WORLD WIDE WEB
FOUNDATION

A SMART WEB FOR A MORE EQUAL FUTURE

A series focused on identifying the challenges and opportunities ahead and ways to address them

ARTIFICIAL INTELLIGENCE

The Road Ahead in Low and Middle-Income Countries

June 2017

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WORLD WIDE WEB FOUNDATION

The Web Foundation was established in 2009 by Sir Tim Berners-Lee, inventor of the World Wide Web. Our mission is to establish the open web as a public good and a basic right.

This paper has been adapted by the Web Foundation from a draft report commissioned to Cath Elliston, Matt Fenech, and Olly Buston of Future Advocacy.

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FOREWORD

"To achieve this vision, we must keep an eye on the trends, technologies and forces shaping the web of tomorrow, and the policy interventions that will be required to ensure digital equality becomes a reality."

Welcome to this new series of policy white papers, produced by the World Wide Web Foundation.

The Web Foundation was established in 2009 by Sir Tim Berners-Lee, inventor of the World Wide Web. Our mission is to establish the open web as a public good and a basic right. Our five-year strategy – developed in 2016 – is to deliver digital equality – a world where everyone has the same rights and opportunities online. To achieve this vision, we must keep an eye on the trends, technologies and forces shaping the web of tomorrow, and the policy interventions that will be required to ensure digital equality becomes a reality.

On the web's 28th birthday in March 2017, Sir Tim Berners-Lee penned a letter on what he believed to be the biggest challenges facing the web today. The challenges he outlined are threefold: we've lost control over our personal data; misinformation spreads too easily online; and we need more transparency and understanding of digital political advertising.

Since then we have been discussing ways in which we could and should tackle these issues. We understood that these could be early warning signals of deeper problems, and set out to distil these in search of their most basic components. We landed upon data, algorithms and artificial intelligence, and the way these interact with existing socio-legal frameworks. These three issues are interdependent – data feed algorithms that are increasingly being used to make critical decisions, algorithms are the bedrock of artificial intelligence, and data gathered by AI and algorithms feed back into the system.

This is one of the three white papers we commissioned to begin to understand more about these issues. All too often, research, debate and discussion on these areas is focused on the US, UK and Europe, while actors from outside these countries are seldom being included as critical actors in thinking through policies at the global level. Our objective was to gain initial insights into how each component is currently playing out in low and lower-middle income countries, and what some of the future risks and opportunities are.

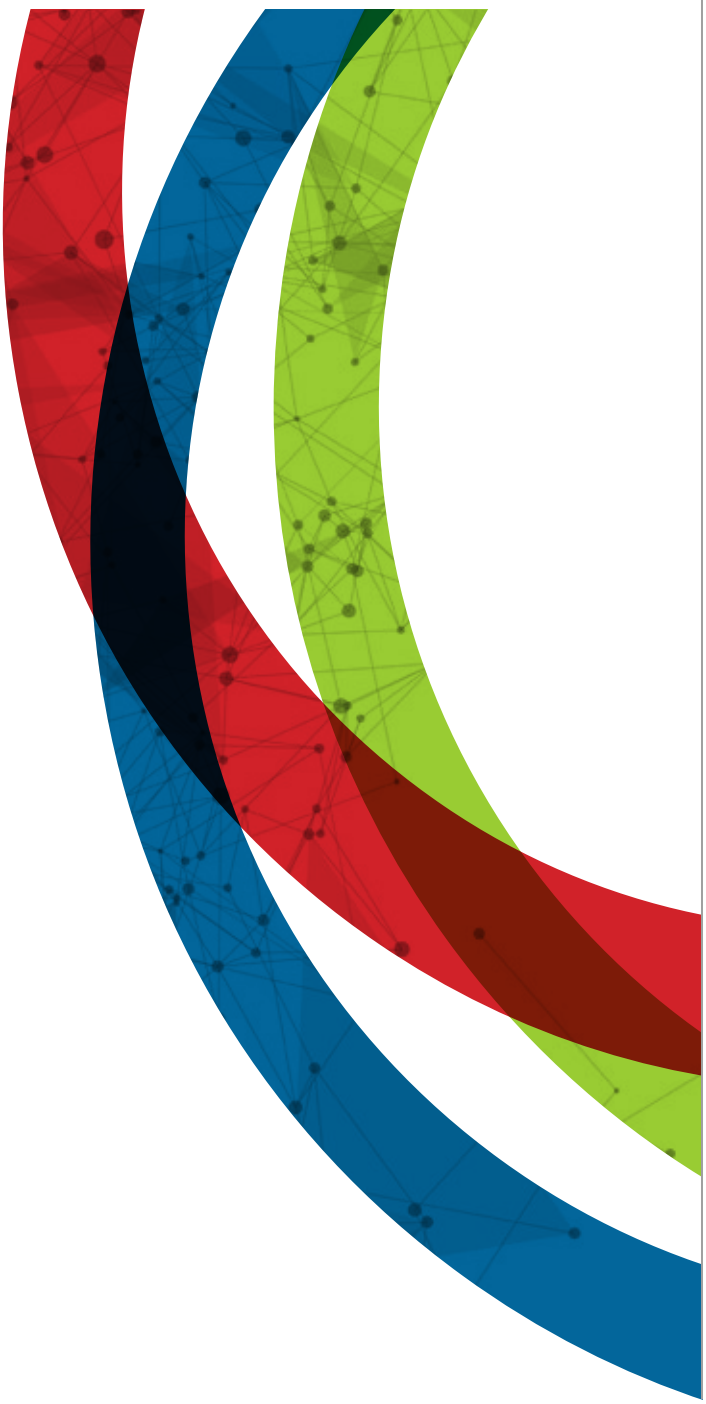
An important step towards enabling collaboration and solving the challenges the web faces is increasing public and key stakeholder understanding of how the individual components of the system work. We hope that these papers make a small contribution towards this goal, including in countries too often ignored in these debates. We will now be using these papers to refine our thinking and set our work agenda in the years ahead. We are sharing them openly in the hope that they benefit others working towards our goals.

We hope you enjoy the read, and we welcome your feedback. Let's work together to build a more open web for a more equal world.

Craig Fagan

Director of Policy, Web Foundation
June 2017

INTRODUCTION



We are in the early stages of a global intelligence revolution. Artificial Intelligence (AI) already permeates many aspects of our lives. All over the world, AI systems filter email spam, recommend things for people to buy, provide legal advice on everything from parking tickets to asylum applications, and in some places can determine whether you are paid a visit by the police.[1,2]

Research by McKinsey has gone as far as describing AI as contributing to a transformation of society "happening ten times faster and at 300 times the scale" of the Industrial Revolution.[3]

Defining AI is difficult, not least because 'intelligence' itself is difficult to define. In this paper we will use an inclusive definition of intelligence as 'problem-solving' and consider 'an intelligent system' to be one which takes the best possible action in a given situation.[4]

Although AI is not new, there has been a recent explosion of activity and interest in the field, which has largely been driven by advances in 'machine learning', and the related field of 'deep learning'. These are computer programs that learn and improve with experience.[5] Progress in machine learning has allowed more versatile AI systems to be developed that can perform well at a range of tasks, particularly those that involve sorting data, finding patterns, and making predictions (see Figure 1). The training process can involve in practice adjusting for millions of parameters relative to computational efforts of the machine being used with "astronomically more possible outcomes than any algorithm could ever hope to try."[6]

