# Digital Transformation of Sub-Saharan African Countries in Historical Perspective: From the First Computers to the AI-driven Economy

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**ABSTRACT**

*The development of breakthrough technologies occupies a special place in the national policies of both well-developed and developing countries, as they can represent an effective tool for ensuring sustainable socio-economic development and solving various problems. In this regard, it seems understandable why African countries have declared the development of information technology as one of their top priorities. Thus, this article attempts to analyze the evolution of digital transformation in Sub-Saharan African economies. Finally, the authors conclude that over the past 30 years, African countries have really achieved remarkable results in this area, despite the absolute zero, which was observed in the late 1990s and early 2000s. But the limited financial and technological resources make African countries extremely dependent on foreign aid to meet their development and this threatens their technological sovereignty.*

***Keywords:*** *Sub-Saharan African countries, artificial intelligence, information technologies, technological sovereignty, sustainable development.*

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## 1. INTRODUCTION

Just after becoming independent states, Sub-Saharan African countries faced the challenge of integrating into the contemporary system of international relations as equal actors. In their desire to match the level of socio-economic development with leading world powers, particularly former colonial empires, these countries adopted a number of socio-economic development strategies aimed at ensuring sustainable growth in all key sectors of their economy in the medium term. However, the question remained how this growth could be achieved, as it required a solid financial and technological foundation, which African countries did not have.

Nevertheless, this fact did not prevent Julius Nyerere, in the Arusha Declaration of 1967, from proclaiming the principle of 'self-reliance,' which was considered a fundamental condition capable of ensuring real independence and socio-economic development in Tanzania.

However, the example of Tanzania clearly shows that, without a solid financial and technological base, such a strategy has proven to be ineffective. In other words, one can declare anything, but it is much more important to ensure the results promised in the strategy, because otherwise it can undermine trust both in the ruling power at the domestic political level and in the state as a reliable partner at the international level.

Returning to the Tanzanian case, which, in our opinion, is the most revealing, we should say that, in fact, the proclamation of the nprinciple of self-reliance led to an opposite result – a sharp increase in Tanzania's dependence on external development assistance, which ultimately became one of the reasons for Nyerere's resignation, first from the post of president (1985), and then from the position of a chairman of his political party (1990), and the beginning of the process of economic liberalization (Bondarenko *et al.* 2014: 7).

Unfortunately, Tanzania is not the only country in this situation. Many African countries have tried to bridge the enormous economic gap with well-developed countries, but in fact they have only increased their dependence on external development assistance.

With the advent of advanced information technologies (ICT), whose capabilities have begun to grow almost every day, many African countries have seen a real chance to move towards a more innovative economy and finally ensure sustainable socio-economic growth, thereby solving all the most significant tasks they face.

Thus, it seems understandable why the governments of the vast majority of African countries have declared the development of in-

formation and communication technologies (ICT) one of their top priorities. In this regard, specialized concepts, action plans, and strategies for ICT development, both long-term and medium-term emerged in many Sub-Saharan African countries in the late 1990s and early 2000s.

Nevertheless, despite the numerous attempts made by African countries over the past three decades to reduce digital inequality, it should be recognized that the current level of ICT development in Sub-Saharan Africa does not allow the countries in the region to rely on rapid and equal integration into the global information and communication space.

African countries do not have adequate financial and technological resources to create a well-developed ICT infrastructure on their territory. In order to catch up with Western countries in terms of the development of ICT sector, they are forced to seek assistance from the same Western countries, which by speculating on the financial dependence of their African 'partners,' force them to implement reforms aimed most of all at full liberalizing the ICT-Industry in African countries and creating favorable conditions for the activity of Western IT giants in the promising African ICT-market.

Thus, we can observe the closed circle effect. African countries recognize the need for developing advanced information technologies in their territories. However, it is also obvious that in order to create an appropriate ICT infrastructure in a country, on the one hand, the elaboration of national programs for the development is required, and on the other hand, it is completely impossible to think about further research in the field of ICT without a solid financial and technological basis, whose lack should be considered as the main obstacle on the way to independent technological development (Pantserev 2021).

