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Emerging technology trends: Artificial intelligence and big data for development 4.0

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Authors: Dr Mirjana Stankovic (Tambourine Innovation Ventures), Aminata Amadou Garba (International Telecommunication Union), Nikola Neftenov (Tambourine Innovation Ventures)

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Please share your thoughts, corrections and suggestions for content additions with the authors by e-mailing to Dr Mirjana Stankovic (mirjana@tivinc.com; mirjana.stankovic@fulbrightmail.org), Aminata Amadou Garba (aminata.amadou-garba@itu.int) or Nikola Neftenov (nick@tivinc.com; nick.neftenov@gmail.com).

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Foreword

In today's fast changing ICT environment, access to information and data on emerging technologies is crucial in order for everyone to benefit from them fully.

Artificial intelligence and big data for development 4.0 is the first report in the series: "Emerging technology trends", which will be published annually. The series offers analysis of the latest technological advances in developing countries and aims to prompt rapid updates and information exchange. These annual reports will also serve as resources that Members can use to build capacity in emerging technologies and develop ICT ecosystems.

The use of big data as a key business tool continues to pick up pace, but big data analysis also has enormous potential as a motor for the attainment of the 17 Sustainable Development Goals, as the international community strives to ramp up efforts to deliver on the 2030 Agenda for Sustainable Development in this final decade of action.

The huge volumes of digital data now being generated by a vast and growing number of platforms and devices offer unprecedented opportunities to gain a better understanding of complex interactions and receive real-time feedback on how well policy responses are working. New sources of data, AI technologies and new analytical approaches, if applied effectively and responsibly, can enable more agile, efficient and evidence-based decision-making.

Despite its great promise, however, the AI and data revolution is yet to yield tangible dividends for most developing countries. More often than not, these countries do not have all the prerequisites in place – from reliable ICT infrastructure and access to electricity, to human capital and enabling regulatory frameworks – in order to collect sufficient data to utilize AI algorithms for development. Furthermore, existing data too often remain unused because they are released too late or not at all, are not available in digital format or lack the level of granularity needed for decision-making and local innovation.

This new ITU report has been designed to help developing countries overcome these barriers and embrace the huge development opportunities offered by AI and big data deployment.

Intended as a guide for policy-makers and other stakeholders in crafting a national AI and data strategy for development, the report highlights opportunities and outlines good policy and regulatory practices for implementation, while also flagging key challenges and offering hands-on suggestions in managing and overcoming these roadblocks.

The report describes the main building-blocks of a national AI and data system for development, including governance, regulation, ethical considerations, digital and data skills, the overall digital environment, the technological innovation landscape and opportunities for international collaboration. It goes on to detail the main components of an effective AI and data system action plan, including the principles governing stakeholder engagement, the setting of clear milestones and budgets and administrative structures to support implementation and coordination mechanisms.

It is our hope that this new report will help developing nations leverage the tremendous potential of big data and AI to break down chronic development barriers and stimulate implementation of successful new data-driven strategies and products that concretely improve development outcomes.

Doreen Bogdan-Martin
Director, ITU Telecommunication Development Bureau

Table of Contents

List of tables, figures and boxes

Tables

Figures

Boxes

Executive summary

This report has been designed to help developing countries embrace the opportunities offered by AI and big data deployment, to highlight the main challenges and to offer hands-on suggestions for regulators and policy-makers. Drawing on case studies and initiatives in five domains of AI and big data application (health, mobile big data, agriculture, education and open data), this report describes how developing countries can benefit from the identification and implementation of adequate big data and AI technologies, the removal of regulatory and policy barriers and the incentivization of AI and big data uptake. It illustrates the significance of these opportunities and outlines good policy and regulatory practices to ensure that they are properly seized.

The report asks the main questions that need to be answered to harness the power of AI and big data for development:

- What are the main opportunities and challenges, and why is addressing them important?
- How do we address these challenges and bring the opportunities offered by AI and big data within the reach of developing countries?
- Who are the main stakeholders that can help in reaping the benefits of AI and big data for development?

The first chapter of the report gives an overview of the data ecosystem and the main challenges to uptake of big data and AI in developing countries: data creation, availability, interoperability and quality; human capital and data skills; infrastructure; and AI trustworthiness. The second chapter presents an in-depth look at the application of AI and big data in health, agriculture and education. The third chapter highlights some of the most salient public policy and regulatory issues for big data and AI for development, such as data protection, privacy and cybersecurity; open data policies; and data skill policies in developing countries.

The fourth chapter guides policy-makers and other stakeholders in crafting a national AI and data strategy for development. It describes the process of conducting a SWOT analysis to identify the main strengths, weaknesses, opportunities and threats for AI and data deployment at the national level. It also highlights the key questions that should guide the formulation of an overarching vision and provides examples of key objectives for a national AI and data strategy for development. Also, it identifies the main building-blocks of a national AI and data system for development, namely: governance; regulation; ethics; digital and data skills; the digital environment and data infrastructure; the innovation system; AI and data-intensive sectors; and international collaboration. Finally, it sets out the main elements that should figure in any action plan: stakeholders, milestones, budget, an administrative structure for strategy implementation and coordination mechanisms.

The fifth chapter offers guidance for policy-makers and regulators in identifying and assessing AI and big data policy and regulatory issues at the national level. It includes a checklist consisting of seven sections that address the key issues in regulation of AI and big data: (i) online consumer protection regulation; (ii) data protection, privacy and cybersecurity regulations; (iii) innovative and agile regulation; (iv) intellectual property (IP) regulation; (v) intermediary liability regulation; (vi) open data regulation; and (vii) anti-trust regulation.

Using big data and AI for development involves taking imperfect, complex, unstructured data and turning that data into actionable information that can be used to identify needs, provide services and predict and prevent crises for the benefit of low-income populations. New sources of data, AI technologies and new analytical approaches, if applied responsibly, can enable more agile, efficient and evidence-based decision-making. This will help better to shape and measure progress towards the successful delivery of the UN 2030 Agenda for Sustainable Development. To date, however, the AI and data revolution has not yielded dividends for most developing countries. More often than not, these countries do not have the prerequisites in place (reliable ICT infrastructure, reliable access to electricity, human capital and a regulatory framework) to collect sufficient data to utilize AI algorithms for development. Too often, existing data remain unused because they are released too late or not at all, are not available in digital format or are not at the level of detail needed for decision-making or local innovation.

Below is a summary of the key recommendations of the report:

- **Make data useful by making them accessible, timely, high quality and relevant to local contexts.** Developing countries have low levels of "datafication," making the issue of data creation and data digitization particularly significant. This would include digitizing existing files, knowledge and information and creating new digital data by digitalizing services in health care, education, social security, etc. Even when digitized, data in many developing countries are not shared and made available as widely as in other parts of the world. To overcome these challenges and gain a contextual understanding of issues, policy-makers need to make data more pervasive and granular by implementing a coordinated cross-sector approach involving increasingly regular data collection and publication, while encouraging the use of open public data and delivering services using open APIs. Widening both access to and use of AI and big data is essential in the context of developing countries; to be sufficient, however, access to data must be affordable.
- **Promote the development of local data that could be used for development projects and innovation in areas such as agriculture, health, education, etc.** This would allow more innovation at the local level and reduce algorithm and data bias.
- **Enable, incentivize and/or accelerate investment in the building of adequate and affordable data infrastructure.** Investment in software, hardware and broadband connectivity is needed for widespread data access and use. This is critical for reaching the underserved. Incentivizing the creation of FAIR data and FAIR data infrastructure is crucial. The next wave of digital solution transformation will depend on the creation of FAIR data lakes and warehouses that do not sacrifice data integrity. Moreover, having adequate infrastructure (access to electricity, ICT infrastructure, transport infrastructure) is inextricable from the deployment of big data and AI for development. Limited and costly access to electricity, insufficient national and international connectivity, difficulties in the roll-out of terrestrial communication infrastructure across large land areas, especially in rural and remote areas, large quantities of data being private and not open and unequal access to data are all impediments to the successful deployment of big data for development. Governments need to create policies and regulations to ensure that data infrastructure is secure, sustainable and resilient enough to support ongoing digitalization and economic growth.
- **Build adequate data skill capacity.** AI and data skills are needed to deploy AI and big data effectively. Hence, there must be a link between research institutes and training centres on the one hand and tech hubs, corporate research departments and entrepreneurs on the other in order to ensure that new AI developments find their way to the market and are deployed on the ground. A data skill shortage may be the most serious systemic factor holding back data-based innovation and productivity in many developing countries. This shortage is something that governments across the globe should work to mitigate quickly.

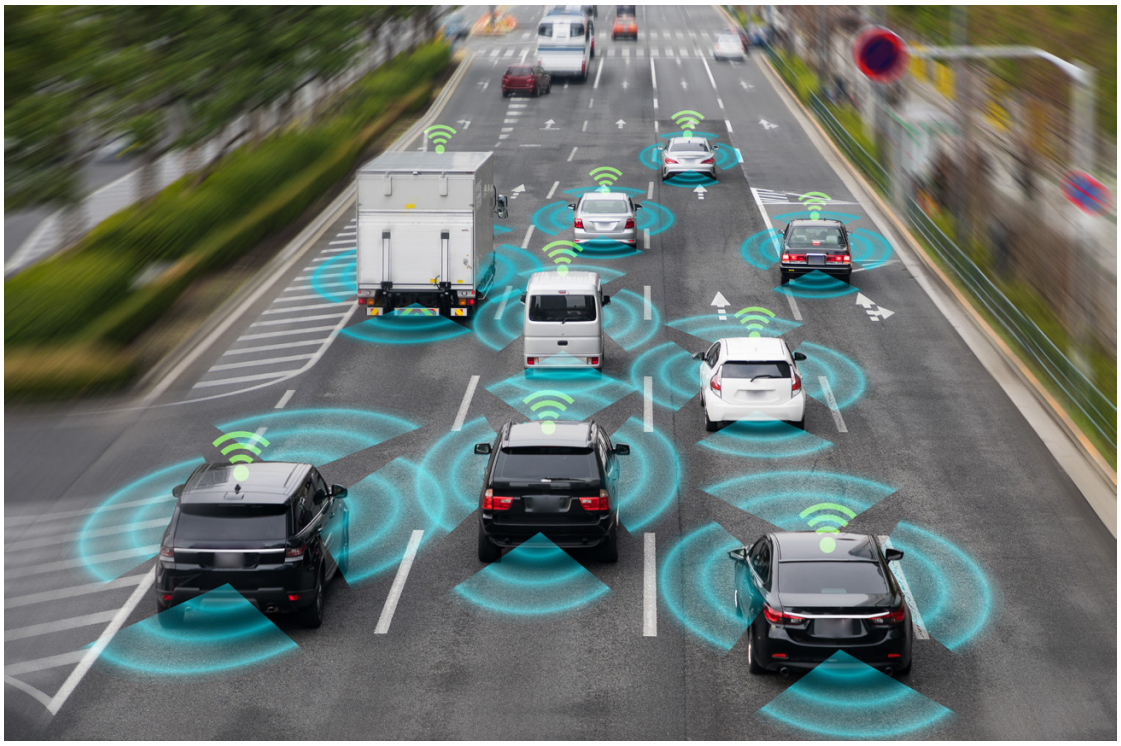
- **Create an enabling environment (governance institutions, policies and laws) for an effective roll-out of AI and big data solutions for development.** Appropriate policies and regulatory measures include the establishment of data protection frameworks and sectoral regulatory frameworks and the promotion and adoption of international standards and international cooperation. Policy-makers should also ensure that adequate levels of privacy and security and handling of data are in place, for example by regulating against the use of data without consent and by reducing the risk of identification of individuals through data, data selection bias and the resulting discrimination by AI models and asymmetry in data aggregation. This also includes addressing safety and security challenges for complex AI systems, which is critical to fostering trust in AI and big data for development.
- **Create a regulatory framework that is innovative and agile.** Public and private stakeholders should work together to develop common resources, databases, platforms and tools that are open, use privacy as a safeguard and promote growth in developing countries. They should deploy innovative regulatory instruments that offer flexibility, such as regulatory sandboxes and public policy labs. Governments should also establish "cross-functional teams" across ministries and tiers of government.
- **Incentivize data harmonization.** This is vital to turning big data into data for development. Data can be structured and unstructured in huge volumes and collected from heterogeneous sources. With harmonized data, the time and energy required to run big data analytics are greatly reduced. Furthermore, standardization would facilitate interoperability. ITU is working with partners to standardize big data-related activities.
- **Establish data governance standards.** Oftentimes, there is a shortage of adequate data governance standards that define how data are captured, stored and curated for accountability. The standardization of application programming interfaces and common data languages should be incentivized.
- **Promote inclusiveness and reduce digital inequalities by ensuring that data do not overrepresent those who are connected.** Big data and AI analytics can exacerbate social exclusion by overlooking groups that are difficult to reach or not represented in publicly available data.
- **Create open data policies and ensure that they address issues such as data access, sharing and protection and the use and management of open data.** Often, data are held by private-sector actors and cannot be accessed by local innovators, researchers or SMEs to use, add value or create local innovation. In this context, it is of utmost importance to provide access to public sector data, including open government data, geo-data (e.g., maps) and transport data; and facilitate private-sector data sharing. Particular focus areas are "data held by the private sector, but of public interest," data in network industries such as transport and energy, data for service interoperability, and personal data portability. Statistical/data analytical capacities should be developed by establishing technology centres that provide support and guidance in the use and analysis of data.
- **Develop guidelines for data sharing frameworks that respect privacy and intellectual property rights.** Possible innovative data sharing modalities include data cooperatives and data trusts. Clear and robust national policies and legal frameworks need to be developed for the regulation of opt-in and opt-out data policies, data mining, access, use, reuse, transfer and dissemination. These policies should enable citizens to better understand and control their own data and protect against attacks by hackers, while still allowing access to and reuse and sharing of non-personal information. At the same time, people's rights to freedom of expression using data while respecting privacy boundaries should be protected.
- **Ensure that AI for development is ethical and trustworthy,** i.e. fair and unbiased, transparent and explainable, responsible and accountable, robust and reliable, privacy compliant, safe and secure, diverse and inclusive and human centred. In this context, policy-makers should create rules to govern AI transparency, liability, accountability, justification and redress for AI decision-making.

- **Develop a national AI and data strategy for development.** Having such a strategy and accompanying action plan is paramount to guiding the deployment of AI and big data for development. This report contains a guide for the devising of a national AI and data strategy.
- **Develop public sector AI and big data expertise**, **with leadership in relevant government institutions; and create codes of conduct for the responsible use of AI and big data by the public sector**. This can be achieved through collaboration with universities and other institutions already working on AI in the country, as well as with regional and international organizations.
- **Work to strengthen the implementation and enforcement mechanisms of AI and big data regulations and strategies.** This will have to be a coordinated effort among different public and private-sector stakeholders and will have to tackle issues such as personal data privacy and information security.

Abbreviations and acronyms

AI – artificial intelligence
APIs – application programming interfaces
ARD – analysis ready data
B2B – business-to-business
B2G – business-to-government
CAGR – compound annual growth rate
CDR – call detail records
Development 4.0 – a concept derived from the concept of Industry 4.0. It denotes development based on AI and big data
EHR – electronic health records
EU – European Union
FAIR – findable, accessible, interoperable and reusable
G2B – government-to-business
GDPR – General Data Protection Regulation
GIS – geographic information system
HRIAs – human rights impact assessments
ICT – information and communication technology
IDRC – International Development Research Centre
IFC – International Finance Corporation
IP – intellectual property
IoMT – Internet of Medical Things
ITU – International Telecommunication Union
LDCs – least developed countries
MBD – mobile big data
ML – machine learning
NPD – non-personal data
OECD – Organisation for Economic Co-operation and Development
SDGs – sustainable development goals
SMEs – small and medium-sized enterprises
STEM – science, technology, engineering and mathematics
UN – United Nations
USD – United States dollars
WEF – World Economic Forum
WHO – World Health Organization

1 Big data and AI are changing the development paradigm



"The world's most valuable resource is no longer oil, but data."
(The Economist, 6 May 2017)

The UN 17 Sustainable Development Goals (SDGs) represent the world's commitment to achieving ambitious global gains for people and the planet by 2030. From ending poverty and promoting inclusive economic growth to reducing maternal mortality, achieving universal literacy and numeracy and doubling the productivity of small farmers, future global development is entwined with the use of AI and big data.

AI could contribute up to USD 15.7 trillion to the global economy in 2030, more than the current GDP of China and India combined. Of this, USD 6.6 trillion will be derived from increased productivity and USD 9.1 trillion from the knock-on effects of consumption. The total projected impact for Africa and Asia-Pacific markets would be USD 1.2 trillion (Figure 1).[1] For comparison, the combined 2019 GDP for all countries in sub-Saharan Africa was USD 1.8 trillion.[2] Thus, the successful deployment of AI and big data would open up a world of opportunities for developing countries.

1 PwC, *The Macroeconomic Impact of Artificial Intelligence* (2018); PwC, *Sizing the Prize* (2017).
2 World Bank *Open Data Portal*.

The quantity of data produced in the world is growing rapidly, from 33 zettabytes in 2018 to an expected 175 zettabytes in 2025.

These developments are due to the declining costs of sensors and data storage, swift progress in advanced analytics and computing capabilities and greater connectivity with faster and cheaper data transmission.

IDC, *IDC FutureScape: Worldwide Digital Transformation 2018 Predictions* (2018).

Fuelled by the increasing availability of computational power, improved connectivity and big data, AI offers profound potential benefits and the opportunity to tackle some of the developing world's most pressing issues by accelerating economic growth, improving agricultural systems, improving the quality of education and tackling health and climate challenges. In the context of governance, big data combined with AI can enhance decision-making and improve accountability. The ability of big data to include an entire population with a particular attribute, rather than depending on small samples, helps to eliminate selection bias and avoids disaggregating samples to cover many sub-samples and categories. New sources of data, AI technologies and new analytical approaches, if applied responsibly, can enable more agile, efficient and evidence-based decision-making. This will help better to shape and measure progress towards the successful delivery of the 2030 Agenda for Sustainable Development (Figure 2).[3]

Figure 1: Expected economic gains from AI in different regions of the world

North America	Latin America	Northern Europe	Southern Europe	Developed Asia	China	Africa, Oceania and other Asian markets
Total impact: 14.5% of GDP ($3.7 trillion)	Total impact: 5.4% of GDP ($0.5 trillion)	Total impact: 9.9% of GDP ($1.8 trillion)	Total impact: 11.5% of GDP ($0.7 trillion)	Total impact: 10.4% of GDP ($0.9 trillion)	Total impact: 26.1% of GDP ($7.0 trillion)	Total impact: 5.6% of GDP ($1.2 trillion)

Source: Adapted from PwC[4]

[3] The Rockefeller Foundation, *Report on Measuring Results and Impact in the Age of Big Data: The Nexus of Evaluation, Analytics, and Digital Technology* (2020).

[4] PwC, *The Macroeconomic Impact of Artificial Intelligence* (2018). All GDP figures are reported in market exchange rate terms; All GDP figures are reported in real 2016 prices, GDP baseline based on market exchange rates.

Figure 2: AI and SDGs

Source: ITU

In the context of the developing world, it must be emphasized that the transformative potential of big data has yet to be realised.[5] Despite all the opportunities offered by the AI and data revolution, the governments of many developing countries still do not have the capacity to capture relevant data fully. Worldwide, basic access to data remains a major challenge, and policies, strategies and regulations enabling the deployment of AI and data for the public good are largely not present in many countries. While today's world is more connected, interdependent and data rich than ever before, there is a growing gap between countries and populations that benefit from big data analytics in decision-making and those who are left behind, remaining unseen and unconnected. This is predominantly true of data for the poorest and most marginalized, i.e. the people that need to be the focus of attention in order to achieve the SDGs and ensure that no one is left behind.[6] For instance, only 73 per cent of children under the age of five have had their births registered.[7] In 2014, WHO estimated that two-thirds of deaths are not registered.[8] Only 11 countries in sub-Saharan Africa have data on poverty from surveys conducted after 2015, and most countries do not collect gender-disaggregated data on Internet access.[9]

Big data and AI cannot be considered a panacea for every challenge faced by developing countries and cannot entirely replace the traditional quantitative statistical evidence that governments use for decision-making. Merely producing more data is not enough for development and the social good. Data need to be transformed, analysed and used in order to

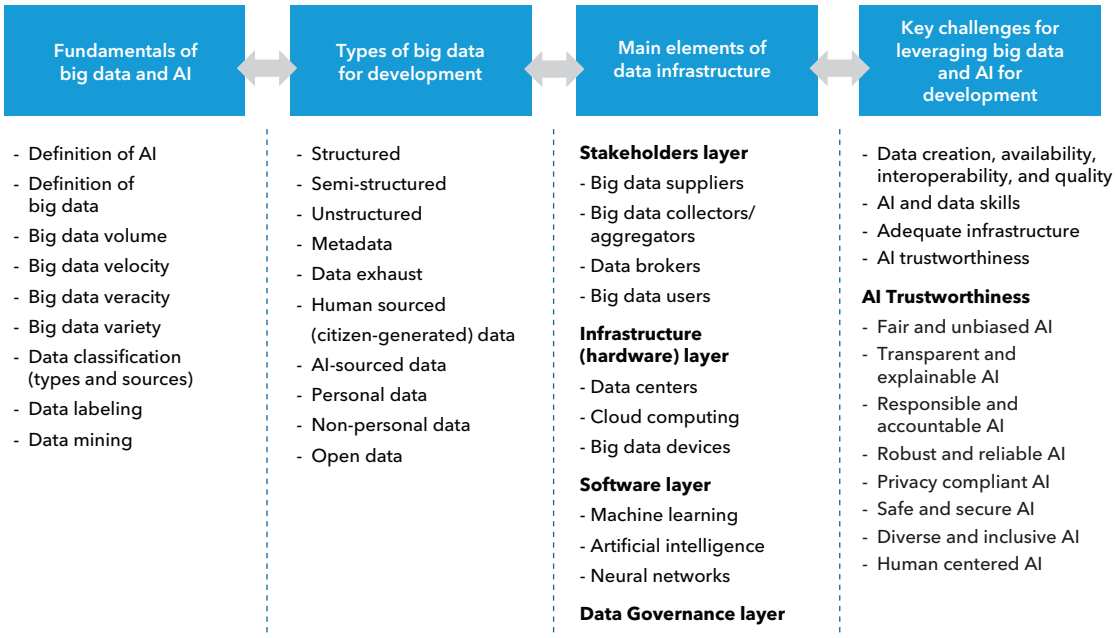
5 UNDP, *The Africa Data Revolution Report – Highlighting Developments in African Data Ecosystems* (2016).
6 UN, *Big Data for Sustainable Development*.
7 United Nations, *The Sustainable Development Goals Report* (2018).
8 World Health Organization, *Civil Registration: Why Counting Births and Deaths is Important* (2014).
9 The World Bank, *Povcalnet*.

be useful for policy-making, monitoring and accountability. Big data can complement traditional statistics and inform public policy-makers and regulators if "further targeted investigation is necessary, or prompt immediate response."[10] To be fully transformative, the use of AI and big data should be aligned with investment in infrastructure, human capital and environmental protection. Widening both access to and use of AI and big data is essential in the context of developing countries; to be sufficient, however, access to data must be affordable.

The collection of massive datasets can also create new vulnerabilities and risks, enabling discrimination against individuals and creating dependencies on centralized infrastructures. For instance, people with lower levels of income and education do not access or create online content as much as more educated middle-class populations do, thereby reinforcing the digital divide. If policy-makers rely solely on big data analytics, they risk overlooking issues important to low-income people and underrepresented minorities.

This section gives an overview of the following issues: (i) fundamentals of big data and AI; (ii) types of big data for development; (iii) main elements of data infrastructure; and (iv) key challenges in leveraging big data and AI for development.

Figure 3: Big data and AI are changing the development paradigm



Source: ITU

1.1 Fundamentals of big data and AI

The term "big data" describes gigantic, complex datasets that have been made available through digitalization and cannot be processed and analysed through the use of conventional data processing techniques. In order to extract meaningful information from data, big data analytics use advanced computational techniques that identify certain patterns, trends and repetition in datasets.

[10] United Nations Global Pulse, *Big Data for Development: A Primer* (2013).

Big data are characterised by the 4 "Vs": volume, velocity, veracity and variety. *Variety* refers to structured, unstructured and semi-structured data that are gathered from multiple sources. *Velocity* refers to both how fast data are being collected and how fast data are processed by big data technologies to deliver the expected results. *Volume* refers to the large volumes of data that are generated on a daily basis from various sources. *Veracity* refers to the biases, noise and abnormality in data. Social media, call detail records, sensors, web scraping and satellite imagery are just a few new sources of information that can be used to produce more and higher-quality data for development.[11]

The term "artificial intelligence" (AI) refers to machines, i.e. computer systems, that can simulate the processes of natural intelligence displayed by humans, such as learning, reasoning and self-correction.[12] AI is an umbrella term that refers to a broad range of research approaches and technologies. Data act as the fuel for the development and deployment of AI. In addition to the quantity of data available, their quality and availability have a significant impact on the potential benefits of AI. If governed and deployed properly, AI and big data can solve some of the world's greatest challenges.

