Research article

ASSESSING THE LEVEL OF INNOVATIVE DEVELOPMENT OF AFRICAN COUNTRIES: TRADITIONAL INDICATORS AND ALTERNATIVE APPROACHES

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Abstract. Innovation plays a key role in the socio-economic development of Africa, but its measurement faces unique methodological and contextual challenges. This article addresses the problem of assessing the level of innovative development of African countries, which remains highly relevant in the context of globalization and digitalization of the world economy, and also highlights the limitations of classical approaches, including an insufficient statistical base and low comparability of data across countries. Traditional indicators, such as the number of patents, R&D expenditures, and publication activity, often do not take into account the specifics of African ecosystems, where informal innovations, adaptive technologies, and local solutions prevail.

The author assesses the level of innovative development of African countries and proposes approaches that take into account the unique economic, infrastructural, and cultural characteristics of the continent. Particular attention is paid to the development of successful innovative ecosystems in individual African countries (Kenya, Nigeria), where a combination of traditional and alternative indicators allows for a more accurate assessment of the development dynamics. The results demonstrate the need to adapt existing metrics to the African context, as well as the potential of alternative approaches in forming a more objective picture of the region's innovative progress. By providing a detailed understanding of African innovation processes, this study aims to help policymakers, international organizations, and investors develop strategies that take into account local specificities. The article contributes to the global debate by rethinking approaches to measuring innovation and challenging Eurocentric paradigms and metrics, forming a basis for studying and building unique models of innovation development in African countries.

Keywords: innovation, assessment of the level of innovative development, research and development costs, results of intellectual activity, global innovation index, adaptive innovation, Africa

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In recent years, the innovative development of African countries has become increasingly dynamic and is characterized by a unique combination of rapid technological progress with persistent systemic problems. Countries such as Kenya, Nigeria, and Rwanda have received worldwide recognition for creating the Silicon Savannah innovation ecosystem in Nairobi, the development of FinTech in Lagos, and innovative Kigali Smart City solutions, respectively. However, the continent's innovation landscape remains uneven. Many countries are faced with limited access to finance and education, infrastructure shortages, climate challenges, and political instability, which hamper sustainable innovation development.

Nevertheless, despite these difficulties, the ingenuity of innovators flourishes at the local level, exemplified by the mobile payment platforms such as M-Pesa, Airtel Money, MTN Mobile Money, Orange Money; Zipline unmanned aerial vehicles for the delivery of medicines; M-KOPA Solar solar energy solutions for remote areas; and green building materials from recycled plastic by Gjenge Makers. These successfully implemented projects highlight Africa's opportunities to use local creative approaches to build unique models of innovative development.

Innovation is increasingly seen as the cornerstone of Africa's prosperous socio-economic future. Since the adoption of the Lagos Plan of Action for the Economic Development of Africa in 1980–2000 and the ongoing long-term strategic program of the African Union, Agenda 2063, science, technology, and innovation have been identified as key tools for achieving the continent's strategic goals.

The Oslo Manual, in its special appendix Innovation Survey in Developing Countries, notes that "the design and planning of innovation surveys in developing countries needs to take into account the relative weakness of statistical systems" [Oslo Manual 2005: 145].

This fact greatly complicates the analysis process, as the available data are incomplete and do not allow us to obtain relevant and representative results, including those necessary for making decisions about investments in science and innovation in African countries and the development of international cooperation.

A correct and reliable assessment of the level of innovative development in Africa, which forms a scientifically sound understanding of science, technology, and innovation, is becoming extremely relevant.

In international practice, a set of absolute and relative indicators is used to assess and analyze the innovative development of an individual state or region, including cost and in-kind indicators reflecting public and private spending on research and development, the number of researchers and the quantitative results of their activities, as well as the position of countries in global rankings.

RESEARCH AND DEVELOPMENT COSTS

One of the most common indicators used to assess innovative development is gross domestic expenditure on research and development, expressed as a percentage of national Gross Domestic Expenditure on Research and Development (GERD) [1].

The GERD calculation takes into account the costs of commercial enterprises, higher education institutions, as well as public and private non-profit organizations for fundamental and applied research and development (R&D), as well as the costs of

[1] Sustainable Development Goals. *UN*. https://www.un.org/sustainabledevelopment/ru/about/development-agenda/?ysclid=mcucunmvtv739970426 (accessed: 08.07.2025)

experimental development (ED), including pilot testing of innovations, as well as activities related to their subsequent implementation and scaling.

According to statistics from recent years, the leaders in total research and development spending have traditionally been the United States and China. The average *GERD* value in the world in 2021 was 1.9% of GDP, in high-income countries according to the World Bank classification, 2.7%. It should be noted that spending on research and development in the world has been on an upward trend over the past two decades (*Fig.* 1).