That is why in their attempts to ensure the digital transformation of their economies, African countries have been forced to carry out economic and political reforms that are mainly aimed at creating favorable conditions for attracting foreign (non-African) investors.

This process, which was called the 'structural transformation' of African countries' economies, initially had the character of 'controlled liberalization,' but it quickly turned into an almost uncontrolled, spontaneous process, resulting in almost the entire ICT infrastructure on the continent falling into the private ownership of foreign companies.

In current circumstances, it seems important to analyze in a historical perspective how the process of digital transformation of African economies has been going on in the last 30 years and what measures have been taken by the countries of Sub-Saharan Africa, which have limited financial and technological potential and are extremely de-

pendent on foreign aid to ensure their development to achieve technological sovereignty.

## 2. THE CREATION OF THE ICT INFRASTRUCTURE IN THE STATES OF SUB-SAHARAN AFRICA

The first task that the countries of Sub-Saharan Africa needed to solve was creating a well-developed ICT infrastructure that would form the backbone of their upcoming digital transformation. In this context, one of the key goals mentioned in the New Partnership for Africa's Development (NEPAD) – a special programme adopted in 2001 – was to create up-to-date ICT infrastructure, including penetration into remote and sometimes inaccessible rural areas. According to authors of the initiative, this would reduce the cost of telecommunication services (The New Partnership… N.d.).

Then, in 2001, almost immediately after the signing of the NEPAD Program, the e-Africa Commission was established. Its aim was to develop specific continental Pan-African programs and strategies in the field of ICT. In 2015, during the 15th Ordinary Session of the African Union, held on 27 July in Kampala, Uganda, a decision was made to change the name of the NEPAD e-Africa Commission to the NEPAD e-Africa Programme. However, despite the change in the name, the mission of this institution has remained the same – 'to drive the ICT priority sector' (Foadey 2015).

The key goal of the NEPAD e-Africa Commission is to promote the construction of the Pan-African ICT Broadband Infrastructure Network that is supposed to significantly increase data transmission capacity and reduce connection costs. This will give a new impetus to the development of ICT within the continent. The adoption of the Broadband Development Program in Africa on March 9, 2003, has become the first step towards the solution of this task. The Program aims to connect African countries to the global communications backbone and has been recognized as one of the priorities among other projects launched by NEPAD.

The Broadband Development Program in Africa itself consists, in fact, of two programs: the broadband development program in Eastern and Southern Africa, and a similar program for West, Central, and North Africa. The Programme for the development of broadband communication systems in Eastern and South Africa was approved at a conference held under the auspices of the NEPAD e-Africa Commission in Johannesburg, South Africa, on July 28–30, 2004. And in July 2005, a similar Programme was approved by the countries of West and Central Africa at a conference held in Dakar (Senegal).

According to the most general estimates, more than 30,000 km of fiber optic cable were supposed to be laid across Africa. Initially, it became evident that this project would require huge financial investment, and it was difficult to expect African countries would be able to take over the full financing of this project themselves. In this respect, they placed high hopes on the support of international financial organizations such as the World Bank, the African Development Bank, the Development Bank of South Africa and the French Development Agency.

In particular, the e-Africa Commission signed an agreement with the French Development Agency worth 850 million euros, which the Agency was going to invest in the development of a broadband communication system in Africa. From our point of view, this fact convincingly indicates that Western countries are striving to actively participate in the construction of the most significant infrastructure projects in Africa in order to preserve their influence over management of ICT-infrastructures that are going to be created in the region.

At the same time, the creation of a well-developed ICT infrastructure was only half of the equation, since in addition to laying fiber-optic communication lines, technical modernization of African telecommunication companies was also required. This was mainly due to the pressure from leading world superpowers seeking to gain a foothold in the African ICT market and providing broad support for the creation of modern ICT infrastructure in Africa. As a result, most countries in Sub-Saharan Africa had to completely liberalize this sector, which led to almost the entire ICT industry of the continent falling into the hands of foreign investors. The most typical example in this regard is the case of TelecomKenya, a Kenyan telecommunication company, whose controlling stake was bought out by the French company FranceTelecom in the early 2000s when the need for technical modernization of its facilities arose.