Big data are the raw material on which AI algorithms are developed, tested and improved. Big data and AI are complementary. On the one hand, AI solutions cannot be successfully deployed without big data; on the other hand, big data would remain unexploited without AI. AI algorithms can identify patterns in the data observed, build explanatory models and make predictions more quickly and with greater accuracy than humans can. Using AI solutions for big data analytics could lead to the next quantum leap in how big data are collected and analysed, and how analysis is used for policy-making and to achieve better results. Advances in big data platforms that allow for the collection of real-time information at a granular level and ML pattern recognition across multiple layers of input could make data more accessible, scalable and finely tuned. The availability of real-time information can shorten the feedback loop between result-monitoring, learning and policy formulation or investment, thereby accelerating the speed and scale at which development actors can implement change.[13]

While the current use of big data is mainly confined to the private sector, governments around the globe are making significant efforts to incorporate big data analytics in the race to improve statistical capacity for evidence-driven decision-making and to tackle key issues such as food insecurity, spread of disease, climate change, etc. Policy-makers are beginning to realize the potential of channelling these massive data torrents into actionable information that can be used to identify needs, provide services and predict and prevent crises for the benefit of the underserved, and often otherwise unreachable, low-income populations. This enables experimental and agile regulatory and policy programming that can adapt and react to dynamic and complex environments based on real-time data.

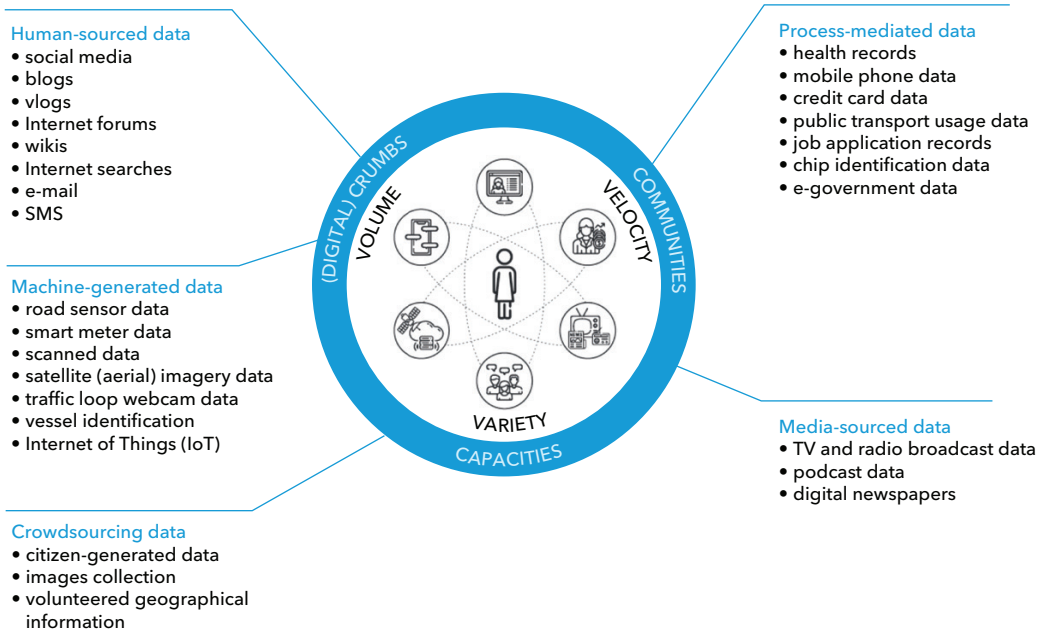
1.2 Types of big data for development

Using big data and AI for development involves taking imperfect, complex, unstructured data and turning that data into actionable information that can be used to identify needs, provide services and predict and prevent crises for the benefit of low-income populations.

11 ITU, *ITU-T Recommendation Y.3600* (2015).
12 Mexico, *AI Policy*.
13 Cohen, J. L., Kharas, H., *Using Big Data and Artificial Intelligence to Accelerate Global Development* (2018).

Traditional data, such as household surveys, institutional records or censuses, are often collected with a specific intention, using a structured format and reliable measurements. While big data are not always collected in this way, the many forms of big data (Figure 4) can help to design alternative poverty and welfare measures, especially in developing countries that have a dearth of other data sources. The real value of big data is unlocked when information collected from various sources (computer terminals and servers, smartphones, sensors, devices, machines, vehicles, etc.) is transported using telecommunication network infrastructure (SMS, fibre, radio, mobile, copper, satellite, etc.), stored in the cloud and shared across various services.[14] Quantifying and tracking development using "digital breadcrumbs," or passively emitted structured data such as credit card or phone transactions, and big data analytics holds real promise for developing countries.

Figure 4: Forms of big data



Source: UN Women, *Gender Equality and Big Data* (2018)

Data typology

Big data can be classified as: (i) structured, (ii) semi-structured and (iii) unstructured data.

Structured data are often stored in databases, which may be organized according to different models, such as the relational, document, key-value and graph models.[15] Accounting for about 20 per cent of total data in existence, structured data are used mostly in programming and computer-related activities. This type of data can be generated either by humans or machines. Human-generated structured data are the data humans input into a computer (e.g. name and other personal details); whereas machine-generated structured data are all data received from

[14] ITU And FAO, *E-Agriculture in Action: Big Data for Agriculture* (2019).
[15] ITU, *ITU-T Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks, Internet of Things and Smart Cities* (2016).

sensors, weblogs and financial systems (e.g. medical device data, GPS data and usage-statistic data captured by servers and applications).[16]

Semi-structured data do not conform to the formal structure of data models; rather, they contain tags or markers to identify the data.[17] This means that the information contained in the data does not follow the same traditional database format as structured data, but it does contain certain organizational properties which make processing easier.

Unstructured data do not have a pre-defined data model and are not organized in any defined manner.[18] Similarly, unstructured data can be either machine or human generated. Satellite imagery data, scientific data from various experiments and radar data captured by various technologies fall into the category of machine-generated unstructured data. Human-generated unstructured data are abundant as they are generated from social media data, mobile data and website content found on the Internet.[19]

Another classification of big data reflects whether the data have been produced intentionally or unintentionally and whether they were generated by humans or machines. The following types of big data are worth mentioning:

- Metadata (data about data). This term is used to classify, categorize and retrieve data files. By assigning attributes (e.g. date of data creation, number of pages, data size and keywords) to existing data, metadata facilitate data analysis.[20] They can also apply to data users, who can be given attributes, sometimes based on inferred data, that equate to a "reputation."[21] Metadata are classified as three main types, i.e. structural metadata (indicating how a digital asset is organized), administrative data (relating to the technical source of a digital asset) and descriptive metadata (essential for discovering and identifying assets).[22]
- Data exhaust. This type of data is unintentionally created by humans and generally has low value; the trail left by millions of users can, however, be mined to extract value. For instance, data exhaust can include CDR metadata derived from mobile phones or data trails left by users engaged in other activities, such as keystrokes (e.g. from a log file or cookies).[23]
- Human-sourced (citizen-generated) data. This type of data is intentionally created by humans through their social media presence, videos, academic papers and blogs, which can be mined. By compiling, combining and anonymizing thousands or more of these types of data, popular or emerging trends can be analysed.[24] Using a citizen-generated data approach can be particularly useful in situations where data from other sources is not readily available, accessible or complete.
- AI-sourced data. These data are also intentionally created, though by AI rather than humans. For instance, secondary data can be created by chatbots assisting users with filling out online forms.[25]
- Personal data. Nowadays, computers are able to recognize everyone in a country in the same manner that a local police officer would recognize a neighbour a century ago. This

16 Knowledgehut, *Types of Big Data* (2016).
17 ITU, *ITU-T Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks, Internet of Things and Smart Cities* (2016).
18 Ibid.
19 Knowledgehut, *Types of Big Data* (2016).; ITU, *ITU-T Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks, Internet of Things and Smart Cities* (2016).
20 World Bank, *Information and Communications for Development, Data-Driven Development* (2018).
21 Ibid.
22 Merlinone, *What are the Different Types of Metadata (and How are They Used)?*.
23 See note 17.
24 Ibid.
25 Ibid.

is made possible through the collection and collation of personal data. For the purposes of this report, we define personal data as information that relates to an identified or identifiable individual.[26]

- Non-personal data (NPD) are data that either never related to an identified or identifiable natural person or have been sourced from personal data excluding any personal identifier, i.e. data which were initially personal but have since been aggregated and/or anonymized.[27]
- Open data are publicly available data that can be universally and readily accessed, used and redistributed free of charge.[28] This type of data is structured for usability and computability. The actors responsible for producing most open data are governments, scientists, and corporations, thereby making it possible for this type of data to exist in a wide variety of fields and domains.

By ensuring proper data mining and analysis, we can use big data to improve understanding of human behaviour and offer support to policy-makers in their attempts to promote global development. This can be done in three main ways:

- Early warning. By detecting anomalies at an early stage, big data can enable faster response to populations in times of crisis.
- Real-time awareness. Big data can inform the design and targeting of programmes and policies by providing a fine-grained representation of reality.
- Real-time feedback. By monitoring the impact of policies and programmes in real time, big data allow for adjustments to be made quickly.[29]

1.3 Main elements of data infrastructure

The data universe has experienced similar growth to that of the ever-expanding physical universe, owing to the rapidly increasing number of Internet users and faster network speeds. To support this rapid expansion, there is a need to create appropriate data infrastructure, consisting of hardware and software processes that enable data capture, storage, flow and analytics.[30] The role of data infrastructure is to create, process, transmit, secure and protect data. The main elements of the data ecosystem are:

- **Big data governance layer**: all the elements of data infrastructure fall under the umbrella of big data governance, the main objectives of which are to: regulate and protect data (ownership, privacy, copyright, cybersecurity); data management; enforce data policies and regulations; and build trust among key data governance stakeholders (Figure 5).
- **Stakeholders layer**, consisting of:

  (i) *big data suppliers*, such as phone and Internet users, universities/research institutes, private sector businesses, government institutions, etc., which produce and supply data;

  (ii) *big data collectors/aggregators*, such as search engines (e.g. Google, Baidu), social media platforms (e.g. Facebook, TikTok), e-commerce websites (e.g. Amazon, Etsy, eBay, Alibaba), different government organizations, mobile network operators, etc., which collect, store and monetize data;

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26 Symanovich, S., *What is Personally Identifiable Information (PII)?* (2017).
27 Lexology, *Report by the Committee of Experts on Non-Personal Data Governance Framework* (2020).
28 Verhulst, S. G., Young, A., *Open Data in Developing Economies: Toward Building an Evidence Base on What Works and How* (2017).
29 SAS, *Big Data and Global Development, a Primer on Using Online and Mobile Data to Make the World a Better Place*.
30 ODC, *What is Data Infrastructure?*.

(iii) *data brokers*, which aggregate, store, analyse and monetize data; and

(iv) *big data users*, such as government institutions, retail, health, media, finance, universities/research institutes, consumers, etc., which store, add value to and monetize data;

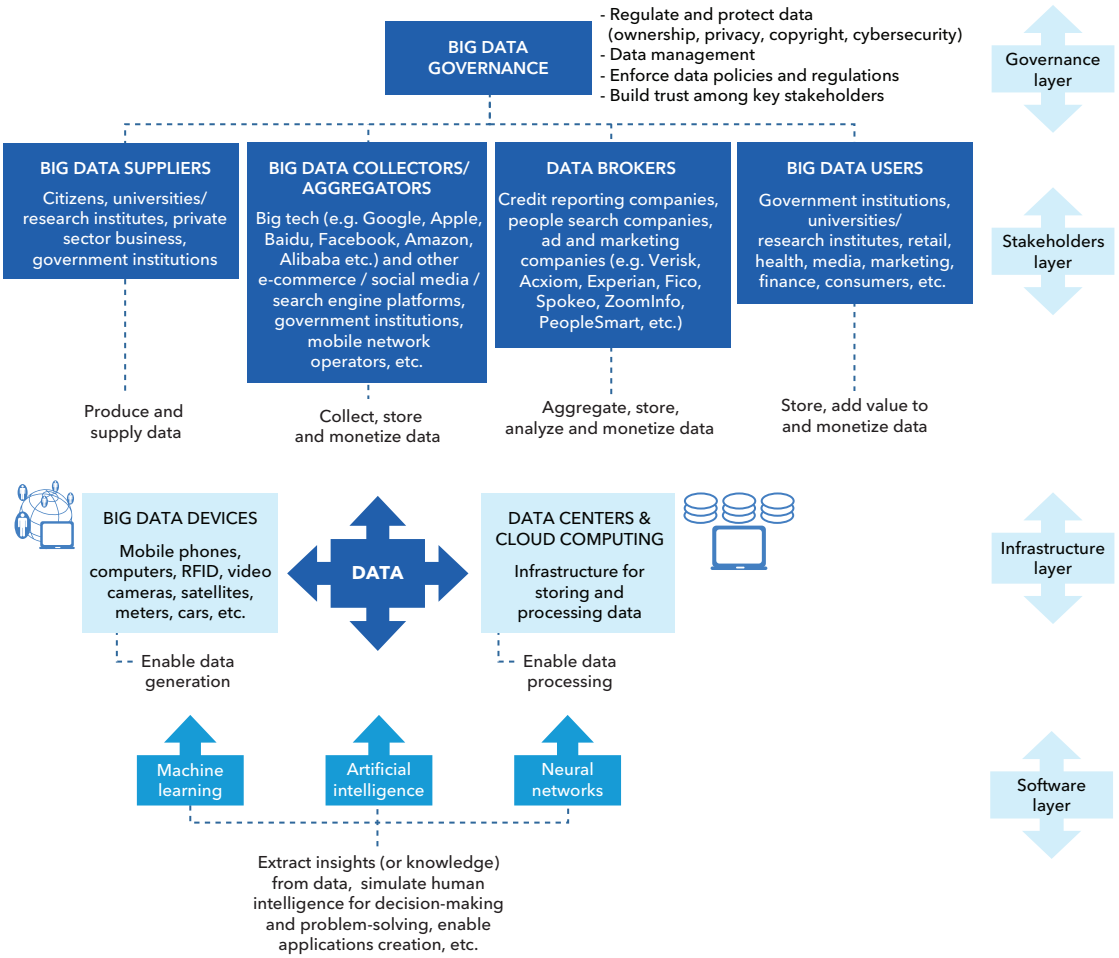
- **Infrastructure (hardware) layer** such as:

  (i) *data centres and cloud computing* (which provide the requisite infrastructure for storing and processing data), and

  (ii) *big data devices*, such as mobile phones, computers, satellites, meters, sensors, etc., which enable data generation;

- **Software layer** that includes AI, machine learning and neural networks.

Figure 5: Big data and AI ecosystem for development



Source: ITU

There are, however, certain prerequisites for sustainable data infrastructure, including: reliable physical infrastructure (electricity and connectivity) and interoperable systems, foundational digital systems (e.g. digital identification and mobile money) and capital investment in AI and data-intensive industries. With these prerequisites in place, digital firms and entrepreneurs can focus on their core business, without having to build an enabling environment from scratch.

A key requirement for digital transformation, robotization and AI is the technical and semantic interoperability of data. The benefits of AI cannot be realized if data do not travel or their meaning is not clear. It is important that digital services are able to make use of high-quality, correct information at the correct time, while taking data protection into account.

Developing and maintaining data connectivity is of the utmost importance for the expansion of big data, as servers send unprecedented quantities of data to clients and vice versa. Data-connectivity links separate datasets and applications, including data from different identity spaces, thereby enabling collaboration between parties with data controls, ensuring safe and effective activation across the broader ecosystem and making every consumer interaction relevant, addressable and measurable.

This section will focus on data suppliers (data sources and mobile phone users as big data suppliers), data centres and cloud computing as key components of data infrastructure for the storing and processing of data.

Data suppliers

Big data for development have a multitude of sources, including:

- Digitized data. This type of data comes from digitized archive documents from governments, hospitals, schools, etc.
- Digitally generated data. This type of data is not digitized manually; rather, it is created digitally allowing data to be manipulated by computers. This type of data can be stored using a series of ones and zeros, and thus can be manipulated by computers.
- Passively produced data. This type of data is generated as a by-product of interactions with digital services. Examples of passive data include the user's browser, default language, device type (mobile or desktop) and the unique user ID that Facebook sends during a Facebook Messenger conversation.
- Automatically collected data. This type of data is automatically extracted and stored by a system. Data produced by IoT sensors are an example of automatically collected data. For instance, IoT devices create a continuous stream of data while monitoring the health of people, which makes such devices a major contributor to big data in health care.
- Geographically or temporarily tracked data. This type of data is usually generated by mobile phones, i.e. mobile phone location data or call duration time.
- Real-time data. This type of data can be analysed in real time as the information contained is relevant to human well-being and development. For instance, map applications such as Google Maps or Waze provide the expected time of arrival for several routes based on data collected in real time from application users. Since big data are collected continuously, data can be visualized through different techniques, such as dashboards providing panoptic views of operations, word clouds capturing citizen sentiment and exposure to shocks, and maps reflecting the movement of people and the intensity of such movements. Real-time data development initiatives rely on partnerships between organizations tackling development problems and technical partners providing software and tools to collect, manage and visualize data. For instance, the health organization

PATH, in partnership with the Tableau Foundation, is working with governments to tackle malaria using real-time data.[31]

- Satellite imagery. This is a source of data that can be used to better understand the effects of climate change, to monitor poverty, hunger and health and to protect human rights. Despite satellite data becoming more accessible, however, translating that data into usable information requires substantial skills and resources. In order for satellite data to be made more user friendly, a handful of providers have begun to offer "analysis-ready data" (ARD), which are data that have already been cleaned of its irregularities through the use of algorithms.[32]

The emergence of the Internet in the 1960s, the worldwide web in the 1990s and the more recent iteration of Web 2.0 have changed the way that content is obtained and created. This has prompted traditional content providers, such as media and audio-visual companies, to move to the digital sphere, either by creating their own websites or by licensing content to streaming platforms. Furthermore, the interconnected online realm has allowed users to become content creators by sharing their own content through blogs, videos, social networking posts and product and service reviews, thus shifting the attention from the carrier of the data to the creator.

Mobile phone users as data suppliers

Mobile phone users also create data. With mobile phone penetration growing exponentially in the developing world, half of the global population now owns a mobile phone, according to the GSMA mobile economy report.[33] This global phenomenon has allowed telecommunication operators to systematically capture individual, social, economic and geographical data points across populations. Whenever a mobile phone call or transaction is made, for example, a CDR is automatically generated by the mobile network operator, creating a digital record of the attributes of a certain telecommunication transaction.[34] Aggregating mobile data makes it possible to analyse social interactions, population density, mobility and spending patterns. Mobile data are a powerful data source with the potential to address social needs and transform development and humanitarian actions. They have already been used for disaster response in post-earthquake Haiti, malaria mapping in Kenya through analysis of the regional travel patterns of millions of mobile subscribers, combatting the H1N1 flu in Mexico through qualitative analysis of CDR data and for estimating poverty levels in Cote d'Ivoire (see Box 1).[35]

The spread of mobile networks and new capabilities in harnessing mobile big data (MBD) present an exceptional opportunity to gather and use more accurate, timely and accessible data for development. MBD solutions refer to network traffic, usage and communication data (from people, sensors, connected devices, etc.), combined with wider datasets and harnessed through big data analytics, AI and ML.[36] Figure 6 gives an overview of potential use cases of MBD and AI for development.

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31 Geekwire, *Tableau and PATH Fight Malaria with Data Analytics, in Unique Seattle-Based Coalition* (2016).
32 Halais, F., *How User-Friendly Satellite Data Could Revolutionize Development* (2020).
33 Zaimova, R., *How Can We Use Mobile Data to Advance Sustainable Development?* (2016).
34 UN Global Pulse, *Mobile Phone Network Data for Development* (2013).
35 Ibid.
36 GSMA, *Mobile Big Data Solutions for a Better Future Report* (2019).

Figure 6: Potential use cases of mobile big data and AI for development

Program area	Potential use cases
Financial services	Using machine learning algorithms to predict liquidity needs across the agent network
	Leverage social network information to target marketing offers driving up-take
Economic development	Developing indicators of wealth, economic diversity and population segregation
	Developing ubiquitous sensing for mapping poverty in developing countries
	Understanding interactions between different ethnic, or socio-economic groups
Health	Using location identifiers to send SMS or voice messages to residents in specific areas to warn them of epidemics or other health related risks
	Identifying immunization coverage rates (i.e., number vaccinated/total population) using mobile phone data to estimate population in different regions
Other	Detecting unexpected changes in weather quickly, by monitoring changes in cell patterns to develop an early warning system
	Monitoring rain patterns by analyzing background noise captures in voice calls
	Using smartphone battery temperature to determine changes in atmosphere/environment
	Combining call records and road data for strategic disaster response planning
	Developing traffic flow estimation models using cellular data instead of fixed sensor infrastructure

Source: ITU

Box 1: Using MBD and AI for development

Fighting pandemics

Governments around the globe have turned to big data in the fight against COVID-19 by using detailed mobile phone data to track and monitor the pandemic and analyse trends with AI solutions. Numerous mobile data collection applications have been developed to assist users in reporting their symptoms and track the disease. In countries such as the Republic of Korea, applications have gone even further by providing authorities with the ability to alert users when they have been in direct contact with a confirmed positive case. While some countries have launched solutions to collect exclusively anonymous and aggregated data, other countries are collecting more personally identifiable data, which allow authorities to implement more active measures to prevent the spread of the disease, though this has given rise to data privacy concerns.

Fighting malaria

Researchers combined malaria-incidence data collected by health officials with anonymized call-record data from 15 million Kenyan mobile subscribers, disaggregated at the cell-tower level, to understand how travel patterns contribute to the spread of malaria. Using these data allows researchers to identify how people typically contracted the disease and where they were likely to travel and put others at risk. Researchers were able to predict on a daily basis which communities were likely to import the disease and the probability of getting sick, providing granular insights on when and where prevention efforts should be focused.

There are other initiatives that use big data and AI to fight malaria and other infectious diseases, such as Zika, dengue and Ebola: from combining infection case data with satellite, environmental and climatic variables and producing disease outbreak risk maps and recommendations for action to using drones that autonomously locate mosquito hotspots, robotic traps to identify and collect interesting specimens and AI algorithms to search for pathogens in the mosquito genetic material.

1. BBVA, *How Do COVID-19 Tracing Apps Work and What Kind of Data Do They Use?* (2020)
2. Wesolowski, A. et al., *The Use of Census Migration Data to Approximate Human Movement Patterns Across Temporal Scales* (2013)
3. See *DiSARM* (2020)
4. See *Microsoft Premonition* (2015)

Across the developing world, mobile phones are used daily to transfer money, buy and sell goods and communicate information such as test results, stock levels and commodity prices. Mobile technology is used to compensate for weak telecommunication and transport infrastructure and underdeveloped financial and banking systems.

Mobile phones are the only form of interactive technology for many low-income people. Data on identity, location, social patterns, movement, finances and even ambient environmental conditions can be derived from the data logged in mobile systems. As these data are uniquely

detailed and tractable, they can capture information not easily found from other sources at a scale that would be difficult otherwise to recreate. While MBD are personal and private, they can be used to enhance the lives of poor people around the world and in many ways, if analysed under proper privacy protection and anonymization protocols.[37]

More than 150 million people across the globe could benefit from MBD solutions within the next few years, while 60 million people across the 41 most affected countries could have better access to health care thanks to infrastructure planning more informed by MBD solutions.[38] The deployment of MBD solutions to understand population movements could significantly reduce the spread of communicable diseases by targeting locations at risk of exposure.[39] Information derived from the use of MBD can be used to improve the public sector understanding of educational needs and knowledge gaps, allowing more targeted and timely initiatives to disseminate critical information. Using MBD solutions to raise awareness of and trust in digital financial services could see 70 million more adults take up financial services across the 58 countries in Africa, Asia and Latin America which account for over 40 per cent of unbanked adults.[40]

Data centres and cloud computing

The dramatic increase in Internet content creation is driving a need for storage and rapid growth in data centres to house this content. Data centres are centralized locations where computing and networking equipment is concentrated for the purpose of collecting, storing, processing, distributing or allowing access to large quantities of data.[41] They are run by global IT companies, governments and enterprises that host other companies' data. Data centres can vary in size, capability, security and redundancy.[42]

Lately, there has been a growing trend towards the creation of giant and hyperscale data centres, which are able to add servers and storage as needed. They are operated by a few dozen global IT companies, including heavyweights such as Amazon, Microsoft and IBM, and by enterprises providing cloud computing services.[43]

However, there is a sizeable discrepancy between the digital technologies used in the developed world and those used in developing countries, which face numerous difficulties in building appropriate infrastructure, owing to insufficient financial resources and, in most cases, an inability to satisfy power requirements.[44]

Cloud computing can be defined as a set of hardware, networks, storage, services and interfaces combined to deliver aspects of computing as a service based on user demand.[45] Successful adoption of cloud computing largely depends on three main factors:

- Faster networks. Rising internet speeds are making the transfer of data between device and cloud increasingly transparent.