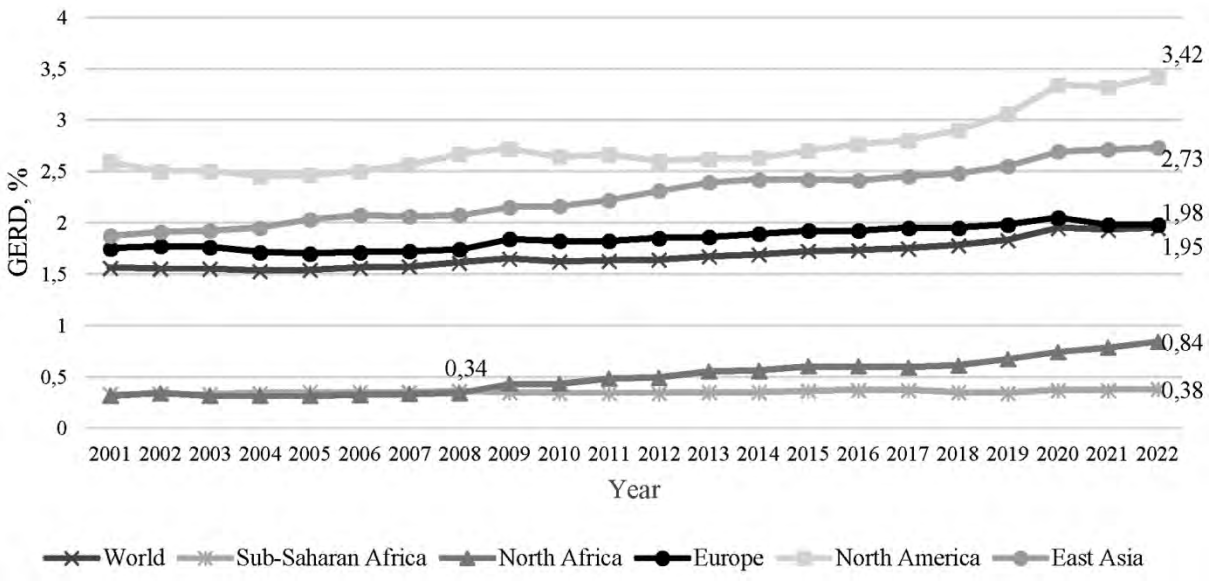

Fig. 1. ***GERD* dynamics in relative terms.**
Compiled by the author on the basis of *UNESCO* statistics: SDG9 Monitoring. Science, Technology and Innovation. *UNESCO.* https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring (accessed: 10.05.2025)

African countries have one of the lowest GERD values in the world. Due to the lack of their own domestic savings and foreign aid, as well as the excessive dependence of the revenue side of government budgets on the volatility of commodity prices, African governments cannot provide sufficient funding for science and technology.

An analysis of the macro-regions of Africa reveals the following feature: in 2008, the *GERD* of the countries of North Africa and Sub-Saharan Africa was the same and amounted to slightly more than 0.3%, but from 2009 to 2022, this indicator increased to 0.8% in the countries of North Africa, while in the countries of Sub-Saharan Africa, the indicator remained at the same level, which characterizes the uneven innovative development of the continent.

L.L. Fituni, a leading Russian Africanist, noted that when analyzing innovations in Africa, it should be borne in mind that not all indicators can be applicable and provide objective assessments, while the effectiveness of the analysis increases significantly with the transition to the national level [Fituni 2021].

The country analysis should take into account that UNESCO statistics contain information on GERD for only 36 out of 54 African countries. Outdated data and irregular innovation surveys in countries such as Uganda, Nigeria, Morocco, Algeria, and Ghana should also be noted.

When analyzing the relative values of GERD, the available statistical data for 2021–2023 were systematized for Egypt, the Republic of the Congo, Burkina Faso, Kenya, Mali, Mauritius, Namibia, Rwanda, and South Africa. For the rest of the countries, the analysis includes the values for the nearest previous year according to the corresponding indicator (*Table* 1).

Egypt is the continent's leader in research and development costs. GERD growth in this country has been observed over the past twenty years. It is also noteworthy that in 2022, for the first time, the indicator exceeded the target value of 1% set out in the pan-African and national strategies for science and innovation [Olaoye et al. 2020], including the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024). In 2023, Egypt's *GERD* also exceeded 1%, which can be described as a steady trend. The high value of the indicator is also typical for other countries in North Africa.

Table 1. **GERD analysis of some African countries in relative and absolute terms**

Percentage interval	*GERD*, %	Country	Year	Rank in the continent	Region	*GERD*, billion US dollars
>1.00%	1.03	Egypt	2023	1	North Africa	21.85
>0.50%	0.81	Kenya	2023	2	East Africa	2.82
	0.79	Rwanda	2023	3	East Africa	0.38
	0.75	Tunisia	2019	4	North Africa	1.11
	0.66	Morocco	2010	5	North Africa	1.49
	0.65	Namibia	2022	6	South Africa	0.20
	0.62	Republic of South Africa	2022	7	South Africa	5.69
	0.58	Gabon	2009	8	Central Africa	0.13
	0.58	Senegal	2015	9	West Africa	0.25
	0.56	Botswana	2013	10	South Africa	0.16
	0.51	Tanzania	2013	11	East Africa	0.53
0.25 – 0.50%	0.48	Algeria	2017	12	North Africa	2.69
	0.41	Democratic Republic of the Congo	2015	13	Central Africa	0.28
	0.38	Republic of the Congo	2022	14	Central Africa	0.15
	0.38	Ghana	2010	15	West Africa	0.37
	0.31	Uganda	2023	16	East Africa	0.47
	0.31	Mauritius	2022	17	East Africa	0.10
	0.31	Mozambique	2015	18	East Africa	0.09
	0.30	Chad	2016	19	Central Africa	0.07
	0.28	Nigeria	2019	20	West Africa	3.20
	0.28	Zambia	2008	21	East Africa	0.10
	0.27	Ethiopia	2017	22	East Africa	0.60
	0.27	Eswatini	2015	23	South Africa	0.03
	0.25	Burkina Faso	2021	24	West Africa	0.14
0.00 –	0.21	Burundi	2018	25	East Africa	0.02