Understanding this fact and in order to try to reduce the dependence on Western development assistance, African countries have made a number of attempts to join their efforts in creating a pan-African ICT infrastructure. Thus, on August 29, 2006, in Kigali (Rwanda), Botswana, the Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Rwanda, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe signed a special protocol aimed at promoting the development of broadband fiber-optic networks in Eastern and Southern Africa. This Protocol entered into force in February 2008, after being ratified by vast majority of countries that signed it.

As for the countries of West and Central Africa, it should be noted that they failed to develop a joint document such as the Kigali Protocol, which would demonstrate, on the one hand, the elaboration of a joint approach to the ways of creating up-to-date ICT infrastructure in East Africa, and, on the other hand, it would show a desire to cooperate and join forces in this area.

Taking this into account, countries that have signed the Kigali Protocol have decided to extend its action to other African states, explaining that they are pursuing the goal of developing an ICT broadband infrastructure network across Africa. A relevant resolution was adopted on October 15, 2007, in Johannesburg (South Africa), at a meeting of ministers responsible for the development of ICT sector in countries that had signed the Kigali Protocol. At this meeting it was especially emphasized that the Kigali protocol does not only cover the development of ICT broadband infrastructure networks in the Southeast part of the continent but also allows other African countries to join in.

To our opinion, the signing of such an agreement and its subsequent expansion to other countries on the continent shows the desire of African countries to elaborate a joint approach to the development of ICT infrastructure on the continent. However, a number of legislative, political, and bureaucratic obstacles stand in the way of implementing the Protocol that was signed in Kigali, which each African country must eliminate on their own.

This means that it is possible to achieve the goals set out in the Protocol only if national strategies are elaborated to establish legislative frameworks for comprehensive development of ICTs and to eliminate existing barriers to their spread across the region. In this regard, governments of Sub-Saharan Africa should, first of all, bring their legislation into line with the requirements of the Kigali Protocol and, first of all, simplify the procedure for establishment and licensing of telecommunication companies that will own and manage regional ICT Broadband Infrastructure Network and provide technical support for it.

As a result, between 2000 and 2010, many countries in Sub-Saharan Africa adopted long-term strategic plans for national development, in which special attention was paid to the development of ICT. In particular, Ghana adopted such a document in 2003 (Ghana ICT 2003), Kenya adopted the Kenya Vision 2030 in 2007 (https://vision2030.go.ke), and Nigeria adopted Nigeria Vision 2020 in 2009 (see Nairametrics 2009). All these strategic plans focused on the following key areas:

a) general liberalization of the ICT sector and creation of favorable conditions for the functioning of private investors (mostly non-African ones);

b) stimulation of public-private partnership in the ICT sector;

c) further development of fiber-optic networks and search for technological solutions for the 'last mile';

d) provision of the universal access;

e) promotion of opportunities for the ICT use among local citizens;

f) implementation of ICT in functioning of public authorities;

g) development of e-government services;

h) application of advanced information technology in education and training;

i) promotion and development of local digital content;

k) development of electronic commerce.

In general, providing an overall overview of the level of technological development in Sub-Saharan African countries, it should be noted that over the past 30 years, these countries have managed to achieve significant success in this field, compared to the 'absolute zero' that was observed for this indicator in the late 1990s and early 2000s.

The main catalyst for this process was the construction of the ICT broadband submarine network along the coast of West and East Africa in the first decade of the twentieth-first century. This network starts in Portugal and runs along the entire coast of Western Africa to Cape Town. Then, the East African cable system starts in Johannesburg and goes along the coast of East Africa via Mombasa (Kenya), and further to Egypt (Chasia 2007: 12). Thus, African countries have been connected to the global communication backbone. The implementation of this project has caused a significant reduction in the costs of Internet connection, making it more affordable for the general public.