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37 Digital Frontiers Institute, *Using Mobile Data for Development* (2016).
38 GSMA, *Mobile Big Data Solutions for a Better Future Report* (2019).
39 Ibid.
40 Ibid.
41 Johnson, B., *How Data Centers Work* (2020).
42 HP Enterprise, *What are Data Center Tiers?*.
43 World Bank, *Information and Communications for Development: Data-Driven Development* (2018).
44 Lehrer, N., *African Datacenters: Understanding Challenges in Emerging Infrastructure in Developing Countries* (2014).
45 Ibid.

- Greater storage. Storage available over the cloud is much greater than what can be saved on a desktop, laptop, tablet computer or smartphone.
- Proliferation of smart devices. As the number of devices owned by a person increases, the cloud provides a useful way of keeping them all synced.[46]

Types of cloud services

Public cloud services are the most common type of computing deployment, owned and operated by a third-party cloud service provider and delivered over the Internet.

Private cloud services are cloud computing resources which are used by one business or organization. Private clouds can be physically located on-site in an organization data centre or hosted by a third-party service provider. These types of service are most commonly used by government agencies, financial institutions and other medium to large-sized organizations seeking enhanced control over their environment.

Hybrid cloud services combine public and private cloud services and allow for seamless movement of data and apps between the two environments.[47]

Cloud computing is a highly popular business model among businesses and SMEs. Indeed, unlike data centres, which require vast amounts of capital and physical premises, cloud computing does not require a great deal of capital investment. Given that SMEs are considered the backbone of an economy, many developing countries are promoting the adoption of cloud computing as they seek to build more competitive and efficient economies.[48]

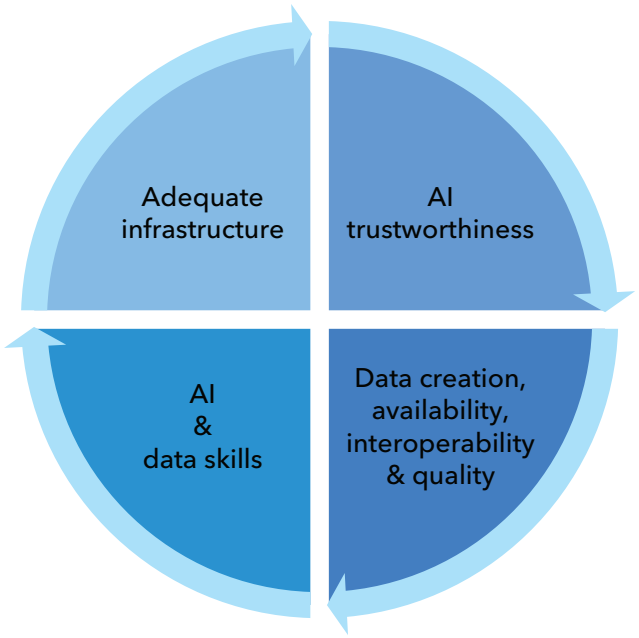
Despite a number of benefits, cloud computing comes with certain risks, such as security and privacy breaches (e.g. cyberattacks) and potential loss of service due to connectivity or electrical failures, which are a persistent problem in some parts of the world.

1.4 Key challenges in leveraging big data and AI for development

The AI and data revolution has not yielded dividends for most developing countries. Often, these countries do not have the prerequisites in place (reliable ICT infrastructure, reliable access to electricity, human capital and regulatory framework) to collect sufficient data to utilize AI algorithms for development. Too often, existing data remain unused because they are released too late or not at all, are not available in digital format or are not at the level of detail needed for decision-making or local innovation.

[46] World Bank, *Information and Communications for Development: Data-Driven Development* (2018).
[47] Microsoft Azure, *What are Public, Private, and Hybrid Clouds?*.
[48] Mitropoulou, P. et al, *Cloud Computing and Economic Growth* (2015).

Figure 7: Key challenges in leveraging big data and AI for development



Source: ITU

A few prerequisites (Figure 7) need to be in place to allow developing countries to leverage AI and big data for development.

Data creation, availability, interoperability, and quality

Developing countries have low levels of "datafication," making the issue of data creation and data digitization particularly significant. This would include the digitization of existing files, knowledge and information and creating new digital data by digitalizing services in health care, education, social security, etc.

Even when digitized, data in many developing countries are not shared and made available as widely as in other parts of the world. To be useful, data need to be high quality, appropriately disaggregated and available and accessible to data users. Data are an inexhaustible resource and their value lies in their use and reuse. The more that the data are shared and used, the more valuable the data become. Several issues raise concerns, however, about the availability of data for the public good:

- Use of public sector information by businesses (G2B data sharing). High-value datasets are often not available for use by SMEs, research institutions and young and independent innovators that cannot afford this fragmentation, to their detriment.
- Sharing and use of privately-held data by other companies (B2B data sharing). Data sharing between companies, despite the economic potential, has not taken off at any sufficient scale. This is due to a scarcity of economic incentives (e.g. fear of losing a competitive edge or current market position), insufficient trust between economic operators that data will be used in line with contractual agreements, an imbalance in negotiating power, a fear of data misappropriation by third parties and an absence of legal clarity on what can be done with the data (such as for co-created IoT data).
- Use of privately held data by government authorities (B2G data sharing). Due to proprietary and privacy concerns, currently there are not enough private-sector data available for use

by the public sector to improve evidence-driven policy-making. In many countries, most data are typically held by telecommunication providers and banks. Access to relevant, high-quality data is a prerequisite for a successful AI deployment, which thus requires the redesign of data architecture and installation of new systems that will allow better access to data and, at the same time, facilitate collection thereof.

For data to be useful, they must be accessible, timely, high quality and relevant to local contexts. Currently, many developing countries lack such data. To overcome this challenge and gain a contextual understanding of issues, policy-makers need to make data more pervasive and granular by implementing a coordinated cross-sector approach involving increasingly regular data collection and publication, while encouraging the use of open public data and delivering services using open APIs.[49] Moreover, data interoperability, structure, authenticity and integrity are key to exploiting value from data, particularly in the context of AI deployment.

AI and data skills

AI and data skills are required for the effective deployment of AI and big data. Hence, it is important that there is a link between research institutes and training centres on the one hand and tech hubs, corporate research departments and entrepreneurs on the other in order to ensure that new AI developments find their way to the market and are deployed on the ground. A data skill shortage may be the most serious systemic factor holding back data-based innovation and productivity in many developing countries. This shortage is something that governments across the globe should work to mitigate quickly.

According to the World Economic Forum "Future of Jobs Report 2018",[50] employers expect more than 40 per cent of skills required for the workforce of the future to change by 2022 and 65 per cent of children to find employment in a job that does not yet exist. According to UNICEF, nearly 4 billion people (29 per cent of whom are 18 to 24-year-olds) remain unconnected from the Internet and, by extension, unconnected from digital products that could dramatically improve their lives. Adding to this challenge, the gender digital divide is also growing, and studies show that men outnumber women on the Internet by as many as two to one. COVID-19 has changed and will change the world permanently: communities are experiencing unprecedented levels of dislocation and people need to stay connected through technology to a degree never seen before.[51]

In a survey of young people in Arab countries, 78 per cent of respondents were concerned about the quality of education in 2019. Adding to this problem is the fact that few women in the region pursue careers in STEM and that the gender gap in Internet use increased from 19.2 per cent in 2013 to 24.4 per cent in 2019.[52] As for Africa, a report by the IFC indicated that "… nearly 20 per cent of Ghanaian companies surveyed recruit only internationally for digital skills, largely because they cannot find local talent,"[53] with demand significantly outweighing supply in the region. In June 2020, the World Bank published the "Future of Work in Africa" report using self-reported data on LinkedIn users from 27 countries across sub-Saharan Africa

[49] United Nations, *A World that Counts: Mobilising the Data Revolution for Sustainable Development* (2014). An application programming interface (API) is a computing interface which defines interactions between multiple software intermediaries. It defines the kinds of calls or requests that can be made, how to make them, the data formats that should be used, the conventions to follow, etc.
[50] WEF, *The Future of Jobs Report 2018* (2018).
[51] UNICEF, *Innovation Fund Invests in Skills and Connectivity* (2020).
[52] Langendorf, *Digital Stability: How Technology Can Empower Future Generations in the Middle East* (2020).
[53] IFC, *Digital Skills in Sub-Saharan Africa, Spotlight on Ghana* (2019).

to better understand the level of digital skills held by workers in the market.[54] According to the report, sub-Saharan Africa is the world region with the lowest score in the percentage of total labour force that uses LinkedIn (4 per cent) and in terms of level of digital skills, with about half the average global level of digital skill adoption or "relative penetration," which had been normalized to a value of 1.0 for a global average.[55] Thus, while Africa has the fastest growing youth population, its workforce has the lowest overall skill base in the world.[56] Similarly, companies in the Middle East are facing challenges in finding skills that support big data and analytics deployment, having to rely heavily on partners for support until solutions go into production.[57]

Adequate infrastructure

Having adequate infrastructure, i.e. access to electricity and ICT and transport infrastructure, is fundamental to the deployment of big data and AI for development. Limited and costly access to electricity, insufficient national and international connectivity, difficulties in the roll-out of terrestrial communication infrastructure across large land areas, especially in rural and remote areas, large amounts of data being private and not open and unequal access to data are all impediments to the successful deployment of big data for development.[58]

Unreliable access to electricity is a huge barrier to tapping into the opportunities of AI and big data in some parts of the world. Africa, for example, lags behind in access to electricity, with its current average 43-per-cent access rate to electricity half the global rate of 87 per cent. There is also variation between countries and regions on the African continent in this respect.[59]

Many parts of the developing world are lacking in access to stable Internet connections and frequently in basic complementary infrastructure, such as electricity supply and roads. Without these foundational pillars, the potential benefits of AI and big data will only be enjoyed by a few elites.[60] Access to AI and big data solutions in Africa, for example, is impeded by insufficient power supply and low Internet density and broadband penetration.[61]

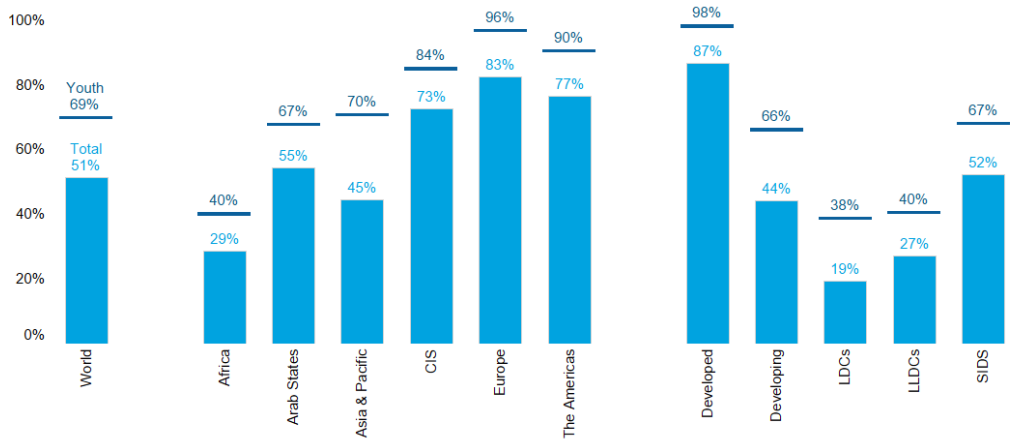
Having appropriate ICT infrastructure is a prerequisite in order to seize the opportunities brought about by the data revolution. ICTs can also increase the speed, accuracy and impact of data collection and dissemination, while reducing costs. For this, though, it is essential to bridge the significant digital divide that underlies the data divide: the Internet needs to be universally accessible and affordable if it is to empower people.

According to ITU,[62] just over half of the world's population was using the Internet at the end of 2019 (Figure 8). Most of the offline population lives in remote and rural areas in developing countries and LDCs without sufficient data infrastructure. Countries with the highest proportions of people not using the Internet are mostly found in Africa and South Asia[63]. In many developing countries, data are expensive and Internet connectivity varies. All such factors put developers

54 World Bank, *The Future of Africa Harnessing the Potential of Digital Technologies for All* (2020).
55 Madden, P., Kanos, D., *Figures of the Week: Digital Skills and the Future of Work in Africa* (2020).
56 Gadzala, A., *Despite Rise in Mobile Technology, Most of Africa is Not Ready for AI* (2018).
57 Business Chief, *Is the Middle East Facing a Big Data Skills Shortage?* (2020).
58 OECD, *Development Co-Operation Report 2017 Data for Development* (2017).
59 Brookings, *Figure of the Week: Electricity Access in Africa* (2019).
60 University Of Pretoria, Access Partnership, *Artificial Intelligence for Africa: An Opportunity for Growth, Development, and Democratisation* (2017).
61 ITU, *Measuring the Information Society Report 2018, Volume 1* (2018).
62 ITU, *Measuring Digital Development Facts and Figures 2020* (2020).
63 Ibid.

and AI entrepreneurs in developing countries at a disadvantage. Without reliable ICT infrastructure, affordable data plans and easy access to AI, the current digital divide will only grow, particularly in areas where Internet access is only possible at low bandwidths, as many AI apps require faster Internet connections and better-quality software.[64]

Figure 8: Percentage of individuals using the Internet, 2019*



Source: ITU
* ITU estimate. Note: youth refers to the sub-group of 15 to 24 year olds.

Governments need to create policies and regulations to ensure that data infrastructure is secure, sustainable and resilient enough to support ongoing digitalization, economic growth and changes to the way that we live and work. In this respect, some governments have been opening their datasets and developing platforms to encourage the secure exchange of private data. The France Health Data Hub, for example, is a platform that stores health data at the national level. The idea behind it was to build a hub that makes it easier to study rare diseases and use artificial intelligence to improve diagnoses. It aggregates data from different sources and makes it possible to share some data with public and private institutions for specific cases.[65]

AI trustworthiness

AI for development should be ethical and trustworthy: it should be fair and unbiased; transparent and explainable; responsible and accountable; robust and reliable; privacy compliant; safe and secure; diverse and inclusive; and human centred.

[64] Ibid.
[65] Gouvernement Francaise, *Artificial Intelligence: Making France a Leader* (2018).

Box 2: Algorithmic bias

In a perfect world, using algorithms should lead to unbiased and fair decisions. However, many algorithms have been found to have inherent biases. AI systems can reinforce what they have been taught from data. They can amplify risks, such as racial or gender bias. Even a well-designed algorithm must make decisions based on inputs from a flawed and erratic reality. Algorithms can also make judgmental errors when faced with unfamiliar scenarios. Many AI systems are "black boxes", the reasons for their decisions are not easily accessed or understood by humans, and thus difficult to question and probe. The fact that private commercial developers generally refuse to make their code available for scrutiny, because the AI system is considered proprietary IP, is another form of non-transparency.

AI bias in criminal sentencing of people of colour

In 2016, ProPublica analysed a commercially developed system that predicts the likelihood that criminals will re-offend, created to help judges make better sentencing decisions, and found that it was biased against people of colour.

Facial recognition bias

Facial recognition algorithms have been proven to be biased when detecting people's gender. These AI systems were able to detect the gender of white men more accurately than the gender of darker-skinned men. Similarly, the Amazon hiring and recruitment algorithm taught itself to prefer male candidates over female. It was trained with data collected over a ten-year period that came mostly from male candidates.

1. Angwin, J., et al, *Machine Bias* (2016);
2. Dastin, J., *Amazon Scraps Secret AI Recruiting Tool that Showed Bias Against Women* (2018).

- AI should be fair and unbiased. Algorithmic bias, which implies that AI is only as good as the data on which it is trained, is an important factor in how AI and big data are used for development. It has a more pronounced effect when AI applications are introduced to the context of developing countries. A preponderance of AI applications are being developed outside the developing world, and most datasets available are generated from people in developed countries, which might affect the sensitivity of AI systems. In addition, AI systems might embed algorithms reflecting specific beliefs and biases of the system creators, which can lead to discriminatory outcomes if applied to low-resource settings without their developmental input and data.[66] Poor data availability and inadequate sample size have a negative impact on the efficacy of AI systems. Any inconsistencies between training and real-world data may lead to algorithms producing incorrect outputs. Challenges arise when there is a shortage of local data to ensure that AI models are trained in a way that reflects the local circumstances and needs of the local population.[67]
- AI should be transparent and explainable. AI systems can embed bias. For instance, when data are sourced from only one operator or produced by a particular social group, the data feeding the AI system might be skewed towards a particular demographic. AI decision-making can be a black box, not understood even by its developers. In order to reap the benefits of AI for development, all participants should have the right to understand how

[66] Owoyemi, A., et al, *Artificial Intelligence for Healthcare in Africa* (2020).
[67] World Wide Web Foundation, *Artificial Intelligence, the Road Ahead in Low and Middle-Income Countries* (2017).

their data are used. AI algorithms must be open to inspection and their decisions fully explainable. However, designing a system to provide an explanation can be complex and expensive. Many developing countries simply do not have the means to build such AI systems, and this might ultimately impact their ability to deploy AI and big data for development.

- AI should be responsible and accountable. Trustworthy AI systems need to have policies that clearly identify who is responsible and accountable for AI output. Placing responsibility on the AI system for poor decision-making is not sufficient. There should be a clear mechanism for reporting any negative impact. Again, developing countries, which rarely have the human resources with the requisite AI and data skills, will be at a disadvantage here, as they might not have the means to develop trustworthy AI systems that can be successfully deployed in local contexts.
- AI should be robust and reliable. AI must be at least as robust and reliable as the traditional systems, processes and people it is augmenting or replacing. This means that AI needs to be available when it is supposed to be and to generate consistent and reliable outputs, even in less than ideal circumstances. The issues of robustness and reliability are especially important in the context of developing countries. AI developed in resource-rich settings will not necessarily render solutions that are accurate, fair and safe in low-resource settings.
- AI should be privacy compliant. Privacy protection is critical for all data systems, but especially so for AI because the insights generated by AI rely on data that are often personal in nature. The issue of privacy protection is more complex in developing countries as, more often than not, such countries do not have sufficient resources to draft and implement robust cybersecurity and privacy-compliant AI systems.
- AI should be safe and secure. AI systems should be safe and secure so that the data on which they are trained cannot be tampered with or compromised. AI systems should be developed using an approach based on risk prevention and so that they reliably behave as intended, while minimizing unintentional and unexpected harm and preventing unacceptable harm.
- AI should be diverse and inclusive. Only a handful of tech companies and elite university labs develop most of the large-scale AI systems, and developers tend to be white, affluent, technically oriented and male.[68] Given that AI is not neutral and that technologies are a product of the context in which they are created, these systems often fail to meet the needs of different communities. Alongside innovation and efficiency, AI applications must emphasize inclusion and justice and prioritize multidisciplinary and diverse teams.
- AI should be human centred. As AI is used to amplify human capabilities, the protection of human interests, including well-being and safety, should be the primary considerations in the design, development and deployment of AI. This principle also extends to the deployment of measures such as HRIAs, human rights due diligence, human determination (i.e. a "human in the loop"), codes of ethical conduct or quality labels and certifications intended to promote human-centred values and fairness in the design and use of AI.

The European Commission Ethics Guidelines for Trustworthy Artificial Intelligence prepared by the High-Level Expert Group on Artificial Intelligence offer an example of an ethical framework for AI and data.[69]

[68] Myers West, S., et al, *Discriminating Systems: Gender, Race, and Power in AI* (2019).
[69] European Commission, *Ethics Guidelines for Trustworthy AI* (2019).

Box 3: What can policy-makers do to address the main challenges in using AI and big data for development?

- **Create an enabling environment (governance institutions, policies and laws) for an effective roll-out of AI and big data solutions for development**. Appropriate policies and regulatory measures include establishing data protection frameworks and sectoral regulatory frameworks and promoting international cooperation and the adoption of international standards.
- **Enable, incentivize and/or accelerate investment in the building of adequate and affordable data infrastructure**. Investment into software, hardware and broadband connectivity is needed for widespread data access and use, which is critical to reaching the underserved. **Incentivize the creation of FAIR data and FAIR data infrastructure**. The next wave of digital solution transformation will depend on the creation FAIR-data lakes and warehouses that do not sacrifice data integrity.
- **Promote the development of local data that could be used for development projects and innovations in various areas such as agriculture, health, education, etc**. This would allow more local innovations and reduce algorithm and data bias.
- **Ensure adequate levels of privacy and security and handling of data**: e.g. regulate the use of data without consent, reduce the risk of identification of individuals through data, data selection bias, the resulting discrimination of AI models and asymmetry in data aggregation. This includes **addressing the safety and security challenges of complex AI systems**, critical to fostering trust in AI and big data for development.
- **Regulate data protection and ownership in MBD and address issues of interoperability**. There is no universally accepted CDR format, and combining datasets from different operators can be extremely difficult. Given that CDRs contain sensitive customer information, mobile network operators may be reluctant to share them, owing either to exposure to legal risks or a desire to protect corporate data assets.
- **Build adequate data skills capacity**.
- **Incentivize data harmonization**. This is vital to turning big data into data for development. Data can be structured and unstructured in huge volumes and collected from heterogeneous sources. Harmonized data greatly reduce the time and energy required to run big data analytics, and standardization facilitates interoperability. ITU is working with partners to standardize big data-related activities.
- **Establish data governance standards**. Oftentimes, there is a lack of adequate data governance standards that define how data are captured, stored and curated for accountability.
- **Incentivize standardization of application programming interfaces and common data languages**.

- **Ensure inclusiveness and reduce digital inequalities by ensuring that data does not overrepresent those who are connected**. Big data and AI analytics can exacerbate social exclusion by overlooking groups that are difficult to reach or that are not included in publicly available data. **Address issues related to exclusion bias.** While MBD can be a useful source of data on people's activity and mobility, its use can also perpetuate exclusion bias. Algorithms that rely on MBD will not be inclusive of people living in areas with low mobile phone penetration or poor network connectivity/availability or of those less likely to own mobile phones (e.g. the poor, women, the elderly), which could be tackled by addressing accessibility and broadband connectivity.
- **Develop guidelines for data sharing frameworks** that respect privacy and intellectual property rights. Possible innovative data sharing modalities include data cooperatives and data trusts. **Provide access to public sector data**, including open government data, geo-data (e.g. maps) and transport data; **Facilitate private sector data sharing**. Particular focus areas are "data held by the private sector, but of public interest", data in network industries such as transportation and energy for service interoperability, and personal data portability.
- **Develop statistical/data analytic capacities** by establishing technology centres that provide support and guidance in the use and analysis of data.
- **Develop national AI and data strategy for development**, which, combined with appropriate action plan, is paramount to guiding the deployment of AI and big data for development. This report contains a template for devising a national AI and data strategy.
- **Create open-data policies**. Data are often held by private sector stakeholders and therefore not accessible to local innovators, researchers and SMEs to use, add value or create local innovation. Creating a data-sharing policy is crucial for development.

2 Using AI and big data for development: Insights from health, agriculture, and education

AI is creating a seismic shift in the way people interact with technology. It stands to help address key global challenges and deliver considerable benefits and is emerging as a powerful means of increasing economic vitality and resolving various social problems. The cognitive, learning and reasoning capabilities of AI will improve industrial productivity and result in new added value across industries by maintaining an optimal environment for production and predicting and managing obstacles. In addition, greater use of AI-based precision diagnosis and real-time risk-detection functions will greatly contribute to solving social problems such as caring for the elderly in the context of an aging population, preventing crime and strengthening public safety.

As AI exploits data to drive innovation, a key contemporary source of growth and well-being, its transformative effects are bound to expand further in a wide array of domains. The main question, though, remains how developing countries will deal with these seismic changes and how prepared they are for them.

Agriculture, health and education are often cited among the development sectors that have made the most progress in the use of big data and AI analytics. From a broader perspective, an increased ability to quantify and explain poverty dynamics is one area where big data and AI analytics could contribute to improving human well-being. This section will highlight different applications of data for development and their connection to SDGs in the areas of health, mobile big data for development, agriculture, education and open data. It will also highlight certain regulatory and public policy barriers to be overcome.

