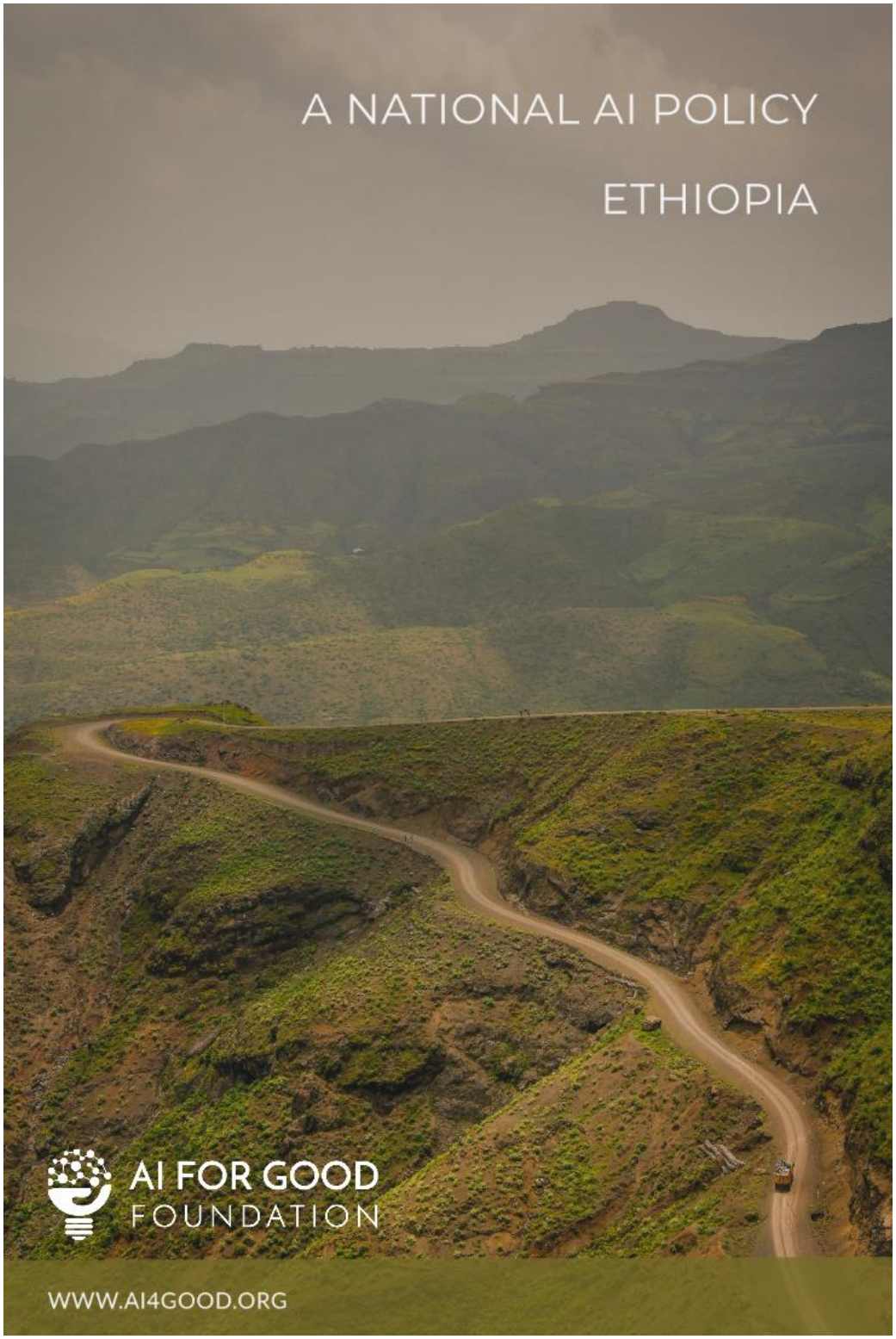
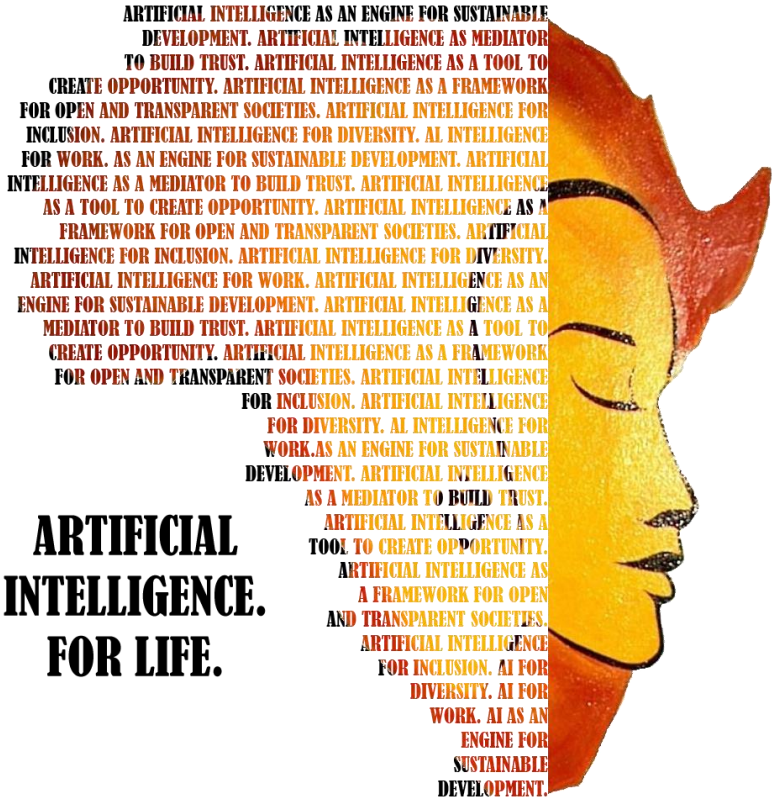

A NATIONAL AI POLICY
ETHIOPIA
AI FOR GOOD
FOUNDATION
WWW.AI4GOOD.ORG

Draft

Commented [SZ1]: Once core content approved by gov, an Executive Summary will be added.

December 2020



Abstract

This National AI Policy Recommendation document represents the joint efforts of the Ethiopian Government, Tony Blair Institute for Global Change, and the AI for Good Foundation. A National Artificial Intelligence Policy framework requires a contextually aware definition of AI, and a strict focus on those areas where impact is likely and practical. The potential of humans can be unleashed through the facilitation of the right opportunities at the right time; and the current state of Artificial Intelligence technologies makes this the right time for Ethiopia to bring the benefits of a technology-enabled economy and society to bear for today's and future generations. AI has the ability to accelerate innovation, increase the scalability of enterprises, boost labour demand, bring core government services to the hands of each individual (healthcare, e-gov, education), and reduce the costs of implementation and operation of critical infrastructure. Getting there will take time, investment, and the effort of all; but Ethiopia is in a unique position to act as a global example of the transformative positive effect that AI can have on society when pursued with reason and a genuine desire to improve the human condition.

Contents

Definitions

Terms that will be used throughout the remainder of this document are defined as follows, *adapted from the OECD Recommendations from the Council for Artificial Intelligence, OECD/LEGAL/0449*.

Artificial Intelligence *System*

An Artificial Intelligence (AI) system is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy.

Artificial Intelligence *System Lifecycle*

An Artificial Intelligence System evolves through several stages of design, implementation, and improvement. In general, it is expected that the following sequences form part of the lifecycle of AI Systems, although not necessarily in this order:

i) 'design, data and models'; which is a context-dependent sequence encompassing planning and design, data collection and processing, as well as model building;
ii) 'verification and validation';
iii) 'deployment'; and
iv) 'operation and monitoring'.

Artificial Intelligence *Knowledge*

AI knowledge refers to the skills and resources, such as data, code, algorithms, models, research, know-how, training programmes, governance, processes and best practices, required to understand and participate in the AI System Lifecycle.

Artificial Intelligence *Actors*

AI actors are those who play an active role in the AI system lifecycle, including organisations and individuals that deploy or operate AI.

Artificial Intelligence *Stakeholders*

Stakeholders encompass all organisations and individuals involved in, or affected by, AI systems, directly or indirectly. AI actors are a subset of stakeholders.

Current State of Artificial Intelligence[1]

Artificial Intelligence is a field of research that attempts to identify optimal decision-making, given some available set of information, and some specified objective. It has branches of study that are based on logic and symbolic reasoning, as well as branches that are based on statistical theories of learning. Although Artificial Intelligence is a research discipline that has been pursued since the 1950's (and some may claim even earlier) with the advent of early Natural Language Processing, Translation, and Automated Function Generators/Solvers, modern Artificial Intelligence relies on statistical and algorithmic techniques in order to learn quickly and effectively by 'abstraction.' That is, by summarising past information in a way that makes it useful for future decisions. Some amount of research work has also attacked the question of reasoning by 'analogy,' which is another important aspect related to human learning. However, it is difficult to claim that such systems exist today, although abstractive systems are becoming better able to learn from data that may have multiple use-cases.

Due to a massive increase in computational power, and the possibility to solve certain linear algebra operations (core to statistical learning) with Graphical Processing Units (GPUs) in a scalable and distributed manner, firms and governments around the world have placed an increased emphasis on data collection since the early 2000s. Many firms have hired aggressively for Artificial Intelligence-skilled human capital over the past 10-15 years, hoping to turn large amounts of operational and customer data into more efficient processes, better tailored products, and decreased operational costs/financial costs.

So far, economists tend to agree that Artificial Intelligence is displaying some of the characteristics of a "General Purpose Technology" with the potential to innovate and disrupt a wide variety of economic sectors. Studies find positive and statistically important relationships between the adoption of Artificial Intelligence and boosts to employment both at a firm and industry level,[2] indicating that there are positive complementarities to be gained from the appropriate integration of Artificial Intelligence into the economic landscape.

Due to the potential for productivity scaling from automating certain monitoring and activities related to national security, governments have significantly increased their investments in Artificial Intelligence over the last 5 years. This has been especially true in the United States, Europe, and China, where investment has been characterised as a modern "arms race."

Although Artificial Intelligence has the potential to create efficiency gains across a broad range of tasks, and enable new tasks, it is important to draw a strong distinction between the present hype around Artificial Intelligence and those areas where its application can be *enabling* of scalable improvements and economic transformation. It is equally important to note that just because Artificial Intelligence *can* be a solution to a particular problem that does not mean it *should* be applied to every context, nor that it will have a better return on investment than more *policy-oriented* strategies. Artificial Intelligence systems are very good at optimising existing frameworks, and historically have lacked the ability to think outside of them.

[1] Some parts are amended from TBI's first draft AI policy document.

[2] Babina, Tania and Fedyk, Anastassia and He, Alex Xi and Hodson, James, Artificial Intelligence, Firm Growth, and Industry Concentration (September 20, 2020). Available at SSRN: https://ssrn.com/abstract=3651052 or http://dx.doi.org/10.2139/ssrn.3651052

The majority of Artificial Intelligence research today is focussed on incremental improvements to problems that are generally already enabled by prior work, rather than on enabling problems that have no well-established solution. It is easy to fall into such a trap when applying Artificial Intelligence at a regional and national level, but it should be avoided at all costs if an AI strategy is to deliver real impact.

This document encourages blended approaches to the application of Artificial Intelligence that jointly consider the first order constraints, alternative organisation strategies, novel interventions, and appropriate (scalable) technology deployment. Basic research should not be undertaken unless there is an identified problem where such research can reasonably be expected to have an enabling impact and where such capabilities are currently not in existence/readily available.

Current AI adoption Ethiopia

The Ethiopian AI sector has very few players. These include:

- EthioCloud is a system of cloud-based APIs developed by US-based Kekros Systems LLC. The APIs cover Amharic language tools such as an Amharic language programming environment, web search engine, and OCR document processor. These services leverage Microsoft Azure's Machine Learning libraries. It is unclear whether any development activity is conducted in Ethiopia.
- GebeyaNet is a software development outsourcing provider with clients across the United States, Europe, and several African nations. This company provides a variety of technology project support from apps and UX design to complete software development. GebeyaNet has several team members capable of incorporating big data, data analytics, AI, and Machine Learning methodologies into client projects.
- Botter is an Ed-Tech company that uses chatbots to provide language courses via Facebook messenger. With over 250,000 language learners around the world, the business model provides a platform which allows content creators to host their courses. Although Botter was established by Ethiopian developers, the company was registered in South Africa to avoid the forex and investment restrains experienced by Ethiopian companies.
- Ethio Robo Robotics aims to transform access to robotics training in the country by focussing on children to promote the early adoption of automation technologies.
- iCog-Labs is an ICT training centre and software outsourcing company based in Addis Ababa. iCog's focus is on providing training in AI and leadership skills. It has received funds from the Mastercard Foundation for outreach programmes and partnered with Kudu Venture Fund to incubate local start-ups that use Machine Learning or Robotics. The company has had partnerships with international companies such as Hanson Robotics for API development tasks and has approximately 5 employees (out of ~50) with a specific focus on, and training in, the development of Artificial Intelligence algorithms.

Ethiopia has recently concentrated its efforts to enhance ICT and innovation. In June 2020, the Government of Ethiopia launched the national digital transformation strategy, Digital Ethiopia 2025. ICT is one of the five key sectors identified in the Homegrown Economic Reform Agenda. And more specifically related to AI, the proclamation to establish an Artificial Intelligence and Robotics Centre of Excellence which was inaugurated in September 2020.

The Centre of Excellence under the Addis Ababa Science and Technology University will work to create a close collaboration between academia and industry in the fields of AI and robotics. It is

expected to play a role in harmonising a regulatory framework to govern and embrace AI technologies as well as enable the nascent but growing ecosystem and direct efforts to use AI for socio-economic development.

AI Core: Thinking about AI in the Ethiopian Context

This section focusses on core challenges being faced by Ethiopia, and how Artificial Intelligence can be leveraged to make progress. We start by discussing the critical enabling infrastructure that is minimally necessary to achieve economically meaningful progress with Artificial Intelligence in society. The development and governance of this infrastructure need not entail vast capital projects (although its construction may certainly play a small role in job creation and institutional innovation), but **its absence would create heavy frictions in the deployment of any digitally-enabled solutions, decrease the potential for domestic and foreign investment by private entities, and miss out on efficiency gains and (per capita) savings for many government programmes**.

