering	160	40	25%

[44] Makerere University, 2019. https://news.mak.ac.ug/2019/06/makerere-private-district-quota-admission-lists-20192020

Total	**478**	**135**	**28.2%**

Table 3: Summary of 2019 Makerere University graduation numbers; Source: Makerere University

AI Workforce

Globally, 12% of machine learning researchers are women.

According to an article published by Face-to-Face Africa, CNN reporter Adeoye[45] reported that Google opened its first Artificial Intelligence lab for Africa in Ghana. The article highlights 4 AI innovations and 5 engineers building a remote-controlled robot that extinguishes fires, robots for brain surgery and traffic congestion, among others. Out of these innovations, only one female engineer is mentioned, while the other 4 are male. In an article by Simonite[46] titled AI is the future, but where are the women, it is estimated that 12 percent of machine learning researchers are women. The article further suggests that when the contribution of women in machine learning conferences was tallied, the machine learning space was even less than in technology in general. Out of 641 people listed to be working at Google's AI research, only 10% are women.

The publicly-posted IBM Research – Africa team[47] shows approximately 9 female staff out of a total of 36.

A recent analysis of AI start-up companies highlighted the shortage of women in top management positions.[48] Of the 14 companies examined, there was only a single woman founder or co-founder out of a total of 21. .

A participant list for an AI for development initiative[49] shows less than 15 female participants out of a total of 47 documented participants. By these numbers, it is clear that there are fewer females in the AI workspace, and this can have consequences on the research, use and implementation of AI-related technologies.

[45] Aanu Adeoye, 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
[46] Tom Simonite, 2018. AI is the Future – But Where are the Women? https://www.wired.com/story/artificial-intelligence-researchers-gender-imbalance/?verso=true
[47] IBM Research Lab – Africa, 2019. https://researcher.watson.ibm.com/researcher/people.php?sn=1&loc=Africa
[48] Stephen Timm, 2017. 6 artificial intelligent startups in Africa to look out for [Digital All Stars]. https://ventureburn.com/2017/04/five-artificial-intelligence-startups-africa-look-2017/?platform=hootsuite
[49] AI4D, 2019. Toward a Network of Excellence in Artificial Intelligence for Development (AI4D) in sub- Saharan Africa. https://ai4d.ai/event/ssa-network/

AI Policies and Strategies in Africa

As indicated in the AI Index[50] Africa is still lagging behind the rest of the world in annual robot installations. The report also highlights increased awareness of gender and racial diversity, though from the study by the researcher, the numbers are still low. As mentioned by Dutton[51], only 2 countries in Africa, Kenya and Morocco, have announced their national AI strategies.

Kenya

Number of women on the 14-member Kenya Blockchain and Artificial Intelligence Taskforce: 4

The Government of the Republic of Kenya created a Blockchain and Artificial Intelligence Taskforce in February 2018, which consists of 14 members from academia and industry, 4 of whom are women. The group was tasked with providing the government with recommendations about harnessing blockchain and AI over the next five years. The strategy, which has been posted on the Ministry of Information, Communications and Technology (MoICT) website[52], does not specifically mention how gender issues will be handled, though it talks about the reconceptualization of employment and work in the consideration of emerging global development, and how some countries are using AI-powered mobile-based solutions to examine women's health issues.

Tunisia

The Government of the Republic of Tunisia developed a national Artificial Intelligence Strategy in April 2018, with an aim to secure a respectable place and enable sustainable and equitable development. A taskforce was created to oversee the process and a steering committee to produce the strategy. The strategy was scheduled to be published in the first quarter of 2019 but during this research, it had not yet been published.

Conclusion, Outcomes and Policy Recommendations

Based on studies and reports, there is a need to develop responsible AI best practices and encourage their adoption by anyone intending to use AI for decision making or to support business processes in an organisation. As the demand for computer systems in businesses, governments and society today increases, it is

[50] AI Index, 2018. 2018 Annual Report. http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf
[51] Tim Dutton, 2018. An Overview of National AI Strategies. https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd
[52] Ministry of Information, Communication and Technology, Kenya, 2018. Emerging Technologies for Kenya. Exploration & Analysis. http://www.ict.go.ke/blockchain.pdf

important not to leave out any stakeholder group, especially the underrepresented and minorities.

The results as shown above clearly indicate that the digital gender divide is also affected by numbers of women opting for Science Technology Engineering and Mathematics (STEM) courses before university, hence affecting university admission and graduation numbers. This definitely has an impact on the AI workforce since fewer women are in the field. This, combined with Research ICT Africa's After Access Survey, clearly show that men are more likely to use technologies and the Internet highlight how the gender inequalities are not being reduced, but instead widening even further. Furthermore, the participation of women in the preparedness for AI and in the AI workforce is wanting. This lack of representation and participation in means that some voices and experiences can easily be overlooked, hence social and algorithmic biases will continue to exist in policy formulation and in the AI solutions developed.

If technologies should start with fairness and equality, disparities mean that some sections of the population are missing out on the benefits that technologies offer. Inclusion is an important aspect of developing technologies. Who is part of the system in terms of research, development and use of ICTs, the Internet and AI has a huge impact on if the technology will cause change or not. These issues can be addressed by formulating policies that are inclusive of underrepresented groups and specifically address AI and gender.

While addressing policy formulation, more African Union member states should adopt AI issues, as only 2 have announced their AI Strategies, even when the majority of the member states have cybersecurity and Information and Communication Technology (ICT) policies and strategies. Member states can be supported by extending the principles of the Cyber Security and Personal Data Protection convention to cover AI and other disruptive technologies like Internet of Things (IoT), robotics, Virtual Reality and others.

Furthermore, only 1 of the 2 countries has published its national AI strategy, though it makes no mention of how gender issues will be handled in the strategy. It is important to specifically mention gender issues given the disparities we see with bias, discrimination and quality of data so that they can be handled during the implementation of projects as required by the strategy.

In conclusion, policy interventions such as continued support for young women to be part of STEM initiatives, equity in AI start-up in terms of representation and

ensuring that stakeholder groups are involved in developing technologies that will ensure that AI is more transparent and fair.

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