Figure 9: Big data and AI: Insights from health, agriculture and education

Source: ITU

2.1 Big data, AI, and health

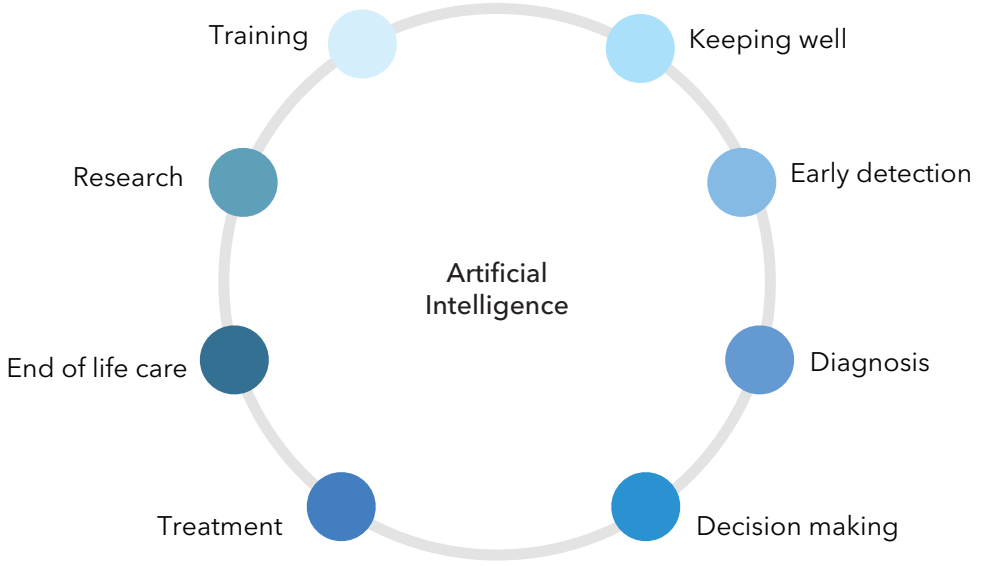
It is estimated that 2314 exabytes of space is needed to store the total volume of global healthcare data produced by 2020.[70] If the 2314 exabytes of data were stacked on top of each other, they would reach 82 000 miles high or circle the earth 3.2 times.[71]

The future of big data and AI in health care is comprehensive, evidence-based, personalized and stratified precision medicine, combining the best available scientific knowledge and professional experience of health professionals for the benefit of individual patients.[72] AI and big data have the potential to improve healthcare systems worldwide by optimizing workflows in hospitals, providing more accurate diagnoses, optimizing clinical decision-making and bringing better medical treatments to patients.[73] Many benefits can be attributed to big data and AI in health care as they can potentially offer higher-quality care at a lower cost.

70 EMC Digital Universe, *The Digital Universe Driving Data Growth in Healthcare: Challenges and Opportunities for IT* (2014).
71 ITU, *How to Unleash the Enormous Power of Global Healthcare Data: Opinion* (2019).
72 UNESCO, *Report of the International Bioethics Committee on Big Data and Health* (2017).
73 OECD, *Artificial Intelligence in Society* (2019).

The global market for AI-driven health care is expected to register a CAGR of 40 per cent through 2021 and to reach a value of USD 6.6 billion by 2021, up from USD 600 million in 2014.[74] Further advances in AI and big data are providing developing countries with opportunities to solve existing challenges in providing appropriate health care to a large section of their populations. AI combined with robotics and IoMT could also help developing countries to address healthcare problems and to meet SDG 3 on good health and well-being (Figure 10). AI can be deployed in health training, keeping well, early disease detection, diagnosis, decision-making, treatment, end-of-life care and health research. For instance, AI can outperform radiologists in cancer screening, particularly in patients with lung cancer, with results suggesting that the use of AI can cut false positives by 11 per cent.[75]

Figure 10: Use cases of AI in health care



Source: Adapted from PwC

Many developing countries are struggling with the challenge of ensuring efficient provision of healthcare services, for which health ministries require data about their populations in order better to understand service requirements. The need for data to ensure both an efficient management and delivery of health services in a low-resource environment has become increasingly important, as data provide a quantitative basis for resource deployment. Furthermore, developing countries are faced with endemic shortages of medical workers. This is a gap that AI and big data can assist in filling.[76]

[74] Frost & Sullivan, *From $600 M to $6 Billion, Artificial Intelligence Systems Poised for Dramatic Market Expansion in Healthcare* (2016).
[75] Northwestern University, *Artificial Intelligence System Spots Lung Cancer before Radiologists* (2019).
[76] Hoyler, M., et al, *Shortage of Doctors, Shortage of Data: A Review of the Global Surgery, Obstetrics, and Anaesthesia Workforce Literature* *World Journal of Surgery 38, No. 2 (2014): 269-280* (2014).

Box 4: Leveraging AI-powered sensors to support health care in sophisticated ways and fight pandemic outbreaks

To fight the COVID-19 pandemic, Baidu, a Chinese technology company, has developed a no-contact infrared sensor system to quickly identify individuals with a fever, even in crowds. Beijing Qinghe railway station has been equipped with this system to identify potentially contagious individuals, replacing a cumbersome manual screening process.

Similarly, Florida Tampa General Hospital deployed an AI system in collaboration with Care.ai at entrances to prevent individuals with possible COVID-19 symptoms from visiting patients. The technology conducts a facial thermal scan and picks up on other symptoms, including sweat and discolouration, through cameras positioned at entrances with the aim of denying entry to visitors with a fever.

Another such example is the Israeli company Diagnostic Robotics, which is an AI-based triage platform that provides public health officials with continuous monitoring of virus spread patterns. The platform has been adapted to tackle the current pandemic, offering an analytical tool that produces risk assessment and predictive models, thereby allowing a quicker and better-targeted medical response.

1. Venture Beat, *How People are Using AI to Detect and Fight the Coronavirus* (2020)
2. The Wall Street Journal, *Hospitals Tap AI to Help Manage Coronavirus Outbreak* (2020)
3. Forbes, *Israeli Innovators Harness Artificial Intelligence Technologies to Curb the Global COVID-19 Pandemic* (2020)

Unlike in developed countries, which have an abundance of readily available data that have driven healthcare decisions, many governments and organizations in developing countries do not have sufficient, reliable systems for data collection, verification and aggregation. The lack of appropriate systems to create and maintain robust, accurate and relevant data makes it challenging to use data to address issues related to disease prevention, intervention assessment and community education.

Nevertheless, there have been frequent attempts to use data collection and AI analysis programs to gather vital information in the context of development. Satellite images, heat maps, social media posts and online media reports, for example, have been used as data points by AI algorithms in disease surveillance and forecasting.

Examples of the deployment of big data and AI in health care in developing countries abound. In the Republic of the Gambia, a probabilistic decision-making system has been used to assist rural health workers in identifying life-threatening conditions in outpatient clinics, with medical AI performing reasonably well in detecting 88 per cent of cases.[77] Elsewhere, Computerized Aid To Treat (CATT) has been used in drug prescriptions in South Africa by nurses, based on a cost-and-effectiveness algorithm.[78] Kimetrica, a social enterprise, has used

[77] Owoyemi, A., et al, *Artificial Intelligence for Healthcare in Africa* (2020).
[78] Ibid.

facial recognition AI in its machine learning tool, MERON, as a less intrusive and more reliable predictor of malnutrition in children aged under five than the traditional measurement of the circumference of the mid-upper arm. The method used by Kimetrica is effective in low-resource environments, such as conflict zones, where it is difficult to send people with large equipment to take measurements.[79]

Maternal and new-born deaths have long plagued the African continent. Nevertheless, the vast majority of these deaths can be prevented with relatively simple and inexpensive tools, ensuring that **the right life-saving interventions reach the right person at the right time.**

Big data and AI could play a crucial and transformative role, particularly in poorer and remote areas by providing critical intelligence to help community health workers prioritize care and resources to those most at risk.[80] For example, Ubenwa, a start-up based in Nigeria, is using signal processing and ML to improve the diagnosis of birth asphyxia in low-resource settings.[81]

The Middle East, meanwhile, is positioning itself as a potential international market leader and hub for AI research and development in health care. Dimension14,[82] a start-up based in Dubai, uses an AI engine for the scheduling of patients and doctors by mapping out personalized journeys for both parties.

AI had been deployed to respond to public health concerns by anticipating outbreaks of diseases such as Zika and dengue fever. By partnering with Artificial Intelligence in Medical Epidemiology (AIME), a start-up that analyses existing local government datasets in combination with satellite-image recognition systems, the Brazilian NGO Viva Rio has been able to deliver low-cost quarterly predictions of where a greater disease incidence may occur. Following its success in Brazil, the AIME low-cost solution has also been deployed in the Dominican Republic.[83]

South Africa is piloting the deployment of robotic pharmacists which dispense drugs to people living with HIV through its Right to Care project in the Helen Joseph Hospital in Johannesburg. These robotic pharmaceutical dispensaries, which are funded by the Department of Health and the Global Fund, do not reveal the patient's identity, thus mitigating any social stigma associated with the disease. Additionally, they dispense medication to other chronically ill patients suffering from tuberculosis. The deployment of such robot pharmacists has eliminated the need for patients to wait for hours at hospitals or clinics to get their monthly dose of antiretroviral medication.[84] Another example of the deployment of AI on the African continent can be found in Nigeria. Aajoh is a Nigerian start-up that uses AI to diagnose patients' medical conditions based on the symptoms they provide via text, audio and photographs.[85]

79 Jack, A., *AI Set to Transform Healthcare in World's Poorer Regions* (2020).
80 Rao, N., *Big Data Can Improve the Health of the World's Most Vulnerable: Mothers and Children* (2019).
81 See *Ubenwa*.
82 See *Dimension 14*.
83 Gul, E., *Is Artificial Intelligence the Frontier Solution to Global South's Wicked Development Challenges?* (2019).
84 Ibid.
85 Ibid.

Box 5: How to address key challenges for the use of AI and big data in health care

- **Address concerns over the privacy, security and protection of sensitive health data** by strengthening personal data protection systems and the cybersecurity of electronic health files and records.
- **Digitize, anonymize and open clinical datasets** by establishing adequate digital infrastructure, electronic health records and safe practices in data sharing between various healthcare providers. There are several challenges in working with big health data, such as unstructured and unorganized data and a lack of interoperability. Access to health data is another obstacle as data owners/ custodians can restrict access because of compliance with privacy-protection laws and ethical and proprietary considerations on their acquisition and use. In order to develop software with data-based AI techniques, healthcare innovators need access to large, representative and curated high-quality clinical datasets that can be mined with big data AI techniques to develop highly personalized clinical guidelines that can be incorporated into rules-based AI software.
- **Create health data governance frameworks that focus on transparency through public communication and stakeholder engagement, explicitly highlighting the importance of trust.** A shortage of trust among patients, the public, data custodians and other stakeholders in how data are used and protected is a major impediment to data use and sharing;
- **Create conditions for public-private partnerships in the use and sharing of clinical data through safe data trusts/pools; make clinical data interoperable; and create a clear framework for clinical data use and sharing.** In many countries, clinical data are fragmented in silos and kept by different providers, such as hospitals and clinics, despite the existence of centralized public health systems. The hospitals and clinics use different databases and IT systems and decide what types of data to collect and in what format to store them. This problem is exacerbated by the fact that patients begin to amass their own repositories of health data from an array of new wellness and healthcare devices.
- **Set clear standards for AI transparency in health care.** Without transparency or human involvement in decision-making, algorithmic bias can creep in. Even if AI systems are fed with correct and representative data, the information might still reflect underlying biases and inequalities embedded in the healthcare system. Transparency can be achieved by ensuring that there is human involvement and overview in AI deployment in health care.
- **Set a clear framework governing the ethical and social implications of patient data, AI and its growing use in health care.** Policy-makers can produce ethical principles for informed consent, such as by ensuring that consumers sufficiently understand that the use of an AI health app or chatbot may be conditional on acceptance of the terms of use.

2.2 Big data, AI, and agriculture

Today's global population of 7.6 billion is expected to rise to 9.8 billion by 2050,[86] with half of the world's population growth concentrated by that time in just nine countries, namely: India, Nigeria, the Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States of America, Uganda and Indonesia.[87] The growing demand for food

[86] UN, *World Population Projected to Reach 9.8 Billion in 2050, and 11.2 Billion in 2100* (2017).
[87] Ibid.

will put massive pressure on the use of water and soil. All of this will be exacerbated by climate change and global warming. Most of the world's food is harvested by smallholder farmers faced with poverty and food insecurity.[88] Concerns surrounding climate change, population growth and food security have made the agricultural sector seek more innovative approaches to protecting and improving crop yield. AI, however, has risen to the occasion and is steadily emerging as part of the technological revolution of the sector, including through improvement in the accuracy of cognitive computing technologies, such as image recognition, even though agriculture has traditionally relied on the eyes and hands of experienced farmers to identify the right crops to pick.

Precision agriculture makes the growing of crops and raising of livestock more accurate and controlled. A key feature of this approach is the use of ICTs and a wide array of devices such as GPS guidance, control systems, sensors, robotics, drones, autonomous vehicles, variable-rate technology, GPS-based soil sampling, automated hardware, telematics and software.[89]

> *Data are a key element in enhancing the sustainability, performance and competitiveness of the agricultural sector. Processing and analysing production data, in combination with other data on the supply chain and other types of data, such as earth observation or meteorological data, allows for precision agriculture.*

The modern farm can now be managed with the aid of AI and big data at the scale of a few feet and even at a granular level. Geo-informatics can be used for precisely targeted field treatments, creating opportunities in terms of efficiency gains. Governments, in partnership with mobile operators, have used phones to coordinate the distribution of seeds and subsidized fertilizers in remote areas through, for example, e-vouchers in Nigeria's large-scale e-wallet initiative.[90] A number of private-sector innovations are aiming for real-time, accurate weather monitoring using remote sensors and technologies enabled with GIS for climate-resilient agriculture. Robot harvesters equipped with AI technologies and data from cameras and sensors can now make real-time harvesting decisions.[91]

The use of AI and related technologies has the potential to benefit productivity and efficiency at all stages of the agricultural value chain (Figure 11).

- Crop and soil-health monitoring and provision of real-time advice to farmers. The agricultural sectors in many developing countries are vulnerable to climate change as variable weather patterns, such as temperature rises, fluctuations in precipitation levels and ground-water density, can affect farmers in these countries. Companies leverage computer vision and deep-learning algorithms to process data captured by drones and/or software-based technologies used to monitor crop and soil health.[92] AI can be used to advise the best course of action for sowing, pest control and input control, while assisting in increasing income and providing stability for the agricultural community. For instance, many agronomic factors (such as vegetation health and soil moisture) can be monitored through remote sensing. Using remote-sensed data, high-resolution weather data and AI solutions makes it possible to monitor crops and provide additional insights to farmers. The

88 FAO, *The Economic Lives of Smallholder Farmers: An Analysis Based on Household Data from Nine Countries* (2015).
89 Schmaltz, R., *What is Precision Agriculture?* (2017).
90 See *E-Wallet, Nigeria*.
91 OECD, *Artificial Intelligence in Society* (2019).
92 Ibid.

agricultural technology start-up PEAT has developed Plantix, a deep-learning application that identifies potential defects and nutrient deficiencies in soil. Software algorithms analyse the data and correlate foliage patterns with certain soil defects, plant pests and diseases.[93] VineView has developed a system to analyse vineyard health based on images taken by drones and uploaded to the company cloud system and subsequently diagnose any problems with the condition of grapevine leaves.[94] Wadhwani AI has developed a smartphone-based solution that classifies pests based on photos provided by cotton farmers and offers localized advice on pesticide use. [95]

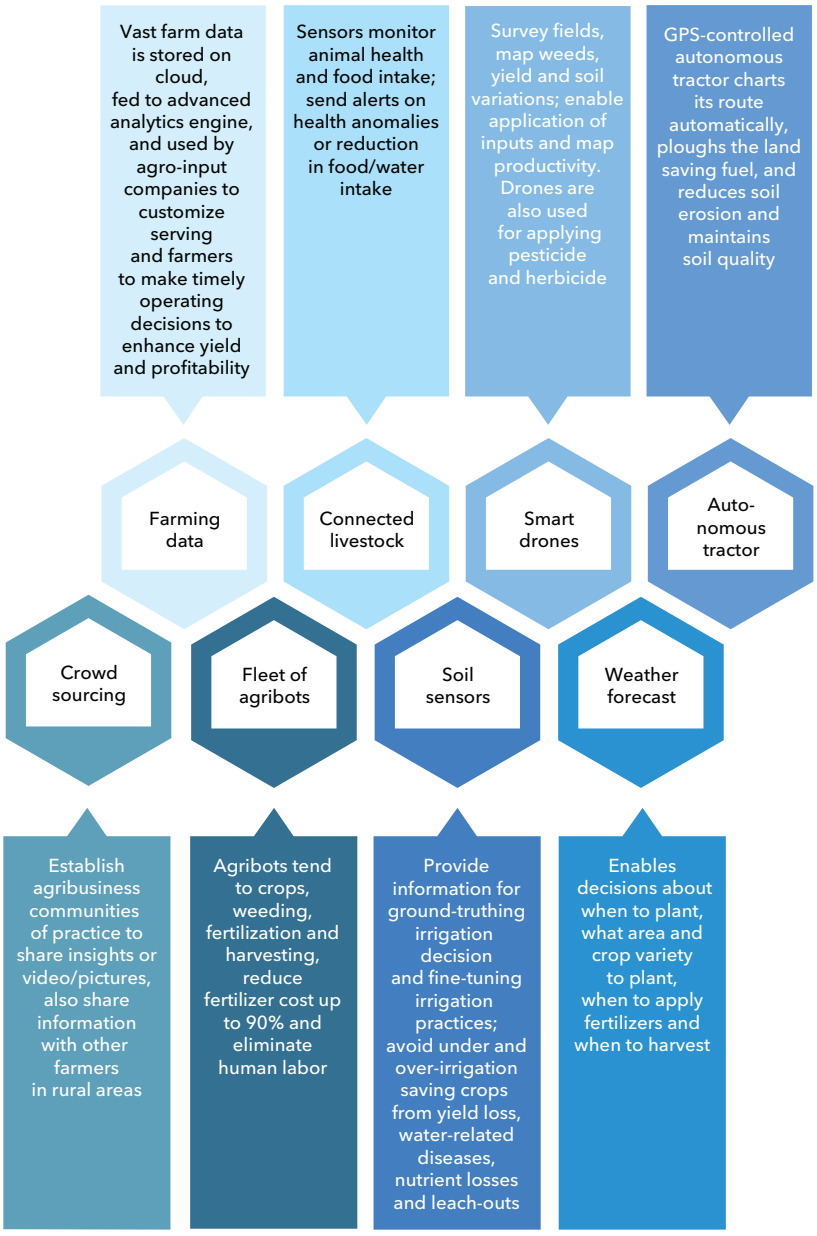
- Increased efficiency and utilization of farm mechanization. Image-classification tools combined with remotely and locally sensed data assist with weed removal, early disease identification and produce harvesting and grading. Horticultural practices require a lot of monitoring at all levels of plant growth, and AI tools provide round-the-clock monitoring of high-value products. aWhere uses ML algorithms in connection with satellites to predict weather, analyse crop sustainability and assess farms for the presence of diseases and pests.[96] FarmShots is a start-up focused on analysing agricultural data derived from satellite and drone images. Its software can inform users exactly where fertilizer is needed and reduce the amount used by nearly 40 per cent. The software is marketed for use across mobile devices.[97]
- Augmenting farmers' capabilities with agricultural robots. Companies develop and programme autonomous robots to handle essential agricultural tasks.[98] Abundant Robotics is a company that has developed an apple-vacuum robot that uses computer vision to detect and pick apples with the same accuracy as a human.[99] Harvest CROO Robotics has developed a robot to help pick and pack strawberries, capable of harvesting 3.2 hectares a day, thereby addressing the issue of labour shortages in key farming regions.[100]

Secondary agricultural activities, involving the produce post-production management phase, are another area seeing increasing use of AI and big data analytics. Big data analytics can forecast consumer demand and can therefore have an impact on crop planning, harvest scheduling and market linkages. Data from sensors in the field are used to monitor crop moisture, soil composition and temperature and to assist AI in improving production and identifying when crops need watering. Combining this information with that from drones also used to monitor conditions can help AI systems to determine when best to plant, spray and harvest crops and when to head off diseases and other problems, resulting in increased efficiency, enhanced yields and lower use of water, fertilizer and pesticides.[101]

AI could also address challenges faced by farmers at the base of the pyramid. While these farmers lack the means to purchase AI-enabled equipment, they can benefit from AI as a service through their mobile devices. The ML app Nuru, for example, has been used on farms in Tanzania, Kenya and Mozambique to identify leaf damage from photos taken by farmers and to send relevant information to the authorities. This process can help to track the presence of invasive pests threatening food security across East Africa.[102]

93 Ibid.
94 See *Vineview*.
95 Donahue, M. Z., *Q&A: AI for Developing Countries Must be Adaptable and Low-Cost* (2019).
96 Ibid.
97 See *Farm Shots*.
98 Faggella, D., *AI in Agriculture – Present Applications and Impact* (2020).
99 See *Abundant Robotics*.
100 See *Harvest Croo Robotics*.
101 Cho, R, *Artificial Intelligence – A Game Changer for Climate Change and the Environment* (2018).
102 See *App: Plantvillage Nuru*.

Figure 11: Ecosystem required to reap the benefits of precision agriculture



Source: Adapted from Accenture Research, *Digital Agriculture: Improving Profitability* (2020)

An international initiative worth mentioning is the CGIAR Platform for Big Data in Agriculture,[103] an open-access/open-data platform which unites agricultural research institutes and companies and aims to bridge the digital divide between farmers in developed and developing countries. Amazon will contribute cloud computing and data processing capabilities, IBM will contribute data analysis capabilities, and PepsiCo will bring its use of big data to manage supply chains.

[103] CGIAR, *Platform for Big Data in Agriculture: Transforming Rural Livelihoods with the Power of Information*.

Box 6: Steps to promote the deployment of AI and big data in agriculture

- Provide enabling data ecosystems that stimulate data sharing and openness in agriculture and preserve privacy and information security.
- Invest in AI research in agriculture by funding core research in fundamental technologies and supporting the transformation of core research into market applications in the agricultural sector.
- Invest in building AI and data expertise, workforce and skilling opportunities in the agricultural sector.
- Promote public-private partnerships in the creation of data commons in agriculture.
- Establish clear privacy security and ethical regulations for the use of AI and big data in agriculture.
- Ensure that the intellectual property regime (patents and plant variety rights) incentivizes the research and adoption of AI solutions in agriculture.
- Standardize by establishing clear standards for the interoperability of AI solutions in the agricultural sector.

2.3 Big data, AI, and education

As a result of the advances in AI and ML, the education sector is starting to change slowly, but steadily. AI and big data could act as an extra pair of helping hands in the classroom and do even more: it could amplify teachers' abilities by giving greater insight into their students' needs.

AI algorithms can assist teachers by collecting, analysing and correlating every interaction that takes place in physical and virtual classrooms, and thereby personalize the learning experience. Online tutoring is another exciting development. For example, Brainly[104] is a social media platform that enables millions of students to connect and do homework and assignments together, while other platforms, such as Freckle,[105] Carnegie Learning[106]and Thinkster,[107] are working on intelligent tutoring systems that are able to mimic the benefits of one-on-one tuition. Another shining example is the company zSpace,[108] which has developed an augmented reality tablet that uses a stylus and glasses for interactive learning experiences. Using AI and big data is likely to make education more immersive.

There are multiple AI-powered platforms that create digital profiles of each student by collecting live information based on the user's interaction with course material. Data models help to find common patterns among multiple students and perform predictive analytics, including forecasting students' future performance. Zoomi,[109] for example, tracks micro-interactions such as viewing specific slides or pages in PDF documents, replaying a specific video segment or posting a question or answer on a discussion forum. Data are then used to

[104] See *Brainly*.
[105] See *Freckle*.
[106] See *Carnegie Learning*.
[107] See *Thinkster*.
[108] Futurism Creative, *The Future of Education Can Be Found Within this AR Tablet* (2017).
[109] See *Zoomi*.

build a model that can give real-time insights into a student's understanding of and engagement with specific topics.

AI technologies can ensure equitable and inclusive access to education, providing marginalized people and communities, such as persons with disabilities, refugees and those out of school or living in isolated communities, with access to appropriate learning opportunities. For example, telepresence robots allow students with specific needs to attend schools at home or in hospital or to maintain continuity of learning during emergencies or crises.[110] Arifu, an education technology company based in Kenya, offers an AI chatbot platform that can deliver personalized learning on mobile devices and provide access to information on topics such as farming, entrepreneurship or financial literacy to the underserved.[111]

Furthermore, AI can aid in advancing collaborative learning by providing students with computer-supported collaborative learning despite being geographically dispersed, thereby affording students choice in when and where they wish to study and allowing the AI to personalize learning in various ways.

AI can reshape high-quality education and learning through precisely targeted and individually customized human capital investments. Incorporating AI into online courses opens up ways of enhancing access to affordable education and improving learning and employment in emerging markets. Educational technology companies, such as Coursera, Andela[112] and Udemy,[113] generate and leverage data on student performance across emerging markets with a view to delivering upskilling recommendations. In India, UpGrad[114] has enrolled 2000 students in entrepreneurship, digital marketing, data analytics and product management courses, whereas Edutel[115] in South Africa uses two-way satellite technology to deliver live lessons by specialist teachers in science, mathematics and English to about 2000 primary and secondary schools. Other companies combine data from online education and job platforms to deliver automatic upskilling recommendations.