From the perspective of commerce, the reliable, efficient, and open flow of information across borders is quickly becoming a primary prerequisite for industrial production. As global demand for goods becomes more personalised and on-demand, the ability to create robust distributed managed infrastructure (RDMI) for production is critical. As production automation systems become more advanced, the workforce required per productive output decreases, and the marginal cost of production is dictated by commodity markets (energy and raw inputs) rather than human capital. The factories of the future require skilled labour, an efficient (flexible) logistics network, and access to cheap and plentiful clean electricity. **A consequence of this shift is that it is becoming increasingly unlikely that the manufacturing industry of the future would sustain the kind of growth in employment opportunities required by Ethiopia as it transitions from a primarily agrarian economy.** This should not be mistaken with a lack of *economic potential* in the manufacturing sector for Ethiopia.

Water and Energy

Ethiopia is blessed with an enormous wealth of hydroelectric, wind, and solar generation potential, and through the Grand Ethiopian Renaissance Dam (GERD) project, which will be the largest hydroelectric generation facility in Africa at 6.5GW of capacity, the country is stabilising the availability of core resources for a growing population. The potential for large amounts of relatively inexpensive excess power generation leads to a number of industrial and 'technology-era' opportunities for rapid development within Ethiopia, and one of the most valuable comparative advantages in the region.

One of the most critical indirect consequences of exploiting additional generation capacity is the need to build robust electrification infrastructure throughout the country (and especially those areas with the highest potential to improve economic conditions and livelihoods). **It is well-established that the availability of affordable and reliable energy has a direct and highly significant effect on job creation and economic output.** Hand in hand with this comes the strategic incentivisation of certain high-potential sectors where comparative advantages will persist into the future.

Commented [RB2]: Would be good to provide references or examples to back this up.

Commented [RB3]: Can we provide examples?

This document proposes several fruitful areas where additional capacity can be leveraged to build highly competitive, digitally enabled industry and services that would have the capability to increase foreign investment and international competitivity. This must go hand in hand with local labour market developments and gradual pressure on labour markets to ensure skills gaps are managed effectively. Additional foreign investment will also require strong guarantees on the availability of basic export infrastructure with minimal downtime.

Key Infrastructure Enabling Artificial Intelligence

In order to take advantage of developments in Artificial Intelligence, and for these to be able to impact Ethiopia for the better, a certain amount of basic infrastructure is critical and unavoidable. Ethiopia's Digital Transformation Strategy already outlines several programmes that are well-aligned with the needs of an Artificial Intelligence development and deployment ecosystem, and the key infrastructure recommendations outlined below reflect that.

1. **A National High-bandwidth Network**

   As of 2018, approximately 10M Ethiopians had access to fixed line or broadband internet connections, and about half of Ethiopians had access to mobile networks. 3G coverage was reported by ITU to be capable of reaching roughly 85% of Ethiopia's population; although it is unclear what the practical coverage is on the ground.

   Commented [SZ4]: All data from ITU? Can we add full source details

   Ethiopia needs a national fibre-backed communications infrastructure that can sustain Terabit connectivity among regional hubs. A variety of technical solutions exist for last-mile connectivity that can significantly reduce the cost of getting reliable and sufficient bandwidth to support data-driven services and government into remote rural locations, once sufficient bandwidth can be delivered to regional hubs. The mere existence of reliable mid-to-high-bandwidth connections will enable significant innovation.

   a. A traditional fibre-backed network, assuming trenching along existing rights-of-way (e.g. telephone/electricity lines, rail, road) would cost on the order of **US$100M+ as an initial outlay, and approximately US$10M per year in maintenance**.[3]
   b. In partnership with Facebook, it will be possible to leverage new infrastructure laying technologies to reduce the cost of installing light-weight-fibre along existing suspended lines. A robot can crawl along existing infrastructure quickly and reliably, with minimal crew support. Such a project is estimated to drive installation cost down to about **US$20M, with the same US$10M per year in maintenance**.
   c. Microsoft has completed several prototype installations of its proprietary TV White Space (TVWS) technology, which uses empty TV channel bands in order to support a low-cost last-mile infrastructure that can cover fairly large areas in moderate to difficult terrain. Many of the recommendations in this document rely heavily on a minimally consistent (although not necessarily 24/7) connection to all populated areas. TVWS technology is cheap and reliable, and Microsoft provides open licenses for its use in specifically these contexts. There exist a variety of alternative 'fixed wireless' approaches that are both low-cost and robust and may be better solutions in certain terrain or particular usage situations. Regional providers would be better incentivised to decide on the best backbone at this level of detail, while the government takes steps to ensure that delivery of a minimal service quality is universal.

   A national network is just that, a means of transferring information within Ethiopia. It does not presuppose international connectivity. Such a network would most likely still leverage web transfer protocols (http, tcp, udp, etc.), but could conceivably be managed entirely through a national DNS system, allowing priority access to certain high-impact sectors (e.g.

[3] These are estimates on the order of magnitude, based on international average costs of cable projects.

telehealth, eGovernment, virtual education, meteorological and agricultural commodity data).

Summary Recommendation:

> The government of Ethiopia to build a national fibre-backed communications infrastructure that can sustain Terabit connectivity among regional hubs. Utilising the existing privatisation and unbundling initiatives, the government should work with technology companies to reduce costs and implement the best solutions in certain terrain and cater their services to particular usage situations (i.e. local industrial, retail, scientific, and social needs).

2. **Public Computing Centres**

It is estimated that it would take on the order of 100 regional fibre hubs in order to effectively blanket 95% of populated areas with reliable bandwidth from fixed line or fixed wireless technologies. Such regional hubs should be supported and incentivised to set up public computing centres (alternatively known as *Community Technology Centres*) where anyone can access key information and services on the network without requiring their own device. Such centres should host training programmes for basic digital literacy, computing access courses for youth, and basic to advanced programming courses (or equivalent virtual courseware, e.g. Coursera).

A wholly government subsidised infrastructure build out for such centres with 100-200 basic computing devices in each might cost on the order of US$5-10M per year (including staff, average rent, average utilities). Such centres would have capacity to serve 1,000-2,500 people per day and have a meaningful impact on information access, digital training capacity, and should prioritise free access to low-income and marginalised groups. These should be viewed as the digital equivalent of public libraries, and there may be significant savings from bundling where such facilities already exist.

Digital literacy and advanced computing skills in a population are strongly associated with faster job growth, and founders of established (>5 years) companies with more than 10, 50, and 100 employees consistently display higher digital literacy than the average population of company founders. **These centres will boost entrepreneurial activity, and lead to more companies on a faster growth trajectory, with increased longevity, and more available jobs.**

Summary Recommendation:

> The Government of Ethiopia to develop 100 regional fibre hubs, each with an attached Community Technology Centre.

3. **A National Computing Grid**

In addition to a National Communication Infrastructure, the government needs to strategically invest in a National Computing Grid and Data Warehouse in close proximity to electric distribution facilities from the GERD project. In a strategic urban location such a project could cheaply house massive data centres and computational capacity for government, scientific, and industrial Artificial Intelligence projects.

Commented [SZ5]: This is interesting and useful – but we'll need to consistently format and highlight impact in other sections – or find some way so there's consistency structure re: other subheadings

Commented [JH6R5]: What if we create 'call out boxes' for each section where we have this kind of call to action, so they stand out, but don't create a need to manufacture one for every single section, which will probably sound forced…?

Commented [SZ7R5]: Call out boxes great – agree no value in forcing recommendations

An initial investment in capacity has a dual purpose of (a) removing frictions in the collection of strategically important data from across sectors and enabling a variety of foundational Artificial Intelligence interventions as recommended in this document, and (b) seeding the creation of a regional high performance computing centre, attracting global cloud and infrastructure players such as Google, Amazon, Alibaba, Microsoft, and Oracle, to create federated computing facilities and a high-tech hub city, much like Hyderabad in India, which has benefited massively from relatively modest initial investments in infrastructure and strategic positioning. However, such a vision requires a commitment to maintaining reliable, high-bandwidth, high-uptime infrastructure into and out of the country, per point (4) below.

Summary Recommendation:

> Government of Ethiopia to invest in a National Computing Grid and Data Warehouse in close proximity to electric distribution facilities from the GERD project. Provide subsidised, low-cost (preferably free) access to scientific and industrial/commercial use-cases that are aligned with the development priorities described in this document. Encourage foreign cloud providers to co-locate facilities and create East African data and computation hubs in Ethiopia.

Commented [RB8]: This is an important point. Can we expand with examples of mechanisms the gov could use to encourage investment? E.g. tax incentives.
Another point to consider here is that many Governments are concerned about the storage of national data outside their jurisdiction. They have privacy and data sovereignty concerns. Could there be an agreement/buy in from other countries in the region for data from foreign companies to be stored in Ethiopia rather the Europe/the U.S./China?

4. **World Wide Web Bandwidth**

Ethiopia owns no international cable bandwidth, and the existing 70 Gigabit connection (representing 0.01% of the world's internet capacity, for 1.4% of its population) is leased from Djibouti Telecom. Djibouti Telecom maintains a gateway landing station in partnership with Djibouti Data Centre (DDC) and the Djibouti Internet Exchange (DJIX) which currently has over 30 Terabytes of incoming bandwidth and has 2 major continental cabling projects coming online in the near-term (including 2Africa). It is unclear how existing major submarine cabling projects such as 2Africa and PeaceCable will affect connectivity in Ethiopia, although they promise hundreds of Tbps of connectivity through Djibouti's landing stations. Unbundling of the telecoms sector, together with a massive bandwidth boost and assurances of the reliability of such connectivity, will create enormous potential for facilitating trade competitivity and attracting meaningful foreign investment**. An open and reliable web is a fundamental pillar of modern economic development.** However, to achieve foreign investment in certain sectors it may be sufficient to guarantee connectivity for targeted network segments and clients.

Summary Recommendation:

> The Government of Ethiopia to take proactive steps to massively increase bandwidth into and out of the country, while ensuring web access remains affordable for individuals and businesses across the country.

Ethiopians will continue to communicate and consume the web primarily through mobile data plans for the foreseeable future. A digitally enabled society will require local access to stable bandwidth, which is an opportunity to upgrade fibre bundles at cell-towers, as well as to establish centrally accessible hot-spots in the most remote rural areas. Even the most remote inhabitant should be able to visit somewhere on a daily basis that is connected, and where they can access key social and business information. The benefits of a better connected population may also extend to more easily combating hate speech and misinformation due to an increased connectedness and unity, improved

mental health in some populations (especially in emergency situations such as global pandemics), and reduced frictions in government information, messages, and services reaching all areas of the country equally.

Education, Skills, and Workforce Diversity

Current situation and challenges

Ethiopia's government has placed a large emphasis on the development of early education through university, and especially on the need to enhance STEM learning and opportunities across the country. The Digital Transformation Strategy identifies several ways in which technology can make a positive contribution in this regard.

Through programmes like SchoolNet, Ethiopia has attempted to increase access to a minimum quality of education provision even in very remote districts. However, infrastructural issues have often created obstacles to these solutions having a maximally beneficial impact; and many communities remain wary of centrally imposed systems. The current status and average usage of the SchoolNet system or related efforts remains unclear.

Commented [JH9]: This needs to be replaced with more specific information. It remains one of the open questions we haven't been able to address.

Commented [SZ10R9]: Can we flag for Taye Girma input?

At the same time, the largest focus of the government's attempts to enhance the education sector has been at the university level, which receives the most federal funding and attention. Several new ICT undergraduate and masters level programmes have been created, as well as university centres specialising in core economic priorities such as agriculture and pharmaceuticals. Adama University of Science and Technology is the flagship engineering university in the country. In 2017, the university had ~2,000 engineering students, and courses covering Artificial Intelligence, Data Science, and Computer Security, among others. Most teaching and advising of students is provided by non-ladder-faculty[4] lecturers. The current capacity for training Artificial Intelligence graduates across Ethiopia appears to be somewhere in the region of 500-1,000 undergraduate degrees each year, although there is high variance in quality across programmes. Bottlenecks to economic development in the coming decades will be driven primarily by a growing wedge between the skill supply and demand, especially outside of major urban centres. **In particular, the transition to more advanced agricultural practices and logistics will require a shift in industrial dependency for rural areas.** These are the areas where the skills gap is largest and most complex to address.

There is some indication of private efforts and international NGO involvement in early-years education outreach and technology. One such prototype, known as YaNetu, was proposed by iCog-Labs in Addis Ababa in 2016. YaNetu planned to build an Android-based assistive tablet for school-age children, with access to core curricula and personalised learning experiences. The cost of a single tablet was envisioned to be under US$200, and materials from 2016 indicate that iCog-Labs intended to run pilots of the technology with schools in Addis Ababa. It appears no further progress was made. A similar story persists with NGO efforts funded by Microsoft and Unilever in the past several years. Coordination and scalability problems must be addressed in order to allow for large-scale experimentation in education delivery mechanisms across the country. **Bold steps must be taken to ensure early education reaches all those who need it in whatever way will have the highest likelihood of success.**

[4] "Ladder faculty" are commonly known as Assistant Professors, Associate Professors, or Full Professors, who have either attained tenured positions at their institution, or are eligible for tenure consideration.

One of the keys to success in bringing early-years education and basic literacy to rural areas (setting the foundation for interventions in better connected areas) is an understanding of the joint pressures on students to contribute to their family's economic base, often through manual labour, which conflicts directly with the need to attend a physical school on a fixed schedule. The difficulties of delivering consistent education under the pressures of global pandemics such as COVID-19 have exacerbated this issue even in developed countries such as the United States, showing the inherent fragility of traditional schooling approaches.

The commonly cited purpose of promoting Science, Technology, Engineering, and Mathematics (STEM) education from the earliest ages is to counteract misconceptions of these disciplines as being inaccessible (too hard), male dominated, or not offering exciting career opportunities. The real value of promoting STEM subjects in rural areas is to engender reasoning, logic, and problem-solving abilities that will be applied to local problems and produce new sources of value for the community. Insofar as skilled trades and agricultural practices are passed down from generation to generation, economic fragility increases, and creative disruption tends to decrease, leaving communities vulnerable to external pressures for change. **STEM can hold the key to an internal innovation cycle to help revitalise rural areas.**

Below, three proposed strategies are outlined for the integration of appropriate technology and data alongside incentive-compatible economic interventions to promote flexible and results-driven education cultures.

1. **Proposed Strategy 1: Reimagining Basic Literacy and Numeracy**

   In the next decade Ethiopia will need to provide early childhood education to more than 30M children across a diverse set of cultural, social, and physical contexts. In the last decade that number was closer to 20M. At current drop-out rates, basic skill acquisition patterns, and university capacities, only 1% of those 30M children will benefit from initiatives at the university level (which currently receives 50% of the federal education budget). On the other hand, 20% of those children will drop out during the first year of schooling, and 90% will not make it to secondary education.

   a. **Flexibility**
      Following the hierarchy of basic education needs listed above, it must be possible for any child to pursue an education through the end of secondary school without being constrained to a traditional model of early education.

   b. **Accountability**
      Teachers in local communities should be responsible for assessing and reporting on the progress being made by each child in their jurisdiction, as well as organising appropriate regular social engagement and group learning opportunities that are flexible (but strictly required).

   c. **Multimodal Unified Resources**
      A full complement of paper-based learning activities (or digital interactive activities if budget allows) should be developed to bridge the gap to basic reading, writing, and numerical skills. This starts with recognition, imitation, association, sorting, conceptualisation, and arrangement. Activities should be possible to complete with minimal guidance from teachers and parents (even in cases where parents themselves may not be literate). Activities should be trackable by scanning printed

Commented [JH11]: These numbers are based on our conversation with Chema, but we need to provide a more specific citation if possible—e.g. some document from the Jobs' Commission?