1 'Chatbot that overturned 160,000 parking fines now helping refugees claim asylum', retrieved from *https://www.theguardian.com/technology/2017/mar/06/chatbot-donotpay-refugees-claim-asylum-legal-aid*, accessed on 10 March, 2017

2 The Chicago police department have used predictive policing to visit those at a high risk of committing an offence to offer them opportunities to reduce this risk, such as drug and alcohol rehabilitation or counseling. See Saunders, J., Hunt, P., & Hollywood, J. S. (2016). Predictions put into practice: a quasi-experimental evaluation of Chicago's predictive policing pilot. Journal of Experimental Criminology, 12(3), 347-371 and Stroud, M. (2016, 19 August) Chicago's predictive policing tool just failed a major test. The Verge (retrieved from *http://theverge.com*, accessed on 11 October, 2016). Areas of the UK, such as Kent, are beginning to use predictive policing. E.g. see O'Donoghue, R. (2016, 5 April) Is Kent's Predictive Policing project the future of crime prevention? KentOnline (retrieved from *http://kentonline.co.uk*, accessed on 10 March, 2017).

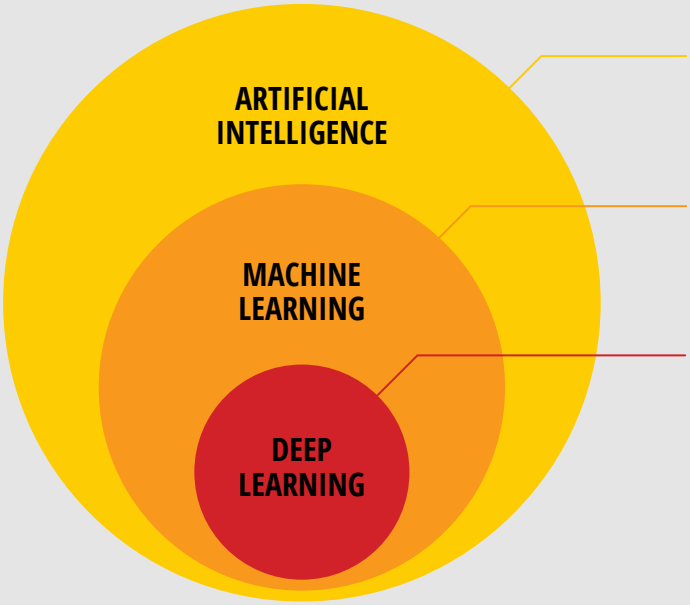
3 Dobbs, Richard, James Manyika, Jonathan Woetzel, (2015) 'The four global forces breaking all the trends', McKinsey Global Institute

4 Russell, S. J., and Norvig, P., (1995) Artificial Intelligence: A Modern Approach, Englewood Cliffs, NJ: Prentice Hall.

5 Mitchell, T. (1997) Machine Learning. London, UK: McGraw-Hill Education.

6 Preparing for the Future of artificial intelligence, (Oct 2016), Executive Office of the President National Science and Technology Council Committee on Technology *https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf*

Figure 1 — Artificial intelligence (AI), machine learning and deep learning[7]



ARTIFICIAL INTELLIGENCE is the study of devices that perceive their environment and define a course of action that will maximize its chance of achieving a given goal.[8]

MACHINE LEARNING is a subset of artificial intelligence, in which machines learn how to to complete a certain task without being explicitly programmed to do so.

DEEP LEARNING is a subset of machine learning in which the tasks are broken down and distributed onto machine learning algorithms that are organised in consecutive layers. Each layer builds up on the output from the previous layer. Together the layers constitute an artificial neural network that mimics the distributed approach to problem-solving carried out by neurons in a human brain.

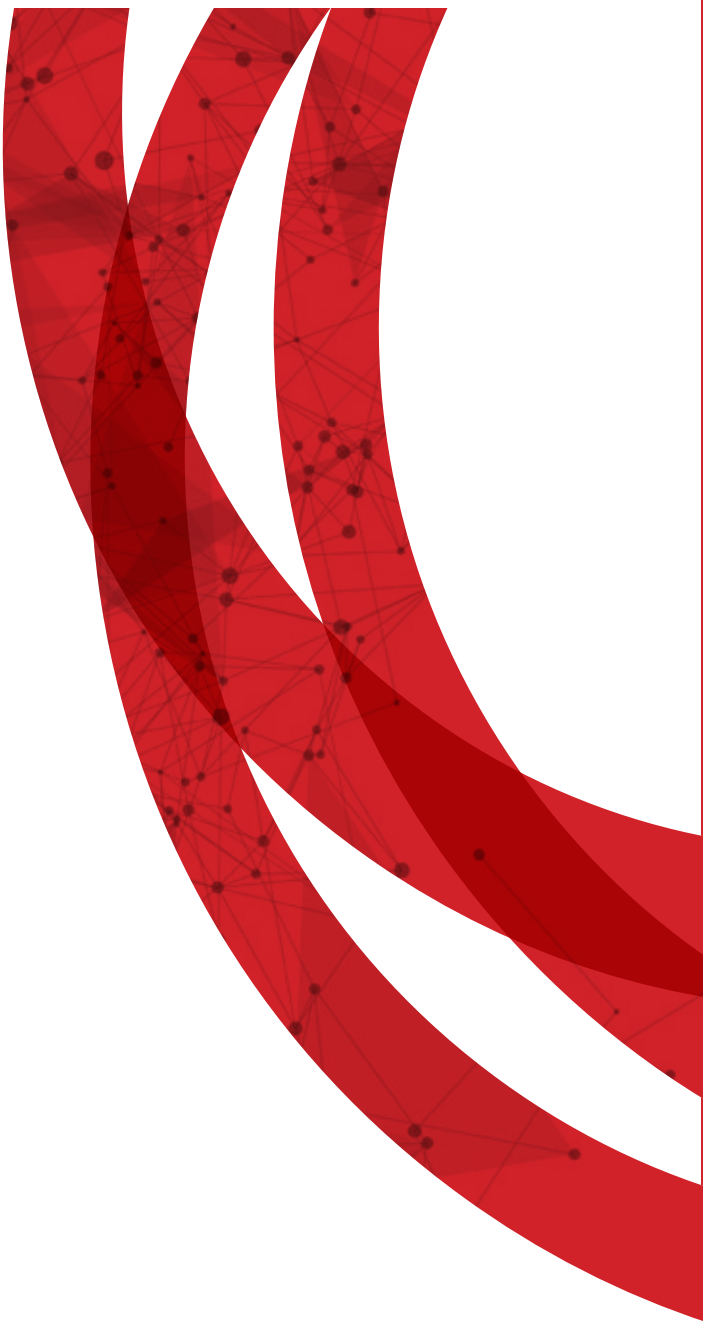
A considerable body of literature exists on the social and economic impact of AI.[9] To date almost all of this work has been focused on the implications of AI for people living in higher income countries such as the EU, UK and US. The focus of this paper is on the impact of AI on people living in low and middle-income countries for whom many of the same opportunities and risks apply (often to a greater extent), along with additional opportunities and risks unique to these countries. As one of our interviewees noted, the discourse around technology is universalising, but social and economic contexts are crucial.