A myriad of AI applications in education are currently undergoing testing across public and private initiatives. Plan Ceibal in Uruguay, for example, is possibly one of the most advanced state agencies devoted to digital education in Latin America and the Caribbean. One of its main initiatives is the Mathematics Adaptive Platform, an online adaptive learning solution where content has been adapted to the national curriculum and which provides personalized feedback according to each student's skill level, based on an analysis of student experience.[116] Learning Equality, on the other hand, is a non-profit initiative and has developed Kolibri, an open-source educational platform and toolkit designed for low-resource communities.[117]

AI can be used to expand training beyond traditional classrooms. Liulishuo, a Chinese company, provides an online adaptive platform for learning English that can offer students the kind of natural language processing, speech recognition, intelligent assessment and feedback that regular teachers offer. "Basically, we mimic the whole process of a human teacher: listen,

110 UNESCO, *Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development* (2019).
111 See *Arifu*.
112 See *Andela*.
113 See *Udemy*.
114 See *Upgrad*.
115 See *Edutel*.
116 Ibid.
117 See *Kolibri*.

understand, think and offer feedback,'' says Ben Hu, Liulishuo CTO and co-founder.[118] The application uses AI to identify and help correct problems that students encounter, such as a strong Chinese accent or mistakes in pronunciation, and tailor exercises to users' needs. In June 2018, it reported having 83.8 million registered users.[119]

Talespin,[120] a US-based company, brings simulated training experiences to a new level through the use of AI and virtual/augmented reality. In doing so, it has created a more engaging, immersive and smart training environment.[121] Talespin has developed numerous virtual platforms that can be adapted to many different training scenarios, thereby accelerating knowledge transfer for employees. As the price of virtual-reality sets continues to fall, such innovations will become even more accessible to developing markets.

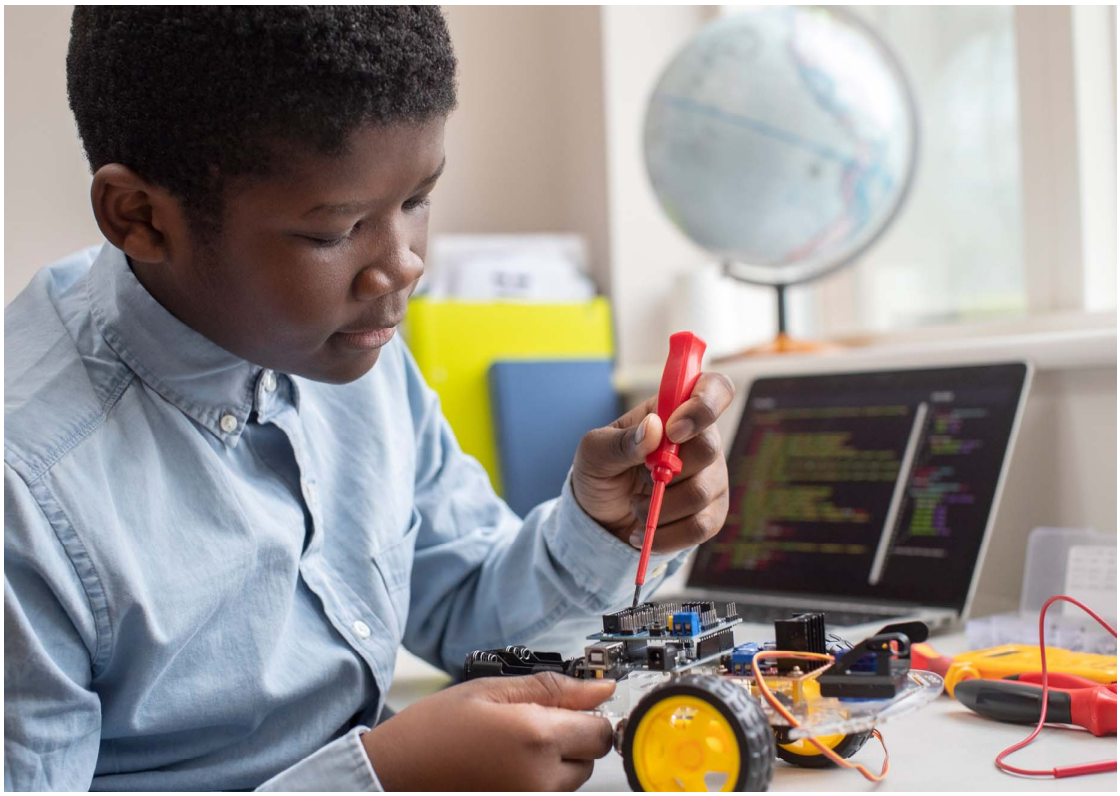
Even though AI and big data analytics can bring many positive developments to the education sector of developing countries, there are still inherent obstacles to their deployment. The benefits of AI are mainly reaped by developed countries with abundant resources and human capital, while job displacement leaves developing countries worse off. AI can contribute to increased inequality due to the uneven global distribution of educational and computing resources. The existing biases in the data used to train AI algorithms may result in increased discrimination in developing countries and among vulnerable populations.[122]

Box 7: How can policy-makers foster the use of AI and big data in education?

- Ensure inclusion and equity for AI in education.
- Prepare teachers for an AI-powered education while preparing AI to understand education.
- Develop high-quality, inclusive data systems.
- Scale up AI research in education: State agencies need to finance, support and incubate research into AI in local educational contexts, while recognizing teachers as actors and not mere beneficiaries of technological "solutions."
- Establish and implement clear rules for an ethical and transparent approach to data collection, use and dissemination.
- Ensure that the use of AI in classrooms does not dehumanize learning, undervalue teachers or compromise fundamental human rights through embedded bias.

[118] The Harbinger, *Who Needs an AI Teacher? – With Liulishuo Founder & CTO Ben Hu* (2019).
[119] Khan, Q., *Will Liulishuo's Full on Artificial Intelligence Model Help Them in the Longrun*? (2019).
[120] See *Talespin*.
[121] Takahashi, D., *How VR Can Help Enterprises with Training, Beyond Firing Barry* (2019).
[122] UNESCO, *Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development* (2019).

3 Big data and AI for development: Policy and regulation



Many developing countries do not have the requisite human capital, policies and regulations, broadband connectivity and electricity networks to take full advantage of the new production techniques and business methods offered by AI and big data. By the end of 2019, only 19 per cent of individuals living in LDCs had access to the Internet.[123] Investment rates in LDCs remain lower on average than in developing countries and well below the rate required to spark digital transformation and the uptake of transformative technologies such as AI. The absence of adequate policies and regulations to mitigate the negative impacts of rapid technological change will result in many developing nations missing out on much-needed value capture. The widespread introduction of AI and related digital technologies is only possible with the rapid scaling-up of broadband infrastructure. While developed countries, with the most expansive and high-speed broadband networks, are embracing and investing in AI at astonishing rates, developing countries are being left behind.

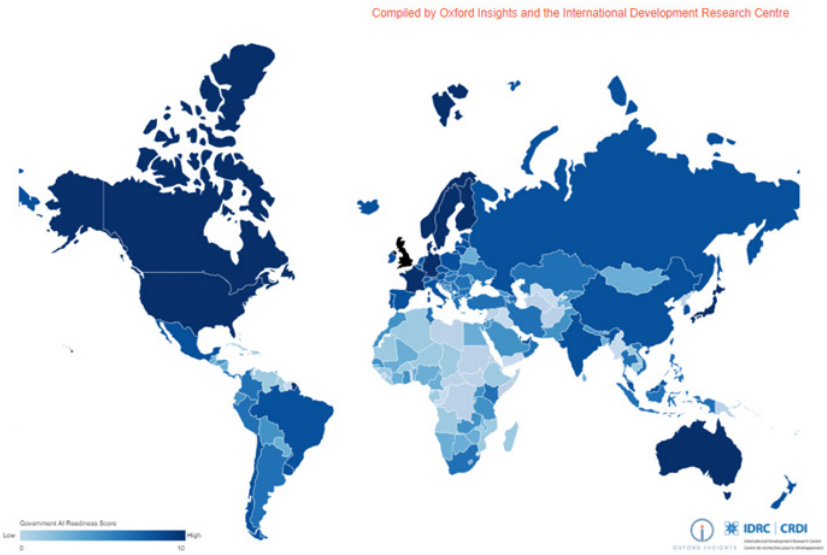
The 2020 Government AI Readiness Index (Figure 12), which was developed by Oxford Insights with the support of the International Development Research Centre (IDRC), scores the governments of 194 countries and territories according to their preparedness to use AI in the delivery of public services. Overall scores are a reflection of 11 input metrics, grouped under four high-level clusters: governance; infrastructure and data; skills and education; and

[123] ITU, *Facts and Figures 2020* (2020)

government and public services. The purpose of assessing and scoring governments' AI readiness is to assist policy-makers around the world in identifying the areas where they are performing well and the areas on which they may wish to focus their attention moving forward.

Figure 12 shows that developing countries around the globe, and LDCs in particular, are lagging behind their developed counterparts in terms of AI readiness. For most governments, where the use of AI in public services is still in its infancy, understanding AI and big data readiness and building capacity to improve that readiness is the essential groundwork on which implementation can be built. The index is used to identify gaps and strengths to best serve implementation. It shows that the lowest-scoring regions on average are sub-Saharan Africa, Latin America and the Caribbean and South and Central Asia. Very few countries in the Global South in particular have published national AI strategies. In sub-Saharan Africa, for example, only Mauritius currently has a strategy, with Kenya in the process of developing one. According to the index, many developing countries should work to expand their technology sectors, develop the business environment and a skilled AI workforce and establish appropriate regulatory and ethical frameworks.[124]

Figure 12: Government AI Readiness Index 2020



Source: Oxford Insights, *AI Readiness Index* (2020)

AI represents one of the most difficult challenges to traditional regulation. Three decades ago, one could think of a piece of software being programmed; in today's AI environment, however, it is no longer programmed, but trained. In addition, information networks can have surprising capacities. AI is not organic intelligence and does not behave by following the same set of rules that humans follow. AI itself is not one technology or even one singular development; it is a bundle of technologies whose decision-making is often not fully understood, even by AI developers. AI solutions can help to address key global challenges and deliver significant benefits, though they also give rise to challenges related to inequality, privacy and discrimination.[125]

[124] Oxford Insights, *AI Readiness Index* (2020).
[125] Stankovic, M., et al. *World Bank Global Forum on Law, Justice and Development White Paper Exploring Legal, Ethical and Policy Implications of Artificial Intelligence* (2017).

It is very difficult to ensure robust regulation for something as technical as AI. Most regulatory systems require transparency and predictability but most people do not understand how AI works. The more advanced that certain types of AI become, the more they become akin to "black boxes" and the less AI system creators know of their decision-making basis. Accountability, foreseeability, compliance and security are big questions in this regard.

Developing countries face a novel set of challenges in the regulation of AI and big data. Most standards and principles used for the regulation of AI are set by developed countries, which may contribute to suboptimal resource allocation in less developed countries. The production of self-driving vehicles, for example, may require the introduction of safety standards that price the cars out of the markets of less developed countries.

Governments need to prioritize the development of sector-specific guidance and co-regulatory tools to accelerate digitalization. Regulatory areas that should be taken into account are the following:

- Data protection laws. Having an appropriate regulatory framework for the protection and transfer of personal and non-personal data is of the utmost importance to creating a suitable national AI and data system. It is important that countries build data regimes that promote growth and innovation for businesses of every size, while maintaining public trust. Regulatory certainty and high data protection standards allow businesses and consumers to thrive.
- Sectoral regulatory frameworks. Given the diverse and fast-changing nature of the technology, sectoral regulatory frameworks may offer extra user privacy and security protection, in addition to a dedicated central law. Japan and Germany have developed new frameworks applicable to specific AI issues, such as the regulation of next-generation robots and self-driving cars, respectively.
- Intellectual property (IP) laws. Having adequate IP laws encourages private-sector investment in AI and data and protects the interests of the public. Text and data mining (TDM) is a key enabling technology for AI, ML and data analytics. In cases where content is protected by copyright, smart TDM regulation is needed for commercial and non-commercial purposes. If licensing models cannot provide satisfactory solutions, a combination of legal permissions and remuneration rights helps to strike a fair balance and ensure that the rights of all parties are respected.[126]
- Anti-trust/competition laws. AI solutions have an impact on competition and openness of markets around the globe. Companies might (ab)use AI as a means of collusion with limited or no human involvement, such as on pricing via price monitoring and matching algorithms. AI could also contribute to abuses of market power by perpetuating discrimination and bias.
- Consumer protection laws. AI and big data are reshaping the risk associated with consumer privacy and data security through profiling and automated decisions. Big data and AI present challenges to traditional consumer protection laws by, for instance, obfuscating the process of purpose specification (i.e. why personal data are collected) and rendering the notice and consent approach less effective (i.e. notifications are not made simple and understandable). Using erroneous and outdated data for data analytics, algorithmic bias and AI black-box decision-making are issues facing consumer protection authorities.
- Cyber and information security laws. The fast-evolving cybercrime landscape is a significant challenge for law-enforcement regulators, especially for cross-border enforcement. This is further compounded by AI solutions making it much easier than ever before to conduct cyberattacks.

For a comprehensive checklist of digital, AI and big data regulations, please refer to chapter 5.

[126] European Commission, *Germany AI Strategy Report* (2018).

3.1 Data protection, privacy, and cybersecurity

In its narrow sense, privacy could be defined as the "right of individuals to control or influence what information related to them may be disclosed."[127] The concept of "personally identifiable information" is interpreted broadly by many data protection authorities: if an individual can be identified from a dataset, irrespective of the source of the data, then the dataset is considered to contain personal information.[128]

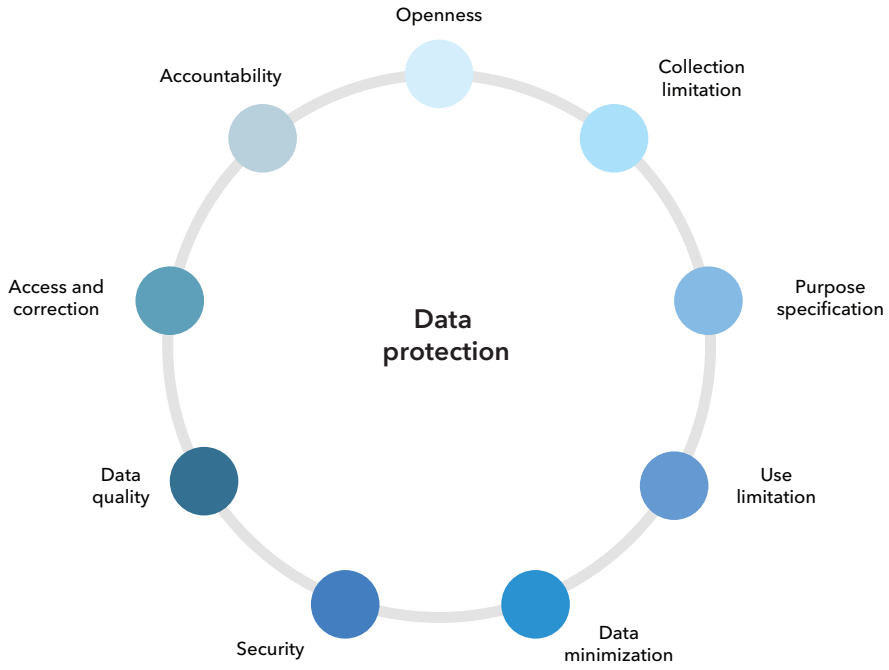
As we continue to generate more and more data, both intentionally and unintentionally, the need for data protection grows. Data protection policies are essential for the protection of data generated by individuals who no longer have the ability to control the use of their personal information. To facilitate protection, a broad international understanding has been reached on the core principles which should be embodied in data protection regulation. Figure 13 and Box 8 give an overview of the core data protection principles found in regulatory systems around the world.

Box 8: Core principles of data protection

- **Openness**. This obliges organizations to be open about practices related to the collection of personal data.
- **Collection limitation**. This requires the collection of a person's data to be limited, lawful and fair.
- **Purpose specification**. This requires personal data to be collected for specified, explicit and legitimate purposes.
- **Use limitation**. This precludes the use of data outside the scope of the previously stated specific purposes.
- **Security**. This requires that an individual's personal data must be subject to appropriate safeguards.
- **Data quality**. This requires that personal data collected must be relevant, accurate and kept up to date.
- **Access and correction**. This provides for the right of individuals to be able to access and correct their personal data.
- **Accountability**. This demands that data controllers and processors comply with all the above-mentioned data protection principles.

[127] UN Global Pulse, *Big Data for Development: Challenges and Opportunities* (2012).
[128] Scassa, T., *Geographic Information as Personal Information. Oxford University Commonwealth Law Journal, 10(2), 185–214* (2010).

Figure 13. Core principles of data protection



Source: UNCTAD

AI can connect different datasets and match different types of information. With the help of AI, non-personal data can be correlated with other data and matched to specific individuals and become personal again, with individuals thereby "re-identified," making it difficult to assess which data will remain non-personal.[129]

People's lives can benefit greatly when decisions are informed by pertinent data that reveal hidden and unexpected connections and market trends. For instance, identifying and tracking genes associated with certain types of cancer can help to inform and improve treatment. However, people, oftentimes unaware, bear many of the costs and risks of participating in data markets. In many jurisdictions, so-called data brokers are amassing and selling personal data, and this is a perfectly legal practice.[130]

[129] OECD, *OECD Artificial Intelligence in Society* (2019).
[130] Matsakis, L., *The WIRED Guide to Your Personal Data (and Who Is Using It)* (2018).

Box 9: How anonymization does not always equate to privacy: the case of re-identification

A recent study by Nature Communications suggests that anonymization does not always equate to privacy. Researchers from Imperial College London and the University of Louvain have developed an ML model that estimates how easily individuals can be re-identified from an anonymized dataset by entering their zip code, gender and date of birth. On average, in the US, those three records can be used to correctly locate individuals in an "anonymized" database 81 per cent of the time. Using 15 demographic attributes for someone living in Kenya, there is a 99.98-per-cent chance that you could find that person in any anonymized database.

MIT Technology Review, *You're Very Easy to Track Down, Even When Your Data Has Been Anonymized* (2019)

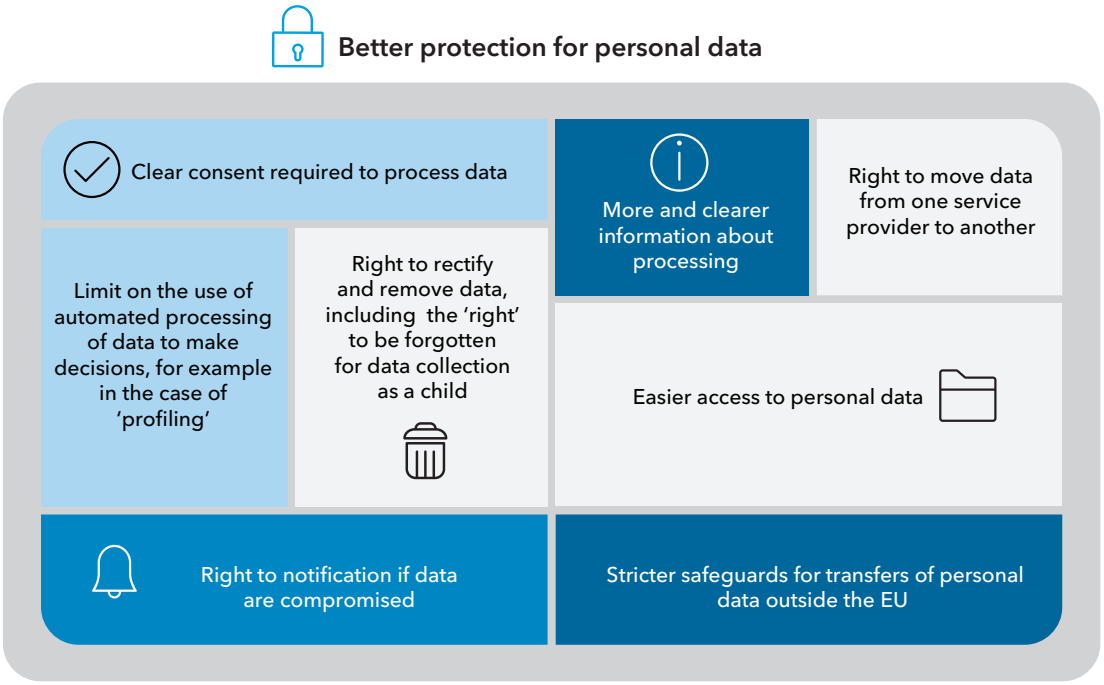
From a regulatory point of view, the crux of the matter is who has access to and control over the data. Is it the government, the users or the service providers who store the data? From a legal perspective, there is no legal system that offers ownership of raw data.[131] Imagine the following scenario: if a car dealer has access to personal information, what obligation do they have to store and protect it? Can personal data be shared with third parties, the so-called data brokers? Can the car dealer charge a higher price to car buyers who refuse to share their personal data?

Many developing economies have adopted measures that create barriers to the cross-border transfer of data, such as data localization laws, tariffs on cross-border data transfers, bans on trade in data and personal data protection laws. Data localization laws require the storage of data, locate data centres within one jurisdiction and restrict the ability to move and process personal data across borders, for reasons of national security, personal data and privacy protection and ensuring of access to law enforcement data.[132]

There is no global agreement on data protection, and regulators around the globe take very different, oftentimes conflicting, stances when regulating data within national borders. For instance, the European Union Regulation (EU) 2016/679 (General Data Protection Regulation),[133] as one of the most prominent regulatory instruments in data protection, provides for the principle of privacy, strict controls over cross-border data transmissions and the "right to be forgotten" (Figure 14).

[131] Kerry, C. F., Morris, J. B., *Why Data Ownership Is the Wrong Approach to Protecting Privacy* (2019).
[132] Stankovic, M., Neftenov, N., Stankovic, B., *Can Regulators Keep Up with Emerging Technologies?* (2020).
[133] European Commission, *Data Protection Rules as a Trust-Enabler in the EU and Beyond – Taking Stock, Brussels* (2019).

Figure 14: Main points of the European Union GDPR



Source: European Union, *Data Protection Under GDPR* (2020)
Although most publicly available big data have potential value for development, there are more valuable data closely held by corporations that are not accessible for development purposes. Any regulatory and public-policy initiative should fully recognise these challenges and the importance of handling data in ways that ensure that privacy is not compromised.

Box 10: Data philanthropy

The promise of big data for development will not be fulfilled if private corporations refuse to share data. The UN Global Pulse, for instance, has promoted the concept of "data philanthropy," under which corporations take the initiative to anonymize their datasets and provide data to social innovators to mine for insights, patterns and trends in real or near-real time.

Kirkpatrick, R., *Data Philanthropy: Public and Private Sector Data Sharing for Global Resilience* (2011).

Other key regulatory challenges in the era of emerging technologies are information security and cybersecurity. Cybersecurity is particularly important in financial technology, digital health, digital infrastructure and intelligent transport systems, where private, sensitive data can be compromised. Self-driving cars, for example, might need to communicate with the transport infrastructure; consequently, designers and manufacturers of such cars should take necessary precautions to ensure that their systems cannot be overtaken by hackers, who might try to steer the vehicle into accidents or manipulate traffic lights in order to disrupt traffic.[134]

[134] Fenwick, M. D., Kaal, W. A., Vermeulen, E. P. M., *Regulation Tomorrow: What Happens When Technology is Faster than the Law?, American University Business Law Review, Volume 6, Issue 3, 2017* (2017).

Box 11: Challenges faced by developing countries in AI and data regulation

Many developing countries may not yet have in place sufficient resources to protect against hacking, deep fakes, algorithmic bias, violation of privacy and black boxes in AI systems. They may also need to create the means to protect against the abuse of AI devices, such as automated social score ranking systems and use of facial recognition technology.

Moreover, the low "datafication" of developing countries' economies and the unavailability of big data make the deployment of AI data analysis capabilities a challenge. Many developing countries do not have efficient enforcement systems for cybercrime laws.