Percentage interval	*GERD*, %	Country	Year	Rank in the continent	Region	*GERD*, billion US dollars
0.25%	0.20	Seychelles	2016	26	East Africa	0.01
	0.19	Togo	2014	27	West Africa	0.03
	0.17	Mali	2021	28	West Africa	0.09
	0.07	The Gambia	2018	29	West Africa	0.004
	0.07	Republic of Côte d'Ivoire	2016	30	West Africa	0.08
	0.07	Republic of Cabo Verde	2011	31	West Africa	0.002
	0.05	Lesotho	2015	32	South Africa	0.003
	0.03	Angola	2016	33	Central Africa	0.06
	0.01	Madagascar	2017	34	East Africa	0.01
	0.01	Mauritania	2018	35	West Africa	0.002

* Data for 2023 or the nearest previous year according to the corresponding indicator.

Compiled by the author on the basis of UNESCO statistics. Science, Technology and Innovation. *UNESCO*. https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring (accessed: 11.05.2025)

Research and development expenditures in Kenya are showing rapid growth in 2023, from 0.4% to 0.8% of national GDP, due to a set of factors reflecting the government's strategic priorities in the long term [Ngigi et al. 2024]. The reverse trend is observed in South Africa, where, from 2017 to 2022, there was a decrease from 0.8% to 0.6%.

The GERD value of less than 0.25% is typical for the least economically developed countries in Africa, which indicates the need to review national policies and strategies of governments in the field of innovation in these countries.

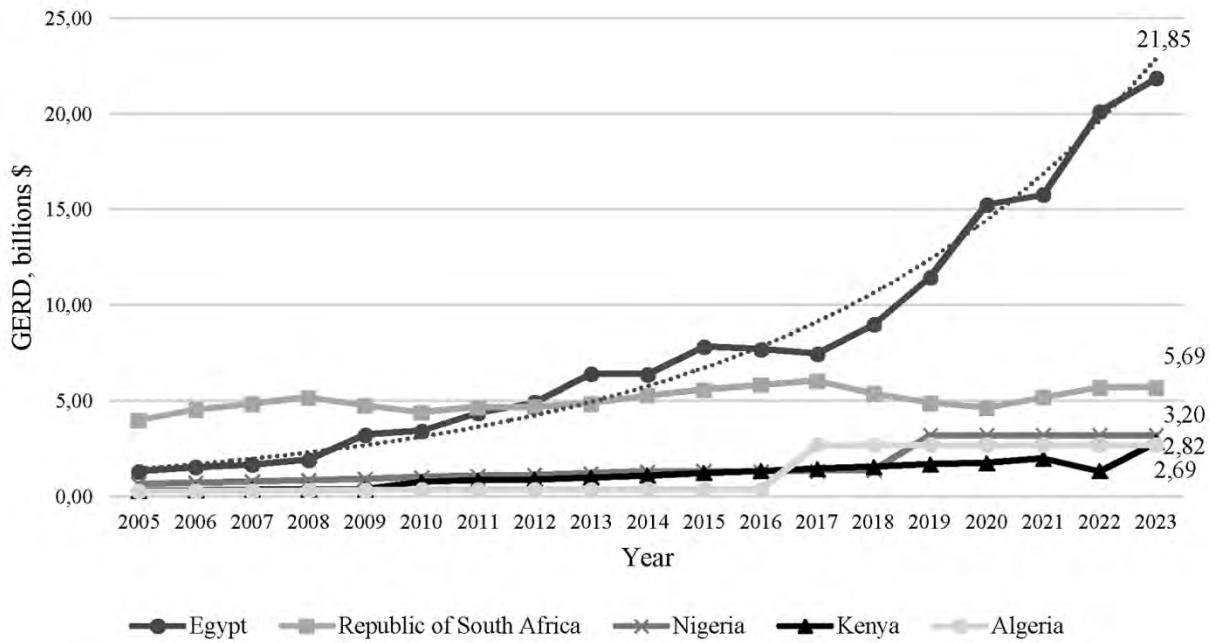

Fig. 2. **GERD dynamics for some African countries in absolute terms.**

Compiled by the author on the basis of *UNESCO UIS* statistics. Science, Technology and Innovation. *UNESCO*. https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring (accessed: 12.05.2025)

Soviet and Russian economist V.K. Pospelov pointed out that the analysis of international relative indicators characterizing the level of innovative development of African countries should be supplemented with absolute values of these indicators in order to make the analysis more informative [Pospelov 2022].

In terms of absolute values of the GERD indicator, Egypt is also an undisputed leader in Africa. Its figure has been growing exponentially since 2007, reaching more than $20 billion by 2023. (*Fig.* 2). The leading countries in terms of GERD in absolute terms also include South Africa, Nigeria, Kenya, Algeria, and Morocco, as research and development costs in these countries have been increasing over the analyzed period.