Commented [SZ12R11]: @Declan – can you f.up please

Commented [DS13R11]: The source is: Jobs Creation Commission: Labour Market Assessment, June 2019

codes, along with minimal details. This will allow development of **targeted interventions at the individual level through Artificial Intelligence at the earliest possible stage of development**. Every teacher should be provided a tablet to scan and annotate student work into a national digital repository with minimal overhead. Tackling the problem of universal literacy in an inclusive and flexible framework that accepts the reality of existing economic constraints on the Ethiopian household will likely be the single largest contributor to economic growth over the next 20-30 years. **At current population growth rates, focus on these areas now may be the only way to avoid widespread humanitarian crises in the future.**

d. Incentives

Families should be incentivised for their children to achieve set learning milestones that are possible with limited but consistent effort. This programme offers unprecedented flexibility to allocate a child's time around necessary family activities, including unavoidable economic activities. This includes the ability to start the programme from as early as 2 years of age, as most children can achieve basic reading and numeracy skills by age 3 or 4 with encouragement and regular limited but focussed time.

It should be noted that this section does not address the potential substantial negative effect of unsafe living conditions, unsafe drinking water, and insufficient and low-quality nutrition. Insofar as these are issues at the local deployment level, additional infrastructure should be put in place to ensure sufficient community resilience to achieve these basic goals, as noted in the main body of this section. Teachers, in this model of early education, become community workers with a responsibility towards their students, and a responsibility to ensure each family has access to the resources they need to ensure their children's success. Teachers are advocates whose voices must be heard at the Kebele and national levels, and the data they will collect will form the basis for a wave of education revolution in Ethiopia.

e. Prerequisites

These recommendations are dependent on social identity structures being in place, as described in the section 'Key Social Structures'.

2. Proposed Strategy 2: Flexible Learning Pathways for Secondary Education

With the establishment of near universal basic literacy for the next generation of learners (those 2-10 years old), there is enormous potential for digital innovation and for Artificial Intelligence to support flexible learning pathways for every child and young adult.

Commented [SZ14]: Is this a statement of fact – in which case, can we have a source. OR are we saying IF There was near universal literacy… ambiguous

In-person, regular, school-like education systems yield better results than virtual AI-assisted learning platforms. Student engagement is higher in school, feedback tends to be of higher quality (although lower frequency), and peer dynamics along with group activities and the need to communicate knowledge actively contribute to faster uptake and increased 'stickiness' of acquired skills. Traditional schools also tend to be more scalable and lower cost per student when all infrastructure and overheads are considered.

Commented [RB15]: Are there sources to back this up?

However, these recommendations relate to situations where the benchmark is not a traditional school environment, but rather *no school environment*. In these cases, a

personalised digitally enabled set of flexible learning pathways can provide a high-quality education, at low cost, around prevailing economic realities.

a. **A Digitally- and AI-enabled Core Curriculum**
   We recommend the creation of a common set of core curricula across reading/writing, mathematics, basic sciences/engineering, digital literacy, health, and citizenship. The flexible format should allow a single student to interact with the curriculum (i) when convenient, (ii) in multiple modalities, e.g. shared computing resources, mobile phone (app/sms), easily accessible paper versions, (iii) in a manner that allows them to easily track progress, receive tailored feedback, receive additional resources when necessary, and be officially recognised for their achievements.

   This should not be an "Artificial Intelligence embodied learning assistant", chatbot, or other similar immersive AI-driven environments. There is no evidence that the increased cost and complexity of creating such systems (in a way that achieves the desired purpose) has any positive causal relationship with education outcomes. Such undertakings will undoubtedly increase costs, increase timelines, and lead to more expensive infrastructure for universal deployment.

   Instead, Artificial Intelligence should be used to guide students towards activities and additional learning resources that are most likely to help them master key concepts of the curricula, to improve and expand the resources available, and be able to provide official records of achievement, possibly linked with future job search ecosystems. Some of the more similar templates for this kind of intervention include Khan Academy.

b. **STEM Extension and On-demand Qualifications**
   The system described in (a) above should provide additional targeted modules that cover such topics as 'algorithms' (i.e. an introduction to logical thinking without writing programming code or using a computer), 'introduction to programming', 'accounting and financial literacy', 'crop sciences', 'industrial management', 'business administration', 'medical record keeping', and a variety of other vocationally-relevant resources to prepare students to enter a shifting economy. A special taskforce should be created in order to develop curriculum recommendations for the systems described.

c. **Resumes and Linking to Employment**
   The Jobs Creation Commission is responsible for addressing the skills gap and access to employment opportunities. One of the areas identified for focus in Ethiopia's National Roadmap for Employment is the lack of job search services and the general asymmetry of information in labour markets across the country.

   We recommend the creation of a centralised job matching system that allows anyone to maintain a job seeker profile linked to their identity and requires any employer with more than 10 employees to also post their vacancies to this system in a timely manner. Any person who has completed any part of the digitally-enabled certifications in (a) or (b) would automatically be able to apply for any relevant job opportunity in such a system, helping to relieve frictions in matching, and providing

a wealth of information on the dynamics of the national labour supply and demand, market clearing dynamics, skills gap, and company/sector growth.

Such a system should leverage Artificial Intelligence to enable suggestions on both sides, and to aggregate and analyse various labour market metrics at the local to national sector, and to macroeconomic levels for use in national statistics, research, and policy work.

3. Proposed Strategy 3: Universities and Beyond

Capacity-building in STEM disciplines will become a critical enabler of increased economic productivity and international competitivity. Beyond course-based education pathways, it is imperative that Ethiopia create channels for talent all the way through to deployment. At the University level, where the majority of the country's education budget is currently spent, there is a critical need for researchers to be involved in solutions that are locally relevant and deployable.

a. AI in the Curriculum

All universities equipped to offer a computer science curriculum to their students should be equipped to provide a 'Data Science and Artificial Intelligence' curriculum that provides the following minimal requirements:

i. An introduction to 'thinking with data', critical analysis, causality, and basic data analysis techniques that follow scientific method.

ii. A 'data science fundamentals' course without requiring or providing significant mathematical grounding—an applied science approach.

iii. An 'advanced data science' course with some mathematical grounding.

iv. A Machine Learning course comprising a survey of approaches and hands on implementation.

In addition, universities offering this curriculum can be linked to the Ethiopian AI Centre's efforts to construct a central repository of AI challenges relevant to Ethiopians, with available data sets. Students should be required to complete capstone "hands-on" projects as part of undergraduate, masters, and PhD qualifications.

b. National Labs

Every university in Ethiopia that offers a Machine Learning, Artificial Intelligence, Data Science, or similar degree programme should be required to participate in building jointly-funded faculty-led applied research laboratories aiming to spur development in a particular strategically chosen area of relevance to their region or AI in Ethiopia. These labs should offer research assistantships to technical undergraduates and masters students in exchange for course credits. The faculty leaders are responsible for ensuring that the lab is appropriately staffed with researchers, and that the problems being worked on are of local relevance through partnerships with local companies and government departments, NGO's, and other stakeholders.

A taskforce must be created in order to identify and recommend the specific areas of research for which each university should be responsible.

c. **An Ed-Tech Lab**
We recommend the establishment of a specific Education Technologies AI Laboratory as part of the laboratory infrastructure laid out in (b) above. The laboratory would be responsible for exploring new types of Artificial Intelligence applications that could have the biggest impact on the quality of education at all levels in Ethiopia, given existing constraints and local variation.

Such a lab would not be responsible for, nor would it likely have the capacity to effectively build out infrastructure described in this *Education, Skills, and Workforce Diversity* section. Multiple private-sector and international partners will likely be needed in order to achieve these priorities.

d. **Granular Education Data**
We recommend the collection of granular data on course offerings, student enrolment, teacher training/background, and individual student performance across all universities in order to enable better data-driven decision-making paradigms at the university level.

e. **Grants to Private Training Providers**
We recommend that special status be given to businesses offering programming and data science programmes that are accessible to those residing in rural and underprivileged areas. Special status might include certain tax credits or direct cash grants for enrolment and achievement, similar to funding mechanisms for municipal schools.

Healthcare

Current situation and challenges

Access to timely healthcare is a challenge in Ethiopia, with much of the population outside of major urban centres living far from their closest assigned medical facilities (hospitals and similar emergency/urgent care facilities). With there being only one trained *general medical practitioner* per ~18,000 people, the number of trained doctors (general practitioners and specialists per capita is well below carrying capacity (although there is a large number of Community Health Workers, medical technicians, and clerks). As a result, wait times for care can be very long, and access to specialists very difficult to secure, especially in rural areas. In 2015 Ethiopia launched a five-year Health Sector Transformation Plan (HSTP), which identified major public health priorities: (i) elimination of malaria, (ii) better case detection and treatment of TB, and (iii) a "Fast-Track Cities Initiative" meant to meet "90-90-90" targets, meaning by 2020 to have 90% of all people living with HIV know their HIV status, 90% of all people diagnosed with HIV infection receiving sustained antiretroviral therapy, and 90% of all people receiving antiretroviral therapy to display viral suppression.

In 2018, Ethiopia's Federal Ministry of Health led the establishment of "HealthNet", a national effort to connect more than 3,000 healthcare facilities to a single virtual private network. This initiative was supported by the USAID-funded Advancing Partners & Communities (APC) project. Part of the

stated aim of HealthNet was to encourage the use and communication of Electronic Medical Records (EMRs), share best practices and research across institutions, and have positive spill-over effects on the scale of care and health resources in the country. To date, it appears that HealthNet is used primarily as a way to share knowledge among specialists around the country.

In terms of Electronic Medical Records—the foundation to tracking the health of an individual and public health over time—there are significant positive efforts from private organisations such as the Tulane University Center for Global Public Health (CGPH) Tenacare system, supported by Microsoft's 4Afrika programme. Tenacare is used in several thousand health care facilities across Ethiopia, and seems to foster positive user experiences.

The Ministry of Health are also currently in early stage discussions with Oracle to explore the potential benefits of the Oracle Health Management System. This is a cloud-based public-health system which, if adopted, will initially be used to manage essential vaccination programmes by creating an electronic health record for every vaccine person.

The Ethiopian Federal Government's AI Centre, created in September of 2020, is targeting oncology research as a primary area for Artificial Intelligence to have a positive impact on Ethiopian society. By bringing together relevant specialists from across the country and providing data infrastructure for storage and processing of medical imagery the centre aims to develop automated medical imagery analysis to support oncology clinics and specialists in the early identification of lymphomas, breast cancer, and certain types of brain tumour, before expanding the programme to additional medical domains. **This is an area where Artificial Intelligence is having an impact and enormous investment around the world, so it may be a case where buying existing solutions would be faster, cheaper, and more effective than in-house efforts with limited data.**

This document has recommendations that focus primarily on last-mile routine and emergency/urgent care provision, public health monitoring, and disease control. Artificial Intelligence has a place in the identification of local priorities, and the assistance of limited medical practitioners in the provision of the country's basic needs. Collaboration with established international partners (e.g. the Sloan Kettering Memorial Foundation, IBM Watson for Healthcare) will be vital for the provision of robust, reliable, and well-tested medical imagery and Electronic Medical Records (EMR) infrastructure where this is relevant.

Taking into account Ethiopia's low healthcare professionals to population ratio, Artificial Intelligence provides an opportunity to support vital health services across the country. A well-connected digital health infrastructure will allow for efficient triaging, patient care, disease treatment and effective training. There are also opportunities to use AI to adapt the healthcare system for changing population demographics as well as data collection and processing, new drug/therapy development, and public health management (e.g. in the case of pandemics).

Below, six proposed strategies are outlined to utilise AI across healthcare.

1. **Proposed Strategy 1: Scaling Medical Practitioners**

   Using Artificial Intelligence technology to assist understaffed medical outreach centres to achieve the following:

   a. **Triage incoming patients more quickly and effectively**
   Artificial Intelligence can be leveraged to guide minimally trained staff in the efficient triaging of incoming patients. Such medical "decision-tree" systems have been around for several decades, but in recent years the level of medical knowledge

and accuracy of systems in diagnosing the vast majority of urgent care and emergency care issues has made significant progress. Some types of triaging systems (e.g. in non-emergency care settings) could be self-administered by literate and able-bodied patients or their carers.

Although self-serve triaging systems will not be able to replace the need for skilled triage nurses and doctors, such systems can significantly reduce the burden on the emergency and urgent care systems, directing resources to the most critical cases, and allowing most people to receive timely advice and care without waiting in long lines. In the United States, only 10% of Emergency Room visitors are considered in a sufficient state of need to warrant hospital admission.[5] 90% of people are discharged after basic vital signs are checked, possibly with instructions to see their assigned general medical practitioner if symptoms persist. Ethiopia's emergency care landscape is very different from that of the United States; but it is very likely that the majority of visits to emergency care centres could be avoided through more efficient triaging techniques.

As with all medical technology, introducing any level of automated decision-making to the healthcare setting requires these systems to be precision-oriented—that is, if the system has substantial doubt, or the cost of an error is too high, the decision should be checked by a skilled practitioner at the earliest possible moment.

Recommendation: Develop an Artificial Intelligence based guided triaging system that can be either self-administered or administered by minimally trained medical field workers to assess the need for care of patients at urgent and emergency care facilities. Such a system should account for more than 95% of the common reasons for emergency room visits in the country and operate in all languages necessary to maximise penetration (including as a voice-based chat-bot for those with limited literacy). In addition, the system should be used to collect and update Electronic Medical Record (EMR) data on individuals, and feed into public health databases. It is likely that a tablet or smart-phone application will be the most viable option, although it may be beneficial to develop an entirely voice-based experience for feature- and fixed-line- phones.

b. Assign patients to the most appropriate medical expert available, according to urgency.

Artificial Intelligence-connected health centres can more effectively manage medical staff bandwidth to ensure each resource is leveraged in the most efficient manner, considering the current needs of patients. This can also aid in enhanced capacity planning as medical centres become more aware of the demand for services in their jurisdiction.