In order to overcome these challenges, regulators in developing countries should pay attention to the following:

- **Work towards a national AI and data strategy** through broad multistakeholder consultation.
- **Develop public sector AI and big data expertise**, with leadership in relevant government institutions. This can be done through collaboration with universities and other institutions already working on AI in the country, as well as with regional and international organizations.
- **Create codes of conduct for the responsible use of AI and big data in the public sector**.
- **Create rules governing AI transparency, liability, accountability, justification and redress for AI decision-making.**
- **Ensure that national AI and big data policies cover issues such as data access and sharing, data protection and the use and management of open data.**
- **Regulations should be innovative and agile through the deployment of public-private partnerships.** Public and private stakeholders should work together to develop common resources, databases, platforms and tools that are open, use privacy as a safeguard and encourage development in developing countries. They should deploy innovative regulatory instruments that offer flexibility, such as regulatory sandboxes and public policy labs. Governments should also establish "cross-functional teams" across ministries and tiers of government.
- **Clear and robust national policies and legal frameworks need to be developed to regulate opt-in and opt-out data policies, data mining, access, use, reuse, transfer and dissemination.** These policies should enable citizens to better understand and control their own data, protect against attacks by hackers, while still allowing access to and reuse and sharing of non-personal information. At the same time, people's rights to freedom of expression using data while respecting privacy boundaries should be protected.
- **Policy-makers will also have to work to strengthen the implementation and enforcement mechanisms of AI and big data regulations and strategies.** This will have to be a coordinated effort among different public and private sector stakeholders and will have to tackle issues such as privacy of personal data and information security.

3.2 Open data policies for development

Open data are central to enabling widespread economic value, fostering greater civic engagement and enhancing government transparency and accountability to citizens. The term "open data" refers to publicly available data that can be universally and readily accessed, used and redistributed free of charge.[135] This type of data is structured for usability and computability. The sectors responsible for producing most open data are governments, scientists and corporations, making it possible for this type of data to exist in a wide variety of domains.

Box 12: Open data policies in Africa

Several African governments, such as those of Ghana, Kenya, Morocco, and Tanzania, have already created central data portals as part of their open government implementation.

An example of good practice on a regional level is the Africa Information Highway, an open data portal that curates open data initiatives in Africa.

Another initiative is the Huduma programme, under which the Government of Kenya is advancing citizen-centric public service delivery by deploying digital technology and establishing citizen service centres across the country. Since 2017, Ghana has been investing in improving online service delivery through its e-Ghana and e-Transform initiatives.

Open data for agriculture in Africa

In 2017, Kenya held a ministerial conference on open data for agriculture and nutrition, where the Nairobi Declaration, a 16-article statement on open data policy in agriculture and nutrition, was signed by 15 African ministers. Francophone African countries have developed a similar network to support public policy development through CAFDO (Communauté Afrique Francophone des Données).

Banzet, A., *#CAFDO2017: The First Francophone African Conference on Open Data and Open Government. Open Government Partnership* (2017).

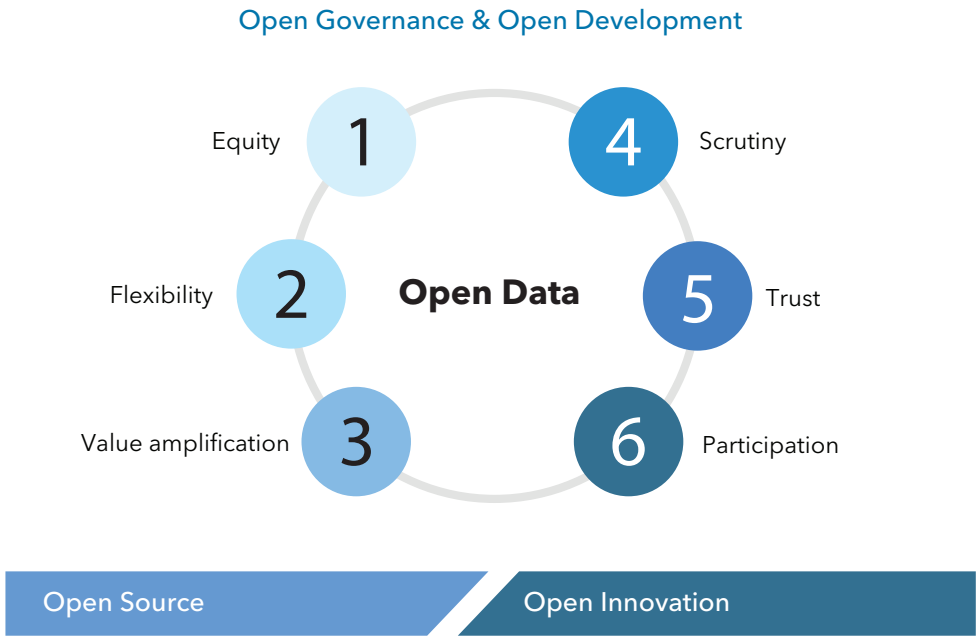
Open data, as a philosophy, intends to encourage access to and comparison of data from different sources to create value and new applications. This involves some investment of public resources and effort, as data must be "refined" and transformed to realize their full potential. By making government data accessible and reusable, individuals, organizations and even governments are able to innovate and collaborate in new ways.

[135] Verhulst, S. G., Young, A., *Open Data in Developing Economies: Toward Building an Evidence Base on What Works and How* (2017).

In a country capable of supporting open data, the presence of a strong ICT for development (ICT4D) sector helps to facilitate the six distinguishing features of open data (Figure 15):[136]

- Equity. Open data can lead to the more equitable and democratic distribution of information.
- Flexibility. Open data are easier to repurpose and combine with other pieces of information when released in an interoperable, machine-readable manner.
- Value amplification. As a key resource for social innovation and economic growth, open data provide new opportunities for governments to collaborate with citizens and evaluate public services by giving access to those services.
- Scrutiny. Open data support the public oversight of governments and help to reduce corruption by enabling greater transparency.
- Trust. The transparency of open data creates avenues for citizen oversight and higher levels of trust.
- Participation. Open data provide individuals with the opportunity to engage with their governments and contribute to the improvement of public services by providing feedback to government ministries on service quality. [137]

Figure 15: Unique features of open data



Source: Adapted from Verhulst and S. G., Young, A., *Open Data In Developing Economies: Toward Building an Evidence Base on What Works and How* (2017)

[136] Ibid.
[137] World Bank, *Open Data Toolkit*.

Box 13: The power of open data in health care

Reducing maternal mortality in Mexico: The Data Science for Social Good programme at the University of Chicago, in collaboration with the Government of Mexico, has explored how available datasets can be leveraged to support reductions in maternal mortality, a key target of the UN SDGs. Working with a combination of open and shared data, researchers have explored how analysis at the regional level could present a more granular picture of the impact of current interventions.

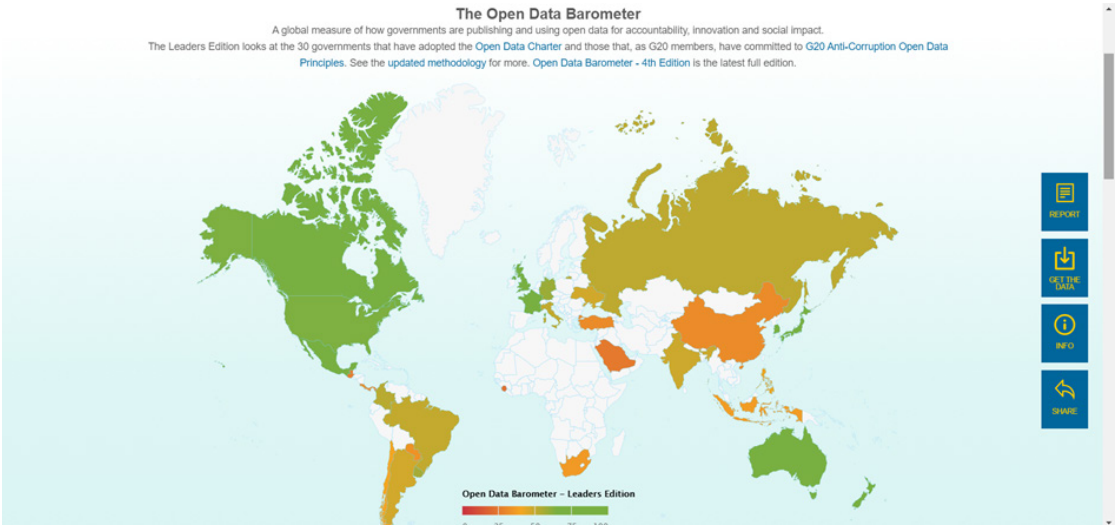
Promoting informed choices on health providers in Uruguay: *A Tu Servicio* has made data on healthcare-provider performance accessible to citizens, enabling individuals to make better decisions during the annual one-month window when Uruguayans can choose whether or not to switch healthcare providers. Data made accessible through the site have been used by politicians, the media and over 35 000 citizens (over 1 per cent of Uruguay's population).

Fighting the Ebola outbreak in Sierra Leone: Responders made use of the open data Humanitarian Data eXchange (HDX) platform to collate up-to-the-minute data from different stakeholders and visualize the results through open mapping tools. The Ministry of Health and Sanitation released geo-coded data on health facilities, while others released data on Ebola cases and current organizational responses. Multiple stakeholders have used the data to identify the regions most in need of urgent medical supplies.

1. Eng, N., *Making Our Moms Proud: Reducing Maternal Mortality in Mexico*. Data Science for Social Good, 4 August. Center for Data Science and Public Policy at the University of Chicago (2014).
2. Sangokoya, D., Clare, A., Verhulst, S., & Young, A., *Uruguay's A Tu Servicio: Empowering Citizens to Make Data-driven Decisions on Health Care*. Brooklyn, NY: GovLab (2016).

However, open data alone do not have an automatic impact on development. The Open Data Barometer (Figure 16), a global measure of how governments around the world are publishing and using open data for accountability, innovation and social impact, recognizes that data are just one element of the equation. Other factors that complement open-data frameworks include fostering the kind of governance and economic and regulatory environments that can influence access to and sharing and use of data.

Figure 16: Open Data Barometer



Source: *Open Data Barometer*

3.3 Data skill policies in developing countries

> *"A massive investment in education and skill transfer is essential if the South is to compete in the global communications marketplace. This too requires long-term international cooperation." (Nelson Mandela)*

To take advantage of the data economy, developing countries need to equip their populations with the requisite digital skills. Educational programmes that deploy rapid data and AI-skill training are in increasing demand in order to develop data skills and capabilities for the use of data tools by innovators, entrepreneurs and government agencies. Data literacy is increasingly considered a core skill, with some research suggesting that 90 per cent of jobs in advanced economies already require a measure of data skills,[138] while less than one-third of the population possesses adequate skills. Governments need to work quickly to close this gap, which is even wider in developing countries. To that end, governments need to recognize that digital literacy should be complemented by foundational, language and non-cognitive skills to help graduates succeed in digital labour markets.

Data and AI literacy could be defined as the ability to generate, process, analyse and present meaningful information from data and develop, use and apply AI and related algorithmic tools and strategies to guide informed, optimized and contextually relevant decision-making processes.[139] Table 1 outlines the key elements of data and AI knowledge and data and AI skills, as identified by the DQ Institute.

[138] European Commission, *New Measures to Boost Key Competences and Digital Skills, As Well As the European Dimension of Education* (2018).
[139] DQ Institute, *What is the DQ Framework?*.

Table 1: AI and data literacy (knowledge + skills)

	Data and AI knowledge	Data and AI skills
Key elements	• Understand the theory of data analysis, statistics, AI-related mathematical concepts and computer programming. • Understand how data are generated, how to process data based on a statistical understanding and how to create and/or use AI algorithms to recognize significant patterns and improve decision-making processes. • Understand concepts across multiple disciplines and identify the benefits, limits and risks of big data and AI.	• Develop efficient and stable processes to collect, store, extract, transform, load and integrate data at various stages in the data pipeline. • Read, manage, analyse and process data from a variety of sources; and prepare data in a structure that is easily accessed and analysed according to specific requirements. • Create and build knowledge by analysing data, communicate its meaning to others with various data visualization tools; and present strategical patterns, trends, analytical insights derived from data. • Recognize data limitations by identifying when data is manipulated. • Develop, select and apply relevant algorithms and advanced computational methods to enable systems or software agents to learn, improve, adapt and produce desired outcomes or tasks. • Use AI as a tool to enhance efficiency in creative processes and develop strategies for using it to optimize performance (e.g. predictive behaviour analytics and pattern recognition). • Understand how data and AI may affect one's perception and reasoning, i.e. being able to leverage AI to augment one's own intelligence while remaining aware of how human value judgements play into data and AI applications.

Source: DQ Institute, *What is the DQ Framework?* (2020)

Governments have used different methods to promote data and AI skills, such as:

(i) **Inclusion of data and AI literacy in government-supported basic-skill programmes**, such as the SkillsPlus scheme in Norway.[140] In Argentina, the Ministry of Education EDUCAR programme incentivizes digital literacy through Internet connection in schools, the delivery of digital tools, the development of software and virtual training platforms and the creation of spaces for technological innovation. With the priority learning hubs and the national connected learning plan, Argentina is seeking to equip younger generations with the skills of the future, including AI-related capabilities such as statistical thinking, mathematics, logic, computer sciences, programming, computational thinking and the comprehension of AI implications.[141]

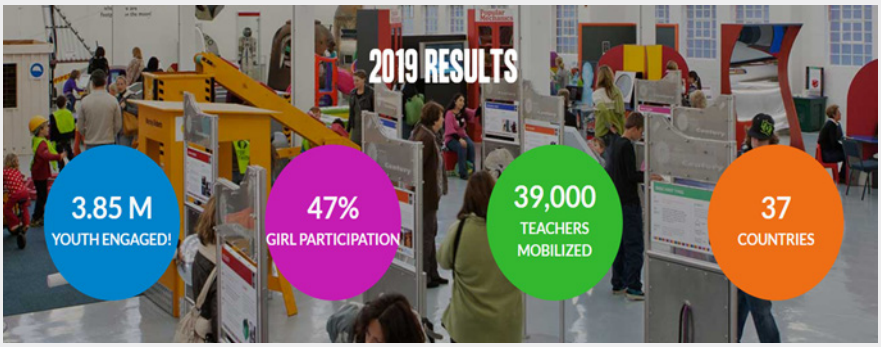
(ii) **Support for advanced digital skills.** The scarcity of AI expertise in low-income countries increases the implementation cost of any AI project. Recent initiatives tackling this issue in Africa include Andela (Nigeria, Kenya, Rwanda and Uganda), the Google AI Lab in Accra, Ghana, the creation of a Master's in Machine intelligence at the African Institute of

[140] See *Skill Plus, Norway*.
[141] See *EDUCAR, Argentina*.

Mathematical Science in Kigali, Rwanda, and a new Master's in AI at CMU Africa.[142] Zindi Africa is an online platform hosting open data-science competitions and hackathons for companies, non-profits and governments facing problems that could be solved with AI.[143]

Box 14: How coding is incorporated into school curricula

Africa Code Week: This initiative aims to spread digital literacy across Africa and shape the skilled workforce of tomorrow. The campaign five-year goal is to reach one million children and youth and equip 200 000 science teachers with the resources they need to teach their subject.



Moringa school coding camp in Nairobi: Students may complete one of two tracks: full-stack development, involving training in Ruby, JavaScript and the Rails framework; or mobile development with training in Java, JavaScript and the Android framework. The 21-week core programme boasts a 99 per cent job placement rate, with most graduates reporting a significant increase in income. The school also offers a two-day introductory programme called Junior Moringa School that covers the basics of coding.

African Girls Can Code (AGCC)

[142] IFC, *The Role of Artificial Intelligence in Supporting Development in Emerging Markets* (2019).
[143] See *Zindi, Africa*.

AGCC is a four-year programme designed to train young girls to become programmers and encourage further education and careers in technology. Launched in 2018, AGCCI is a joint initiative between ITU, UN Women and the African Union Commission and holds several camps throughout the year across Africa. The AGCC initiative teaches girls how to programme robots, create animations and code with Scratch.

1. See *Africa Code Week*.
2. See *Moringa School*.
3. See *ITU Initiative: African Girls Can Code*.

(iii) **Incorporation of coding into school curricula.** This is done in an e-school programme in Estonia[144] and similar programmes around the globe (see Box 14).

(iv) **Organization of campaigns and training to develop AI and data skills in under-represented groups and adaptation of AI and big data curriculum and training methods to be more inclusive.** Campaigns can be home-grown or part of ongoing international, regional or national campaigns. One example is ITU International Girls in ICT Day, which is designed to attract more women and girls to studies and careers in ICTs. Campaigns should include outreach to decision-makers, teachers, parents and employers, as well as to members of population groups identified as needing training.

Examples of successful AI and data skill training include the She Will Connect initiative in Nigeria, Kenya and South Africa, supported by Intel,[145] and the Mozilla partnership with UN Women to support a network of web literacy clubs in Kenya and South Africa specifically aimed at upskilling girls and women through face-to-face peer learning.[146]

For participants with no prior background in coding, curricula can be adapted. For instance, beginner courses can be offered by focusing on more intuitive coding languages and integrating exercises that demonstrate how creative coding can develop solutions to challenges that under-represented groups may face.

Other measures may include incorporating team projects into the curriculum, ensuring that students with previous advanced digital skill experience do not dominate classroom discussion and that students with limited previous experience are supported in their learning. Adaptation also entails gender bias training for teachers. For persons with disabilities, there is a need for training programmes on creating accessible ICTs, such as accessible websites, mobile apps and devices. Similar approaches are needed for other groups, such as the elderly and members of indigenous communities.

(v) **Offering of free or subsidized AI and big data training.** Private-sector stakeholders could offer scholarships funded through corporate social responsibility programmes, and governments could offer tax incentives for such scholarships. Training costs could be subsidized and repaid when the trainee finds paid employment. Policy-makers could incentivize the creation of capacity-building structures and initiatives in AI and data skills. Universities and private-sector firms could offer "AI residencies" – usually one-year training programmes at corporate research labs – and shorter-term AI "boot camps." Such opportunities can provide training to participants in AI research without requiring them to spend years in a graduate programme (Master's or PhD).[147]

144 See *E-School, Estonia*.
145 Intel Initiative, *She Will Connect*.
146 Dhalla, A., *New Partnership with UN Women to Teach Key Digital Skills to Women* (2016).
147 Chui, M., et al, *Applying Artificial Intelligence for Social Good* (2018).

Box 15: How to create data skill policies for the future

- Public policies might not be able to cope with the rate of innovation in AI and its impact on traditional institutions, meaning that new institutions will need to be created to deal with the issue. Governments can facilitate the creation of new public and private institutions.
- Governments should develop anticipatory and experimental regulatory tools, such as public policy labs and incubators to develop innovative solutions for AI implementation in education.
- Government agencies need to develop private-sector partnerships in order to tap into AI solutions for better education.
- To address ethical and development issues, governments need to create blueprints and roadmaps for ethical AI development in education.
- It is crucial to create new funding opportunities for research and innovation and the education and training of digital, AI and data specialists.
- Countries will need to enhance and experiment with the introduction of adaptive learning platforms, online assessments and similar smart education initiatives.
- It is necessary to ensure that data literacy programmes are multistakeholder, involving government, private-sector and civil-society actors.
- Blending traditional non-digital education with data and digital literacy and bringing together formal and informal sources of education, such as using mobile phones as a learning tool in developing countries.
- New regulations are needed in order to regulate data uses, privacy and transparency in algorithm design for educational purposes. In particular, governments will need to safeguard the transparent and auditable use of education data.
- Governments need to develop training programs in AI and big data that continually adapt and retrain workers, with targeted initiatives and incentives for women and girls and vulnerable social groups.

4 Data and AI for development: A guide for national strategies

4.1 Why is a national AI and data strategy for development necessary?

National AI and data strategies for development should maximize benefits while minimizing risks and harm brought about by AI and big data. Questions that countries around the globe are trying to answer include: What impact will AI have on the workforce, and how can we prepare for it? How can we encourage economy-boosting and job-creating technologies? How can we ensure that AI will be implemented ethically and with minimal bias? How will society benefit?

The national AI and data strategies of developing countries should guide an inevitable wave of change for quicker and better impact. Developing countries' policy-makers need to take into consideration that the AI and big data ecosystem is rapidly evolving and taking societies into uncharted territory. For now, they can begin by asking some of the big questions that each society should answer for itself: Are we ready to manage data ethically? How do we bridge the data divide? Which AI innovations are worthy of public funds and partnerships? Bringing these questions into the open is the most important step in ensuring that advances in AI promote a better society.

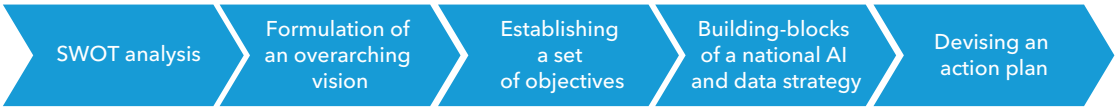
The drafting of a national AI and data strategy for development does not simply mean thinking up ways of accessing or recovering existing data; it also means establishing new means of collecting high-quality data. To that end, technological expertise needs to be maintained and promoted in developing countries, and this is closely linked to AI and data expertise. Moreover,

access to raw data is sometimes not enough. Data must be annotated to enable optimal use by AI, which can require major investment and development and represent a major hurdle for developing countries to overcome. Such issues should be kept in mind when formulating national AI and data strategies for development.

This guide is intended to assist policy-makers and regulators in creating a national AI and data strategy for development. The first section sets out the main processes involved in conducting a strength, weakness, opportunity and threat (SWOT) analysis for AI and data deployment at the national level. The second section highlights the key issues that should guide the formulation of an overarching vision. The third section gives an overview of the main objectives that a national AI and data strategy for development should contain. The fourth section identifies the primary building-blocks of a national AI and data system for development: governance; regulation; ethics; digital and data skills; a digital environment and data infrastructure; an innovation system; AI and data-intensive sectors; and international collaboration. The last section outlines the main components of an appropriate action plan: stakeholders, milestones, tasks, budget allocation and a suitable administrative structure for implementation of the strategy and coordination mechanisms.

The guide highlights examples taken from the current national AI and data strategies of different countries around the globe. These examples are only illustrative, however, and should be seen in the context of each developing country's circumstances, needs and aspirations.

Figure 17: Creating a national AI and data strategy for development



Source: ITU

4.2 SWOT analysis for national AI and data strategies

A national AI and data strategy for development could start with an assessment and review of a country's strategic priorities and a SWOT analysis. This should be carried out in line with the country's needs and requirements in terms of strategic priorities, governance, economic and geopolitical concerns and the needs of its citizens.

Table 2: Main elements of a SWOT analysis for national AI and data strategies

Elements	Strengths	Weaknesses	Opportunities	Threats
Governance				
Regulation				
Ethics				
Digital and data skills • AI and data human capital • Reskilling/upskilling • Employment/social security				

Table 2: Main elements of a SWOT analysis for national AI and data strategies (continued)

Elements	Strengths	Weaknesses	Opportunities	Threats
Digital environment and data infrastructure • Access to electricity • ICT infrastructure • Quality of data • Availability of data • Data capability				
Innovation ecosystem Research and innovation in AI and data Entrepreneurship				
AI and data priority sectors • Agriculture • Education • Health • Transport and mobility • Energy • Governance, inclusiveness • Other				
International collaboration				

National AI and data strategies for development need to be adapted to each country's unique needs and aspirations and, at the same time, be able to ensure that the country can maximize its leveraging of AI and data developments. Therefore, each country should identify its priorities in accordance with the SWOT analysis. Any digital environment would require the existence of accessible and affordable digital infrastructure, such as data centres housing computers and storage capabilities, cloud computing and a large array of the networks required for the successful delivery of applications and services and for data processing. In a country where digital infrastructure is underdeveloped, national efforts should focus on building this infrastructure.

Implementing and navigating a national AI and data strategy for development requires coordinated action. The process should be all inclusive and involve the private sector and civil society in the broadest sense, including community leaders, academia, trade unions, NGOs, youth representatives and faith groups. Dialogue should result in a national AI and data compact: a human-centred vision of the future to which everyone agrees and commits.

Box 16 gives an example of a SWOT analysis being used to formulate a national AI and data strategy.[148]

[148] The SWOT box was adapted, based upon the SWOT analysis of the *AI Strategy of Finland*, the SWOT analysis of the Canadian AI Strategy, the *AI Strategy of Mauritius*, and the *AI Strategy of Serbia*.

Box 16: SWOT analysis being used to formulate a national AI and data strategy

Strengths	Opportunities
• Digital hubs that offer reskilling and upskilling in AI and data. • Fast-growing young population. • Regulatory sandbox for AI and big data. • Agile government ready to implement robust changes and introduce evidence-based decision-making. • Readiness to create and implement national AI and data strategy. • A rapidly growing digital start-up ecosystem.	• Deployment of AI and big data leading to leap-frogging in energy, education, transport, health care etc. • Opportunity of labour growth through AI and big data. • E-government: the use of AI and big data for the provision of better-quality government services. • Smart education: AI and big data open up new opportunities in the education sector by providing personalized educational profiles and assisting teachers in delivering content. • Smart health: using AI and big data for evidence-based, personalized medicine. • Smart energy: possibility of leap-frogging in the energy sector. • Opportunities for regional cooperation and connecting through digital technologies. • Empowerment of women and other vulnerable social groups.
Weaknesses	**Threats**
• Absence of a strong digital SME sector. • Health data records are not digitized. • Weak ICT infrastructure. • Shortage of AI and data skills. • Lack of local content in AI solutions. • Outdated educational system. • A culture of avoiding risks. • Citizens do not always have access to the data they need. • Dispersed resources, no economy of scale. • Weak human-capital productivity. • Shortage of data centres. • Lack of innovative and agile regulation (innovative regulatory sandboxes, public policy labs, etc.). • Public unprepared for the implementation of a national AI policy.	• Slow and ineffective commercialization of the digital sector. • Insufficient access to international innovation and technology markets. • Low level of foreign direct investment in the digital sector. • Obstacles related to data availability, access and quality. • Labour market rigidity. • Cyber security and data privacy. • Loss of jobs due to automation. • Ethical and moral challenges in AI deployment (algorithmic bias and black boxes).