The report provides a detailed outlook of the risks and opportunities artificial intelligence (AI) poses for low and middle income countries, as well as the key elements that can be leveraged upon to maximise the benefits and minimize the risks generated by AI. The insights provided throughout the paper are the result of over two dozen in-depth interviews with key experts and practitioners based in these countries and an extensive literature review.

7 Loosely based on an infographic developed by David Sangokoya, DataPop Alliance
8 Poole, David; Mackworth, Alan; Goebel, Randy (1998). Computational Intelligence: A Logical Approach. New York: Oxford University Press.
9 'An intelligent future? Maximising the opportunities and minimising the risks of artificial intelligence in the UK', 25 October, 2016. Available at *https://www.futureadvocacy.com/s/An-intelligent-future-3.pdf*

01

THE OPPORTUNITIES



1.1 Employment, Economic Growth and Redistribution of Wealth

AI is already enabling a wave of innovation across many sectors of the global economy. It helps businesses use resources more efficiently (e.g. through automated planning, scheduling, optimised workflows, optimised supply chains, optimised logistical pathways) and enables entirely new business models to be developed, often built around AI's powerful ability to interrogate large data sets. Many businesses in low and middle income countries will benefit from these AI capabilities, translating into greater opportunities for small entrepreneurs to develop new businesses. The São Paulo-based start-up QuintoAndar, for example, has changed the property rental market by using machine learning to optimise pricing, leading to benefits for both the homeowners (whose properties spend less time on the market) and for tenants (who have access to better prices).[10] In Nigeria, Kudi.ai uses natural language processing and other AI-based technology to provide mobile banking and conversational payment services to users who are unfamiliar or unable to interact with traditional browser-based online banking systems, but can interact with a familiar text-based messaging system.[11] Across Africa, micro-credit platforms, while sometimes controversial, are leveraging AI to define how to measure risk when potential clients do not have a traditional credit 'footprint'.[12] AI is also used for fraud detection and operational optimisations as part of these platforms.[13]

These advancements promise to provide further dynamism to local economies by reducing transaction costs associated with lack of information. This applies to the issue of basic government data. There are expectations that AI may help to cost-effectively improve the quality of national statistics (for example on employment and wealth) that are needed for good economic planning and policy-making.

1.2 Delivery of Public Services and Public Goods

There are plenty of instances where AI is being used to improve delivery of public services and public goods in low and middle income countries, ranging from pilot projects to larger scale roll out. AI seems particularly fit for simplifying transactions on government websites.

AI has also been deployed as a response to public health concerns, such as to anticipate outbreaks of diseases such as Zika and dengue fever. For example, the Brazilian NGO Viva Rio partnered with start-up AIME (Artificial Intelligence in Medical Epidemiology) which analyses existing local government datasets in combination with satellite image recognition systems to deploy low cost predictions of where we should expect greater incidence of disease in an upcoming three month period. Notably, the technology was designed to work in Malaysia, but it had success rates of 84% diagnosis in Brazilian trials[14]. Following its low cost success in Brazil, AIME has been deployed in Dominican Republic.

10 Interview with Helio Perroni Filho, 30 March, 2017
11 Interview with Pelumi Aboluwarin, 1 March, 2017
12 Interview with Yasaman Hadjibashi/Rani Shah, 21st March 2017
13 Wright, B. "Can AI bring fintech to Africa and help bank the 'unbanked'?" IDG Connect, available at *http://www.idgconnect.com/abstract/19810/can-ai-bring-fintech-africa-help-bank-unbanked* (accessed on 29 March, 2017)
14 2015, AIME Pilot To Work in Sao Paulo (Brazil) Starting Next January 2016, viewed 8th June 2017, *http://aime.life/Post/get/88*

In other cases, AI has been used to improve police coverage, such as in dealing with transit issues. In Uganda[15] AI is used to advise individuals or emergency vehicles on optimal routes, dynamically redeploying a limited number of traffic police officials, and analysing possible reconfigurations of the road network to remove bottlenecks.

In other cases it has been used for environmental ends. In Kenya, for example, the World Wildlife Fund (WWF) supports the use of an AI device with drones. After nine months, over a dozen hunters had been apprehended in the Maasai Mara. WWF has received a $5 million grant from Google.org to employ this AI-powered device to protect wildlife.[16]

AI has also been used for agricultural matters, including identifying crop disease with a smartphone.[17] Mcrops, developed in Uganda, is a diagnostic tool for diagnosing viral crop diseases in cassava plants.[18] Sick plants are flagged in real time, which allows farmers to take action and stop the spread of the disease.[19] In Nigeria, AI is being employed to help farmers sell their produce and buy services via a bot platform that relies on SMS and other channels such as USSD, Slack, etc. [20]

Finally, AI has been used to prevent and predict natural disasters. The Red Cross/Red Crescent Climate Centre has an on-going project with Togo's Nangbéto Dam, which frequently overspills, causing great disruption to the livelihoods of people living downstream. In the past models were poor at predicting the likelihood of overspill, but using a combination of crowdsourced information (including by mobile phone) and AI techniques, an improved model of overspill prediction was developed.[21] Also, the Netherlands Red Cross' 510 data initiative has developed models using data from previous natural catastrophes to allow better resource management and prioritization of aid.[22] It was employed after Typhoon Haima in the Philippines in 2016, and proven to be accurate after a comparison with data on damaged property.[23]

1.3 Strengthening Democracy

In many countries, in order to fully participate politically and economically, citizens still generally need to read/speak English, French, Portuguese or another colonial language, which is often the main language of government. This is a major barrier for participation in civic life for those who speak an indigenous language or who are illiterate.

AI-based automated translation and voice recognition systems could have significant impact in countries with multiple languages. This is the case for numerous low and middle income countries, including India, Indonesia and Nigeria. These systems could also have an impact in places with high levels of illiteracy, allowing people to engage with the government or public service provision interfaces by spoken rather than by written means. This would particularly benefit marginalised groups who experience disproportionate rates of illiteracy. Globally, 87% of men can read and write, compared to only 77% of women who can do so. This contrast is especially pronounced in Afghanistan and Niger, in which around three times more women than men are illiterate.[24]

Shashi Shekhar Vempati, an Indian digital policy expert,[25] gave a striking example of this. He explained the process by which topics for discussion during Indian Prime Minister Modi's monthly radio address are chosen. A call for contributions is placed in advance of addresses, and suggestions of issues to discuss flood in from all over the country in over 27 different languages and dialects via a mobile app, an online government portal, and even postcards. The sheer volume of these contributions makes it exceedingly difficult to take them all into account. But technology that organises, translates and even analyses them to extract common themes would ensure that the views of hitherto excluded groups are represented.[26] Similarly, Professor Tommie Meyer, of the Centre for Artificial Intelligence Research (CAIR) in South Africa, indicated that this is an area CAIR is working on. By enabling greater access of minority language speakers (South Africa has 11 official languages and many local dialects) to public services and publicly available information, the team at CAIR hopes to better engage these democratically marginalised people with the democratic process.[27]