Of course, it is impossible to say that all the problems of creating an ICT broadband infrastructure network across the continent have been solved, since high-speed Internet connections have appeared mainly in large cities and industrial centers, and in countries like Chad, Niger, and the Central African Republic, only main lines have been laid out, which are supposed to link West and East Africa together.

Therefore, mobile communication services have been actively developing in Africa, which provide an opportunity for even residents of rural areas to access the Internet using mobile devices. This rapid development of mobile communications in African countries has been called the 'mobile revolution.'

## 3. AFRICAN PATTERNS OF SILICON VALLEY

The creation of an appropriate ICT infrastructure should be considered a necessary basis without which it is not possible to initiate the process of digital transformation. The second component will be the start of research and development in advanced information technologies.

Sub-Saharan African countries recognize this fact. In this regard, special attention is paid to the development of national innovative technological parks that would be responsible for developing both software and hardware that would reduce the dependence on imported, mainly Western, technologies.

That is why, starting from 2013, they have been building huge innovative complexes – technological hubs – in several African countries. They were supposed to be responsible for developing the ICT industry in their countries of origin in the future. However, the further realization of all these projects faced the typical problem for most African countries – lack of funds.

It is necessary to point out that Sub-Saharan African countries initially recognized that the construction of these innovation complexes would be very expensive. That is why the final realization of these projects depends on a steady flow of private investment because national governments can only cover up to 10 % of the costs, mainly for the construction of basic infrastructure, communications, and several administrative buildings. The remaining expenses must be covered by private investors, who will be responsible for building universities, ICT-centers, offices, residential areas, and hotels (Tueva 2023).

Despite expectations, it cannot be said that private investors show great interest in these projects, and the lack of a steady flow of investments causes delays in the construction of these technological hubs that were initially announced.

One of the most well-known examples of such innovative complexes is the Konza TechnoCity, the construction of which began in the savannah about 70 km from Nairobi, Kenya, in 2013 (https://konza.go.ke/). According to the general master plan, the new city will house key telecommunication companies as well as research institutes, including the Kenyan Institute of Science and Technology.

Initially, they were planning to finish this project in 2020. However, construction was delayed – only one of the eight administrative buildings had been built by that time. The main reason was a lack of investors, although the Kenyans assure that foreign investors show great interest in the project, in the near future all areas allocated for construction will be taken over by private investors. However, now we

can only talk about the completion of the first phase of construction, which involves laying all necessary communications and roads – the so-called 'horizontal infrastructure' (Otieno 2022).

There is also a project for the creation of a technopark in Ghana, called HOPE City (it is an abbreviation for *Home Office People's Environment*). In 2014, the masterplan for the new city was introduced. And they planned to complete this very ambitious and expensive project within just three years by 2016 (HOPE City N.d.). But unfortunately, this project remained only on paper and the construction was frozen at the early stage due to lack of funds.

In this regard, the Ethio-ICT Village in Ethiopia, which was opened in 2015, should be considered to be the only technopark in Africa that is actually functioning. The Ethio-ICT Village was supposed to serve as the headquarters for both the telecommunication company Ethio Telecom and the Ministry of Communications and Information Technology, and it was expected to become the leading ICT center in Africa. 'Software development center, cloud ERP (Enterprise Resource Planning) data center, call center (contact center), research center and auditorium' are currently functioning in the Ethio-ICT Village (Bekele 2017). And more than 20 companies have already become residents of the Village. This experience has turned out to be so successful that the government has decided to create similar technology parks in other parts of the country.

Among other projects that involve the construction of technological parks in Africa, it is necessary to highlight the building of Diamniadio *Lake City*. This city, which is being built 30 km away from Dakar near Diamniadio lake, has been declared the most high-tech and smart city in Africa. This initiative differs from similar ones in Kenya, Ghana, and Ethiopia, as its main goal is not to create a technological park, but to relieve overcrowded Dakar, although it assumes the creation of an industrial park and university for about 30,000 students (Bendix 2018). Besides, a more realistic deadline for completion of this project was initially announced – 2035. Now the active phase of construction is underway, and there is reason to believe it will be completed by that time.