In order to identify gaps in healthcare capacity and service provision, it is first and foremost necessary to understand the currently available medical bandwidth across the nation, alongside population demographics and risk factors.

Every medical centre is a bundle of resources (skilled medical staff and equipment) with the capacity to care for a certain number of people with a certain range of conditions. In the optimal scenario, each patient that visits a medical centre can be

[5] https://www.cdc.gov/nchs/data/nhamcs/web_tables/2017_ed_web_tables-508.pdf

paired with the most skilled staff and most appropriate equipment to address the issue. However, in real life medical centres assign patients to staff on a rotating as-needed basis, which often can lead to sub-optimal resource allocation due to schedule-misses.

Artificial Intelligence can be leveraged in order to manage the allocation of staff and equipment to current patients, while understanding how the pressures on the medical centre might change through the day, week, year. The system provides a direct method of collecting information about staffing levels across the country, the distribution of expertise, and would form part of a concerted public health system for reporting on conditions and capacity constraints.

Recommendation: Develop a scalable national database of medical resources and equipment that can (a) be used locally to provide real-time AI-enabled allocation of patients to the best possible medical professionals and equipment, and learns to better predict daily and seasonal demand patterns; (b) contribute public health and resource allocation data to a national public health infrastructure to help in identifying health system risks, imbalances, and constraints to prioritise spending where it can save the most lives; (c) report on patient cases, recommendations, and outcomes at the level of patients and medical practitioners in order to make optimal decisions.

c. Enhanced Telehealth

Provide tools to enhance remote diagnosis and telehealth services where the necessary expertise are not locally available.

We recommend the creation of remote telehealth facilities with direct access voice and video lines to skilled medical staff who can provide guidance when reaching in-person skilled medical care is not feasible, and can coordinate emergency responses in the case of urgent identified need. Specialty medicine can be siloed in that one GYN, Oncologist, etc. can be assigned to provide telehealth consults to a wide geographic region.

We also recommend the use of staffed nurse voice and video lines as an additional approach to relieving non-urgent volume on the healthcare system. It is well understood that frictions in access to healthcare cause people to avoid seeking medical attention when they need it, even in critical situations. Providing consultations via telehealth can assist with cultural and religious sensitivity by offering privacy and same gender provider care.

A scalable and functional telehealth-care system allows people in even the most remote locations to easily obtain the expert healthcare advice they need, reducing reliance on traditional/holistic medicine, and reducing the friction to obtaining medical care. Such a system serves the dual purpose of also registering the healthcare needs of remote populations so that they may be considered as part of public health and healthcare system planning priorities. In addition, a well-functioning system can be scaled with resources from anywhere in the country, allowing for resource constraints to be alleviated by leveraging skilled staff from elsewhere in the country, or even internationally.

Recommendation: Develop a national telehealth system that leverages Artificial Intelligence voice and language processing technologies in order to quickly connect patients to the most appropriate available skilled medical practitioner via video link. One possible implementation of such a system calls for the development of booths with integrated video and medical technologies in order to perform adequate screening and measurement of vital indicators (weight, heart, breathing, etc.). Such booths would be made available in remote areas where access to skilled medical staff is limited. A portable system to complement such high-tech booths could be deployed more rapidly and broadly in areas where resources are constrained, but medical staff are still available to perform in-person physical examinations on a regular basis. Such a system will require careful planning to ensure the user experience is simple and accessible to all.

Telehealth can also be adapted to be accessible on home electronics and within tech hubs. Utilizing equipment for dual purposes can cut down on implementation costs and make economic, educational, and medical resources available in a compact setting. However, training for both providers and the general public is essential when implementing a telehealth model. If this technology is being used for mental health or geriatrics, additional safety and user interface protocols need to be addressed.

d. Training

Medical knowledge is changing continuously. New methods and more efficient procedures are available which improve patient outcomes and reduce cost. Identifying the training and resources that each medical practitioner could benefit from, and providing timely access, are areas that Artificial Intelligence can help to address.

Together with point (b) above, a national healthcare network can offer insight into which practitioners appear to have consistently superior outcomes for similar cases, and recommend pathways to improve outcomes in areas that are not achieving at the same level. Achievement can be for a number of reasons, including environmental factors, lack of equipment, more severe cases, larger caseloads, etc. However, appropriate and timely training can have a consistent positive effect in terms of real outcomes, patient confidence in the system, and medical practitioner confidence in their work.

Recommendation: Build a national database and Artificial Intelligence system to identify and recommend training opportunities for medical staff (especially staff in remote medical outreach centres). By tracking incoming patients, whom they are allocated to, diagnoses, and outcomes, it is possible to identify relative strengths and weaknesses of staff and provide additional training recommendations where appropriate. Such a system will require the use of global databases of medical knowledge (such as PubMed), national medical association input on training materials, digitisation of training materials, and tracking of completion status. It may also be necessary to impose penalties on staff who do not complete training repeatedly and within reasonable timeframes for critical knowledge acquisition.

2. Proposed Strategy 2: Public Health and Shifting Demographics

Ethiopia has been experiencing a population explosion for the last decade, which will likely continue for the next decade. Currently, children make up approximately one third of the population, which will likely become closer to 50% by 2030. At the same time, life expectancy has increased in Ethiopia, and the country should anticipate that more than 20M people will be 60 or above by 2030. Healthcare for a spike in the aging population, and appropriate post-natal and paediatric care for a vast number of new births will quickly deplete existing bandwidth, which was not designed for the distribution of demand that will be present.

As life expectancy increases, healthcare costs per capita will increase, and the average cost per medical procedure will also increase, as older populations tend to have more diverse and complex medical needs.

Unless drastic steps are taken to anticipate these changes, it is likely that average life expectancies will decrease, and basic healthcare will not be available to an ever-increasing number of people.

Recommendations:

a. A Unified National Public Health Reporting System

It is difficult to plan appropriate interventions to improve public health without comprehensive data about the health care issues affecting the entire population, from high-density urban areas to the remotest pastoral regions. If large pockets of the population have no healthcare interface (a general practitioner, a medical outreach staff, etc.), then not only will they not receive adequate healthcare, but it will never be known that they did not receive adequate healthcare.

Therefore, in line with section (1) above, a national network and database should be built to enable reporting of all health-related transactions between patients and official points of care. At a minimum, details should include date and time of transaction, location, care providers and role, patient demographics, health history, symptoms and description, assessment of severity, case notes, actions recommended, actions taken (timing), outcome, according to an *officially coded taxonomy to allow for adequate information interchange*.

Information should be collected by telehealth systems, triaging systems, EMR systems, and patient management systems within all official points of care. For the sake of public health records and analysis, it is not necessary for personally identifiable information to be included beyond coded health information, or for links to exist between records generated by the same person. However, we would encourage a system whereby patients can choose to maintain a single identifier and share additional information with the public health system, such that the public health system may consist of both large-scale transaction data (anonymous) and smaller scale linked longitudinal panel data (with identifiers).

Participation in contributing data to the national public health system brings with it (i) the opportunity to offer access to highly targeted experimental studies by the medical research community, (ii) enables the development of ongoing public health

survey instruments, and (iii) can provide the substrate for real-time public health monitoring that does not require mass participation without informed consent.[6]

Artificial Intelligence can bring unprecedented insights into population-scale public health data in the following ways:

- Early identification of shifts in healthcare demand, including seasonal variations and longer term underlying structural shifts;
- Optimal allocation of healthcare resources to the locations and issue areas that can have the most beneficial impact;
- Real-time monitoring of disease outbreak dynamics;
- Building a comprehensive public health reporting system that is transparent to medical professionals and the population at large to make informed care decisions in a timely manner;
- Enabling and encouraging medical research into the areas that could have the largest beneficial impact to Ethiopians, as well as growing the research community to international prominence through the availability of unprecedented data on developing country public health.

b. Special Attention to Demographic Shifts

When deploying infrastructure described in section (1) and (2) above, the government should ensure that the scalability of maternal, paediatric, and senior care procedures is prioritised, and that appropriate training resources exist to allow less specialised medical practitioners to release some of the pressure in the system at times of peak demand. That is, special attention must be given to tracking these issues today, and Artificial Intelligence should be leveraged in order to provide early-warning indicators of capacity constraints in the system, so these might be addressed as soon as possible.

3. Proposed Strategy 3: Electronic Medical Records and Communication

It is of paramount importance that all official health care providers in Ethiopia have access to a low-cost fully-digitised electronic medical records (EMR) system that allows for profiles of each patient to be accurately recorded by all relevant practitioners and administrators at all points during the healthcare lifecycle. The system must be possible to use in offline scenarios, providing simple ways to synchronise information once connectivity becomes available. The system should be operable through desktop and mobile solutions for any relevant format of device, while maintaining the security and privacy required for sensitive health data of individuals.

An individual's electronic health record must be easily accessible to the subject (patient) in a variety of formats and languages, and easily accessible by any official health practitioner or administrator (trustees) to manage and update information. Each trustee should only have access to the information strictly necessary to perform one of a limited set of valid actions. It

Commented [RB16]: Implementing this strategy and other requires health professionals to have access to devices. Is it the case that in Ethiopia Community Health Workers all have access to a laptop or smartphone? If not we should discuss in the strategy a need for the Government to invest in devices for medical staff.

Commented [DS17R16]: I doubt all CHW have access to a smartphone, but we can confirm with Gov't

[6] The question of informed consent to healthcare in populations with low literacy rates and little experience with modern healthcare systems and technologies is one to be taken seriously. It is beyond the immediate scope of this document, but the government should take steps to ensure that clear and effective communication is available to all patients regarding the provision and use of healthcare data, the benefits and risks of participating in additional data provision, and the opportunity to clarify any questions or concerns in a straightforward and timely manner.

should be possible to amend records with justification, but never to remove information (i.e. the history of all edits should be available for the life of the medical record). Access to the health record of a patient requires the joint authorisation of patient and trustee. All sessions and data transactions related to an electronic medical record must be recorded and associated with a trustee and reason. In cases where the patient is not able to authorise access directly, trustee sessions are considered 'unverified' until closed by the patient or authorised personnel with jurisdiction at the designated place of care. Any access of an electronic medical record that is 'unverified' must be reported to the patient (this might be through automated voice, email, in-person authorisation, or verified mail), and only a limited number of 'unverified' sessions should be permitted before a health record becomes 'locked' and subject to audit/investigation by an appropriate responsible body.

Governance: The punishment for misuse of electronic medical records or enabling misuse of electronic medical records by an official health care worker should be severe. A patient should never be denied care based on an inability to access or unwillingness to provide access to an electronic medical record. However, official healthcare facilities that have high rates of missing, partial, or incoherent medical records should be investigated and provided with appropriate training and resources to rectify the situation.

Artificial Intelligence should be leveraged within an electronic medical record system to achieve the following critical goals:

- Alert patients and trustees to the need for regular check-ups, opportunities for new medicinal products or procedures, new services in their area, and recommendations for leading a healthier lifestyle based on their health profile and location;
- Aggregate relevant anonymised data to the public health reporting system on a regular basis, without violating patient privacy norms indirectly;
- Identify partial and incoherent medical records that should be checked by trustees and relevant local authorities;
- Maintain predictions of related conditions and risk factors that trustees should be aware of when providing care to the patient;
- Provide recommendations of the best care provider for the patient, building expertise in providers and helping to scale the system through appropriate (demand-driven) specialisation;
- Ensure that database transactions between triaging systems, public health reporting systems, and the electronic medical records system are consistent and coherent.

4. Proposed Strategy 4: Robotic Surgery

Robotic surgery allows for repeatable, higher quality surgical procedures, with lower cost per patient, and faster recovery times. However, capital outlays and infrastructure costs are still very high, and require very different spending plans from current healthcare budgets that are human-capital-centric.

A well-installed robotic surgery system can require fewer skilled medical practitioners on site in order to provide a very high level of care. It also acts as the foundation for building libraries of surgical training materials that can improve medical school student outcomes and accelerate the training of medical staff. These benefits are well-aligned with the needs of the Ethiopian healthcare system over the next 10-20 years. The nation's best surgeons could potentially operate remotely on patients with critical need in an entirely different

region, and multi-institution teams could more easily collaborate in real time on complex cases.

Based on US and European data on surgical admissions, surgical procedures have a yearly per-capita rate of about 0.17. That is, on average, each person should anticipate to undergo one surgical procedure every 6-7 years. It is estimated that the rate of surgical procedures in Ethiopia is currently much lower due to a lack of capacity, a lack of awareness in target populations and a low rate of elective surgeries in the country. It is likely that if surgical capacity increased, many easily treatable ailments could be addressed that are currently ignored, and that this alone could have a significant impact on quality of life and life expectancy.

Succeeding other recommendations in this section and the availability of key infrastructure, we recommend the introduction of several targeted pilot projects in under-served regions to evaluate the potential impact of such technology. This should be done in partnership with an appropriate research centre, per recommendation (5).

5. **Proposed Strategy 5: A MedTech Lab**

   We recommend the establishment of a specific Medical Technologies AI Laboratory as part of the laboratory infrastructure laid out in part 3(b) of Education, Skills, and Workforce Diversity. The laboratory would be responsible for exploring new types of Artificial Intelligence applications that could have the biggest impact on the quality of healthcare in Ethiopia, given existing constraints and local variation.

   Such a lab would not alone be responsible for, nor would it likely have the capacity to effectively build out infrastructure described in this *Healthcare* section. Multiple private-sector and international partners will likely be needed in order to achieve these priorities.

Key Social Infrastructure

Unlocking the benefits of Artificial Intelligence for all Ethiopians requires all Ethiopians to be common stakeholders in their society. This simple statement entails certain 'societal infrastructure' that is a necessary precursor to many of the recommendations made in this document (or, at least, to their successful implementation). Key social infrastructure is designed to increase access to core government services, minimise fraud, and increase the safety of children and vulnerable groups from exploitation. Although predominantly human institutional processes, the collection of vital information and verification of eligibility are areas that are perfect for Artificial Intelligence mediation, increasing efficiencies and driving down administrative costs when deployed appropriately.

1. **Universal Identity Services**

   All children must be registered, and all people must be given documentation to prove who they are and basic details about them. Identities can be officially assigned 'in the field' by government officials working in tandem with local government, education, and healthcare workers. Official documentation must be free to all and require minimal accessible details to issue. Artificial Intelligence can be leveraged to ensure a robust and efficient process of identity registration, guaranteeing minimal ability to defraud the system (i.e. duplicate registrations). This includes advanced biometrics, anomaly detection and fraud detection algorithms on national-scale data, and linking of a national identity specifier to all government services, benefits, and financial accounts.