One challenge to these approaches is that machine translation models tend to be refined with scale of usage, and currently mainly rely on written language to train the models. This may not be viable for some less widely used languages yet, but machine translation models already exist for some of the more widely spoken languages in low and middle income countries.[28]

15 Quinn, J., Frias-Martinez, V. and Subramanian, L. (2014) 'Computational sustainability and artificial intelligence in the developing world', AI Magazine, 35(3), pp. 36–47.
16 Lorica, D. (2016) 'Artificial Intelligence Used To Catch Poachers In Kenya' available at *http://www.telegiz.com/articles/11332/20161128/illegal-poaching-artificial-intelligence-wwf.htm#ixzz4bsTbOl8A*
17 Gill, C. (2016) 'Artificial intelligence could help farmers diagnose crop diseases', available at *http://news.psu.edu/story/429727/2016/10/04/research/artificial-intelligence-could-help-farmers-diagnose-crop-diseases*, accessed 13th March 2017
18 Gill, C. (2016) 'Artificial intelligence could help farmers diagnose crop diseases', available at *http://news.psu.edu/story/429727/2016/10/04/research/artificial-intelligence-could-help-farmers-diagnose-crop-diseases*, accessed 13th March 2017
19 Mcrops website accessed 22/3/17 at *http://air.ug/mcrops*
20 Email communication from Sanusi Ismaila, 2 February 2017
21 Interview with Michael Veale, 24 February, 2017.
22 Interview with Maarten van der Veen, 9th March 2017
23 For more information see *https://510.global/tag/disasters/27/3/17*, accessed 13th March 2017
24 Graham, M., Hale, S. A. and Stephens, M. (2011) Geographies of the World's Knowledge *http://www.oii.ox.ac.uk/publications/convoco_geographies_en.pdf*, accessed 14th March 2017
25 Since our interview with Shashi Shekhar Vempati, he has been appointed CEO of Prasar Bharati, India's Public Broadcaster.
26 Interview with Shashi Shekhar Vempati, 28th February 2017
27 Interview with Tommie Meyer, 24 February 2017
28 Khemani, D. (2012) 'A Perspective on AI Research in India' AI Magazine 33(1);96-8

02

THE RISKS

2.1 Employment, Economic Growth and Redistribution of Wealth

A lot of attention has been given to the upheaval of employment markets that AI will cause in high-income countries. However, the World Bank Development Report (2016) estimates that the 'share of occupations that could experience significant automation is actually higher in lower income countries than in higher ones, where many of the jobs susceptible to automation have already disappeared, and this concerns about two thirds of all jobs'.[29] The impact on low and middle income countries could indeed be profound but is likely to vary significantly in different countries depending on their demographics and the makeup of their economies. Table 1 shows the World Bank's predictions for the automatable share of employment in some countries of particular interest for the Web Foundation.

Although the World Bank has adjusted these figures based on an 'adoption time lag', it does feel that these predictions should be taken with further caution. It was pointed out in our interviews that many low and middle income countries lack the communication, energy and other infrastructures that are required to support highly automated industries[30]. Also, regulation (local and/or global) would directly impact the evolution and adoption of these technologies in ways that are difficult to foresee.

However, it is reasonable to assume that a significant level of automation will take place in low and lower middle income countries. Improvements to microprocessors means that as workers shift from executing the tasks directly to operating or supervising machines, companies could soon rely on groups of workers that are smaller in number but more technically skilled.[31] The 2016 World Bank Development Report finds that the distributional impacts of robots on employment and income in low and middle income countries will 'at least initially, tend to move against inclusiveness, as in high income countries countries'. Job creation will likely be concentrated in high-skilled activities with comparatively fewer benefits for low-skilled and medium-skilled workers[32].

Automation in high income countries could erode the labour-cost advantage of low and middle income countries, taking away a traditional route to development. The path pursued by the East Asian Tigers, and later by China and India, simply may not be available in the future. Ian Goldin, founding Director of the Oxford Martin School and currently Professor of Globalisation and Development at Oxford University, noted that the price of capital, not the price of labour, will determine the location of production as technology gets better. Places where capital markets are more developed thus have a great advantage over places where capital markets are thin.[33]

The impact of automation will not just be felt in manufacturing. Jobs in lower-skilled service sectors like call centre work are also ripe for automation, as well as some of the tasks involved in higher-skilled professions. Indeed the very things that made certain jobs easy to outsource may make them easy to automate. The consequences of this could be stark. India's IT boom was based on Indian IT professionals providing services to customers in high

29 World Bank (2016), World Development Report 2016: Digital Dividends. Washington, DC: World Bank. doi:10.1596/978-1-4648-0671-1. License: Creative Commons Attribution CC BY 3.0 IGO

30 Interview with Michael Veale, 24 February, 2017

31 United Nations Conference on Trade and Development (UNCTAD) (2016), 'Robots and Industrialisation in Developing Countries', UNCTAD, Geneva *http://unctad.org/en/PublicationsLibrary/presspb2016d6_en.pdf*

32 Ibid

33 Interview with Ian Goldin, 15 March 2017

Table 1 — Estimated share of employment that is susceptible to automation in key countries of interest.

COUNTRY	AUTOMATABLE SHARE OF EMPLOYMENT UNADJUSTED FOR ADOPTION TIME LAG (%)	AUTOMATABLE SHARE OF EMPLOYMENT ADJUSTED FOR ADOPTION TIME LAG (%)
ETHIOPIA	84.9	43.9
INDIA	68.9	42.6
SOUTH AFRICA	66.5	47.9
NIGERIA	65.0	40.2
DOMINICAN REPUBLIC	62.2	44.7
OECD AVERAGE	**57.0**	**57.0**

Source: World Bank. 2016. World Development Report 2016: Digital Dividends. Washington, DC: World Bank. doi:10.1596/978-1-4648-0671-1. License: Creative Commons Attribution CC BY 3.0 IGO

income countries. Shashi Shekhar Vempati claimed, however, that "algorithmic tools have replaced a lot of these professionals in the last 12 to 18 months".[34] We have been unable to independently verify this claim, but it is certainly clear that many Indian and multinational companies are actively developing chatbots to handle interactions with customers.[35, 36, 37] This point is echoed by Urvashi Aneja, Founding Director of Tandem Research in India.[38] She indicated that the "employment crisis" in India is well recognised, describing a "youth bulge" of young men aged 17-25 who are likely to constitute the majority of the people looking for the 250 million jobs that need to be created by 2030. "The problems are severe enough even without thinking about AI; add in AI and the problems become more urgent."[39]

While the impact on the employment market for many Indian men could be significant, the picture for women across the world could be even more devastating. Just 14% of women were in full-time formal employment – an indicator of a 'good' job – compared with 33% of men across 17 countries in the Middle East, Northern Africa, and Sub-Saharan Africa regions of the world (considered to be regions with the highest gender inequality).[40,41] This means that while automation could affect more men than women, the reduction in job opportunities could exacerbate inequalities as more men compete with women for fewer jobs.