Rwanda also has its project to create a smart city called Kigali Innovation City (World Construction Network 2024). The aim of the project is to attract technological companies to Rwanda and strengthen the country's innovation ecosystem. It will position the country as a leading pan-African center and accelerate its transformation into a knowledge-based economy. Within the framework of the project, they are going to build four universities, offices and living areas, business incubators for startups, and retail facilities and hotels (Kagire

2024). However, the construction of the city began only in 2022 so it is too early to sum up results, but taking into account the current level of socio-economic development in Rwanda, this project is likely to be completed.

Based on the facts stated above, one can see that Sub-Saharan African countries are trying to conduct appropriate research and development in the field of advanced information technologies and are thinking about the creation of specialized ICT hubs in this regard.

But it is evident that full implementation of such ambitious projects is only possible with the involvement of big foreign (non-African) investors. Therefore, the backbone of the business models of all these technological hubs is a public-private partnership. At the same time, the government definitely plays a small role of just building the so-called horizontal infrastructure, which supposes the construction of all appropriate communications and administrative buildings. Whereas foreign (non-African) investors from all over the world: Europe, the United States, China, the United Arab Emirates should be responsible for creating the technological clusters in these ICT hubs.

That is why the creation of a favorable investment climate remains the main priority for the economic policy in most African countries, and the lack of a steady flow of these investments is the main cause of delays in finishing these ambitious projects that were initially announced.

## 4. AI-TECHNOLOGIES AS A NEW STAGE IN THE DIGITAL TRANSFORMATION OF SUB-SAHARAN AFRICAN COUNTRIES

The contemporary level of development of advanced information technologies poses new challenges for sub-Saharan African countries. Nowadays all leading nations are paying increased attention to the development of hybrid intelligent systems that are ‘capable of learning and self-development’ (Grinin *et al.* 2024a).

Today, artificial intelligence (AI) is actively penetrating our daily life and is used in different fields, from machine translation to medical diagnostics and even in the generation of new content: it can formulate ideas, conduct dialogues, create works, stories, images, videos, and music, as well as edit images, videos, *etc.* (Grinin *et al.* 2024b).

At the same time, the support for domestic developers in the field of AI is often provided by governments. Today, more than 30 countries have adopted national AI strategies, including the USA, China, France, Japan, the UAE, and Russia.

Despite the fact that countries of Sub-Saharan Africa generally lag significantly behind well-developed countries in terms of development of advanced information technologies, they still consider further development of hybrid intelligent systems as a key priority in their national policies and are sure that those technologies can become key tools to give a new impetus for economic development, making it more innovative.

In this regard, many African countries have begun to develop national AI strategies. The first national AI strategy in Sub-Saharan Africa was adopted by Mauritius in November 2018 (Mauritius AI Strategy 2018). Rwanda, Senegal, and Benin also elaborated their own AI strategies and became the first countries in continental Sub-Saharan Africa to adopt such a document (Hankins *et al.* 2023).

The National AI-strategy in South Africa, called the National Artificial Intelligence Policy Framework, has been elaborated for a long time (more than 4 years), as it demanded a large number of different consultations. It was finalized only in August 2024 (South Africa National … Framework 2024). And before that, the key document which defined the main lines of development of AI technologies in the country was the Report of the Presidential Commission of the Fourth Industrial Revolution that was adopted in 2020 (Presidential Commission … 2020).

And finally on March 27, 2025, after seven years of hard work and intensive consultations with all stakeholders, the National AI-strategy of Kenya was introduced.

The elaboration of such documents strongly demonstrates that the development of advanced information technologies has become a key priority for national development in the vast majority of African countries. Among the concrete steps towards further implementation of AI technologies is the creation of appropriate government bodies and educational and research centers.