The total GERD of African countries in 2023 amounted to more than $40 billion, which is comparable to the value of the indicator for the Russian Federation, equal to $36 billion in 2023. Given the current dynamics and the fact that some African economies have experienced high economic growth rates in recent years [Saidi et al. 2024], it can be assumed that the GERD value for the leading African economies in relative and absolute terms will increase over the long term, and, in some cases, outstrip the GDP growth rate. This trend will be typical for such growing economies as Ethiopia and Kenya, for which GDP growth in 2024 was 7.3% and 4.5%, respectively[2].

GERD growth will be caused not only by an increase in government spending on fundamental and applied R&D but, to a greater extent, by the spending associated with ED aimed at introducing innovations. The stage of commercialization of innovative products and technologies is usually the most expensive in the innovation lifecycle [Dudić et al. 2016], and across the globe it is largely organized and funded by private business.

In most of the economically developed countries, the contribution of the private sector to the financing of ED exceeds 50%. For example, in Japan, the share of non-public sector sources reaches 80%. Similar percentages are typical for the economies of China, Germany, Sweden, and France[3].

On the African continent, government allocations are the dominant source of funding for research and development. ED is publicly funded for more than 90% in Nigeria, more than half in Mauritius and Ghana, and more than a third in Rwanda and Mali. The share of private national sources is extremely low, with the exception of South Africa and Zambia, where they account for more than 35% of the total investment in science per year. At the same time, it should be noted that the financing of ED in the Republic of South Africa from private sources has significantly decreased over the past decade against the background of the ongoing economic crisis, which can be considered a negative trend[4].

Increasing the role of private national capital in financing scientific and technological activities is a reserve (an untapped opportunity) to increase *GERD* for African countries, especially in terms of the costs associated with the direct introduction of technologies, commercialization of intellectual property deliverables (IPD) obtained as a result of fundamental and applied research, including through crowdfunding investments [Chao et al. 2020].

[2] World Bank Open Data. *World Bank.* https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=ZG (accessed: 12.05.2025)

[3] Naidu E. Africa's article output grows, but R&D funding is lacking. *University World News.* https://universityworldnews.com/post.php?story=20231122073213618 (accessed:12.05.2025)

[4] South Africa's science spending drop is about more than just R&D. *ResearchProfessionalNews.* https://www.researchprofessionalnews.com/ (accessed: 10.07.2025)

The development of infrastructure and the creation of conditions for the promotion of innovation by national governments will contribute to the active involvement of private business entities in the innovation process, which will increase the value of GERD in the future. At the same time, national governments will be more likely to increase investments in basic and applied research in an environment where there are guarantees that the private sector will contribute to the commercialization of the results of such research.

NUMBER OF RESEARCHERS

According to UNESCO statistics, Africa has a relatively low share of researchers in relation to its population (*Fig.* 3). In Europe and North America, the figure in 2022 exceeded 4,000 people per 1 million, and the global average was 1,420 people, while in North Africa, this figure was 893 people, and in Sub-Saharan Africa, 95 researchers.

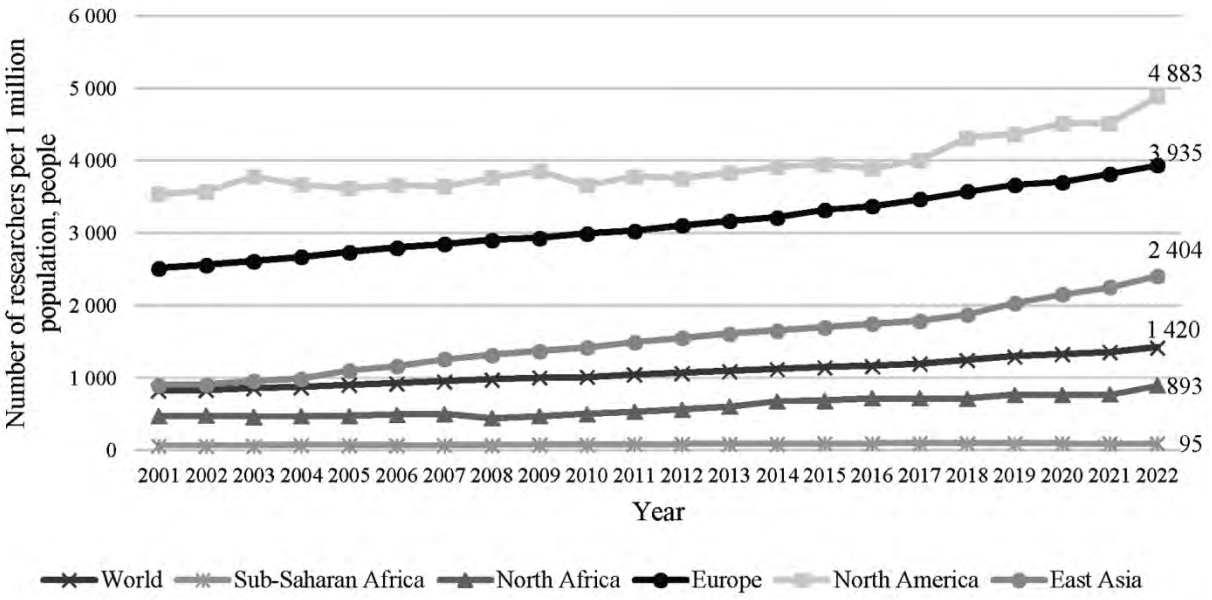

Fig. 3. **Dynamics of the number of researchers per 1 million population.**
Compiled by the author on the basis of *UNESCO UIS* statistics. Science, Technology and Innovation. *UNESCO*. https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring (accessed: 06.05.2025)

The indicator reflecting the number of researchers per million inhabitants has shown positive dynamics for North African countries over the past twenty years, with an increase of more than 80%, due to improved access to higher education and the development of universities and research centers [Meyer et al. 2023].

