Illustrations of frontier technologies in the African region

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What is frontier technologies?

There is no single definition of frontier technologies, but they are generally understood to be new and rapid developing technologies that take advantage of digitization and connectivity.

Technology	Description
Artificial intelligence (AI)	AI is normally defined as the capability of a machine to engage in cognitive activities typically performed by the human brain. AI implementations that focus on narrow tasks are widely available today, used for example, in recommending what to buy next online, for virtual assistants in smartphones, and for spotting spam or detecting credit card fraud. New implementations of AI are based on machine learning and harness big data.
Internet of Things (IoT)	IoT refers to myriad Internet-enabled physical devices that are collecting and sharing data. There is a vast number of potential applications. Typical fields include wearable devices, smart homes, healthcare, smart cities and industrial automation.
Big data	Big data refers to datasets whose size or type is beyond the ability of traditional database structures to capture, manage and process. Computers can thus tap into data that has traditionally been inaccessible or unusable.
Blockchain	A blockchain refers to an immutable time-stamped series of data records supervised by a cluster of computers not owned by any single entity. Blockchain serves as the base technology for cryptocurrencies, enabling peer-to-peer transactions that are open, secure and fast.
5G	5G networks are the next generation of mobile internet connectivity, offering download speeds of around 1–10 Gbps (4G is around 100 Mbps) as well as more reliable connections on smartphones and other devices.
3D printing	3D printing, also known as additive manufacturing, produces three-dimensional objects based on a digital file. 3D printing can create complex objects using less material than traditional manufacturing.
Robotics	Robots are programmable machines that can carry out actions and interact with the environment via sensors and actuators either autonomously or semi-autonomously. They can take many forms: disaster response robots, consumer robots, industrial robots, military/security robots and autonomous vehicles.
Drones	A drone, also known as unmanned aerial vehicle (UAV) or unmanned aircraft systems (UAS), is a flying robot that can be remotely controlled or fly autonomously using software with sensors and GPS. Drones have been often used for military purposes, but they also have civilian uses such as in videography, agriculture and in delivery services.
Gene editing	Gene editing, also known as genome editing, is a genetic engineering tool to insert, delete or modify the genome in organisms. Potential applications include drought-tolerant crops or new antibiotics.
Nanotechnology	Nanotechnology is a field of applied science and technology dealing with the manufacturing of objects in scales smaller than 1 micrometre. Nanotechnology is used to produce a wide range of useful products such as pharmaceuticals, commercial polymers and protective coatings. It can also be used to design of computer chip layouts.
Solar photovoltaic (Solar PV)	Solar photovoltaic (Solar PV) technology transforms sunlight into direct current electricity using semiconductors within PV cells. In addition to being a renewable energy technology, solar PV can be used in off-grid energy systems, potentially reducing electricity costs and increasing access.

Source: UNCTAD.
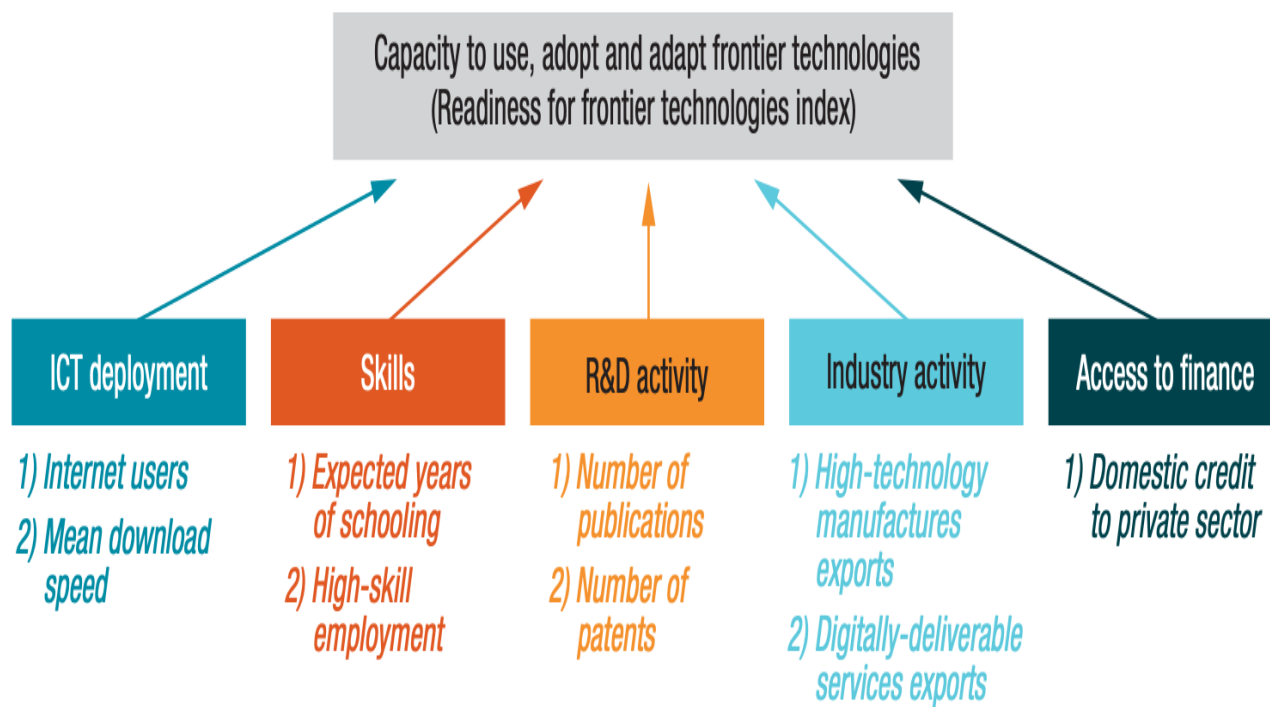
Use of Frontier Technologies in Africa