This could be compounded by sector growth and decline. The World Economic Forum (WEF) Future of Jobs Report found that labour market disruptions are likely to be concentrated in some of the job families with the largest share of female employees, such as office and administrative functions.[42] Jenny McAllister, Labour Senator for New South Wales (Australia), also argues that sector growth could exacerbate wage inequality. While there might be more demand for care sector roles, dominated by women, these roles are likely to be low paid. On the other hand, there is likely to be a growth in demand for high wage STEM (Science, Technology, Engineering, and Math)-related jobs, where women are strikingly underrepresented.[43] Sector growth could thus entrench the 'gender pay gap'. The 2016 WEF Report on gender disparities in industry found that if current ratios persist over the 2015–2020 period there will be nearly one new STEM job created for every four jobs lost for men, but only one new STEM job created for every 20 jobs lost for women.[44]

Of course, women are not a homogenous group, and these impacts will vary greatly among women of different ages and ethnicities in different countries. Female labour force participation varies across different regions, from 26% in the Middle East and North Africa, to 35% in South Asia, to 61% in Sub-Saharan Africa[45]. At a country level, these numbers range from just 27% in India and 44.5% in South Africa; to 48.2% in Nigeria, 51.3% in Dominican Republic, 51.4% in Indonesia, and 59.4% in Brazil. Furthermore, a 2013 study of global employment trends found that 49.1% of the world's working women were in vulnerable employment, often unprotected by labour legislation, compared to 46.9% of men. Women were more likely than men to be in vulnerable employment in East Asia (50.3% versus 42.3%), South-East Asia and the Pacific (63.1% versus 56%),

34 Interview with Shashi Shekhar Vempati, 28 February 2017

35 Deoras, S. (2016) "10 Chatbots from India making it big!", Analytics India Magazine, available from *http://analyticsindiamag.com/10-chatbots-india-making-big/* (accessed on 29 March, 2017)

36 Interview with Amber Sinha and Sumandro Chattapadhyay, 29 March, 2017

37 Chathurvedula, S. (2016) "Five Indian start-ups using bots in different ways", available from *http://www.livemint.com/Companies/7cmSlfcqGiBJr4LjGsSTAK/Five-Indian-startups-using-bots-in-different-ways.html* (accessed on 29 March, 2017)

38 Tandem Research is a think tank focusing on policy for issues of technology, sustainability and governance.

39 Interview with Urvashi Aneja, 27 February 2017

40 Stotsky, J.G., Shibuya, S., Kolovich, L. and Kebhaj, S. (2016) 'Trends in gender equality and women's advancement.' Washington, DC: IMF

41 Hunt, A. and Samman, E. (2016), 'Women's economic empowerment: Navigating enablers and constraints', Overseas Development Institute Research Report, ODI, London

42 World Economic Forum (2016), 'The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution', available at *http://www3.weforum.org/docs/WEF_FOJ_Executive_Summary_Jobs.pdf* (accessed 4 March 2017)

43 McAllister, J. 'Automation will embed gender inequality at work – unless we fix it now', The Guardian, 8 November, 2016, available from *https://www.theguardian.com/sustainable-business/2016/nov/09/automation-will-embed-gender-inequality-at-work-unless-we-fix-it-now* (accessed 5 March 2017)

44 The Industry Gender Gap Women and Work in the Fourth Industrial Revolution (2016) World Economic Forum (*http://www3.weforum.org/docs/WEF_FOJ_Executive_Summary_GenderGap.pdf* accessed 9 March 2017).

45 World Bank (2012), World Development Report 2012: Gender Equality and Development. Washington, DC: World Bank (pg 10) *https://siteresources.worldbank.org/INTWDR2012/Resources/7778105-1299699968583/7786210-1315936222006/Complete-Report.pdf*

South Asia (80.9% versus 74.4%), North Africa (54.7% versus 30.2%), the Middle East (33.2% versus 23.7%) and Sub-Saharan Africa (nearly 85.5% versus 70.5%).[46] More targeted interventions aimed at disadvantaged groups, like STEM skill programs for women, and government investment in digital literacy, could help ensure that these groups do not get left further behind.

There is also the risk of 'brain drain' in the AI space.[47] Sharma Punit describes the case of 25-year-old Tushar Chhabra, co-founder of Cron Systems, which builds internet of things-related solutions for the defence sector.[48] He is quoted as saying that an Indian Institute of Technology (IIT)-educated engineer based in the US and working on AI for seven years "asked for Rs2.5 crore [~$375,000] per annum as salary. As a start-up you cannot afford that price." Thus, the higher pay and increased opportunities in high-income countries act as a significant pull factor, leading to a dearth of trained, experienced AI engineers in lower income countries, where they may have been trained at significant public expense. Dr Helio Perroni Filho, a postdoctoral researcher in machine learning at the Federal University of Espírito Santo, Brazil, claimed that this is a pressing issue in his country, too.[49] Furthermore, as the Indian Digital Policy expert Vempati points out, if AI talent is concentrated in a few private corporations that have the ability to pay the most, AI research may not be as diverse and research priorities 'could be narrowly focused on a few commercial ideas while many areas of social and national importance could suffer for want of talent'.[50]

The concentration of skills in certain countries and global companies could lead to a situation where other (native) companies are crowded out. And increasing automation could further worsen the deal for native industries. Currently the value produced by platforms like Uber are split between the company that owns the app and the drivers. If self-driving cars powered by AI are introduced (trials are taking place all over the world, although mainly in high income countries)[51] income will be redistributed away from the drivers. This could result in a situation where value produced in low and middle income countries is extracted into high income countries, echoing the exploitation of minerals and natural resources in Africa by Western countries in the nineteenth century.

2.2 Delivery of Public Services and Public Goods

While AI can help to deliver a range of public services and goods to address challenges in low and middle income countries, John Quinn–a Data Scientist at the United Nations Global Pulse lab in Kampala, Uganda–cautions against such solutions coming from a developed-world perspective[52]. This could lead to solutions which do not match the realities on the ground. For example, when designing a system to optimise the flow of traffic, local driving habits and customs can vary widely, which must be taken into account.

There is also a risk that there will be over-reliance on AI. It is important to recognise the limitations of data analysis. AI today is capable of recognising patterns, and large and diverse datasets can throw up many patterns indeed. Some are meaningful, others are not. Correlation does not equal causation. This should be borne in mind as our use of AI for data analysis increases, especially when used to inform public policy. Google's ability to predict flu outbreaks, for instance, failed after what seemed like strong initial successes.[53]

While AI can enhance some public services, AI and automation may also threaten the funding of centrally-delivered public services. Low and middle income countries traditionally have larger informal economic sectors than richer countries, with many workers being paid in cash, leading to difficulty in identifying the income tax base and in effectively collecting this tax which has often led to many of these countries relying on flat consumption taxes, such as VAT, which are easier to collect. If automated agents, such as chatbots or mechanical robots, perform the majority of work then the potential tax base is eroded further, leading to lower government revenues and ability to spend on the delivery of public services.

Finally, these goods and services should not just be available to those who can pay for them. Particular consideration of how systems can be made accessible to the lowest income groups and marginalised populations is paramount to ensuring that inequalities are not entrenched by this technology.

46 ILO, Global Employment Trends, 2014. Table A12, p. 99. *http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_233953.pdf*

47 This is defined as "the departure of educated or professional people from one country, economic sector, or field for another usually for better pay or living conditions" [Docquier, F. 2006. "Brain Drain and Inequality Across Nations." IZA Discussion Paper Series. IZA DP 2440].