4.3 Formulation of an overarching vision

There are certain choices that guide the formulation of an overarching vision (Box 17). Beyond the headline numbers of the economic impact, an inherently disruptive technology such as AI needs to be seen from the perspective of its potential transformative impact on the greater good and development by improving quality of life and providing choice to a large section of the population in developing countries. With the right groundwork in place, such as digital infrastructure, research and innovation systems and a suitably prepared workforce, the revolutionary powers of AI and big data can allow developing countries to: achieve increased access to quality healthcare facilities, including by addressing local barriers to access; foster inclusive financial growth for large sections of populations hitherto excluded from formal financial products; provide real-time advice to farmers; help to address unforeseen obstacles to increasing productivity; and to build smart and efficient cities and infrastructure to meet the demands of a rapidly urbanizing population. Enhanced health care, an efficient food and agricultural system, greater access to finance, smart energy and smart and efficient cities are some elements that a strategic vision might involve.

In order to promote social innovation and support economic activity, policy-makers should develop a vision that encompasses issues of transparency, archiving, management, usability, interoperability and privacy in the era of AI and big data. This would enable data users and producers to unlock the value of data and provide better services, support evidence-based decisions, create internal efficiencies and better understand the real impact of programmes so that funds can be directed towards the most impactful interventions.[149]

Box 17 provides a non-exhaustive list of strategic questions that can help to guide the formulation of an overarching vision of a national AI and data strategy in developing countries.

[149] Government of Canada, *Report to the Clerk of the Privy Council: A Data Strategy Roadmap for the Federal Public Service*.

Box 17: Examples of strategic questions for the formulation of a national AI and data strategy

- How can big data and AI help to address development challenges?
- What are our key priorities in terms of development, and can big data and AI be useful tools in addressing them?
- What are our specific goals, preconditions and expectations for AI and data?
- What is the long-term motivation behind our investment in AI and data?
- Will AI have a positive impact that justifies the investment?
- What are the main challenges in AI and data investment in our country?
- How can the public and private sectors best work to ensure that companies receive adequate support for the production of AI-based innovations?
- How can data-driven businesses benefit from the secondary use of public-sector data and information resources?
- How will AI affect us as individuals and what impact will it have on the future of work, the labour market and social security? What will be its wider impact on society?
- What types of measures are required from the public sector as we move into the age of AI? What is our approach to questions of ethics, personal data protection, privacy, transparency, trust and accountability?

Colombia's AI strategy[150] illustrates how a developing country can formulate a sound overarching vision for its AI strategy:

Box 18: The vision of Colombia's AI strategy

The objective of this policy is to create and develop the most dynamic and thriving AI market in Latin America and one of the most important AI markets in the world. Colombia will become a laboratory for the creation of its own AI market, where designers, suppliers, intermediaries and consumers of this technology can easily interact. This market will become the driving force for the emerging Fourth Industrial Revolution ecosystem and will place Colombia at a highly competitive level. Therefore, the Government must create an investment climate that is more attractive to foreign and local entrepreneurs developing this technology.

Box 19 presents examples of different points worth considering when creating a national vision, based on the national AI strategies of Singapore, Republic of Korea, Sweden, Mauritius, and Mexico.

[150] See *Colombia's AI Strategy*.

Box 19: Statements to guide a national AI and data vision

- Become a national, regional and/or international hub for developing, test-bedding, deploying and scaling AI solutions in health care, agriculture, transport and education. This includes learning how to govern and manage the impact of AI and big data through innovative and agile regulation.
- The public and private sector will use AI to generate economic and societal gains and improve lives in the following sectors: health and well-being, food, energy, agriculture, education, manufacturing and transport.
- AI will increase the government ability to deliver anticipatory and personalized services and be a strong driver of growth in key economic sectors.
- The public will understand AI technologies and their benefits; the workforce will be equipped with the necessary AI and data competencies to participate in the AI economy at national, regional and/or international levels.
- Deliver national AI and big data projects and strengthen AI and data ecosystem enablers.

4.4 Establishing a set of objectives

SMART (specific, measurable, achievable, relevant and time-bound) objectives should be set and aligned with the SWOT analysis and the vision to address the following list of issues, which are non-exhaustive and in no particular order:

Objective 1. Create a human-centred AI and data system

- Example: create a guideline on human-centred AI and data systems.

Objective 2. Develop robust digital infrastructure

- Example 1: Create or increase the capacity of national data centres to a capacity of X within N years.
- Example 2: Invest X per cent more in connectivity and electricity infrastructure within N years.

Objective 3. Create a skilled workforce in AI and data

- Example: Increase the workforce with appropriate digital, data and AI skills by X per cent within N years.

Objective 4. Increase R&D in data, AI and priority areas

- Example: Increase or launch research and development grants in data, AI and priority areas for a total of X million within N years.

Objective 5. Improve the targeted sectors (e.g. health care, education, agriculture, trade, transport, energy, food, etc.)

- Example: Increase investment in the targeted sectors by X per cent within N years.

Objective 6. Create an enabling environment to foster the development of AI and data

- Example: Create, adopt and enact policies and regulations that are prerequisites for AI and data development, i.e. data protection, intellectual property, anti-trust, consumer protection, etc.

Objective 7. Develop innovative and agile regulation

- Example: Create X public policy labs, regulatory sandboxes, etc. within N years.

Objective 8. Unlock the value of data across the economy

- Example: Create a data sharing framework (including interoperability) within N years.

Objective 9. Digitalize public (and private) sector services and transform the government use of data to drive efficiency and improve public services

- Example 1: Digitalize X per cent of public (and private) sector services, including national archives, health records, etc.
- Example 2: Increase the government use of data by X per cent to drive efficiency and improve public services.

Objective 10. Ensure the security and resilience of data infrastructure

- Example: Ensure X-per-cent security and Y-per-cent resilience of data infrastructure within N years.

Objective 11. Promote the full opening of public data held by public institutions

- Example: Make public data held by public institutions fully open and online within N years.

Objective 12. Promote the international flow of data, while respecting privacy

- Example: Create X policies and regulations to promote the international flow of data, while respecting privacy.

The National AI Strategy of Mauritius[151] offers an example of setting strategic objectives for AI and data (Box 20).

Box 20: National AI strategy of Mauritius: objectives

"This report aims at providing a roadmap defining the key considerations for the development of the right ecosystem to enable Mauritius to adopt new technologies as enablers of growth for the next decade. The main focus areas of the strategies include: (i) prioritization of sectors and identification of national projects; (ii) skills attraction and capacity building; (iii) incentives to catalyse implementation; (iv) ethical considerations of AI; (v) development of strategic alliances in emerging technologies; (vi) sensitization campaigns; and (vii) adoption of new technologies for improved public-service delivery."

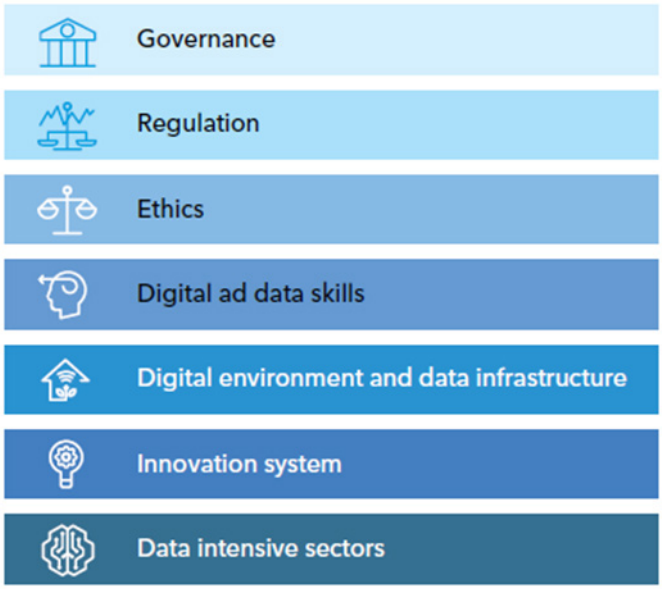
4.5 Building-blocks of a national AI and data strategy

While formulating the main components of an AI and data strategy, the key questions that need to be asked are: What do we have? What do we need? What needs to be changed?

Most national AI and data strategies contain building-blocks such as governance, regulation, ethics, digital and data skills, digital environment and data infrastructure, innovation system, AI and data-intensive sectors, and International collaboration.

[151] See *National AI Strategy Of Mauritius*.

Figure 18: Building-blocks of a national AI and data strategy



Source: ITU

Governance

Having an adequate governance structure is of utmost importance to the successful formulation and implementation of a national AI and data strategy. AI and big data are difficult to govern and regulate, owing to their innate disruptiveness and novelty. This process is even more difficult in developing countries that face obstacles arising from a shortage of AI and data skills, adequate infrastructure and good-quality, reliable and timely data. Incorporating novel and emerging technologies into society is a multifaceted challenge and often the long-term effects cannot be fully anticipated. The inherent risks associated with AI and big data can only be known empirically. These technologies might generate unpredictable results if left entirely unregulated. In the context of developing countries, good governance, risk foresight and ethical guidance should be imperative at all times.

Given the versatile nature of AI, approaches to governance can no longer be designed in sector-specific isolation, such as only for health care. Policy success will also depend on multistakeholder collaboration to ensure AI solutions can be adequately incorporated into the context of developing countries. Policy interventions aimed at ensuring the affordability of devices and data services for end users, affordable bandwidth and energy are critical for the deployment of AI and big data for development. Creating local content and applications in local languages, enhancing digital literacy skills among the public and creating AI and data engineering, coding, economic and creative capacity are all vital to establishing the requisite enabling environment to harness the opportunities offered by AI and big data for development.

Mexico's AI policy[152] lists the prerequisites for building adequate governance systems in AI and data (Box 21).

[152] Mexico, *AI Policy*.

Box 21: Mexico's AI policy: prerequisites for building adequate governance systems in AI and data

- Set a clear strategic direction.
- Appoint teams dedicated to emerging technology innovation in selected ministries.
- Government should act as a champion.
- Develop guidelines for smart AI procurement.
- Create a multistakeholder steering group to develop and promote the Mexico Government AI strategy.
- Create a network of AI practitioners from all sectors and disciplines, including national and local actors, to develop a multisector AI roadmap.
- Create an AI working group in Congress.
- Take a leading role in the global debate.

Regulation

It is important that national AI and data strategies for developing countries promote data regimes that foster growth and innovation for businesses of every size, while maintaining public trust. Regulatory certainty and high data protection standards allow businesses and consumers to thrive. Governments need to prioritize the development of sector-specific guidance and co-regulatory tools to accelerate digitalization.

The regulatory frameworks of the future should be innovative and agile to make allowances for the disruptiveness and velocity of AI and data. The governments of developing countries should set up innovation sandboxes with a threefold purpose: to temporarily lift certain regulatory constraints in order to leave the field free for innovation; to help actors to take account of their obligations; and to provide the means of carrying out experiments in real-life situations.

For policy and regulatory issues related to AI and big data, please refer to chapter 3.

Ethics

National AI and data strategies need to ensure that data-driven technologies and AI are a force for good. Biases related to data or algorithm use will need to be addressed to ensure that the potential of data is harnessed as a motor for a better, more inclusive and less biased society, rather than to compound existing problems or create additional biases. Data should be accessed and used in an ethical and responsible way. One possible solution is to create a national AI and data ethics council to spearhead initiatives such as a safe data sandbox. For instance, France and Canada have already tasked specific teams to focus on issues of ethics, while the United Kingdom has established the Centre for Data Ethics and Innovation.[153] Another example is establishment of a governing AI ethics board in Dubai, comprising government policy, academic, legal and industry experts. The Executive Council of Dubai has directed government entities to follow the principles and guidelines when considering AI development,

[153] United Kingdom, *Centre for Data Ethics and Innovation*.

and entities including the Dubai Road and Transport Authority and the Police have formally acknowledged their adoption of the self-assessment tool when developing AI.[154]

Another example is Singapore's Model AI Governance Framework, which translates key ethical AI principles into implementable practices for industry. Accompanied by an implementation and self-assessment guide for organizations, the framework guides organizations in the responsible deployment of AI.[155]

For ethical issues related to AI and big data, please refer to section 1.4.

Digital and data skills

Advances in AI and big data will simultaneously create and eliminate jobs. Any AI and data national strategy should anticipate the potential impact on the current workforce and the skills of the future workforce and create national capacity and infrastructure for this shift. The strategy should map a path to ensuring that workers have the skills to compete in the digital economy, through action plans that envisage investment in STEM education, national skilling and reskilling programmes and lifelong learning.

Box 22 gives examples of data skill development objectives, based on the national data strategies of the United Kingdom and Canada:[156]

Box 22: Examples of data skill development objectives

- Work with the appropriate institutions to understand how data science is integrated into relevant technical qualifications.
- Ensure that AI and data skill training is accessible to all, including low-income groups, by providing support for training and relevant skill development for both women and men.
- Ensure that high-quality data-science courses are offered and that data-related skills are given due consideration in their work to support emerging skills.
- Test the most effective ways of teaching foundational data skills to undergraduates by offering modules including wider subjects such as AI, cyber and digital skills and by integrating data skills in other subject areas. Universities can take part in the pilot project on a voluntary basis.
- Examine ways of expanding the supply of advanced data skills among research engineers and professionals to help maximize R&D investment, increase mobility across business and academia and foster links between industry and universities at the regional level.

Qatar's national AI strategy has specific recommendations for the development of digital and data skills (Box 23).

[154] Smart Dubai, *Smart Dubai's Artificial Intelligence Ethics Advisory Body Convenes for Its 2nd Meeting for 2020, Explores Next Steps* (2020).
[155] Singapore, *Model AI Governance Framework*.
[156] Based on the United Kingdom and the Canadian national data strategies.

Box 23: Qatar's national AI strategy and digital and data skill recommendations

- Encourage local businesses to embrace new AI solutions and resist the temptation to use low-cost labour as a substitute through incentives and regulations.
- Educate/train Qatari citizens to manage, build and invest in AI solutions to continuously improve living standards and economic productivity in Qatar.

For a comprehensive overview of data skill policies in developing countries, please refer to section 3.3.

Digital environment and data infrastructure

In order to successfully deploy big data and AI for development, the national AI and data strategy needs to focus on achieving the main prerequisites for a conducive digital environment, i.e. reliable access to electricity, reliable physical infrastructure, interoperable systems and digital transformation of public and private services, and develop data governance rules and guidelines that facilitate broad access to and sharing of data.

Data sharing can be impeded by two factors: first, data has strategic and monetary value to data collection organizations; and second, data sharing has an impact on privacy. A successful example of a national data sharing initiative is Singapore's national AI strategy, which provides for a trusted data sharing framework (see Annex II).

Colombia's AI strategy contains a vision for building a robust national data infrastructure (Box 24).

Box 24: Colombia's AI strategy: an example of building a robust national data infrastructure

The government objective is to facilitate data access for AI designers by removing unnecessary and unjustified barriers to access to this information. Therefore, the national government must promote an ambitious data policy that will facilitate data access and sharing. One of its priorities is to promote data interoperability and increase the quantity of public datasets, especially those that contain structured data. Additionally, it is necessary to design models and methodologies to improve data sharing between different organizations. It is essential that data can be easily shared with entities located in Colombia or abroad. The Government, therefore, will analyse the implementation of different data sharing models, such as data trusts or data commons. The Colombian data protection regulation must protect citizens considering a risk-management approach.

The United Kingdom national data strategy[157] is an example of formulating four pillars to support the use of data (Box 25).

[157] United Kingdom, *National Data Strategy*.

Box 25: The United Kingdom national data strategy: formulating data-related pillars

- Data foundations: The true value of data can only be fully realized when data are fit for purpose, recorded in standardized formats on modern, future-proof systems and held in a condition that means data are findable, accessible, interoperable and reusable. By improving the quality of data, we can use data more effectively and derive better insights and outcomes from that use.
- Data skills: To make the best use of data, we must have a wealth of data skills to draw on, which requires delivering the right skills through the education system and ensuring that people can continue to develop the data skills they need throughout their lives.
- Data availability: To ensure maximum effectiveness, data must be appropriately accessible, mobile and reusable, which means encouraging better coordination, access to and sharing of data of appropriate quality between organizations in public, private and tertiary sectors and ensuring appropriate protections for the flow of data internationally.
- Responsible data: As we drive increased use of data, we must ensure that data are used responsibly, in a way that is lawful, secure, fair, ethical, sustainable and accountable, while also supporting innovation and research.

For a comprehensive overview of the issue of data infrastructure, please refer to section 1.3.

Innovation system

AI and data skills and competences are critical in ensuring that AI can contribute to the success and competitiveness of developing economies, where the focus should be on creating centres of excellence for AI and applied basic research. Furthermore, national AI and data strategies should propose a way forward for creating national research and innovation systems in AI and data and also assess how existing R&D incentive systems could be reformed for greater cross-sector integration in industry and governance.

Countries should conduct a thorough assessment of their research and innovation capabilities and identify their needs in AI and data for development. Box 26 illustrates the identification of Sweden's key needs in AI and data research and innovation:

Box 26: Sweden: identifying key needs in AI data research and innovation

- We need pilot projects, test beds and environments for the development of AI applications in the public and private sectors that can contribute to the safe, secure and responsible use of AI.
- We need to invest in local research in AI (STEM and social sciences/humanities) through cross-disciplinary collaborations with researchers (e.g. ethicists, ethnographers, lawyers, social scientists, computer scientists, engineers, etc.) to examine the ethics of AI and related policy issues.
- We need to continue to develop efforts to prevent and manage risks associated with AI.
- We need to develop partnerships and collaborations with other countries on the use of AI applications.

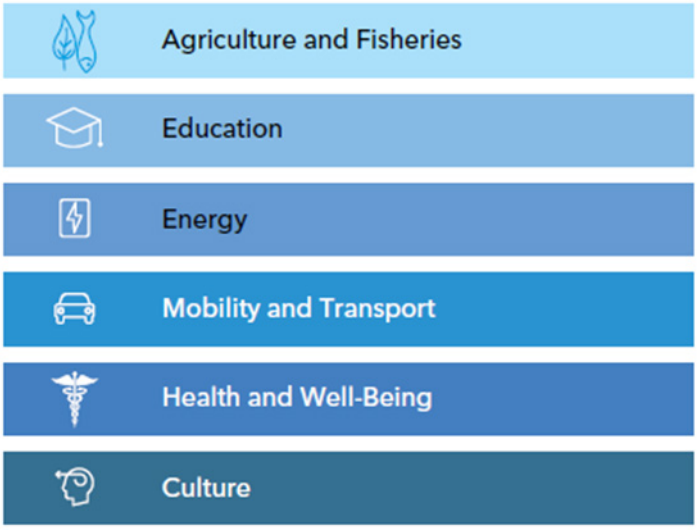
Canada's Digital Charter Innovation and Skills Plan (see Annex II) is yet another excellent example of the national assessment of research and innovation capabilities in AI and data, while Brazil offers another example of a developing country committing to the establishment of eight applied research centres in AI with the aim of conducting research, fostering an AI ecosystem and start-ups and building human capacity in related technologies.[158]

AI and data-intensive sectors

National AI and data strategies should focus on the comparative advantages and sectors of excellence in AI and data of the country concerned. The AI ecosystem should be built around the national economy propulsive industries, such as agriculture and fisheries, ocean economy, food and beverages, manufacturing, energy, mobility and transport, health and well-being, education, culture. Thinly spreading resources across every sector should be avoided, especially in developing countries with limited public funding. India's national AI strategy[159] and Japan's industrialization roadmap[160] are good examples in this regard. India has taken a sectoral approach, identifying application areas and enablers in health care, agriculture, education, smart cities and infrastructure and smart mobility and transport. A non-exhaustive list of priority sectors for AI and data is given in Figure 19. National AI and data strategies can add to this list other sectors important to the respective country.

[158] Brazil, *AI Strategy*.
[159] NITI Aayog, *National Strategy for Artificial Intelligence #Aiforall* (2018).
[160] Strategic Council for AI Technology, *Artificial Intelligence Technology Strategy* (2017).

Figure 19: AI and data-intensive sectors



Source: ITU

France's AI strategy, as reflected in the Villani Mission report,[161] outlines exemplary indicators for identifying propulsive industrial sectors for AI and data (Box 27).

Box 27: France's Villani Mission report: Identifying propulsive industrial sectors for AI and data

- Impact: it should bring about far-reaching transformations from both an economic and general-interest point of view.
- Ecosystem: the ability to create and sustain momentum requires a reliable group of robust public and private actors from the outset.
- Initial fuel: this may take a variety of forms, but, whichever form it takes, there must be enough of it available and usable over the short term. In this context, financial considerations play a lesser role. It would appear more important, at least initially, to provide at least one of the following: data, use cases, business know-how, resources, flexible framework, market, etc. Data are obviously a key factor and constitute a major comparative advantage.
- Finance and resources: the financial aspect remains crucial, though finance is not enough on its own. Sectors identified must be able to mobilize public and private funding alike and the requisite human resources.
- Markets and openness: actors' ability to make best use of their know-how on public and private markets in France and abroad is also important in terms of scaling up and fostering the emergence of large-scale ecosystems.
- Duality and percolation of fields: even when effort is focused on specific fields, the fields are chosen in order to enable technological percolation, whereby a technology developed in one field can be rapidly transposable to another.
- Impetus from the government: finally, the sectors concerned will require major initial involvement by the State in order to transform themselves, which does not look likely for a great majority of industrial sectors.

[161] Villani, C., et al, *For a Meaningful Artificial Intelligence Towards a French and European Strategy* (2018).

International collaboration

International, open ecosystems are more suitable for ensuring successful implementation of national AI and data strategies because they involve multidisciplinary expertise and capabilities, within academia and industry, distributed across the world. Thus, it becomes imperative that nations develop a plan to draw on international collaboration. Collaborative efforts should not be limited to technology development but extend to regulation and governance. Germany's AI strategy contains specific plans to use international cooperation in AI development and regulation. An illustrative international initiative is the OECD principles on AI, signed by 42 countries in 2019.[162] The signatories agreed to ensure that AI systems are designed in a way that is safe, fair and trustworthy. In 2020, 14 governments and the European Union joined together to create the Global Partnership on Artificial Intelligence (GPAI)[163] to support the responsible development and use of AI. These, and other intergovernmental agreements, highlight that AI and related emerging technologies transcend national boundaries and will need to be dealt with on an international level.

4.6 Devising an action plan

To be effective, any national AI and data strategy for development should include an action plan with specific milestones and the tasks to be accomplished. The plan should assign the roles/responsibilities of all stakeholders involved and governments should develop a stakeholder task/role/responsibility matrix, connecting each task to a specific objective of the strategy. Action plans should cover the following points:

Stakeholders

Action plans should be all-inclusive and cover all stakeholders important to the implementation of the national AI and data strategy, such as governmental institutions, academia, the private sector and civil society.

- Government: ministries, legislature and local authorities;
- Independent organizations: standard-setting organizations and industry organizations;
- Start-ups, charities and SMEs, especially those struggling to use data effectively;
- Technology and data-driven or data-rich companies;
- Investors in technology and data companies;
- Civil-society organizations focused on vulnerable people, consumer rights, digital rights, privacy and data protection, youth, etc.;
- Academic, research and policy organizations with a particular interest in the role of data in the economy and society;
- International data standards, regulation and governance bodies;
- Law firms and other professional business services.

Milestones

It is important to define milestones for each task in the action plan. They should be attainable and closely linked with the budgetary allocations for tasks/activities in the action plan.

[162] OECD, *Forty-Two Countries Adopt New OECD Principles on Artificial Intelligence* (2019).
[163] Government of the United Kingdom, *Joint Statement from Founding Members of the Global Partnership on Artificial Intelligence* (2020).

Tasks

Action plans should detail the tasks needed for successful implementation of the national AI and data strategy. Tasks should be closely aligned with the SWOT analysis, overarching vision and objectives. Examples of tasks include:

- Promoting the opening up and reuse of data;
- Reinforcing the link between public and private data maps in order to provide comprehensive support for the production, distribution and use of data in all areas of society;
- Securing high-performance computing resources;
- Building data centres;
- Complete reorganization of AI-related R&D;
- Regulatory innovation and revision of laws.

Budget allocation

Each task needs to have a budget line allocated to it, and the budgetary resources allocated need to be attainable. Policy-makers in developing countries should consider incentivizing the private-sector deployment of AI and big data, which might involve but not be limited to: matching grants; tax credits; fiscal incentives; equity financing and training grants.