Despite low resources and capabilities, frontier technologies can also increase in Africa productivity and improve livelihoods.

For example :

- AI Is use by TrueSpec Africa in West and central Africa to detect fake drugs,
- Robots and big Data have been used in Rwanda to fight against COVID-19,
- Drones is use in Uganda by around 7,000 farmers to better manage their crops,
- 3D printing is use in Ghana and kenya to allow rapid iterative prototyping of new products,
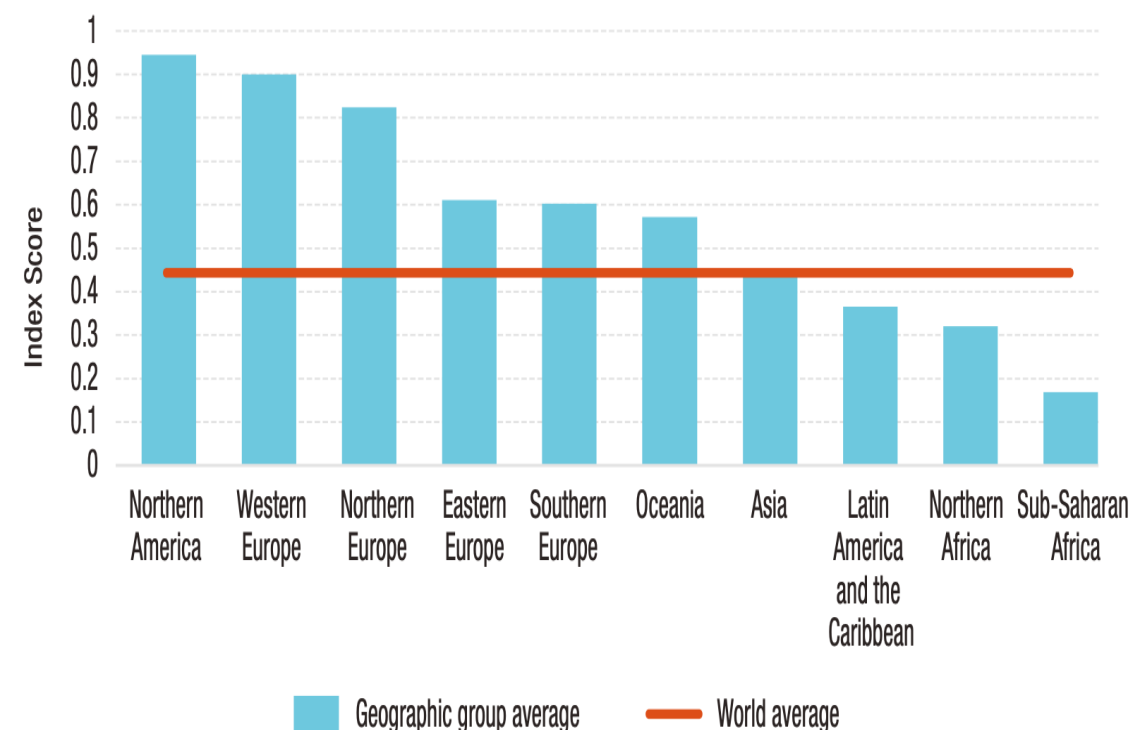- IoT is being used in Nigeria to generate advice on farming techniques.