Current situation: A Biometric Identity Management System (BIMS) was introduced in partnership with UNHCR to provide a digitally-enabled identity for immigrants into Ethiopia (approximately 900,000 people). In addition, the Registration of Vital Events and National Identity Card Proclamation No. 760/2012 came into force in 2016 (amended in 2017) to provide the legislative backbone for a birth registration system, putting responsibility at the level of the approximately 19,000 Kebeles around the country. The impact on birth registration rates is unclear, but it is highly likely that the Proclamation has had only a limited effect on the vast numbers of home-based, non-medically attended births in rural areas. Additionally, most regions charge for issuing certificates. However, the benefit to the government of encouraging registrations and collecting complete data should far outweigh any fees collected. In fact, the enormous benefits of accurate real time data on vital statistics, coupled with a universal biometric identity system linked to eGovernment, education, healthcare, and finance, necessitate proactive fieldwork efforts to ensure everyone is counted.

Opportunity: A single field worker should be able to register a child's or adult's identity centrally in under one hour from any location in the country. At this rate, issuing a digitally-secured identity to every person in the country would take 50,000 field workers one year of effort. According to several Ethiopian legal frameworks and policies between 1960 and the present day, the duty of registration and reporting vital statistics and events belongs to Officers of Civil Status, which includes a wide variety of responsible parties already employed throughout the country. It is estimated the maximum total cost of implementing the required infrastructure systems, digital equipment, and (all) manpower to be on the order of US$100M. The real cost may be as low as US$25M depending on the extent of existing infrastructure in the Kebeles, or existing digital-identity initiatives.

2. **Mobile Payments and the Cashless Society**

Current Situation: Ethiopia is almost solely a cash-based society. Even when accessing cash, a physical cashier is the main withdrawal method (83%) compared to ATMs (1%).

Opportunity: By making all government benefits and distributions a cashless disbursement (via mobile payments, pay-wave enabled cards, and identity-linked cards), and providing every Kebele[7] with centrally shared devices for completing transactions (in traditional marketplaces and inter-family transfers) where digital devices are not otherwise available, Ethiopia can become a near-cashless society, virtually eliminating fraud in financial systems, government services, and unlocking a wealth of information on the needs of the most vulnerable groups.

Perago Systems, the technology company who have developed the governments eGovernment service portal are operationally ready to utilise Ethio-Switch to accept digital payments for eGovernment services.

Artificial Intelligence can be leveraged to closely monitor the flow of funds to ensure integrity and efficiency, to understand the effect of government programmes/benefits, and to better understand the Ethiopian economy at the most detailed level.

Commented [RB18]: Note that the Ethiopia Government are currently engaged with a pilot for MOSIP for implementing a digital ID system. the Government has indicated that digital ID is important to Ethiopia's development, which can enhance inclusion as well as facilitate Ethiopia's trade in the Africa Continental Free Trade Area. Ethiopia has received $40m funding from France for a digital ID system.
https://www.economist.com/international/2020/12/07/covid-19-spurs-national-plans-to-give-citizens-digital-identities

A mckinsey report on Digital ID indicates that Ethiopia could capture economic value of 4-6% of GDP by 2030 with a digital ID programme.
https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Digital%20identification%20A%20key%20to%20inclusive%20growth/MGI-Digital-identification-Report.ashx

Commented [DS19R18]: Thanks Roxanne, we will add a paragraph re Digital ID

Commented [RB20]: If expanding on digital ID, I suggest adding a paragraph in here re: addressing concerns around the largescale capture of private data and security, vender lock-in, discrimination of marginalised groups. E.g.
- **Ensure robustness and security:** this will build trust.
- **Implement privacy-by-design.** Individuals should have agency over their data. Aggregated insights and analysis should be privacy-preserving.
- **Ensure well defined regulatory frameworks are establish** including data protection laws.
- **Focus on inclusion:** Governments must work to understand the needs of marginalized groups and encourage uptake and usage.

Commented [DS21R20]: We can summaries these in a small paragraph referencing the *Principles on Identification of Sustainable Development* which is also referenced in Digital Ethiopia 2015

[7] Larger Kebeles should be provided with more devices to ensure nobody is locked out from the system.

eGovernment and Society

AI provides an opportunity to develop comprehensive e-government systems with streamlined processes, increased access to benefits and services, increased accountability, and transparency. Ethiopia is a large country with a rapidly growing population. Many people depend on government aid and assistance programmes, but many more lack access to and knowledge of these lifelines. Artificial Intelligence can be used in order to expand access, understand utilization, and make citizens' and visitors' interactions with government as efficient and pleasant as possible.

Implementing efficient eGovernment services requires a functioning, secure, universal identity system through which all programmes can be linked and analysed. Recommendations for the prioritisation and constructions of such infrastructure can be found in the *Key Social Infrastructure* section of this document.

Because penetration of government benefits disbursement is low across the country, it is possible to expand benefit provision hand in hand with the introduction of biometric identification systems. It is critical that data are collected regarding consumption patterns, conditional and unconditional transfers, and how these impact poverty, property, educational achievement, access to core services, and labour market participation/entrepreneurship. As in any network, there are certain nodes and structures that are enablers, and Artificial Intelligence can help to identify the places where government intervention can quickly scale its positive impact, and other areas where government transfers will make little or no difference, or potentially disincentivise the target group.

Current situation and challenges

The government runs the Productive Safety Net Programme which is targeted at food insecure households. The programme provides conditional (on work) and unconditional cash or food transfers. Conditional transfers are aimed at households with labour capacity while households with limited labour capacity, pregnant or nursing mothers and infants, are provided unconditional transfers. The programme operates in six regions with chronic food insecurity and targets roughly 20% of the poor. The government has signalled plans to expand the programme to more cities and beneficiaries over the next five years. Beneficiaries can choose to receive cash, food, or a combination of both. Food distribution is 15 kg of cereals and 4 kg of pulses per month or its cash equivalent. Due to inflation, the cash amount distributed hasn't kept up with the price of food despite increases (cash payment started at 6 birr per day, before being increased to 8 birr in 2008, 10 birr in 2010 and 14 birr in 2012). Cash payment on the programme is now between 16 and 18 birr per day. Most beneficiaries therefore prefer to receive some combination of cash and food. The programme is estimated to have reduced poverty in the country by 2%. The current phase (ending 2020) was targeted at 8 million beneficiaries and cost US$3 billion. Little is known about the specific conditions of beneficiaries that have seen significant economic productivity boosts from the intervention.

Research by the World Bank found the Productive Safety Net to be well targeted, with beneficiaries more likely to be poor and having food shortages, owning fewer assets, and living in more remote and drier places. However, the intervention has some regional bias with caseloads exceeding poverty or food security indicators in certain regions and falling short in other regions. There is also significant under-coverage. The programme is highly concentrated with almost two-thirds of beneficiaries residing in three regions – Amhara region accounts for 24% of recipients; Oromia for

22% and Somali for 21%. In terms of binary poverty status, 39% of beneficiaries were below the national poverty line in 2016.

Artificial Intelligence can be leveraged in order to help provide a customised cash transfer benefits programme that considers local factors when determining need, as well as global factors when considering optimal allocation within and across regions. Programmes like the Productive Safety Net cannot scale to the entire population that might currently derive some benefit, nor even to the entire population that has a critical need due to chronic food insecurity. Therefore, **the programme must be maximally optimised and targeted to those beneficiaries that will produce the largest positive spill-over effects.**

Beyond cash-transfer benefits programmes, the federal and local governments issue a variety of business licenses, permits, certificates and other instruments that enable the execution of business activities, tax collection, import and export of raw, semi-processed, and finished goods, and the registration of foreign individuals, displaced peoples, or citizens' life events (birth, marriage, death, etc.). As well as being core requirements to enable the functioning of local economies and basic data collection, these services provide an important portion of revenue in several regions. Tax revenue from payroll, property, business profit, value-added taxes, and excise account for the majority of the government's income base, and collections can be significantly limited due to the lack of well-organised information on employment relationships, property holdings, and unregistered businesses. A large portion of the country's population participates in informal labour markets where there is little or no fiscal accountability, no application of health and safety law, and no application of general employment regulations.

Below, three proposed strategies are outlined to utilise AI across eGovernment.

1. **Proposed Strategy 1: Government Benefits**
   All cash disbursements should eventually be replaced with fully tracked and identity-linked electronic transfers that should be just as liquid as cash, per recommendations in the *Key Social Infrastructure* section of this document.

   The Government of Ethiopia has a duty to its people to spend from its budget in a manner that will maximise future revenues and economic productivity across the country. Thus, any person who receives cash or other transfers must agree for certain information of primary importance to be tracked relative to their economic life and consumption patterns. Such data will also allow for optimal linking to education opportunities, labour market opportunities, and timely healthcare for vulnerable groups (such as those not able to work).

   These changes are precursors to the implementation of Artificial Intelligence algorithms to help the government optimise spending and maximise impact. These data will also provide the basis for improved future interventions and better-informed economic development.

2. **Proposed Strategy 2: Business Registrations, Licensing, Permits and Individual Registrations**
   These areas of government can be fully digitised and commoditised. There exist a variety of off-the-shelf Artificial Intelligence tools for achieving all core revenue-generating government services, from business registrations and licensing, to land management, property transfers, property taxes, and additional configurable services. One example of such a service provider is Camino Technologies[8], which provides fully managed or on-site

Commented [DS22]: Informed consent will be difficult to implement – as it is important that understand what people are consenting to. We should caveat how informed consent will be a vital pre-requisite.

Commented [JH23R22]: I assume it is already the case that certain information must be provided in order to receive government aid. Most legal systems include provisions allowing the government to collect, process, and store information about its citizens for a variety of purposes, including the proper administration of social security systems. We should check this, but I was not imagining an informed consent process per se.

Commented [SZ24]: Reference current ethiogov portal – that its there and underutilized but has potential with AI to be even more useful/effective etc.

[8] https://camino.ai

solutions for any size government, together with secure data processing and linking to existing data in a variety of formats.

Such solutions will lead to efficiency gains, increased revenue from these activities, as well as increased compliance with existing requirements. Extensive Artificial Intelligence-based GIS land-use monitoring can also allow local governments to be alerted in near-real-time as changes happen to parcels of land in their jurisdiction, tracking potentially illegal logging activities, grazing patterns, or land-use changes over time.

Moving these activities to a virtual environment can also help municipalities to deal with back-logs by hiring additional flexible staff to work remotely when necessary, coordinating with field workers, and limiting the scope of corrupt actions within the system. Staff can be freed up to pursue compliance-oriented activities to increase adherence to rules and provide tailored assistance to help businesses and individuals succeed.

3. **Proposed Strategy 3: Tax Collection**
   In order to ensure sustainable tax revenues to achieve universal economic development goals it is necessary for all businesses, employees, and property to be registered and identity-linked in national registers. Achieving this goal will also ensure that minimum health and occupational safety standards are adhered to, and that exploitation of vulnerable groups is minimised. It is the responsibility of each Kebele to ensure that any business-like activity and employer-employee relationship that meets certain criteria is registered, and that registration is (as) free (as possible) and achievable by/accessible to everyone with little overhead.

   It may be necessary to provide positive incentives for initial proper registration, including reduced licensing fees, tax credit schemes, etc. It may be useful to apply alternative approaches, such as employer indemnity schemes and land-use monitoring to identify potential unregistered business activities, as noted above in point (2).

   Artificial Intelligence can help to determine the elasticity of productivity relative to multiple candidate tax schemes. For instance, to encourage the establishment of 'high-growth innovation-based SME's', it is likely that the corporate tax rate for these companies ought to be minimal, with concomitant benefits for in-country investors, akin to the United Kingdom's *Enterprise Investment Scheme*, or similar. One possible approach would be a graduated tax based upon a revenue-to-net-new-jobs ratio, encouraging fast growing and successful start-ups to create high-quality full-time work opportunities in return for lower tax treatment. With a sufficiently detailed view of the employment landscape in the country, Artificial Intelligence can be leveraged to model these scenarios statistically to better understand key economic parameters.

   Furthermore, with universal identity-linked benefits and financial transactions, Artificial Intelligence can mediate tax and benefits fraud monitoring, providing highly effective disincentives for the types of activities that ruin public trust in such government schemes.

Mobility and Urban Planning

Current situation and Challenges

Mobility refers to how people interact with their environment to conduct business, exchange goods, consume, and otherwise cause people or goods to change location. Ethiopia is currently a highly decentralised country, with the majority of the population remaining within a short distance of their settlement for extended periods of time. Fewer than 1% of Ethiopians travel via air each year, despite the country being very well connected by air.

Ethiopian Airlines currently operates more than 23 airports within Ethiopia, connecting the country with efficient air routes, as well as managing a significant portion of exports requiring highly technical transportation procedures (e.g. fresh cut flowers).

Although it is unclear what long-term cultural and behavioural shifts will occur as a result of the Coronavirus pandemic that started in 2019, historically, populations have demanded more mobility as they develop and expand economically. It is likely that the demand for mobility will increase significantly in Ethiopia, and the question is "what kind of infrastructure can best support future mobility objectives?"

The optimisation of route planning and ride sharing will grow rapidly as road infrastructure improves, as the population of Ethiopia continues to grow, and as more Ethiopians work in secondary and tertiary industries with places of work further from their dwellings. Similarly, as the productive capacity of the economy expands, the logistics sector will place more strain on available physical infrastructure.

An alternative is also possible, with many jobs conducive to remote working arrangements, and services becoming more localised, building fewer interdependencies over long distances. As more products can be manufactured locally and on-demand (e.g. through 3D printing), it is possible to reduce heterogeneous logistics loads. As technology and interconnectivity increase, more of the value of in-person interactions might become possible in shared 'virtual spaces'.

In terms of urban planning, there is a general push towards sustainable living solutions, whereby buildings are energy efficient, light-efficient, recycle water resources, and are able to promote circular economies from resources used. Urban gardening, green roofs, accessible common spaces, and integrated living solutions that provide a host of needed services in easily accessible clusters without individual motorised transport being necessary (or possible) are also gaining in popularity.

Ultimately the choice about how to live, work, and travel will be up to Ethiopians; but Artificial Intelligence can help provide more options, and help make smarter decisions about the types of infrastructure that may be necessary to support an optimally healthy, happy, and productive population.

Below, four proposed strategies are outlined to utilise AI across mobility and urban planning sectors.

1. **Proposed Strategy 1: Concerted Data Collection**
   Put mechanisms in place to understand mobility patterns around Ethiopia. This includes:

   - Road-based sensors;
   - Increased digital data collection at ports, such as electronic bills of lading;
   - Tracking wireless and Bluetooth device mobility patterns through telecoms partners;
   - Satellite and GIS data to understand economic activity patterns, agricultural productivity, etc.

Understanding the demand-based signatures of mobility will pave the way for smarter infrastructure investment, better placement of government and core services to reduce travel times and maximise reach, and better overall urban planning.