Thus, in Nigeria, the Nigerian Ministry of Science and Technology announced the creation of the National Agency for Research in Robotics and Artificial Intelligence (NARRAI). And the University of Lagos established the Artificial Intelligence Hub in June 2018. This research center was established with the initiative of Bayo Adekanmi, one of Nigeria's leading specialists in data science. It is expected that the Center will largely focus on developing data collection tools necessary for the development of machine learning instruments and, of course, selecting young talent specialists in data analysis (Ndiomewese 2018).

Kenya is not far behind Nigeria. In particular, Strathmore University in Nairobi has created an African Research Center (@iLabAfrica), which aims to conduct research in the fields of big data and artificial intelligence.

And, of course, South Africa has managed to achieve the greatest success in this field among all Sub-Saharan African countries. For example, the University of Pretoria has created the Intelligent Systems Group (ISG), which specializes in the development of various hybrid intelligent systems, mainly in the field of computer vision.

In addition to the development of research centers in the field of AI, an active implementation of AI-based technologies is taking place in industry in several African countries. Currently, many companies use AI in their business processes in Sub-Saharan Africa. South Africa is the undisputed leader in this respect (726 companies), followed by Nigeria – 456 companies and Kenya – 204 companies. For comparison, Ghana has 115 such companies, Cameroon has 54, and Mauritius has 35 (DIPLO 2022).

In South Africa, financial and insurance companies, for example, actively use chatbots to answer consumer questions about financial products. AI now makes decisions in the banking sector on granting loans and vehicle insurance. South Africa also holds a leading position in the production and sale of AI-controlled drones in Sub-Saharan Africa capable of performing various civilian and military tasks, from moving goods of various weights to monitoring the terrain (carrying out search and rescue or reconnaissance operations, assessing damage from natural disasters or hostilities, adjusting fire on enemy positions, *etc*.).

Cameroon-based Agrix Technology offers an AI platform that identifies plant diseases and offers treatment options. Farmers can scan a sample of an affected plant directly using a smartphone without the Internet. The app has text and voice recognition options in local African languages (https://www.agrixtech.com).

The first Kenyan startup using AI technologies is FarmDrive (https://farmdrive.co.ke), a technology platform based on large amounts of data that provides financial institutions with models relevant to the agricultural industry, which is necessary for assessing the risk of issuing a loan and developing targeted loan products that meet the needs of small farmers.

Another Kenyan startup suggests the integration of a specialized chatbot called Sophie into social networks and messengers. This free chatbot, equipped with a simple voice interface, represents a platform where any user can ask questions in the intimate sphere, including in the field of reproductive medicine, and receive an exhaustive answer.

This service is available on popular messaging apps (Sophie Bot: http://sophiebot.tk).

In Nigeria, one of the first technological platforms to use the AI was the Kudi.ai service, which was launched in 2017 (*kudi* means 'money' in Hausa language). This service is a chatbot that provides financial assistance, including transferring money and paying bills. Just like Sophie, Kudi is integrated into the most popular messengers and social networks (Akinwamide 2017).

Another Nigerian startup, chatbot Lara, which was launched on March 5, 2017, is an intelligent system that helps users get from one place to another by providing detailed, step-by-step text–based instructions and calculating the exact fare in advance (Ndiomewese 2017).

Basing on the examples above, one can make a conclusion that Sub-Saharan African countries start to use AI technologies to create various services that will significantly simplify people's lives (Pantserev 2020). However, it is clear that in order to conduct in-depth research and development in the field of AI, African countries need strong financial and technological bases, which, for obvious reasons, they do not currently possess. As a result, these countries continue to rely on Western technologies. This leads some experts to believe that there is no real AI in Africa and what we see today is simply copying Western technologies (Matuluko 2017).

As for the world's largest IT companies, such as Microsoft, IBM, and Google, they are trying to preserve their position in the promising African ICT market under the pretext of implementation and localization of their innovative technical solutions in Africa. The most well-known example of this is the opening of the AI Research Center in Africa by Google Corporation in Accra, Ghana, in 2018 (Miley 2019). On the one hand, such initiatives really stimulate the development of technologies in Africa, but on the other hand, they undermine the technological sovereignty of African countries.