48 This exemplar case is described by Itika Sharma Punit in her article 'Why are Indian engineers so afraid of 'artificial intelligence'?', Quartz India, February 19th 2017, available at *https://scroll.in/article/829652/why-are-indian-engineers-so-afraid-of-artificial-intelligence* (accessed 20 February, 2017).

49 Interview with Helio Perroni Filho, 30 March, 2017

50 Vempati, Shashi S., (2016) India and the Artificial Intelligence Revolution, Carnegie India

51 Mui, C. (2016) 'Uber Is Positioned To Slingshot Ahead Of Google In Driverless Cars' Forbes, available from *https://www.forbes.com/sites/chunkamui/2016/08/22/uber-slingshots-google/* (accessed 6 March 2017)

52 Quinn, J., Frias-Martinez, V. and Subramanian, L. (2014) 'Computational sustainability and artificial intelligence in the developing world', AI Magazine, 35(3), pp. 36–47.

53 Lazer, D. and Kennedy, R. (2015) 'What We Can Learn From the Epic Failure of Google Flu Trends' Wired, available at *https://wired.com* (accessed 11 October, 2016).

2.3 Weakening Democracy

There are several ways in which AI could undermine democracy in low and middle income countries. Authoritarian regimes could use AI for surveillance, for example by identifying and targeting political opponents based on personal data. These risks could become greater as smartphone penetration increases. One of our interviewees described the case in Uganda, where the National Statistics Authority came under significant pressure from central Government to provide regional/community-level information of voting records and intentions of different areas in the country. There was significant concern that this information would then be used to identify political opponents.[54]

AI could be used to identify and deny services to certain demographics. In Ethiopia, where the state operator EthioTelecom has a monopoly on internet access, authorities have intermittently shut down mobile phone and internet connections, blocked social media like Facebook, WhatsApp, and Twitter, and used evidence from these channels to implicate and charge dissidents and critics.[55] There is evidence to suggest that intelligence services are using machine intelligence techniques to break encryption and find patterns in social media posts that can be used to identify dissidents.[56]

There are also concerns that AI may be used to spread 'fake news' and misinformation around election periods. There have been concerns expressed about how this has allegedly happened around the recent Brexit referendum in the UK and the Presidential election in the USA, through the microtargeting of individual voters with persuasive information based on an assessment of interests, personality type, and other criteria.[57] Though access to the internet may be more limited in lower income countries, the trend does not seem to be exclusive to higher income countries. Daudi Were, Executive Director of NGO Ushahidi described the case in Kenya where there is an 'industry of fake news'.[58] AI can be a powerful electoral tool and though the risks are hard to quantify, these anti-democratic trends could certainly impact elections in low and middle income countries.

54 Kelly, S., Truong, M., Shahbaz, A., Earp, M. (2016), 'Freedom on the Net. Silencing the Messenger: Communication Apps under Pressure' Freedom House, Washington, D.C.

55 Kuo L. 'Only China, Syria, and Iran rank worse in internet freedom than Ethiopia', 16 November, 2016, available at *https://qz.com/838908/internet-freedom-in-ethiopia-is-the-fourth-worst-in-the-world-after-iran-syria-and-china/*, (accessed on 15 March 2017)

56 Interview with Ian Goldin, 14 March, 2017

57 Doward, J. and Gibbs, A., 'Did Cambridge Analytica influence the Brexit vote and the US election?', The Observer, 4 March, 2017, available from *https://www.theguardian.com/politics/2017/mar/04/nigel-oakes-cambridge-analytica-what-role-brexit-trump* (accessed 15 March, 2017)

58 Interview with Daudi Were, 17 March 2017

03

THE CONTEXT

Across many applications and countries the answer to the question "will AI be more of an opportunity or more of a risk?", is of course "it depends". And what it usually depends on is whether the right enabling environment is in place to maximise the opportunities and minimise the risks.

Currently in many countries there is a lack of enabling environment to help scale up positive applications of AI. The weak enabling environment also leaves low and middle income countries more vulnerable to many of the risks of AI.

3.1 Data

The quality and quantity of available data is critical to the success of AI systems. Huge volumes of data are now available in low and middle income countries thanks to the vastly expanded number of mobile phone users (which rose from 2.8 billion in 2012 to 3.6 billion in 2016 according to the 2017 GSMA survey).[59] This data, which can reveal insights from traffic information to mobility patterns, presents numerous opportunities in low and middle income countries, as this paper has outlined.

Professor G. Ayorkor Korsah drew a helpful distinction between the need and readiness of certain sectors.[60] The sectors where there is the most need for action, like education, health and food security, are not always the sectors where large amounts of data are generated in a helpful format. In Ghana, for example, many records are still paper-based; on the other hand, banks and mobile phone companies collect reams of useful data across the low and middle income countries. On-going efforts to implement electronic record systems for agricultural extension officers and nurses can help to make data useful, but this also raises questions about how the reams of existing data might be put to best use.

Pilot projects like that of Yetunde Sanni and Farouq Oyebiyi, who are currently undertaking research on the use of machine learning to improve the diagnosis of malaria from blood samples, are held back by their restricted access to data. The lack of open data in Nigeria means that they are currently working to approach

59 GSMA (2017) The mobile economy: *https://www.gsma.com/mobileeconomy/*
60 Interview with Professor G. Ayorkor Korsah, 28 February 2017

hospitals independently, and with limited success.[61] Without an adequate sample size, the efficacy of machine learning systems will be severely limited. Moreover, any discrepancies between training data and production/operational, 'real-world' data may lead to machine learning algorithms producing incorrect outputs. Real problems could arise when there is a lack of local data or local resources to ensure that the models are trained in a way that reflects the circumstances and needs of the local population.[62]

This urge for more data increases indirect risks associated with AI and its enabling ecosystem. Information that people would rather have kept confidential could be revealed or leveraged upon for uses others than those the data-subjects would approve of. Certain forms of data, such as commercial and medical information, are collected and stored under conditions of anonymity. However, advances in AI make anonymity increasingly fragile and it may become possible to re-assign identity to particular sets of information because of AI's ability to cross-reference between vast quantities of data in multiple data sets.[63]

These developments worsen existing concerns about privacy and raise new ones. Furthermore, high levels of corruption in some developing countries as well as a weak data infrastructure through which data might be more likely to leak means that there is work to be done around securing data properly. For example, in Nigeria, there is no data protection law (only in a draft form) and there have been a number of documented data breaches, such as information being put online in an un-anonymised form and also information being left in physical form openly (such as government files dumped on streets and then reused by street vendors to wrap food).[64]

One of our Kenyan interviewees noted that data protection and privacy issues is a particular area where marginalised groups are heavily impacted, given the lack of policy and legislation in those areas. They pointed to the fact that a data protection law has been making its way through parliament for six years in Kenya. It is critical that data protection laws are pushed through to ensure the data of marginalised groups is not unduly exploited for profit or politics.[65]

3.2 Infrastructure

Some of the optimism about the application of AI in developing countries rests on the ubiquity of mobile phones. Yet, across low and middle income countries, internet and mobile penetration varies significantly between urban and rural areas, age groups and genders. In its 2015 Gender Gap study, the GSMA found that women in low and middle income countries were 14% less likely than men to own a mobile phone — and 38% less likely in South Asia — equating to 200 million fewer women than men owning mobile phones in these markets.[66] In terms of internet use, according to the Web Foundation's Women's Rights Online survey, in urban poor communities "women were nearly 50% less likely to access the Internet than men."[67] In order for those in low and middle income countries to benefit equally from AI, further work must be done on making sure marginalised populations have access to this technology.