Collecting and organising such data will also allow Artificial Intelligence to be used to forewarn capacity constraints.

Specifically, Artificial Intelligence should be leveraged in the following ways:

- Understanding and analysing common mobility patterns and the semantic relationship that different points-of-interest hold, e.g. 'home', 'office', 'retail', 'port', etc.;
- Understanding the dynamics of goods entering and leaving the country, where they go, and how this is changing over time. This will allow for better decision-making with respect to the development of new and synergistic industries, and understanding the productive capacity of the country;
- Understanding high resolution satellite-based mapping data and similar GIS beacon sensors to classify granular items of interest, such as the productivity of agricultural lands, key infrastructure monitoring, shifts in land use, etc.

2. **Proposed Strategy 2: Mobility Tech AI Laboratory**
We recommend the creation of a Mobility Artificial Intelligence Laboratory as part of the recommended National AI Labs initiative. The lab should have access to national mobility data described in (1) in an academic setting, with the ability to engage in commercial spin-off activities that leverage data and Artificial Intelligence for *qualified use cases*.
The lab should work closely with the Ministry for Transportation and other relevant stakeholders. This will require academic interaction within the ministry on a rotating basis in order to expose ministers and staff to new ideas and potential of Artificial Intelligence in their domains of specialisation. Further, we recommend objective-based scientific funding, and a requirement for regular joint workshops, conferences, and reporting.

3. **Proposed Strategy 3: Traffic Incident Reporting**
Create a unified traffic incident reporting database, as currently planned within the Ethiopian Artificial Intelligence Centre in Addis Ababa. This will help inform road infrastructure development decisions, as well as the development of additional traffic laws and enforcement.

Ethiopia has a traffic fatality rate that is significantly lower than many of its neighbouring countries, but significantly higher than countries that have enacted strict legislation to address the five basic risk factors of traffic-related deaths: speed, drunk driving, helmets, seat-belts, and child restraints. Artificial Intelligence will not create any marginal improvement in traffic-related fatalities until these globally validated key areas have been fully addressed. However, as noted above, there may be some incremental benefit to urban planning from aggregating and deploying unified and comprehensive reporting data.

4. **Proposed Strategy 4: Automated Vehicles**
Automated vehicles are currently being tested around the world in well-mapped and fairly predictable settings and driving scenarios, and will remain so commercially for some time (especially as regulatory conditions in developed countries remain fairly risk-averse in terms of the wide-spread introduction of such technologies).

Commented [SZ25]: Makes sense to reference Deliver Addis, Ride and other similar apps here as that data is presumably being collected and exists -it's a question of sorting and utilizing..

Commented [SZ26]: Source?

Commented [DS27]: Let's find the level of current legislation, as I know legislation is stricter than many peer countries (i.e seat belts)

Commented [JH28R27]: I agree that some of the regulations may be stricter than peer nations, but these areas are not difficult to address via a legal-only framework. There is no reason for developing nations to be further behind than developed nations in addressing these 5 risk factors. The point here is that there is no gain from working on AI solutions to traffic incidents UNTIL all of these areas have been brought to the current best practices. Having said that, please definitely do add context for the current state of things, since the info we have is limited on existing traffic laws.

Commented [JH29]: This is an enormous economic opportunity, and it makes sense for Ethiopia to be doing this. However, we will hold off on filling out more details until the government tells us this is something they are excited about.

This creates opportunity for Ethiopia to capitalise on a nascent sector of rural mobility, mobility in difficult terrain, and automated vehicle solutions for:

- Disaster relief;
- Reconnaissance;
- Agricultural monitoring; and
- Population mobility in difficult rural terrain.

There is global demand for automated mobility solutions that are capable of performing in risky situations, including construction, military, agricultural, disaster response, and other scenarios. The regulatory hurdles to commercialisation of such technologies on a global scale are lower than for general automated vehicles, and the market is one that is currently receiving very little if any focus.

These are areas with enormous global market potential that lack access to experimental settings to test and validate ideas. **Ethiopia has ideal terrain variations and regular real-world testing opportunities to build advanced research and manufacturing facilities around these technologies.**

Commented [SZ30]: So we're saying test in Ethiopia because of its challenging terrain…? Can we also say something about the magnitude of cost to implement driverless cars in Ethiopia and the tension w.r.t. drivers losing jobs potentially?

Financial Inclusion

Ethiopia has a large (majority) unbanked population, and an even larger number would be considered 'underbanked'.[9] An efficient and orderly financial system allows the best projects to receive timely capital, encourages broad participation in the capital value chain, and incentivises private solutions to public challenges.

Commented [SZ31]: @Declan - Reference National Bank of Ethiopia Financial Inclusin strategy which emphasizes mobile money/digital solutions.

Artificial Intelligence can help provide better risk assessments for individuals and organisations with little or no credit history, increasing the useful outlets for investment flow, and bringing economic opportunity to even the most remote areas and challenges.

As outlined in the Key Infrastructure and eGovernment and Services sections, the move to a less cash-oriented society has enormous positive potential for optimal allocation of government benefits and services, tax collection, and facilitating the growth of enterprises. In addition, financial inclusion is impacted directly through each individual having more direct control over their financial existence, and it being more difficult to exploit at-risk categories such as women, those with limited literacy, and the elderly.

Artificial Intelligence can be leveraged in the following ways to increase financial inclusion and benefit Ethiopian society through increased entrepreneurship and better individual financial planning:

- **Financial Literacy.** Even the smallest smallholder farmer is a business owner, managing assets in order to produce and sell a product. However, the vast majority of businesses are extremely fragile and can suffer large impacts from small changes in their market or environment, making it very difficult to adapt and survive. Increasing financial literacy

[9] An individual who is *underbanked* conducts most of their transactions in a manner that does not involve communication among financial institutions, either through cash exchanges or a barter economy. These people would benefit from a more formalised system that gives them opportunities to build wealth more securely, leverage revolving credit, and smooth consumption. Financial Literacy is an important risk factor, and an important consideration when encouraging people to switch to more formal financial products such as credit cards, mortgages, etc.

among the population can help people take control of their financial lives and build some resiliency into the system. Artificial Intelligence can help to build training materials for deployment in Public Computing Centres as described in the section *Key Infrastructure for Artificial Intelligence*. These training materials should be linked to formal recognition of achievement and access to micro-financing credit lines where possible, in order to encourage broad participation.

- **Credit Scoring, Transaction Costs, and Market Frictions.** The ability to accurately predict the likelihood of fulfilment of contractual obligations, and therefore the expected risk of default, forms the basis of investment selection. However, most projects that need initial investment to grow and create jobs and become sustainable will not get access to credit because they lack the basic information necessary to determine a traditional *credit score*. However, as has been shown in the microfinance industry, repayment rates on buffered micro-loan products tend to be very high, indicating that there is a potentially vibrant market to increase credit and entrepreneurial activity among the poorest members of society. Through programs like Financial Literacy (above), and additional survey-based behavioural instruments, Artificial Intelligence can help financial institutions build sufficiently useful financial profiles of large numbers of unbanked and underbanked people to create commercially viable credit opportunities that increase economic development.
  Government efforts should be focused on capturing broad financial behaviour data (as part of the Key Infrastructure identified in this document) to enable anyone to quickly build their creditworthiness. The more people have credit profiles that the government and lenders can use to provide appropriate and tailored financial products, the lower transaction costs will be on those transactions, and the fewer market frictions will exist between providers and consumers of credit.
- **A Common Pool of Investment Opportunities.** Ethiopia lacks a public market for equity or debt investors to easily identify and evaluate private industry investment opportunities. This makes it difficult to offer benchmarked insurance and credit products, and holds back the development of pension funds, mutual funds, and other vehicles for deploying large pockets of capital back into the Ethiopian economy from private investors. As a result, the lack of internal markets leads necessarily to asset-hoarding, cash surpluses in some parts of the population, and investments in foreign markets that bring little benefit to Ethiopians more broadly.
  Regulatory activities should create simple mechanisms for Ethiopian and foreign investors to put money into Ethiopian private enterprises that operate within Ethiopia and hire primarily Ethiopian human capital. Any established Ethiopian company that is able to provide a minimal amount of financial information and related investment documents should be eligible to raise capital in a centralised and visible marketplace backed by government infrastructure. This should be true for a small operation looking to launch a co-working café in a remote village just as much as for a tour operator with multiple helicopters in Addis Ababa.
  The primary role of Artificial Intelligence in such a system is to identify fraudulent activities, anomalies, and provide value-added analysis of investment opportunities and funding opportunities to better match market participants—building a strong pool of national liquidity for investments across the country.

National Defence

Leveraging Artificial Intelligence towards the goals of defending Ethiopia's national interests and internal territorial integrity is increasingly a necessity. As Ethiopia's institutions become more mature and economic development leads to more and more complex relationships across key stakeholders in the country, Artificial Intelligence can be leveraged to identify potential anomalies in internal activities, communication networks, and interference by foreign state and non-state actors.

Key areas to be addressed include unmanned aerial surveillance, monitoring communications over complex network architectures, counter-terrorism activities, and countering foreign propaganda and disinformation campaigns.

- **Territorial Integrity.** The identification of potential risks and anomalies along Ethiopia's borders, and intelligence regarding military activities within the country, can be scaled effectively through the use of Artificial Intelligence to identify 'unexpected' changes in the landscape, unusual equipment, and augment existing on-the-ground monitoring systems and human deployment. Among these solutions are unmanned aerial vehicles (drones), satellite imagery, mobile surveillance operations, and the availability of high-bandwidth connections to security services data centres for aggregate analysis in near-real-time.
- **Network Monitoring.** Artificial Intelligence should be leveraged to minimise the risk of Ethiopia's national communication infrastructure becoming subject to a variety of security threats and attacks on its integrity (e.g. Distributed Denial of Service-style attacks). Steps should be taken to ensure critical network segments are independent, critical information pathways leverage upgraded network protocols or entirely separate protocols from external network traffic, and that all connections are verified through multiple multimodal stages to ensure only legitimate connections have access to secured objects and resources. Artificial Intelligence can be specifically leveraged as part of a network packet auditing process that continuously observes connections made and packets sent, and provides integrity scoring of transactions in the network to nodes that request it.
- **State and non-State Actors.** Artificial Intelligence has the potential to allow for the scalable monitoring of content creation and publishing in fora that have potential to cause widespread impact on public perception, including advertising and media networks, news and social media sites, and cell networks. In addition, keeping track of specific geographic locations, organisations, groups, and individuals for lawful monitoring due to suspected terrorist or other involvement can be greatly improved through the use of Artificial Intelligence algorithms to maintain profiles, trigger events for security personnel, and surface additional linked content for review.

In the aerospace sector there is a lot to be stated in terms of missile guidance systems, and advanced Artificial Intelligence for equipment in the field. However, these latter topics are beyond the scope of this document.

Job Creation Opportunities

In several legislation and policy documents (for example the Homegrown Economic Reform Agenda and the National Digital Transformation Strategy), a series of sectors have been identified, that are to be prioritised for investment and economic development. This list includes sectors that are core to the current employment landscape, growing segments of the economy, and strategic areas for new types of economic activity and value creation. The main objectives for development of these

sectors are job creation, decreasing the trade deficit between Ethiopia and its trading partners, and economic transformation from a primarily agricultural producer to a primarily industrial and services-driven economy.

In this section we focus on each of the government's priority areas, highlighting what is currently being done, and how Artificial Intelligence might be leveraged to bring about efficiency improvements, create new jobs, and exploit synergies.

Sustainable Food Networks (Agriculture)

The current challenges of low yield, climate change risks, increasing desertification and low productivity faced by the agricultural sector provide opportunities in AI for crop and land use optimization, agriculture monitoring, farmer education and precision agriculture.

Sustainable Food Networks place an emphasis on resilient distribution networks, ensuring overall system stability, appropriate hedging agreements, and an analysis of population needs/demand over time.

A large emphasis is placed on the development of the agricultural sector, including from an ICT perspective. Ethiopia's Digital Transformation Strategy covers 'Unleashing Value from Agriculture' as one of four main priority areas for its digital strategy. The sector currently provides around 70% of Ethiopia's employment base (down from 80% in 2005) and one third of GDP.

The major crops produced include coffee, cereals, cotton, sugarcane, oilseed, and cut flowers. In rural areas, over 70% of households derive their income from agriculture (specifically crop production). Non-farm income only accounts for 6% of rural households.

Commented [SZ32]: Several statements need sources

Over 90 percent of crops are produced by small holder farmers, with average landholding between 0.5 to 1.2 hectares. Grains (maize, sorghum, wheat, teff) are the most common types of crops produced by farmers. About 70% of crops are produced for household consumption; under 10% of production is replanted/used as seeds; and less than 30% sold. Smallholder farmers predominantly sell at village markets or to assemblers, cooperatives, and local traders. The figure of 30% is aligned with internal demand, since this is the proportion of the non-farming population reliant on purchasing food. It is expected that as agricultural production increases and average landholdings increase, the proportion of food produced for household consumption will drop drastically, providing more scope for food processing and packaging industries, lowering the marginal cost of production, and leading to supply imbalances that will both lower prices of staples as well as cause entrepreneurial activity to create new products and distribution networks to raise demand back to equilibrium levels.

Of Ethiopia's 273M acres of land, approximately **55% (150M acres) is arable land**. Using modern farming techniques, assuming average productivity, average loss projections from extreme climate events, and the need for fallow land, it is estimated (leveraging comparable land quality in the United States) that a future agricultural industry would be capable of sustaining **one individual in the population with ~0.8 acres of arable land**. This places the current **carrying capacity of Ethiopia at about 188M people** (assuming current proportions of exports), following an agricultural transition to modern techniques, equipment, and logistics/storage. As this transition takes place, of the 40M people currently working in agriculture, **35-38M people will likely transition to supply chain, equipment, logistics, as well as entirely different sectors of the economy**. Specifically, at current rates of yield improvements it can be estimated that **Ethiopia will only sustain around 40% of its workforce in commercial agriculture in ten years' time (2030)**. Such a shift would result in doubling

the number of new jobs needed in other areas of the economy over the next 5 years (currently estimated by the Ethiopian Jobs Creation Commission as 14M).

AI in Agriculture

With such a large proportion of jobs derived from primary agricultural production, it is necessary to thoughtfully weight potential transition strategies. If Ethiopia wants to build a modern agricultural sector with modern equipment and high yields, then Ethiopian's will no longer be working as smallholder farmers. Farming will no longer be the main human occupation in Ethiopia, and the bulk of economic development and job creation will need to be provided by other (complementary and local) sectors.

If Ethiopia does not take steps to build a modern agricultural sector, it risks increasing its reliance on food imports, and not being able to sustain currently projected population growth rates, along with the humanitarian consequences such an outcome would entail.