## 5. HUMAN CAPACITY BUILDING AS AN INDISPENSABLE CONDITION FOR DIGITAL TRANSFORMATION OF SUB-SAHARAN AFRICAN COUNTRIES

As has been shown above, nowadays we can observe widespread implementation of AI technologies into the business processes of various enterprises in Africa. However, this requires significant transformation of education in Sub-Saharan African countries, as it is necessary to organize training of highly qualified personnel who would be

able to work with advanced technologies. Special attention should be paid to training of data analysts and ML engineers in this regard.

Sub-Saharan African countries have already started solving this problem, and there have appeared a number of relevant educational programs in African universities over the past ten years.

Thus, for example, the University of Pretoria established the Institute for Big Data and Data Science in September 2017. The University of Lagos, in Nigeria, Strathmore University in Kenya, and the University of Rwanda are also training data scientists.

But the appearance of such educational programs in certain African universities cannot fully meet the demand of the entire region for highly qualified IT specialists. As a result, many talented young professionals are often forced to leave African countries in order to get high-quality technical education. And not all of them return.

In order to improve the situation, online education platforms are being actively developed in Africa today. For this purpose, back in 1997 the African Virtual University (AVU) was established. Initially, it was a project of the World Bank, but later, in 2002, the university headquarters were moved to Nairobi, Kenya and in 2003, it became into a pan-African intergovernmental organization aimed at improving education quality in Africa. At present, 54 African universities are involved in its activities.

The experience of the AVU turned out to be so successful that several African countries have launched their own online education startups (Halilou 2016). For example, Samaskull, the Senegalese online platform, provides access to various online courses. In this regard it is an analogue to the world-famous Coursera platform, but made in Senegal with a very ambitious goal to become an innovative and open platform that allows Africans to fully control their future. The slogan of this platform is ‘made by Africans for Africans.’ Daptio, a South-African Startup launched in Cape Town in 2013, also uses AI technologies to help students find relevant educational content.

The appearance of such new educational programs, together with online courses offered by the AVU, has led to an increase in the number of young professionals in the fields of applied mathematics and computer science in Africa. However, the specifics of data scientists training lie in the fact that basic skills are not enough. This can be explained by the fact that computer science represents a field that is developing very quickly and no educational standard can keep up with its development. That is why, the most crucial aspect of preparing highly qualified data scientists is developing of knowledge-sharing

professional groups that would bring together leading researchers and practitioners in the field, who would share their ideas within the community.

In order to provide such a platform, Data Science Africa was launched in 2015. The key mission of this non-profit organization is 'to provide quality training in data science, machine learning, and other emerging technologies, with the aim of leveraging these technologies to develop solutions to African problems.' Thus, since 2015, Data Science Africa has organized a number of summer schools and workshops at a wide range of universities across East Africa (Data Science Africa N.d.).

Another remarkable initiative in this regard is the establishment of the Machine Intelligence Institute of Africa in 2016. It is a non-profit organization whose key mission is 'to transform and help build an AI-powered Africa through a strong, innovative and collaborative Machine Intelligence, AI and Data Science community consisting of individuals and key players in the African Artificial Intelligence Ecosystem' (MIIA N.d.).

All those initiatives have caused the increased growth of the data science community in Africa. Various specialized conferences in machine learning are held regularly in different African countries. It is a remarkable fact that in 2023 Rwanda hosted the International Conference on Learning Representations (ICLR), which is one of the largest ML-conferences that annually brings together the best specialists in AI and its proceedings have the highest ranking (A*) according to CORE (International Conference on Learning Representations N.d.).

To our opinion, the choice of Rwanda as a venue for such a remarkable event demonstrates that Sub-Saharan African countries have really managed to build a data science community that is recognized by leading experts in the field.