In many countries, it is still difficult to connect to the [global] internet from mobile phones, which weakens the potential of AI. The authors of an Oxford Martin School and Citi report have found that the divergence in penetration rates of technology adoption can account for 82% of the increase in income gap across the globe.[68] Thus, efforts to expand internet access, like that of the Alliance for Affordable Internet, are crucial in ensuring AI advances do not benefit only the richest, smart phone owning section of a population.

AI may be good at identifying problems and recommending solutions, but the actual implementation of those solutions (e.g. medical treatment) may require technical, economic and socio-political infrastructure that is lacking or weak in many low and middle income countries. Before designing solutions to be rolled out, it is fundamental to ensure that some key elements of an enabling infrastructure, such as governance institutions, policies and laws required for an effective roll-out are in place. For instance, in order to improve safe water coverage in Liberia after the civil war, an organisation called Akvo is working to install monitoring systems to generate up-to-date information about the infrastructure gaps. Furthermore, whether AI will provide, for example, medical services appropriately and effectively in any given country will depend on whether doctors have the right socio-technical infrastructure to help operate and deliver AI based recommendations to local citizens in a fashion that complies with cultural norms, privacy and security laws. In most cases, neither the required governance instructions, nor the digitization of local medical customs, exist. If local practices are not encoded digitally they cannot be taken into account by AI code and will hence lack a digital voice.[69]

61 Interview with Farouq Oyebiyi, 23rd February 2017
62 Interview with Sean Legassick, 28 February 2017
63 Ohm, P. (2010). Broken promises of privacy: Responding to the surprising failure of anonymization. UCLA law review, 57, 1701.
64 Based on roundtable discussion on data privacy held on 28 April in Lagos with national stakeholders.
65 Interview with Daudi Were 17 March 2017
66 GSMA (2015) Bridging the gender gap: Mobile access and usage in low and middle income countries
67 Web Foundation, "Women's Rights Online", October 2015.
68 Technology at Work v2, p.16
69 Interview with Olaf Groth and Mark Nitzberg, 23 March 2017

INDIA AND THE NEED FOR AI INFRASTRUCTURE

In his policy paper, Shashi Shekhar Vempati argues that 'the infrastructure for an AI revolution in India has been neglected by policymakers'.

In particular, cloud-computing infrastructure, which can store vast amounts of data and possesses the large amount of computing power required by AI, largely resides in servers beyond India's borders. From the Amazon Web Service (AWS) elastic cloud to the Google machine learning infrastructure, nearly all of the online tools that have made AI accessible to the entrepreneurial community rely on infrastructure that exists outside India. While Microsoft pledged to invest in three data centres for its Azure cloud infrastructure in India, and Amazon promised to locate some of its AWS infrastructure in India in 2016, the delay in investment has had a harmful effect on the Indian business community. Vempati asserts that a number of start ups have located themselves outside India, 'in no small part due to easier access to cutting-edge technology and infrastructure with the simplicity of doing business abroad offering a further incentive for corporate flight'. He proposes that the Digital India initiative must be reconfigured to establish cloud infrastructure in India on a fast-track basis, calling the current situation both a 'critical infrastructure gap' and a 'national security risk'.[70]

3.3 Skills

In order to maximise the benefits of AI it is vital that populations in low and middle income countries have the skills to develop and deliver programs. This is the case for all levels of society. For poor communities, STEM skills could be a path to economic empowerment. For programs intended to work under government supervision, there is the need to be mindful of the limited government capacity in many low and middle income countries.

There are commendable initiatives aiming to combat skills-based inequality, often geared towards marginalised groups. African-led NGO #iamthecode supports women and girls in learning how to code through STEAMD (Science, Technology, Engineering, Arts, Mathematics and Design), aiming to reach 1 million girls by 2030. On a smaller scale, Code Clubs benefitting 600 to 700 females aged five to 24 in Kenya, Uganda and Senegal have been set up by NGO Their World in partnership with Kano, Codeacademy, and Africa Gathering. In South Africa, a group of data analysts primarily based at Barclays Africa, Johannesburg, set up the 'Africa Success' initiative, which will use AI to provide mentorship, resilience training and educational support to underprivileged youth in three South African townships.[71] Although programmes like these are valuable, there is a need for larger scale roll-out and government investment in STEM.

Education for older generations must not be neglected. Tim Noonan, Director of the Campaigns and Communications Department of the International Trade Union Confederation, raised the question of whether coding was being taught to older generations: are we leaving a whole generation of older people behind?[72] Urvashi Aneja, Director, Tandem Research, and Associate Professor at the Jindal School of International Affairs, also noted that e-skills programs are sometimes limited in their reach. In India, classes teaching general digital skills to adults usually take place in the evening, when women are expected to be in their homes, cooking and looking after their children.[73] Jerry Kaplan, a US computer scientist and futurist, argues that an even more radical shift in education systems is necessary to ensure that skills stay relevant into later life.

70 Vempati, Shashi S. (2016) India and the Artificial Intelligence Revolution, Carnegie India
71 Interviews with Obins Choudhary (2 March 2017) and Yasaman Hadjibashi/Rani Shah (21 March 2017)
72 Interview with Tim Noonan, 9/3/17
73 Interview with Urvashi Aneja, 27 February 2017

3.4 Ethics

AI developers in low and middle income countries are not well plugged into the larger-scale coordinated networks of AI development. The 'Partnership for AI', for example (an initiative including Amazon, Facebook, Google, Microsoft, IBM, and Apple focused on establishing best practices for artificial intelligence systems and educating the public) has not successfully engaged actors from the developing world. IEEE, another global initiative focused on AI and ethics, engages with developers from low and middle income countries but is lacking in representation at the top level.[74] There is certainly the potential for closer collaboration with actors in low and middle income countries.

Questions of ethics overlaps with concerns about biases. Biases can occur when the data available is not an accurate reflection of what it is taken to represent, which might be the result of inaccurate measurement methodologies, incomplete data gathering or other data collection flaws. 'Cleaning the data'[75] and/or making the data collection process more robust can often help in tackling this type of bias.

Moreover, concerns about bias are compounded by the severe lack of diversity in the AI field, raising fears that bias may be considered less of a problem or may not be identified when it occurs. Kate Crawford has written compellingly about what she terms 'artificial intelligence's white guy problem', whereby a lack of representation can limit the perspectives and experiences of AI's creators, leading to a greater possibility of "like me" bias.

This question about who is designing AI systems leads to the risk that programs developed in high income countries will work inefficiently in low and middle income countries because they do not reflect their realities. Indeed, many of our interviewees have emphasised how important it is for communities affected by the problems to actively drive forward and design AI systems rather than passively receiving them.