An analysis of the number of researchers in relative and absolute terms in Africa at the national level (*Table* 2) also demonstrates significant differences between individual regions and countries. For Tunisia, the number of researchers per 1 million population in 2022 was 1,671, which is higher than the global average. The same indicator had an extremely low value for Nigeria: about 20 people per 1 million inhabitants. Egypt, Morocco, Algeria, South Africa, Tunisia, Ethiopia, Kenya, and Senegal occupy the leading position on the continent in absolute terms.

The relationship between *GERD* and the number of researchers in African countries is non-linear; however, there is a direct correlation: the higher the spending on science,

technology, and innovation, the more researchers are involved in research and development. In countries where GERD exceeds 0.5%, there is a noticeable increase in the number of researchers.

In turn, economic risks and low R&D budgets, political instability in a number of countries, and the active recruitment of African researchers by Western companies lead to a high level of brain drain [Adeyemi et al. 2018], which largely determines the dynamics of the number of researchers in Africa.

Table 2. **Analysis of the number of researchers in some African countries per 1 million population**

No.	Country	The number of researchers per 1 million population, people	Year	Number of researchers, people*	Rank on the continent by total number of researchers	Region
1	Tunisia	1671.99	2022	20,581	5	North Africa
2	Morocco	1080.71	2016	37,709	2	North Africa
3	Egypt	845.32	2023	94,547	1	North Africa
4	Algeria	832.42	2017	33,912	3	North Africa
5	Senegal	580.95	2015	8,227	8	West Africa
6	Mauritius	569.01	2022	739	22	East Africa
7	Republic of South Africa	469.47	2021	27,763	4	South Africa
8	Namibia	251.45	2022	641	24	South Africa
9	Kenya	200.85	2023	10,957	7	East Africa
10	Botswana	173.95	2013	382	29	South Africa
11	Seychelles	152.46	2005	13	35	East Africa
12	Eswatini	139.10	2015	157	31	South Africa
13	Rwanda	131.85	2023	1,837	11	East Africa
14	Republic of the Congo	128.25	2022	774	20	Central Africa
15	Republic of Cabo Verde	117.87	2014	64	33	West Africa
16	Zimbabwe	99.44	2012	1,305	12	East Africa
17	Ethiopia	90.24	2017	9,632	6	East Africa
18	Ghana	86.98	2015	2,482	10	West Africa
19	Republic of Côte d'Ivoire	67.65	2005	1,269	13	West Africa
20	Chad	58.76	2016	843	18	Central Africa
21	Malawi	50.47	2010	732	23	East Africa
22	The Gambia	49.98	2018	121	32	West Africa
23	Burkina Faso	46.75	2010	742	21	West Africa
24	Togo	44.40	2022	5	36	West Africa
25	Mozambique	43.95	2015	1,162	14	East Africa
26	Zambia	42.45	2008	536	27	East Africa

No.	Country	The number of researchers per 1 million population, people	Year	Number of researchers, people*	Rank on the continent by total number of researchers	Region
27	Madagascar	33.73	2018	894	17	East Africa
28	Mali	29.32	2021	632	25	West Africa
29	Uganda	28.73	2014	1,028	16	East Africa
30	Niger	26.76	2013	490	28	West Africa
31	Lesotho	23.57	2015	50	34	South Africa
32	Burundi	23.20	2018	262	30	East Africa
33	Nigeria	22.83	2019	4,584	9	West Africa
34	Tanzania	19.15	2013	929	16	East Africa
35	Angola	18.95	2016	543	26	Central Africa
36	Democratic Republic of the Congo	10.42	2015	806	19	Central Africa

* Data for 2023 or the nearest previous year according to the corresponding indicator.

Compiled by the author on the basis of *UNESCO UIS* statistics. Science, Technology and Innovation. *UNESCO*. https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring (accessed: 07.05.2025)

INTELLECTUAL PROPERTY DELIVERABLES

One of the indicators characterizing the level of national science, especially in the field of fundamental research, is **publication activity**, including books, articles, and conference materials.

The publication activity of African scientists increased by 60% from 2018 to 2022, crossing the threshold of 160,000 publications, with a global growth rate of 22.0% (*Table* 3). In recent years, Africa's contribution to global science has increased from 1.0% to 4.0%, despite both objective factors, related to the lack of funding and underdeveloped infrastructure, and also subjective ones, such as the language barrier for researchers from French-speaking and Lusophone countries, the bias of reviewers, as well as the "tyranny of the impact factor" [Marincola, Kariuki 2020: 24156]. In modern conditions, the scientific significance and quality of the conducted research are largely determined by the level of the journal in which its results are published. Overcoming this "tyranny" requires a radical revision of scientific productivity assessment systems at the global level.