Administrative structure for strategy implementation and coordination mechanisms

A national AI and data strategy should be multidisciplinary, requiring the establishment of a committee, task force, working group or board to take charge of administering and coordinating the strategy action plan.

Table 3: Simplified action plan template

Stakeholders	Milestones	Tasks	Budget allocation
Government: ministries, legislature, local authorities			
Independent organizations: standard-setting organizations, industry organizations			
Start-ups, charities and SMEs			
Technology and data-driven or data-rich companies			
Investors in technology and data companies			

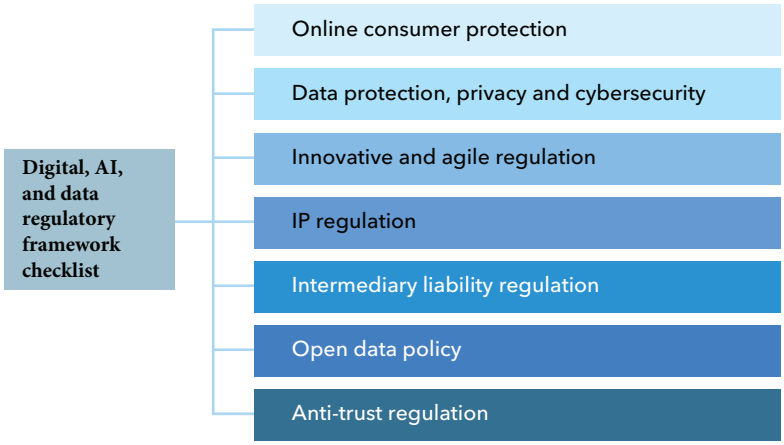
Table 3: Simplified action plan template (continued)

Stakeholders	Milestones	Tasks	Budget allocation
Civil-society organizations focused on vulnerable people, consumer rights, digital rights, privacy and data protection, youth, etc.			
Academic, research and policy organizations			
International data standards, regulation and governance bodies			
Law firms and other professional business services			

5 Digital, AI, and data regulatory framework checklist

The digital, AI, and data regulatory framework checklist is intended to serve as a guide for policy-makers and regulators in identifying and assessing policy and regulatory issues concerning AI and big data at the national level. The checklist comprises seven sections that address the key areas in the regulation of AI and big data: (i) online consumer protection; (ii) data protection, privacy and cybersecurity; (iii) innovative and agile regulation; (iv) IP regulation; (v) intermediary liability regulation; (vi) open data policy; and (vii) anti-trust regulation.

Figure 20: Digital, AI, and data regulatory framework checklist



Source: ITU

Table 4: Digital, AI, and data regulatory framework checklist

Digital, AI, and data regulatory framework checklist		
I. Online consumer protection framework	**Examples**	
I.1. International treaties on consumer protection	Is the country party to international treaties in the area of digital/online consumer protection?	• OECD Guidelines for Consumer Protection in the Context of Electronic Commerce (1999) • UN Guidelines for Consumer Protection • Other
I.2. National law on consumer protection	When assessing the *national law on digital/online consumer protection*, national policy-makers should ask themselves the following questions: • Is there a specific digital consumer protection regulation? If not, is there a general consumer protection law? • Are unfair contract terms prohibited? • Are remedies for consumers' breach of contract proportionate to the damage caused? • Are consumers participating in e-commerce afforded equivalent protection to those in other forms of commerce? • Does the law prohibit businesses from making representations, omissions or engaging in deceptive, misleading, fraudulent or unfair practices? • Are there any regulations addressing information disclosure requirements, the right to withdraw from a transaction, dispute resolution and redress? • Is there a regulation that addresses information-disclosure requirements? What information are commercial data processors legally obliged to disclose to consumers prior to online purchases? • Is liability of online/digital vendors regulated? • Do any regulations require digital businesses to adopt minimum quality standards (an established set of rules) for consumer protection? • Are there any regulations that oblige digital businesses to provide any of the following information to the consumer: initial price and variable/optional charges during the transaction; terms and conditions and methods of payment, including contract duration, recurrent charges and ways to opt out; terms of delivery or performance; conditions related to withdrawal, termination or cancellation, exchanges, refunds, warranties; privacy policy; dispute resolution and redress options; and quality standards? • Does the law require that businesses provide enough information to enable consumers to make informed decisions regarding transactions? If so, which of the following are required: functionality and interoperability features; technical or contractual requirements; age restrictions? • Does the e-payment system include limitations on consumer liability for unauthorized or fraudulent charges? • Does the law provide consumers with access to fair, easy-to use, transparent and effective dispute resolution mechanisms? If so, do these protections apply to domestic and/or cross-border disputes? • Are there rules for consumer protection in the following areas: intermediary liability; out-of-court complaint and redress mechanism; mandatory notification for modifications to terms and conditions?	

II. Data protection, privacy and cybersecurity regulations		Examples
II.1. International treaties for personal data protection and digital privacy	• *Data-related agreements:* Is the country party to data-related agreements?	• International Covenant on Civil and Political Rights, 1966 (Article 17 on the right to privacy) • Council of Europe Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data, 1980; revised 2016 (Note: This agreement is open to all countries worldwide) • Other
	Cross-country agreements and harmonization Does the country have arrangements with foreign countries or multinational entities or schemes, including decisions of domestic and foreign bodies or agencies, to require, permit or limit the transfer of personal data between countries (e.g. treaties, adequacy decisions, binding corporate rules or mutual recognition arrangements)?	
II.2. National legal framework for personal data protection and digital privacy	*General data law:* Is there a general law covering the protection of personal data or sensitive data? • If so, which international guidelines or regulations served during its drafting as the basis or model for the final legislation? Indicate all that apply.	• APEC Privacy Framework (2015) • African Union Convention on Cybersecurity and Personal Data Protection • OECD Privacy Guidelines (2013) • EU General Data Protection Regulation (EU GDPR) • Commonwealth Model Privacy Bill • East African Community (EAC) Framework for Cyberlaws (2008) • Economic Community of West African States (ECOWAS) Supplementary Act on Personal Data Protection • Southern African Development Community (SADC) Model Law on data protection • African Union Convention on Cyber Security and Personal Data Protection (the Malabo Convention) • Council of the Common Market for Eastern and Southern Africa (COMESA) Model law on electronic transactions • Council of Europe Convention 108 • EU Data Protection Directive for Police and Criminal Justice Authorities Directive 2016/680 • Other (specify)

	Personal data law: If a general personal data law does not exist, are there any drafts or planned legislation covering personal data and data privacy? • Outside of general law, are there any decrees/ordinances, guidelines or directives, legal precedents or understandings which act to protect personal data and digital privacy? • If there is a general data protection or digital privacy law and does any such law specify any exceptions to its application? • Are there any regulations that require that the collection and use of personal data be done on a lawful/legal basis? [A lawful basis is a defined basis on which data can be lawfully processed – typical standards for lawful basis include the consent of the data subject, performance of a legitimate interest or concluded contract, in compliance with legal obligations/requirements and vital or public interests.] • Are there any regulations that require that the collection and use of personal data be done fairly and transparently (or similar standards), such as requiring the data subject to be informed of the purpose of data collection and the intended use and sharing of the data? • Are there any regulations requiring that the collection and processing of personal data be made for a lawful purpose? • Are there any regulations that require the data subject be informed of or consent to which parties the data will be shared with? • Are there any regulations that stipulate that consumers should be informed of all commercial uses of their personal data, including by any third parties that their data have been shared with? • Are there any regulations that oblige data processors to comply with online information disclosure rules? • Do data subjects have the legal right to access and review the use of their personal data by data controllers/processors? • Do data subjects have the right to challenge the accuracy of their data and have them rectified, completed or amended? • Do data subjects have the right to have their personal data (including data trails) deleted? • Do data subjects have data portability rights, i.e. the right to move, copy or transfer personal data from one system to another electronic environment? • Are there any regulations for data minimization requirements, i.e. the data collected should be adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed? • Are there any regulations that require systems collecting and processing personal data to incorporate privacy-by-design or data protection-by-default principles or use privacy-enhancing technologies (PETs), such as de-identification and pseudonymization? • Are there regulations that restrict the automated processing of personal data for making any kind of decision concerning data subjects? • Is there a legally mandated data protection authority (DPA)?

II.3. Cross-border data transfers (data localization laws)	• Cross-border data laws: Are there any restrictions on the export of data collected through digital platforms or businesses to foreign entities? • Are there any regulatory requirements on the local processing of data that require firms to construct local data-centre storage, with or without allowing a copy of the data to be moved offshore? • Are there any conditional measures, such as restricting data flows for particular sectors, e.g. health and financial data and geospatial and mapping data? • Are there regulations requiring the use of particular technologies or procedures to store or process data? • Under which conditions can local personal data be transferred to non-domestic third parties? See options: - Adequacy – when the country in which the non-domestic third party is based provides an "adequate", "sufficient" or "equivalent" level of protection or any provision entailing an adequacy approach; - Accountability – the original data controller remains accountable for compliance with the original privacy framework that applied when and where the data were collected.
II.4. Non-personal data protection	• Does the law provide for protection in terms of access to and sharing of non-personal data? Personal data should be protected; non-personal data, however, should flow freely, e.g. EU Regulation on the free flow of non-personal data).
III. Innovative and agile regulation	
III.1. National innovative and agile regulation	• Are there any regulations that enable access to sandboxes, regulatory labs and other innovative forms of public-private regulatory partnerships that enable testing of digital business models in experimental environments, e.g. financial technology, drones, AI, Blockchain, IoT, etc.? • Are there any regulations that pertain to emerging technologies, e.g. AI, Blockchain, 3D printing, IoT, virtual/augmented reality, 5G, net neutrality, facial recognition, etc.?
IV. Intellectual property (IP) regulation	
IV.1. National copyright regulation	• Are there any regulations for content control, text and data mining exceptions to copyrights (fair use in digital copyrights)? • Is there copyright protection of software? • Is there copyright and/or sui generis right protection of databases? • Are AI-generated works copyrightable? • Is there a data ownership right?
IV.2. National Patent regulation	• Can FRAND (fair, reasonable and non-discriminatory) patent licenses for interoperability be enforced in the particular jurisdiction? • Can software be patented? • Are AI-generated inventions patentable?
V. Intermediary liability regulation	

V.1. National intermediary liability regulation	*Intermediary liability* rules are the set of provisions that assign liability between intermediaries (website and apps) and actual vendors or content developers when problems arise. For digital intermediaries, e.g. search engines, application platforms, social networks and broadband companies, responsibility may arise mainly from two types of conduct: the offering for sale of counterfeit products or the publication of unlawful content, such as images or text, by users. The offering of counterfeit products would normally entail a violation of intellectual property rules, typically under trademark protection. Unlawful content can violate intellectual property rules when the content unduly features other people's work (a violation of copyright protection), for example by reproducing music or video without the authors' permission. In addition, content may violate criminal law provisions against libel, hate speech or child pornography or laws protecting individual privacy or classified information, or amount to a crime of *lèse-majesté*. • Are there any regulations that address the issue of intermediary liability? • Is intermediary liability regulated by copyright law? • Is intermediary liability regulated by criminal law? • Are there any take-down provisions? • Are there any safe-harbour provisions that provide protection from liability or penalty under specific situations or conditions?
VI. Open data policy	
VI.1. National open data policy	• Has the country's government adopted any *open data policies*? • Who has legal access to public-sector data? • Are there any regulations that allow/promote APIs that are open to third-party developers/open banking, e.g. Nigerian NIBSS Open APIs Sandbox and open banking regulation in Rwanda)
VII. Anti-trust regulation	
VI.1. National anti-trust regulation	• Are there any regulations covering mergers in digital markets? • Are there appropriate thresholds for notification in digital markets? • Are there regulations on "killer" acquisitions in digital markets? • Are competition authorities mandated to provide opinions on draft regulations regarding digital businesses? • Does the mandate of competition authorities extend to providing oversight/review/opinions on State support for digital business? • Are there any regulations against algorithmic collusion targeting businesses that use AI and machine learning to acquire more market information and set prices/collude? (Examples of collusion might resemble the following situations: humans collude in person and use programs and technology as a tool to achieve pricing aims; one algorithm emerges as an industry influencer, acting as a hub around which industry-wide collusion revolves; algorithms exist in parallel where they continually adjust against each other's data and market prices (tacit collusion); or, AI technology advances so far in processing high volumes of data that it achieves a bird's-eye view of the market.

Annex I: International and regional initiatives in AI and data

OECD Principles for trust in and adoption of AI

In May 2018, the OECD Committee on Digital Economy Policy established an expert group on artificial intelligence in society. It was created to develop principles for public policy and international cooperation that would foster trust in and adoption of AI. Ultimately, these principles became the basis for the OECD ***Recommendation of the Council on Artificial Intelligence,*** to which 40 countries adhered on 22 May 2019. In the same spirit, the Chair of the 2018 OECD Ministerial Council Meeting urged "the OECD to pursue multistakeholder discussions on the possible development of principles that should underpin the development and ethical application of artificial intelligence in the service of people."

OECD AI Policy Observatory

The OECD launched an AI Policy Observatory in 2019 to examine current and potential developments in AI and their policy implications. The aim is to promote the implementation of the aforementioned AI principles through collaboration with a wide array of external stakeholders, including governments, industry, academia, technical experts and the general public. The observatory is expected to be a multidisciplinary, evidence-based and multistakeholder centre for policy-relevant evidence collection, debate and guidance for governments. At the same time, it would provide external partners with a single window into policy-relevant AI activities and findings from across the OECD.

European Commission and other European institutions

In April 2018, the European Commission issued a Communication on artificial intelligence for Europe, outlining three main priorities: to boost the European Union technological and industrial capacity and AI uptake across the economy; to prepare for socio-economic changes brought about by AI; and to ensure an appropriate ethical and legal framework. The Commission presented a coordinated plan on the development of AI in Europe in December 2018. It aims primarily to maximize investment impact and collectively define the way forward.

As part of its AI strategy, the Commission also established the High-Level Expert Group on Artificial Intelligence (AI HLEG) in June 2018. AI HLEG comprises representatives from academia, civil society and industry and was given two tasks: to draft ethics guidelines for AI, providing guidance to developers, deployers and users to ensure "trustworthy AI;" and to prepare AI policy and investment recommendations for the European Commission and Member States on medium to long-term AI-related developments to advance Europe's global competitiveness. In parallel, the Commission set up a multistakeholder forum, the European AI Alliance, to encourage broad discussion on AI policy in Europe. Anyone can contribute through the platform to the work of AI HLEG and inform European Union policy-making.

Council of Europe

In 2017, the Parliamentary Assembly of the Council of Europe (CoE) published a recommendation on technological convergence, AI and human rights, urging the Committee of Ministers to instruct CoE bodies to consider the challenges posed to human rights by emerging technologies, such as AI. It also called for guidelines on issues such as transparency, accountability and profiling. In February 2019, the CoE Committee of Ministers adopted a declaration on the manipulative capabilities of algorithmic processes, recognizing the "dangers for democratic societies" that arise from the capacity of "machine-learning tools to influence emotions and thoughts" and encouraging Member States to address this threat. In February 2019, the Council of Europe held a high-level conference on "Governing the Game Changer – Impacts of artificial intelligence development on human rights, democracy and the rule of law."

In addition, the CoE European Commission for the Efficiency of Justice adopted the first European ethical charter on the use of AI in judicial systems in December 2018, setting out five principles to guide the development of AI tools in European judiciaries. In 2019, the CoE Committee on Legal Affairs and Human Rights decided to create a subcommittee on AI and human rights.

United Nations

- In September 2017, the **United Nations Interregional Crime and Justice Research Institute** signed a host country agreement to open the Centre on Artificial Intelligence and Robotics within the UN system in The Hague, the Netherlands.
- The **International Telecommunication Union** has worked with 37 other UN agencies to host the AI for Good Global Summit, which annually gathers government officials, UN agencies, civil-society organizations, industry leaders and artificial intelligence experts to look into how big data and artificial intelligence can be applied for social good and SDG attainment. The third AI for Good Summit in 2019 gave rise to AI Commons, a framework for collaboration to achieve global impact. It will help to ensure that AI development and application builds on the state of the art, enabling AI solutions to scale with the help of shared datasets, testing and simulation environments, AI models and associated software and storage and computing resources.

  ITU has also partnered with organizations such as the XPRIZE Foundation and the Association for Computing Machinery.
- **UNESCO** has launched a global dialogue on the ethics of AI, given the complexity of AI and its impact on society and humanity, holding a public roundtable with experts in September 2018 and a global conference in March 2019 on "Principles for AI: Towards a Humanistic Approach?" Together, their aim was to raise awareness and promote reflection on the opportunities and challenges posed by AI and related technologies. In November 2019, the UNESCO 40th General Conference was to consider development of a recommendation on AI in 2020-21, if approved by UNESCO Executive Board in April 2019.

- **UN Global Pulse**, a flagship initiative of the UN Secretary-General, and the Data-Pop Alliance are two prominent initiatives for data-related issues.
- The **UN Statistical Commission** has created the **Global Working Group on Big Data for Official Statistics**, which looks into the potential benefits and challenges of big data to complement and improve traditional statistical sources and to monitor progress towards SDG attainment.

International Organization for Standardization

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) created a joint technical committee (JTC 1) in 1987 to develop information technology standards for business and consumer applications. In October 2017, subcommittee 42 (SC 42) was set up under JTC 1 to develop AI standards. SC 42 provides guidance to ISO and IEC committees developing AI applications, and its activities include providing a common framework and vocabulary, identifying computational approaches and architectures of AI systems and evaluating associated threats and risks.

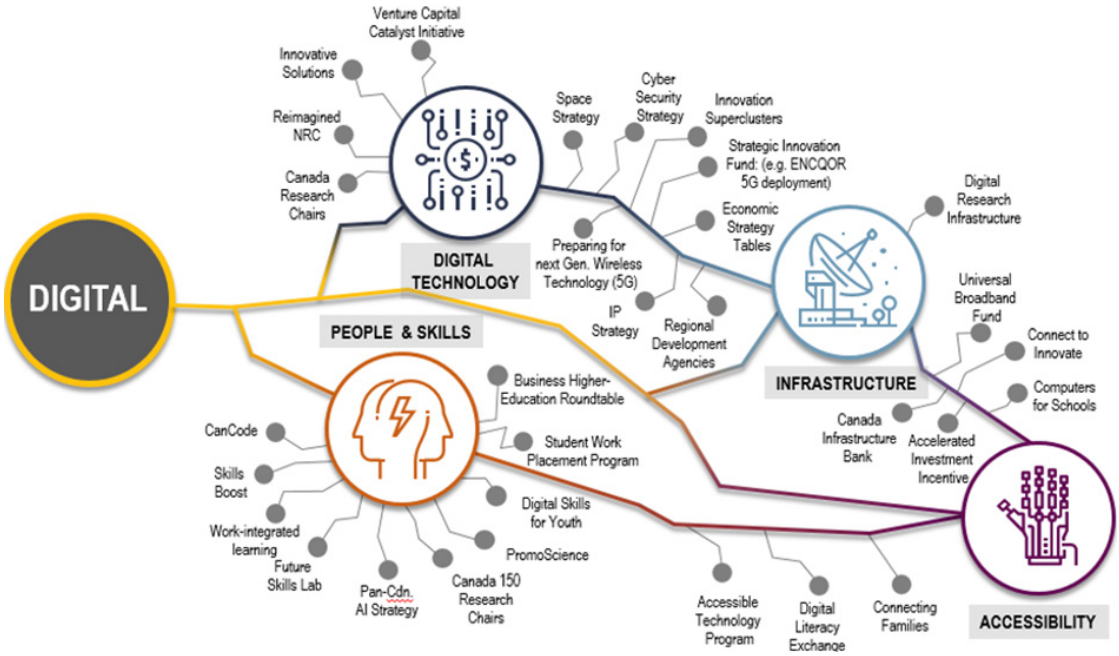
Open data actors

Open data actors include non-profit organizations (e.g. Open Knowledge, the Open Data Institute and the World Wide Web Foundation), philanthropic organizations (e.g. the Omidyar Network), multilateral organizations (e.g. UN Department of Economic and Social Affairs and the World Bank); think-tanks (e.g. NYU Governance Lab and the International Development Research Centre) and regional organizations (e.g. the Latin American Open Data Initiative and Code for Africa).

Annex II: Examples of national AI strategy building-blocks

1. Canada – Digital Charter Innovation and Skills Plan

The aim of the plan is to make Canada a competitive, data-driven digital economy. It serves as an excellent example of outlining the main features of a modern research and innovation system in AI and data.



Source: Government of Canada, *Canada's Digital Charter in Action: A Plan by Canadians, for Canadians* (2019)

2. Singapore – Trusted Data Sharing Framework

Singapore's national AI strategy is yet another successful example of envisioning a trusted data sharing framework, which is an important element in fostering successful private partnerships in data architecture. The framework articulates the key legal, regulatory and technical considerations and safeguards that each organization should take into account and gives sample legal provisions and templates to draft data sharing agreements. Singapore's national AI strategy also envisions the creation of a public-private data sharing framework. As the national custodian of personal and administrative data, the Singaporean Government can help drive cross-sector data sharing and innovation by curating and cleaning government datasets and providing the private sector with access thereto. The public-private data sharing framework will define the scope, type and granularity of government data that can be shared with the private sector and appropriate safeguards (people, process and technical). The government will identify organizations to serve as trusted data intermediaries for data fusion and distribution. These trusted entities could be situated in either the private or public sector, depending on the sector, type of data and where most data are located.[164]

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Source: Singapore's national AI strategy

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Office of the Director
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Office of Deputy Director and Regional Presence
Field Operations Coordination Department (DDR)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5131
Fax: +41 22 730 5484

Digital Networks and Society (DNS)

Email: bdt-dns@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Digital Knowledge Hub Department (DKH)

Email: bdt-dkh@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Partnerships for Digital Development Department (PDD)

Email: bdt-pdd@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia

International Telecommunication Union (ITU) Regional Office
Gambia Road
Leghar Ethio Telecom Bldg. 3rd floor
P.O. Box 60 005
Addis Ababa
Ethiopia

Email: itu-ro-africa@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon

Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé
Cameroon

Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal

Union internationale des télécommunications (UIT)
Bureau de zone
8, Route des Almadies
Immeuble Rokhaya, 3e étage
Boîte postale 29471
Dakar - Yoff
Senegal

Email: itu-dakar@itu.int
Tel.: +221 33 859 7010
Tel.: +221 33 859 7021
Fax: +221 33 868 6386

Zimbabwe

International Telecommunication Union (ITU) Area Office
TelOne Centre for Learning
Corner Samora Machel and
Hampton Road
P.O. Box BE 792
Belvedere Harare
Zimbabwe

Email: itu-harare@itu.int
Tel.: +263 4 77 5939
Tel.: +263 4 77 5941
Fax: +263 4 77 1257

Americas

Brazil

União Internacional de Telecomunicações (UIT)
Escritório Regional
SAUS Quadra 6 Ed. Luis Eduardo Magalhães,
Bloco "E", 10º andar, Ala Sul (Anatel)
CEP 70070-940 Brasilia - DF
Brazil

Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados

International Telecommunication Union (ITU) Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown
Barbados

Email: itubridgetown@itu.int
Tel.: +1 246 431 0343
Fax: +1 246 437 7403

Chile

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Santiago de Chile
Chile

Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Altos de Miramontes
Calle principal, Edificio No. 1583
Frente a Santos y Cía
Apartado Postal 976
Tegucigalpa
Honduras

Email: itutegucigalpa@itu.int
Tel.: +504 2235 5470
Fax: +504 2235 5471

Arab States

Egypt

International Telecommunication Union (ITU) Regional Office
Smart Village, Building B 147,
3rd floor
Km 28 Cairo
Alexandria Desert Road
Giza Governorate
Cairo
Egypt

Email: itu-ro-arabstates@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia-Pacific

Thailand

International Telecommunication Union (ITU) Regional Office
Thailand Post Training Center
5th floor
111 Chaengwattana Road
Laksi
Bangkok 10210
Thailand

Mailing address:
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210, Thailand

Email: ituasiapacificregion@itu.int
Tel.: +66 2 575 0055
Fax: +66 2 575 3507

Indonesia

International Telecommunication Union (ITU) Area Office
Sapta Pesona Building
13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10110
Indonesia

Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta 10110, Indonesia

Email: ituasiapacificregion@itu.int
Tel.: +62 21 381 3572
Tel.: +62 21 380 2322/2324
Fax: +62 21 389 5521

CIS

Russian Federation

International Telecommunication Union (ITU) Regional Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

Email: itumoscow@itu.int
Tel.: +7 495 926 6070

Europe

Switzerland

International Telecommunication Union (ITU) Office for Europe
Place des Nations
CH-1211 Geneva 20
Switzerland
Email: eurregion@itu.int
Tel.: +41 22 730 5467
Fax: +41 22 730 5484