## 6. CONCLUDING REMARKS

Basing on the analysis that has been undertaken, we can see that Sub-Saharan African countries today are paying increased attention to the development of advanced information technologies. And over the past 30 years, they have managed to achieve remarkable results in this area, if we keep in mind the absolute zero in this indicator which was observed in the late 1990s and early 2000s, specifically:

1) the backbone fiber-optic infrastructure network was constructed, which caused a significant reduction in costs for Internet traffic;

2) vast majority of Sub-Saharan African countries adopted national strategies for the further development of the ICT industry, both in the short and long term;

3) a number of African countries initiated the construction of innovation technical hubs that are supposed to be responsible for the development of advanced information technologies.

Nowadays, African countries pay increased attention to the development of AI technologies and their rapid implementation into the daily life of ordinary Africans. This means that the digital transformation of Sub-Sharan African countries has turned into a number of attempts at rapid implementation of different technological innovations with very weak financial and technological support. Therefore, the full implementation of all these initiatives faces serious challenges, namely:

1. The need to provide broadband high-speed Internet access to citizens. Despite the fact that a major high-speed broadband network was built in the first decade of the twenty-first century, it must be recognized that the problem of providing high-speed Internet access throughout the continent remains unsolved. This is because, for African countries, the most pressing issue is still the search for a solution to the 'last mile' from backbone fiber-optic networks to households. As a result, today only 22% of urban and 10% of rural populations have high-speed Internet access, and the effectiveness of AI technologies, as is known, directly depends on having high-speed Internet.

2. Human capacity building. Today, this problem is gradually beginning to be solved and one can observe a significant growth of the Data Science community over the past ten years. But nevertheless, there is still a lot to be done to ensure that enough specialists are trained in such a rapidly growing field as data science.

3. The creation of AI laboratories that would be equipped with sufficient computational powers capable for developing and training hybrid intelligent systems.

4. The construction of an extensive network of data centers. Nowadays, there is taking place an extreme imbalance in the distribution of data centers across Africa. Today, there are about 165 data centers in Sub-Saharan Africa, but all of them are located in 28 Sub-Saharan African countries (out of 49!). At the same time, South Africa has the largest number of such centers (47). Kenya has 18 data centers, Nigeria – 16 and Mauritius – 10 (DataCenterMap N.d.). This forces governmental bodies in African countries to continue storing data on servers located in the United States, which cannot but threaten the

information security of African countries. It should also be noted that not all these data centers launched in Africa belong to African companies. In particular, on March 6, 2019, Microsoft announced the launch of two data centers in Cape Town and Johannesburg. And the Amazon Web Services data center was launched in Cape Town in 2020.

5. The availability of domestic software, which should be considered as an indispensable condition for ensuring technological sovereignty for the country. This is because only domestic software can be maximally adapted to the demands of local citizens. At the same time, we must highlight the extremely unsatisfactory state of research and development in AI in African countries, where they mainly import ready-made technical solutions instead of producing their own software. Today, Microsoft and other Western corporations continue to be the main software suppliers for African countries. Their licenses, as a rule, do not imply or rather even explicitly prohibit making any changes to the code of computer programs. This fact makes some experts conclude that there is no AI in Africa at all, and what we see today is simply copying Western technologies (Matuluko 2017).

African countries will have to redouble their efforts and investments in international cooperation to improve their digital sovereignty and develop their own AI research and technologies. Strong bilateral coalitions or smaller ones should be created for cooperation within the framework of international organizations (UN, UNESCO, African Union, and BRICS), as well as with various states that are already advanced in AI development. The challenge is also to find voluntary actors that are ready to pool the necessary resources and skills in order to ensure their independence and future digital sovereignty in order to avoid being totally dominated by a single country.

These challenges seem to be rather complicated in nature, and African governments should involve all stakeholders in their solution: scholars, private investors, civil society, politicians, and different regulatory bodies. In our opinion, only in this way can an effective exchange of experience and search be organized and optimal solutions be found to meet specific local and regional demands and ensure the creation of a high-tech ecosystem in the region.

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