Publication activity in African countries is uneven, with about 48% of the continent's scientific output produced in Egypt and the Republic of South Africa. Another 46% is made up of scientific products from Nigeria (10.8%), Morocco (7.7%), Ethiopia (7.2%), Algeria (6.6%), Tunisia (6.3%), Ghana (4.0%), and Kenya (3.4%). The remaining 6% is accounted for by the remaining 45 countries in Africa, mostly located in Sub-Saharan Africa.

The predominance of international collaborations is typical for scientific products in Africa: up to 70% of articles by African scientists are written with foreign co-authors, mainly from the EU, USA, and China [North, Hastie, Hoyer 2020]. It can also be noted that "analysis of Africa's key partners indicated how important other countries are rather than Africa for them" [Sooryamoorthy 2023].

Table 3. **Publication activity in some African countries**

Name	Period of time, year					Growth rate (2022/2018), %
	2018	2019	2020	2021	2022	
World	3,332,974	3,546,452	3,721,635	3,995,987	4,065,230	22.0
African Union (AU)	104,565	117,183	134,328	153,745	166,915	59.6
% of the world	3.1	3.3	3.6	3.8	4.1	–
Algeria	8,539	8,427	8,586	9,948	11,070	29.6
% of the AU	8.2	7.2	6.4	6.5	6.6	–
Egypt	22,645	26,080	32,477	38,948	44,188	95.1
% of the AU	21.7	22.3	24.2	25.3	26.5	–
Ethiopia	3,764	4,962	6,770	9,160	11,944	217.3
% of the AU	3.6	4.2	5.0	6.0	7.2	–
Ghana	3,141	3,751	4,551	5,487	6,732	114.3
% of the AU	3.0	3.2	3.4	3.6	4.0	–
Kenya	3,471	3,989	4,662	5,532	5,668	63.3
% of the AU	3.3	3.4	3.5	3.6	3.4	–
Morocco	7,773	8,926	10,337	11,677	12,823	65.0
% of the AU	7.4	7.6	7.7	7.6	7.7	–
Nigeria	10,194	12,916	15,263	17,887	18,001	76.6
% of the AU	9.7	11.0	11.4	11.6	10.8	–
Tunisia	8,561	8,488	8,706	9,413	10,488	22.5
% of the AU	8.2	7.2	6.5	6.1	6.3	–
Republic of South Africa	27,442	30,071	32,376	34,560	35,378	28.9
% of the AU	26.2	25.7	24.1	22.5	21.2	–

Compiled and calculated by the author on the basis of African Innovation Outlook IV (AIO 2024). AUDA-NEPAD African Union Development Agency. *NEPAD*. https://nepad.org/publication/african-innovation-outlook-iv-aio-2024 (accessed: 20.05.2025)

It should also be noted that scientific articles are not always objective quantitative indicators characterizing IPD and may not reflect a real contribution to science. Some scientists may publish many articles with low significance and repetitive research results, or publish fewer of their papers due to high fees from journals indexed in the international databases, such as Scopus and the Web of Science, or not publish at all for privacy reasons, in order to create and protect their intellectual property later.

Patent activity analysis. In Africa, the total number of patent applications has increased by more than 40% over the past decade to 21,500 applications[5]. At the same time, their share in global statistics is still small and amounts to 0.6%.

South Africa held the leading position in terms of the number of patent applications filed until 2022, but in 2023 there was a 2.5-fold decrease to 1.2 thousand applications.

[5] WIPO statistics database. *WIPO*. https://www3.wipo.int/ipstats (accessed: 16.02.2025)

At the same time, the number of patent applications in Algeria tripled to 1.4 thousand (*Fig*. 4).