Measure of Frontier Technologies: A country readiness index

The readiness index comprises five building blocks: ICT deployment, skills, R&D activity, industry activity and access to finance.

Capacity to use, adopt and adapt frontier technologies
(Readiness for frontier technologies index)

ICT deployment	Skills	R&D activity	Industry activity	Access to finance
1) Internet users 2) Mean download speed	1) Expected years of schooling 2) High-skill employment	1) Number of publications 2) Number of patents	1) High-technology manufactures exports 2) Digitally-deliverable services exports	1) Domestic credit to private sector

Source: UNCTAD.

Average index score by geographical group

Geographic group average — World average

Source: UNCTAD.

Readiness towards the use, adoption and adaptation of frontier technologies, selected countries.

Country name	Total ranking	ICT ranking	Skills ranking	R&D ranking	Industry ranking	Finance ranking
Top 10						
United States of America	1	14	17	2	20	2
Switzerland	2	7	13	13	3	3
United Kingdom	3	17	12	6	11	14
Sweden	4	1	7	16	15	16
Singapore	5	4	9	18	4	18
Netherlands	6	6	10	15	8	23
Korea, Republic of	7	19	27	3	9	8
Ireland	8	24	6	21	1	87
Germany	9	23	16	5	10	39
Denmark	10	2	4	25	21	5
Selected transition and developing economies						
China	25	99	96	1	7	6
Russian Federation	27	39	28	11	66	45
Brazil	41	73	53	17	42	60
India	43	93	108	4	28	76
South Africa	54	69	84	39	71	13

Source : UNCTAD

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Index results Sub-Saharan Africa:

Country name	Total score	Total ranking	Score group	ICT ranking	Skills ranking	R&D ranking	Industry ranking	Finance ranking
South Africa	0.55	54	Upper-middle	69	84	39	71	13
Mauritius	0.45	77	Upper-middle	83	58	94	74	40
Namibia	0.34	91	Lower-middle	97	109	101	59	58
Gabon	0.33	94	Lower-middle	103	99	133	43	143
Cabo Verde	0.29	101	Lower-middle	92	107	153	82	63
Ghana	0.28	103	Lower-middle	106	121	81	90	148
Kenya	0.28	105	Lower-middle	108	123	78	89	108
Eswatini	0.27	107	Lower-middle	119	115	127	53	129
Botswana	0.26	111	Lower-middle	111	104	109	114	102
Senegal	0.24	118	Lower-middle	107	137	82	112	107
Nigeria	0.20	124	Low	124	106	74	155	149
Uganda	0.18	128	Low	125	131	89	110	137
Togo	0.17	129	Low	139	126	140	103	93
Madagascar	0.16	130	Low	94	143	127	115	145
Côte d'Ivoire	0.16	131	Low	114	148	118	113	113
Cameroon	0.15	132	Low	144	118	103	123	140
Rwanda	0.15	133	Low	128	136	112	107	125
Zambia	0.15	134	Low	121	119	118	148	141
Congo	0.13	135	Low	157	125	122	80	136
Zimbabwe	0.13	136	Low	126	140	96	138	142
Malawi	0.12	137	Low	142	139	127	85	150
United Republic of Tanzania	0.12	138	Low	131	154	98	86	144
Benin	0.12	139	Low	150	124	118	122	122
Sao Tome and Prin-cipe	0.12	140	Low	141	110	153	128	123
Mali	0.11	141	Low	146	157	127	76	117
Comoros	0.10	142	Low	137	127	153	117	139
Burundi	0.08	145	Low	138	135	146	142	133
Djibouti	0.07	146	Low	122	158	153	108	126

What African countries should do ?

Base on the country readiness index, most of the least ready countries to frontier technologies are in sub-Saharan Africa. So African countries, to be ready to use, adopt and adapt the ongoing technological revolution, they should overcome a number of challenges :

Lower technological and innovation capabilities : Low-income countries have fewer skilled people and depend to a large extent on agriculture which tends to be slower to take advantage of new technologies.

Slow diversification : Developing countries typically innovate by emulating industrialized countries, diversifying their economies, and absorbing and adapting new technologies for local use, but this process is slowest in the poorest countries.

Weak financing mechanisms : Most developing countries have increased their R&D expenditures, but these are still relatively low. The African Union, for example, has established a target of one per cent of GDP, but on average sub-Saharan African countries are still at 0.38 per cent.[1] There is very little private funding of industrial technologies for productive applications.

Intellectual property rights and technology transfer : Stringent intellectual property protection will restrict the use of frontier technologies that could be valuable in SDGs related areas such as agriculture, health and energy.

1. UNESCO, 2019

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