A possible strategy for transitioning to a modern agricultural landscape would be as follows:

1. Incentivise and encourage the legal registration of smallholder farmers as limited liability corporations.
2. Incentivise and encourage the formation of legally coupled farming cooperatives with yield and profit-sharing stipulations. Provide access to low interest mechanisation credit for the purchase of jointly owned heavy equipment for harrowing, tilling, sowing, harvesting, and other similarly labour intensive farming tasks. Equipment leases should be long, and tied to performance as much as possible. This will promote coordination, more scalable farming processes, less labour intensive operations, and more predictable outcomes. Since farms work at the family level, the increased availability of labour should encourage additional business formation in synergistic industries.
3. Formalise commodity exchanges and local markets along all major crop production (not just exportable products) to enable effective futures markets to develop and risk-hedging mechanisms on forward contracts, providing cooperatives with guaranteed demand and stable prices. This will encourage specialisation and appropriate crop planning and land management practices. It will push some smallholder cooperatives to leave the farming industry altogether or move along the supply chain.
4. Incentivise and encourage the creation of local agri-processing industries that create derived food products, textiles, and other products leveraging farming products and by-products as inputs. This might be through microfinancing, tax relief, guaranteed demand, etc. This will lead to an explosion of derived refined products, trading-based entrepreneurship, and a large number of potentially exportable products. An increase in local variety may also have positive spill over effects in demand and agricultural product margins.
5. Encourage the creation of vertically integrated supply-chain partnerships with national distributors to provide stable supply to stores and supermarkets throughout the country; and create stable margins on agricultural products. The most effective cooperatives will expand and absorb less productive operations. Financial transactions will provide local economic spill over to accelerate non-farm job creation.
6. Encourage precision agriculture, automated crop-monitoring solutions, in-country seed development for local soils and conditions, and Artificial Intelligence for farm management and yield optimisation. This is the final step to building a globally competitive agricultural sector. The sector is no longer human labour-heavy at this point, but it serves a large intermediary market of products with stable demand, can effectively produce sufficient food

Commented [SZ33]: Reference Ethiopia Commodity exchange as a DT strategy project – will be interesting to hear from MINT where that is…

to feed the country and generate export revenues, and attracts foreign investment. There may be additional positive effects from Ethiopian seed development across the continent.

a. In addition, Microsoft and the Microsoft AI for Earth programme have developed robust and scalable "agri-tech" solutions for efficient and low-cost crop monitoring and management on edge networks. We would recommend a set of pilot projects in strategically located 'high-risk' agricultural areas to bring real-time wide-area monitoring to crop-lands on a cooperative basis (i.e. groups of small-holder farms), at least for certain staple crops (e.g. Teff).

Although Artificial Intelligence only appears to be playing a role in the final stages of the agricultural transition, there are opportunities for the use of data and AI in decision-making from the very beginning. This will be especially critical when monitoring the formation and merging of smallholder farms, the dynamics of job creation in each local economy, and the selection of appropriate economic interventions and incentives along the way. In addition, precision agriculture and crop monitoring for yield optimisation should continue to be tested and developed in selected farms that are already at the latter stages of maturity described. This is especially the case in the coffee and fresh-cut flowers sectors.

Tourism + Lifestyle

Tourism is a key component of Ethiopia's development roadmap, and the country has an extensive cultural patrimony that provides ample opportunity for sustainable and green tourism initiatives in a variety of settings. This section will delineate recommendations for core infrastructure and enabling AI technologies to accelerate preparation for a significant tourism sector in the future.

Beyond the core infrastructure needed to support a growing tourism sector, there is an opportunity for Ethiopia to become a 'lifestyle-hub' for the broader region and world. A lifestyle-hub provides networks of lifestyle enhancing activities from fitness to business training, to holistic retreats, nature retreats, and adventures, linked together to allow infinite unique experiences for the individual.

AI for a Lifestyle Hub

Ethiopia has unmatched history, a vibrant cross-cultural art scene, incredible nature, and more that can quickly be leveraged to create new business opportunities throughout the country, without the need for a large number of centralized developments. These opportunities are AI-compatible, which offers tremendous scale advantages and efficiency improvements over competitors.

The modern tourist seeks experiences that are aligned with their lifestyle goals, and that embody modern ideals of sustainability and respect for the planet's resources. There is an expectation that experiences will be consistent and compatible, yet tailored to individual needs and tastes.

Recommendation: A Lifestyle Marketplace

Through networks of regional and local tourism offices, the government should provide a national infrastructure for the interoperability of as many tourist activities as possible. This includes:

- Accommodation: hotels, vacation rentals, RVs, spa retreats, camping, with common operating regulations, booking, and reservation management infrastructure;
- Transportation: air, boats, cars, scooters, RVs, day tour operators, buses, etc.
- Food: restaurants, tour operators, catering providers, food delivery services, venue concessions;

- Activities: events (e.g. concerts, theatres, fashion shows, art exhibitions/interactive), self-admission (e.g. zoo, cultural exhibit, art galleries), guided tours, day spas, sports, health and relaxation, shopping, farmers markets, adventures, hiking, kayaking, etc.;
- Services: concierge, haircuts/barbers, monetary exchanges, insurance, clothing, wedding planners, etc.
- Model itineraries curated by local guides and celebrities.

Once all tourist activities are regulated to collect similar information, and operate under a common reservation interface, then Artificial Intelligence can help users (potential visitors or internal tourists) to build and manage their ideal itinerary from start to finish, purchase additional services, complete payment securely online (including tourism taxes), and submit identification documents and registration requests. In addition, users should be able to receive assistance from virtual chat assistants, as well as real people, to ensure a seamless experience that maximises visitors and money spent within the country. Putting visitors in control of their experience, in their local language, with the ability to easily amend any aspect of their trip, will provide an unrivalled service to drive millions to discover Ethiopia each year.

Extractive Sectors (Mining and Drilling)

Sectors like mining and drilling have benefited from Artificial Intelligence primarily through more advanced algorithms for efficient exploration and exploitation of identified reserves, predictive maintenance of equipment in the field, and reducing on-the-job injuries, mine shaft collapses, and other similar occupational risks of the industry.

Artificial Intelligence should be leveraged alongside geophysical analysis in order to enhance safety audits of mines and drill rigs. There are opportunities to increase the range and usability of sonar probes, fracture identification, and mine shaft stability through Artificial Intelligence modelling of these areas. It is unclear to what extent such initiatives should be undertaken at the government level vs. left to private industry. In the case of safety, the government can play a role in creating the right regulatory pressures to ensure appropriately sophisticated methods are used to de-risk working conditions as much as feasible.

Secondary Industries

Across the secondary industries of manufacturing, processing, and refinement, Artificial Intelligence is being applied around the globe to achieve significant operational and logistical improvements, from reducing equipment down-time, to shortening lead times for orders, and predicting inventories more accurately for just-in-time management.

Artificial Intelligence, Internet of Things (IoT) Technologies, and innovations in areas such as 3D Printing and micro-farming are potential risk factors to consider as investments are made in these strategic industries. Large multi-national players are actively exploring distributed manufacturing solutions and alternative business models that adhere to the 1.5C Climate Compact considerations, which may conflict directly with a medium-term strategy of reliance on traditional hub manufacturing for economic growth.

Both the positive opportunities and possible risk factors will be discussed in the following sections, along with additional areas that have been identified for disruptive innovation.

Leather

The leather and tanning industry relies on raw inputs from the primary sectors, and Ethiopia has a distinct advantage in terms of the proximity to raw materials, and the largest livestock population in

Commented [JH34]: To be clear, we are saying that a lot of additional work needs to go into ensuring that large capital expenditures on manufacturing (especially clothing and anything that might be 3d printed) will not be obsolete within 10 years, leaving Ethiopia even further behind in job growth than doing nothing. This is an extremely important point, as large clothing retailers are becoming more vertically integrated and designing hyper-local just-in-time manufacturing facilities, as well as printed textiles. 3d printing in general is about to start having a very large impact on traditional manufacturing in any resin-based industry, ceramic-based industry, or similar. However, there remain large segments like tanning which are probably quite safe for large investments. What's the best way of getting this message across?

the continent. Working approaches in the industry promote high standards of ethical labour practices and sustainability-conscious processing through the Ethiopian Leather Industries Association and partnerships with global brands.

Artificial Intelligence will most likely not play a large role in the leather and tanning production process, although there may be opportunities for improved quality assurance (for example, US and European meat processing plants leverage Artificial Intelligence and Computer Vision to automatically grade the quality of carcasses, augmenting human quality assurance engineers), especially as exports grow and products become subject to regional or global quality standards. The main areas recommended for the potential introduction of Artificial Intelligence are:

- **Guaranteeing genuine tracing:** ensure that customers can verify the exact source and story behind the goods they receive by introducing smart identifiers to all products that are manufactured. Building Ethiopian Leather into a globally recognised brand for ethical business practices and sustainable sourcing, with the ability to see the product at different stages of development, and the faces behind it.
- **Flexible manufacturing practices:** build a large pool of artisans capable of adapting to customer needs at very short notice, and leverage this comparative advantage to allow extremely flexible order specifications that can be fulfilled quickly and with high quality.
- **Improved logistics:** leverage Artificial Intelligence to provide end to end efficient logistics for global leather shipping, especially for unfinished products that require particular storage and shipping methods.

Textiles

The textile and clothing industries have been powerhouses for economic development in developing nations for the past several decades. As clothing requires extreme dexterity, attention to detail, and often requires the addition of various accessories and other components, it has been considered fairly robust to complete automation, and as a result large investments have been made in capacity building in countries where the marginal cost of labour is cheap, and materials can be sourced quickly and easily.

However, the process of clothing manufacturing in particular (but textiles in general) is starting to shift, and will likely shift significantly over the next decade. Fashion lifecycles are shortening each year, with designers and consumers demanding more and more customisation and smaller batch sizes. As a result, large global brands are looking at ways to reduce supply chains and logistics pathways to create faster turnaround times to retail outlets, and bring their operations closer to consumers.

One of the principal ways in which increased efficiencies and flexibility will be achieved is the move to 3D printed garments. In 2016, Ministry of Supply, a US-based garment manufacturer, unveiled a men's suit jacket that could be fully 3D printed without seams in 90 minutes, with zero waste from yarn, and a reduction of more than 80% in overall water usage. Production times have since decreased, and the number of fabrics that can be leveraged within such a system have increased rapidly to include wool, cotton, and polyester-type fabrics, as well as varieties of blends that have entirely new visual and wearable properties. It is logical that the cost of such machines will decrease rapidly in the coming years, and they will provide several attractive advantages to manufacturers and designers:

- Drastically shorter lead times;

- Drastically reduced human capital cost;
- Drastically reduced waste and cost of materials;
- Drastically increased workshop density—less floorspace needed per output;
- Flexibility to produce any garment on any machine;
- Flexibility to produce garments individually tailored to each customer.

As the industry moves from a human-capital-driven cost-base to a raw-materials-driven and energy-driven cost-base, the need or advantage of locating large manufacturing hubs in low-income countries effectively disappears. The relative cost of creating a manufacturing capacity equivalent to today's large clothing factories may end up making the transition much faster than might be observed in other compound manufacturing industries like car manufacturing.

As a result, we do not recommend large capital investments in job creation in the clothing industry without long contractual lock-in periods, or de-risking of upfront capital costs in the case that demand falls or disappears. Focussing job creation on other areas of the economy now may be a better use of resources than repeating the exercise in a few years' time.

One exception to the above is the generation of raw inputs into the textile industry, yarn spinning, and advanced textile manufacturing as inputs to the creation of finished products. Ethiopia has the potential to generate large amounts of natural wool, cotton, and textiles derived from agricultural by-products.

Construction

The construction industry is being revolutionised by Artificial Intelligence, with advanced materials and structures designed through automated CAD software, faster and more accurate quality verification, and a reduction in material cost, waste, and complexity of the construction processes.

Construction is another industry where 3D printing methods will have a medium-to-long-term impact, with houses being 3D printed with concrete extrusions in a matter of hours. However, residential and commercial structures are far more than the shell, and it is a long way to a time when all infrastructure could be autonomously constructed and all details completed. In addition, the cost of equipment setup still makes these methods inappropriate for certain types of smaller scale projects, or those where geophysical conditions need to be accounted for as the project progresses.

Commented [SZ35]: Worth referencing initiative to build 3D refugee housing? Refugee accommodation is a major concern in Ethiopia: https://www.mercycorps.org/blog/3d-printing-syrian-refugee-camp

We recommend leveraging Artificial Intelligence as part of the design process in order to reduce materials waste and ensure the construction plans are as efficient as possible, using low-cost production processes whenever they yield equivalent end results and durability.

Pharmaceutical

The pharmaceutical industry is among the most high-tech industries, and has undergone significant data-driven shifts in drug discovery and production processes in recent years. Artificial Intelligence is leveraged to speed up the process of simulating cell interactions, synthesising chemical compounds, and identifying research that can help accelerate experimentation.

In addition, Artificial Intelligence can better help to understand patient outcomes in studies, and to understand how well drugs are operating in the real world.

The use of Artificial Intelligence in the pharmaceutical industry means that a large number of skilled workers is needed in order to enable a modern discovery and production process. **Therefore, efforts**

should focus on ensuring a sufficient bandwidth of potential employees exists that can feed into planned operations, since this will be the primary constraint on development.

Manufacturing and the 4th Industrial Revolution

Broadly recognized as the 4th Industrial Revolution, global manufacturing and logistics operations are being reimagined to capitalise on advances in automation, shorter innovation timelines, demand-driven production, and proximity to (a)primary marketplaces, (b) cheap energy, (c) raw materials. This section highlights recommendations for Ethiopia's comparative advantages in this area, including the expectations of future labour stability and productivity growth.

It is to be expected that as the reliance on skilled workers in manufacturing decreases, certain large-scale manufacturing activities will migrate to regions that can provide (a), (b), and (c) above. Ethiopia is very well placed to take advantage of (a) and (b), with the potential to target specifically those product categories where there exists a competitive edge in (c) as well.

Where these conditions are met, Ethiopia will be able to attract major global producers and gain sizable market share. One such segment may be the textile industry, as noted in the *Textiles* section above. In such instances, manufacturing hubs will be able to leverage the latest technologies and processes to create high quality products for export. In addition, such segments will ensure that labour participation in manufacturing (and therefore the creation of high quality jobs) remains relatively stable, and will encourage upskilling of workers, providing positive education spill-over effects and a more flexible/adaptive workforce for future shifts in labour demand.

NB: We would like to add a variety of example segments here, but we have not been able to get a good understanding of existing manufacturing capabilities in the country.