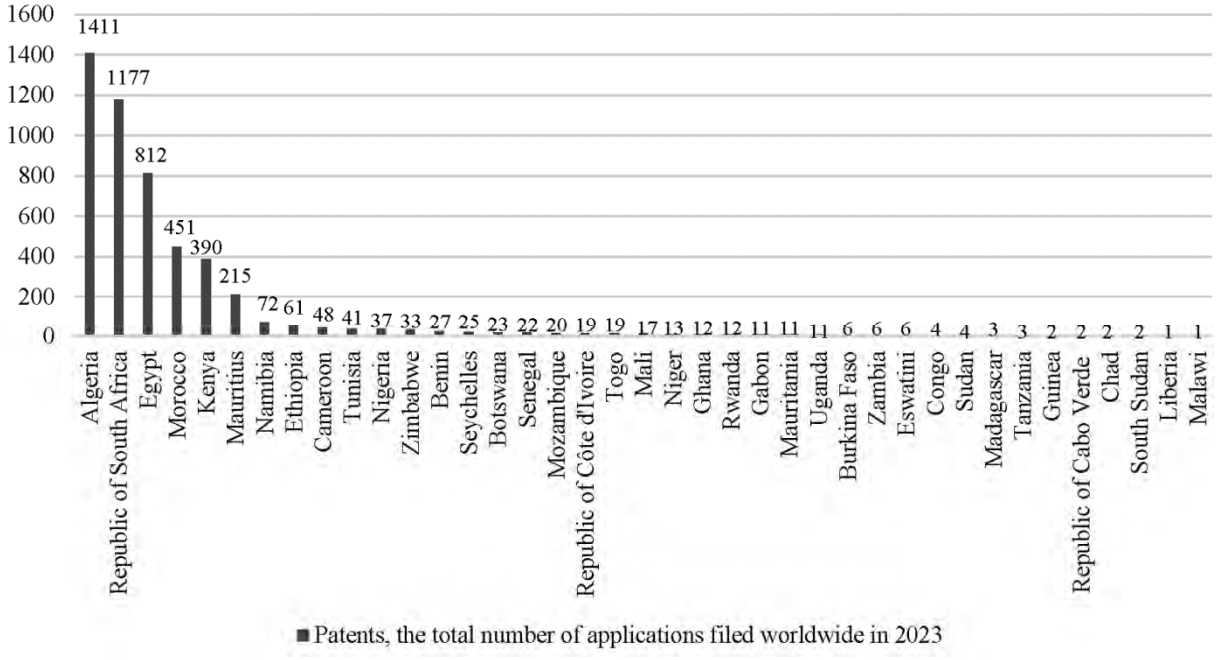

Fig. 4. **The number of patent applications filed worldwide by applicants from some African countries in 2023.**

Designed by the author according to the World Intellectual Property Organization (WIPO). WIPO statistics database. *WIPO*. https://www3.wipo.int/ipstats (accessed: 17.02.2025)

The continental patent landscape is uneven, with notable contributions from applicants from Egypt, Morocco, Kenya, and the Republic of Mauritius, while inhabitants of many other AU states register fewer than 15 patent applications per year.

The growth of patent applications is mainly driven by non-residents, reflecting the increased interest of foreign companies in African markets. According to WIPO statistics, in the Republic of South Africa, more than 80% of applications are submitted by non-residents; in Morocco, this figure exceeds 75%, and in Egypt, 65%. A low proportion of non-residents is observed only in Kenya (less than 50%) and Nigeria (less than 30%) due to the growing activity of local startups in the field of digital technologies and FinTech.

The low patent activity of African researchers is primarily determined by systemic barriers associated with the high cost of filing patent applications, as well as the level of patent fees that must be paid during its validity period. The filing of a patent application in the Republic of South Africa by the profiled company *Smit & Van Wyk*[6] costs more than $1.5 thousand, which is not always affordable for startups and small businesses. Patent fees for maintaining a patent effective in large geographical regions are measured in hundreds of thousands of dollars [Porter et al. 2023].

The extremely long period of application review by national patent offices, ranging from three to five years, also has a significant impact on patent activity[7]. Many African innovators, especially in the informal sector, prefer immediate commercialization to

[6] Patent costs. *Smit and Van Wyk.* https://www.svw.co.za/south-africa-patent-costs/ (accessed: 13.05.2025)

[7] Moreira V.S. Africa: patenting against the clock. *INVENTA.* 29.11.2021. https://inventa.com/ip-news-insights/opinion/africa-patenting-against-clock (accessed: 13.05.2025)

patenting. In these circumstances, trademark registration is becoming a more popular way to protect intellectual property rights.

According to WIPO, in Africa, about 300,000 trademarks are registered annually with national patent offices, which is about 2% of the total number of applications in the world. In terms of the number of trademark applications, Egypt is the undisputed leader on the continent (*Fig.* 6), occupying a fairly high 27th place in the global ranking, ahead of such countries as Hong Kong, Portugal, and Israel.

At the same time, the share of non-residents is about 10%, which indicates a significantly greater activity of local innovators in using more flexible and affordable tools to protect intellectual property rights. For example, M-Pesa mobile payment systems were protected by trademarks rather than patents [Foster 2021].

Trademarks are registered by Africans 50 times more often than patents for inventions, while globally this ratio is five to one. However, it should be noted that trademarks do not provide a sufficient level of legal protection, especially in terms of the substantive elements of the invention (device) and the features of the patented method.