It is particularly important that developers are sensitised to the ethical issues around artificial intelligence so that issues of bias, privacy, consent, or automation do not harmfully impact the population when AI is applied. However, at least in the case of interviewees from Brazil, there appear to be 'few or no' ethical considerations included as part of computer science or technological courses in the country.[76]

The need for more transparency and accountability as to the workings of AI in low and middle income countries has been emphasised by many of the people we have interviewed. AI decision-making systems are often deployed as a background process, unknown and unseen by those they impact: essentially making them a black box. This is particularly true of some complicated machine learning algorithms, which evolve over time. This 'black box' issue is exacerbated by the fact that significant stores of data are not in the public domain, meaning it is often impossible to test or challenge results.

As questions around ethics continue to be posed and addressed, it is essential that this discussion is opened up to different interest groups from within and outside of the AI community. Any attempt to make AI more ethical and responsive will have to be done through an inclusive process that incorporates the views, ideas and realities of a diverse group of countries and individuals.

74 *https://standards.ieee.org/develop/indconn/ec/ec_bios.pdf*, accessed 15 March, 2017
75 Data cleaning refers to identifying incomplete, incorrect, inaccurate, irrelevant, etc. parts of a data set and then replacing, modifying, or deleting them.
76 Interview with Eduardo Magrani and Renato Rocha De Souza, FGV, 3 March, 2017

04

A WAY FORWARD

Throughout this paper we have outlined some of the many challenges and opportunities AI poses for low and middle income countries. Though some of the risks and opportunities are common to high-income countries, the paper provides arguments and data that suggest many others are context-specific.

Given these local complexities, it is key to further develop local networks and South-South cooperation on these issues, as well as to ensure the interests and values of the inhabitants of low and middle income countries (in particular those of systematically excluded groups) are taken into account by global companies developing core AI advances, or leveraging on AI to execute tasks in low and low-middle income countries.

The rapid evolution of AI will continue and is something that needs to be leveraged for all countries and all people. The areas set out above are steps towards ensuring that the winners outnumber the losers, and AI's benefits reach everyone.

POTENTIAL AREAS FOR ACTION [77]

1. Create bridges between developers in low and middle income countries and high income countries

- Provide economic support to AI developers from low and middle income countries to attend global AI conferences where many of the informal networks are built and sustained.
- Provide the necessary resources (technical, financial and human) to embed closer relationships, collaboration and partnerships between AI initiatives in low and middle income countries.

2. Ensure the interests of low and middle income countries are represented in key debates and decisions relating to AI

- Advocate for the specific circumstances of low and middle income countries to be considered in global efforts to tackle news silos and fake news.
- Advocate for a more inclusive 'Partnership on AI' and IEEE, which actively involve developers from a variety of low and middle income countries.
- Support and further develop existing South-South collaboration efforts and initiatives on AI.

3. Facilitate access to open, good quality data to enable the development of AI technologies, while ensuring personal data is not misused

- Promote the transparent, and accountable use of personal data; and ensure proper data protection standards are in place (by governments and companies).
- Promote access to free, open, and anonymised, curated datasets so ethical developers have access to good data sets to train AI systems while also ensuring privacy.

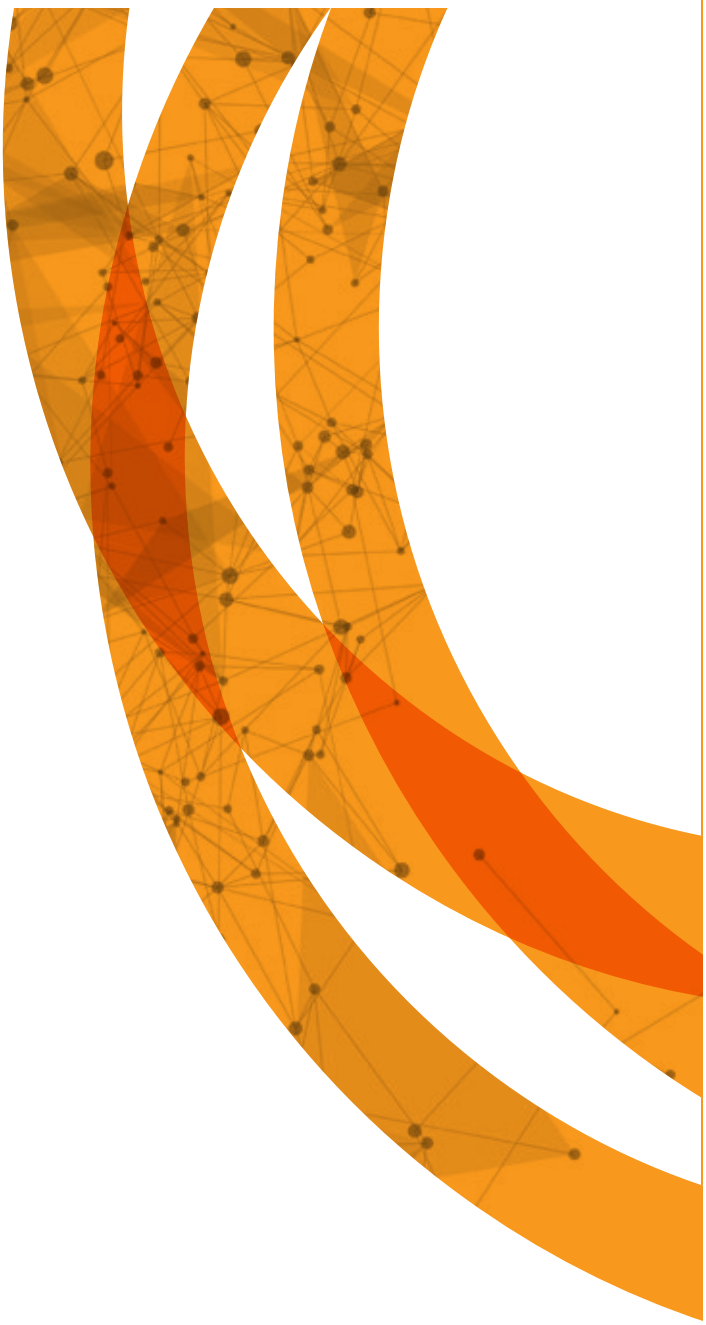
4. Maximise the opportunities for AI to be used for public good, with a particular focus on marginalised groups

- Support the development of impactful tools that use AI to improve the delivery of public services and public goods, in particular those that allow delivery of services to marginalised groups.
- Advocate for governments to adopt these AI tools to deliver public services and public goods, particularly to marginalised groups.
- Ensure systems of liability, accountability (including the 'right to an explanation'), justification, and redress for decisions made on the basis of AI.

77 The authors have considered in great detail the potential role for each recommendation in the context of each of the Web Foundation's main countries of interest (Brazil, Dominican Republic, India, Indonesia, Nigeria and South Africa), as well as other notable countries (China, Kenya, Uganda, Ghana, Mexico, Philippines, Colombia), with particular reference to whether the best approach is one of 'depth' or 'breadth' (as described above). The process and data informing these decisions can be found in the *Conceptual Framework* spreadsheet.

05

REFERENCES AND APPENDICES



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Appendices

A: List of Interviewees:

http://bit.ly/AnnexA_ai_Interviewees

B: Economic metrics:

http://bit.ly/AnnexB_ai_EconomicMetrics

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