Creative Arts

Creative Arts are described as a priority for job creation and industry development in Ethiopia, and this is an industry that should expect minimal disruptions from Artificial Intelligence over the coming decade. Ethiopia is well placed with a highly creative culture, and many artisans, artists, and contributors to build a vibrant creative arts industry. Artificial Intelligence can certainly help as part of distribution channels and maximising the reach of products and programmes, but we do not believe there are priority items that should be developed in the near term.

Export-led Innovation

A key objective for the Government of Ethiopia is to boost exports, narrow the trade deficit, and increase holdings of foreign cash. This section will address this issue directly, drawing on various recommendations throughout this document to provide a holistic view of how Artificial Intelligence may be able to help.

At times of economic transformation, governments must take a leading role in enabling appropriate lean legislative infrastructure and removing frictions to experimentation in the private sector. A relatively fast-growing economy with a low-cost base must take risks in order to find and define its comparative advantage. Beyond lower costs, foreign investors need to be assured that the services and products they produce in Ethiopia will have seamless access to global markets. This requires more permissive tax and import/export regimes, as well as identifying the country's core strengths.

Commented [RB36]: Could reference how 3D printing is being used in the fight against covid-19 i.e. to produce ventilators and masks. E.g. Maisha Technologies are producing face shields https://techbuild.africa/12-start-ups-east-africa-150k-villgro-kenya-covid-19/ https://www.facebook.com/AusEmb.ET/posts/to-help-fight-covid-19-in-ethiopia-young-social-entrepreneurs-and-technologists-/1601014306729818/

Commented [JH37]: It appears primary resources like wood, granite, clay, etc. are not well developed in the country, such that the real advantage to manufacturing is mostly cheap energy and central location to global markets. To the extent that raw materials can be obtained sustainably and with short/consistent lead times, almost any manufacturing activity could be beneficial to the economy, although we would not expect a huge impact on job creation.

Commented [SZ38R37]: Worth reaching out to Tesfachew on this? He is the exports guru in our team….?

Ensuring Inclusivity: Female Workforce Participation

Female literacy rates are consistently lower than men across Ethiopia, and there is a significant gap in formal workforce participation. Due to the extent of the informal labour market it is difficult to verify overall female workforce participation, or to effectively measure differences by sector and task.

In 2018, the Ministry of Trade and Industry and UNDP Ethiopia released a report titled "A Study on Women in Manufacturing in Ethiopia", which proposed a policy framework for addressing some of the frictions faced by women in the manufacturing sector, and encouraged the development of opportunities for women in emerging industrial sectors, especially with respect to newly developed industrial and agro-industrial parks. At the same time, USAID's efforts have focussed on the rural female workforce, addressing issues such as child marriage, female genital mutilation, and patriarchal societal structures, all of which limit female participation in education, household decision-making, and the formal economy.

"Addressing the challenges facing female participation in the manufacturing labour force will catalyse the growth of the manufacturing sector in Ethiopia." (from *A Study on Women in Manufacturing in Ethiopia*).

Female workforce participation is critical to a well-functioning society and economy, but it is important to be aware of first order constraints that may make progress difficult for some time. Due to rapid population growth, the Ethiopian economy has been unable to keep up with the numbers of young people entering the workforce each year. Over the past decade, youth (15-24) participation has dropped from 76% to under 70%, representing a gap of more than 1.5M unemployed youth. Between 2020 and 2025 it is projected that 14M young people will enter the labour market, making it difficult to address female workforce participation until economic growth is capable of keeping pace with organic growth.

A well-educated female population is an empowered female population that can be a primary force for economic growth and value creation. At the same time, educating and employing the nation's female population can go hand in hand with building an AI-influenced infrastructure. Internationally, there is a push for women and people of colour to enter the field of STEM. Ethiopia is strategically positioned to activate an underserved portion of the population to make the entire country more technologically competitive.

1. **Particular Consideration**

   Young women drop out of school at a much higher rate than young men, and school may often be viewed as less important for them, especially in rural and agriculturally reliant regions. For each of the recommendations made in this section on *Education, Skills, and Workforce Diversity*, as well as Healthcare, we recommend that the particular matters of female participation, equity in employment opportunities, pay, and protection of basic rights be monitored closely as a priority.

Data Ethics and the Governance of Artificial Intelligence

This section focusses on the difficult questions of how Artificial Intelligence solutions should interface with society and legal frameworks, as well as how to adapt data privacy, processing, and governance standards to ensure that the development of Artificial Intelligence solutions is encouraged while protecting the rights of individuals to privacy and fair treatment.

Governance of AI

Globally there has been a great emphasis placed on the need to protect vulnerable groups from the (un)intended consequences of automated decision-making, whether it be (i) physical risks of harm (e.g. a driverless car selecting a series of actions that leads to the death of a human being), (ii) unfair treatment of a protected category (e.g. denying credit to female applicants who are otherwise indistinguishable from male applicants), or (iii) economic risks of wide-scale worker replacement from advanced automation of occupational tasks.

Proponents of strong regulatory frameworks point to examples where Artificial Intelligence-based systems have been found to display undesirable behaviours. For instance, a Microsoft social chatbot prototype that consumed and emulated inflammatory remarks on Twitter, a sentencing tool called COMPAS, from Northpointe, which predicts the likelihood of recidivism for court systems across the US and has been accused of systematically favouring non-black defendants, or an internal resume scoring system developed by Amazon.com that purportedly assigned a lower likelihood of success to resumes that were more likely to be from female candidates. In the US and Europe, the question of risk or harm in application of Artificial Intelligence has stemmed primarily from the treatment of protected categories (ethnicity, gender, age, sexual orientation, religion, etc.). The evaluation criteria applied to these cases is consistently whether an Artificial Intelligence algorithm displays decision-making that, when deconstructed along protected categories, shows different distributions of outcomes. In addition, in some cases, the evaluation might further consider whether these differences in a particular sample lead to 'correct' or 'incorrect' predictions.

However, the following is a more useful framework for understanding Artificial Intelligence applications in Ethiopia:

- The benchmark for introducing automated decision-making in government contexts should be based on whether a proposed system is consistent with existing procedures, and produces results that are consistent with existing non-automated results.
- Where an automated system differs from existing decisions being made, those differences should be investigated to ensure they are either (a) harmless, (b) more useful than existing decisions, or (c) rare enough to be acceptable relative to improvements elsewhere.
- All critical applications of Artificial Intelligence in government or regulated industrial contexts should be subject to risk-adjusted evaluation. That is, a set of real world validation cases is developed independently of the system, and each case is annotated by experts to assign a 'cost of failure', which is the relative harm of each type of error that could be made for that case. The risk adjusted evaluation is then the total 'cost' of mistakes made by the system, relative to the total 'cost' of mistakes that were actually made with an existing non-automated process.
- Systems in regulated contexts should be reconstructed and re-evaluated on a regular basis, where the exact time frame should be determined by the underlying rate of change in the predicted context. That is, systems making predictions about the allocation of healthcare resources would likely need to be re-assessed more frequently than systems making short term weather predictions (where the underlying physical system is unlikely to change drastically in the near term).
- Systems in less regulated contexts, e.g. operational optimisation in industrial settings, customer service chatbots, marketing optimisation, and the like should be managed according to prevailing legal and ethical frameworks that are not specific to Artificial Intelligence. That is, it would be expected that some of these systems will act in undesirable ways from time to time, and that such behaviour will be challenged by interested groups,

which can be pursued in much the same way as it would be absent an automated system, insofar as responsibility for any automated decision is legally grounded in the organisation responsible for the system's deployment.

- In less regulated contexts, it is expected that market forces will ensure that Artificial Intelligence algorithms will minimise unfair bias. That is, bias that is not a good predictor and an actual driver of real-world outcomes.[10] To take the case of a candidate pre-screening algorithm from a company that is biased against women. If those women are just as qualified as other candidates that are considered, then the company's competitors should be able to hire them instead at a lower cost and realise better productivity and scale efficiencies, thus driving the market back into balance. An open and competitive hiring market should have no reason to systematically block out top talent that differs only along attributes that are irrelevant to workplace success.
- Even if some biases persist in less regulated contexts within Artificial Intelligence solutions, the negative consequences on economic productivity and innovation would likely far outweigh any positive consequences from regulation.

In general, Artificial Intelligence cannot be expected to solve unfair treatment in society. However, a natural consequence of Artificial Intelligence is that it is much easier to identify problematic outcomes in a consistent functional manner, and to incentivise progress in the right direction. **Holding Artificial Intelligence solutions accountable to a higher bar than is effectively used for human actors will unnecessarily harm economic development and scale/cost/productivity improvements, especially in nascent economies like Ethiopia. Having said that, in core government contexts it is important to adhere to standards that ensure decision-making is at least as good as through non-automated methods, and that the cost of errors is properly assessed. This is an opportunity to build better governance processes in general, not just for Artificial Intelligence.**

In April of 2019, the European Commission's *High Level Expert Group on Artificial Intelligence* published a report entitled "Ethics Guidelines for Trustworthy AI". The document highlights three main aims. "Trustworthy AI" should be:

1. lawful - respecting all applicable laws and regulations
2. ethical - respecting ethical principles and values
3. robust - both from a technical perspective while taking into account its social environment

Insofar as these guidelines are irrefutable, such constraints should be applied to all government and industrial processes/products equally, rather than making special legislative cases for Artificial Intelligence systems.

Data Ethics

The last decade of acceleration in adoption and commercialisation of Artificial Intelligence technologies around the world has caused a joint acceleration in the volume and types of data being collected to fuel analysis. In turn, this has raised questions over how existing data privacy laws interact with the needs of data-driven products, services, and economies. On the one hand, there are extraordinary benefits to having real-time, up-to-date, accurate information on individuals, companies, goods, events, and other entities. This can range from improved medical care, more efficient disaster response efforts, to a better interest rate on a loan. On the other hand, ambiguous and incomplete legislation, or a lack of public trust, can lead to worries of data being used in

[10] For example, an oncology model that learns that women are more likely to suffer from more severe breast cancers, need not be a cause for concern.

undesirable or harmful ways, especially by third parties who do not have a direct relationship with the data subject. Such worries also extend to the inherent difficulty of contesting the accuracy or validity of data used in decision-making, including issues such as merged files or incorrect attribution.[11]

These types of issues are not created by Artificial Intelligence, but they are exacerbated by the current focus on data-driven decision-making, such that it is necessary to ensure that clear guidelines and accountability exist. The following is a list of recommended ethical data guidelines:

1. Any individual should be able to request all information that is held about them in 'open-file' government repositories, or by private commercial entities who are under the jurisdiction of the Ethiopian Federal government.
2. Any individual should be able to request a description of the uses of their data within 'open-file' government contexts or by private commercial entities.
3. Responses to requests should be fulfilled within a reasonable period of time, and an ombudsman should exist to protect these rights should organisations fail to comply in a reasonable and timely manner.
4. Any individual should be able to contest uses of information about them as unlawful, following a defined escalation process, and leading to appropriate fines or other action if organisations are found to be regularly and significantly in breach.
5. If an organisation collects information about individuals that includes certain categories protected by Ethiopian law, then, if these categories are used in decision-making, the organisation should be able to show that the information is not being leveraged in a way that leads to unlawful decision-making, irrespective of whether it forms part of an automated system.
6. Organisations with a lawful need to process certain sensitive personal details (e.g. medical records, financial records, identification, government benefits) must adhere to international data processing and storage standards for that information (such as ISO/IEC 27001), and must have a fiduciary duty to not sell or share such information with organisations that do not have a *qualified need*.

The European Union's General Data Protection Regulation imposes onerous data governance responsibilities, and requires significant business process overheads, infrastructure audits, and hefty fines for infractions anywhere in the world. Such a heavy-handed legislation would not be in the best interests of the Ethiopian people or economy. However, a lack of implicit guidelines at the outset, could set Ethiopia up for complications as the scope and breadth of work continues to scale. Therefore, efforts should be focused primarily on removing frictions to doing business in the country, while maintaining sensible and adequate protections on personal and sensitive data, especially when used for sensitive government or commercial purposes.

[11] For example, consider the case of 'credit reporting' and 'credit scoring' of individuals. Since data are often gathered from a wide variety of sources, it is common for two individuals with a similar name and location to be merged into a single file, or for two independent files to contain information that is incorrectly associated. This incorrect information will be used to make decisions on the credit-worthiness of an individual to buy a car, own a house, open a bank account, in most cases without that individual realising that such a procedure exists, and having very little practical recourse to correct their records.

Hate Speech and Disinformation

In February 2020 the Ethiopian parliament passed the Hate Speech and Disinformation Prevention and Suppression Proclamation, which criminalises certain incitation to violence based on a set of protected groups including ethnicity, religion, race, gender, and disability.

The Government of Ethiopia also maintains infrastructure for monitoring communications and social media use within the country, like most governments around the world.

Ethiopia's latest law uses a broadly accepted 'effects-based' definition of hate speech, which maintains victims front and centre and evaluates the intended and actualised outcomes of the communication. It also focusses on social media accounts that have wider following and more opportunity to influence opinion.

Any content monitoring and participation in publishing information through public channels comprises risks of being perceived as 'propaganda' or 'inciting dissent'. Determining the factual worthiness and intent of a communication is beyond the capability of existing Artificial Intelligence algorithms, and such attempts are more likely to guide the linguistic choices and cultural memes chosen rather than lead to a definitive solution to unilateral hate speech or disinformation. In many cases, such a categorisation is also beyond human consensus. However, there is a place for Artificial Intelligence monitoring of web-scale communications data within a comprehensive anti-terrorism and national security framework, where such data can augment a nation's insight into potential threats, and help provide the public with timely information to guide their understanding of messaging by certain actors. This document does not recommend the usage of current AI tools within a criminal liability framework.

Commented [DS39]: I do not think that current tools have the ability to process local language content?

Commented [JH40R39]: Amharic seems like it has several associated NLP implementations and is fairly robust. Somali seems possible too. Oromo and Tigrinya would need work. Oromo is clearly the biggest missing piece as far as I can tell, but if official government documents are both Amharic and Oromo then I am confident we could build tools very quickly. That wasn't so much the point of this last sentence though—it was just a warning to not think deploying AI in general for the problem of hate speech would work particularly well, even if it were all in English.

Concluding Remarks

To be added when finalised.

About the AI for Good Foundation

AI for Good pursues the creation of technical capabilities, infrastructure, research communities, policy frameworks, and implementation to ensure Artificial Intelligence is used in the right place at the right time to accelerate progress towards the United Nations' Sustainable Development Goals. The Foundation was created in 2015 and operates globally, with public charity registrations in the United States (501c3) and Europe. For further information, please visit https://ai4good.org or email info@ai4good.org.

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