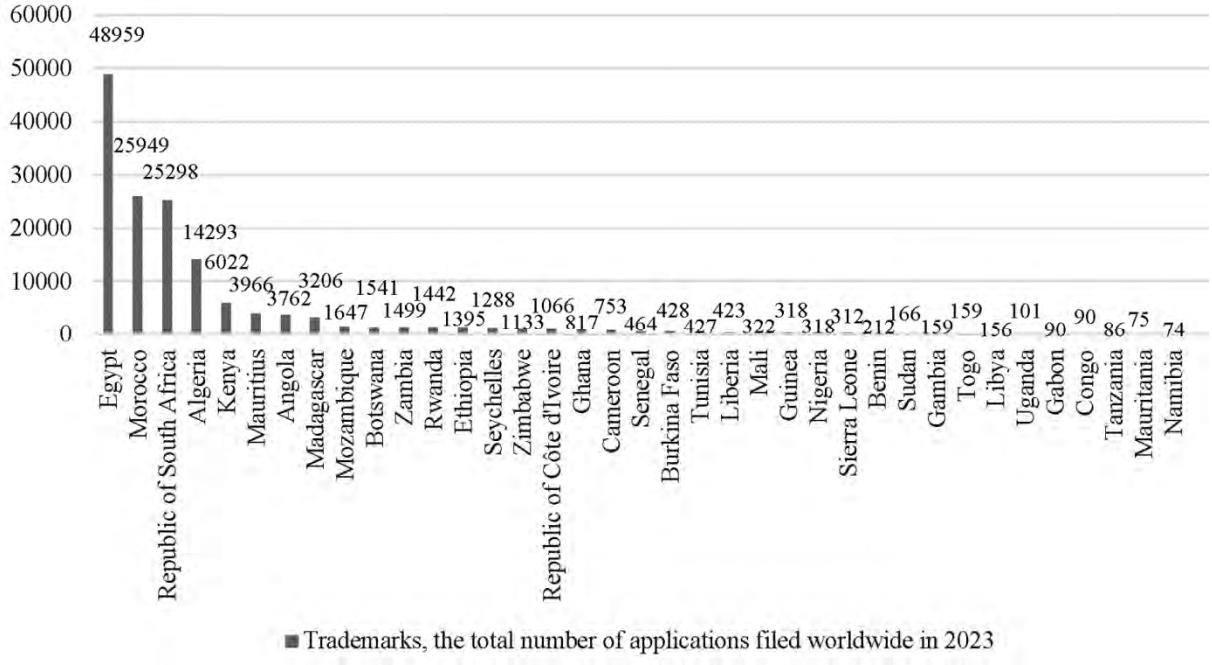

Fig. 6. **The number of trademark applications filed worldwide by applicants from some African countries in 2023.**

Designed by the author according to the WIPO statistics. WIPO statistics database. *WIPO*. https://www3.wipo.int/ipstats (accessed: 13.05.2025)

In addition to national patent offices, there are also two regional organizations on the continent that promote the registration and protection of patent rights: the African Intellectual Property Organization (Organisation Africaine de la Propriété Intellectuelle, OAPI) and the African Regional Intellectual Property Organization (ARIPO).

The OAPI comprises 17 French-speaking countries of the African continent: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Republic of Côte d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Togo, Comoros. The absence of national patent offices in the member states is a distinctive feature of this organization, which determines the need for the OAPI to perform the full range of functions for accepting patent applications, conducting an

examination, and issuing a single security document. This organization annually registers more than 500 patent applications and more than 10 thousand trademarks[8].

In order to stimulate and support innovators, OAPI offers individuals a 90% discount on the fees for filing an application for an invention, as well as a 100% reduction of fees for publication of application, correction of the priority claim by a notice submitted and additional claims [Ildyakov 2024].

Currently, ARIPO consists of 22 African countries, mostly English-speaking ones: Botswana, the Republic of Cabo Verde, The Gambia, Ghana, Zambia, Zimbabwe, Kenya, Lesotho, Liberia, Malawi, Mauritius, Mozambique, Namibia, Rwanda, São Tomé and Príncipe, Sierra Leone, Seychelles, Somalia, Sudan, Tanzania, Uganda, Eswatini. Every year, ARIPO registers more than 800 patent applications and about 1,000 trademarks[9]. The patent procedure at ARIPO provides for a formal examination of patent applications and, if the necessary requirements are met, their transfer to the national offices of the participating countries for substantive examination and further registration of intellectual property rights.

The main task of national patent offices and regional organizations is to develop patent protection in Africa: an essential aspect of intellectual property rights that supports innovation, technological progress, and economic development.

A number of initiatives have been implemented in this area in recent years. The Nigeria Startup Act, adopted in 2022, significantly simplified the procedure for international patent registration for small technology companies, which facilitated their entry into global markets [Okolie, Akwiwu 2023]. ARIPO, in order to simplify the procedure for filing patent applications, is actively developing and implementing an online platform (ARIPO e-Filing).

By aligning the policies of national patent offices and regional organizations with Africa's unique innovation ecosystems, in terms of simplifying the patent registration procedure and effectively securing patent rights, the continent will be able to transform patents from a marginal indicator into a driver of technological progress.

GLOBAL RANKINGS

International indexes reflecting the level of innovative development include the Global Innovation Index (GII), the Bloomberg Innovation Index, the European Innovation Scoreboard, and others.

The most complete picture of the innovation status of the world's countries is provided by the Global Innovation Index (GII), which is an annual ranking of more than 130 countries published jointly by WIPO, Cornell University, and the European Institute of Business Management (*L'Institut européen d'administration des affaires, INSEAD*). This ranking evaluates the degree of innovative development of countries based on more than eighty indicators divided into two groups. When calculating the index, both indicators reflecting innovative resources (human capital, R&D costs, infrastructure, institutions, and the environment for innovation development) and indicators characterizing the results of innovative activities (knowledge, technology, patents, and creative products) are taken into account.

Switzerland, Sweden, the United States, Singapore, and the United Kingdom have been leading the GII over the past decade. The leading regions in the global innovation landscape are Western Europe and North America.

[8] WIPO statistics database. *WIPO*. https://www3.wipo.int/ipstats (accessed: 11.05.2025)
[9] WIPO statistics database. *WIPO*. https://www3.wipo.int/ipstats (accessed: 14.05.2025)

The most innovative economies of the African continent according to the GII are: Mauritius (55th place), Morocco (66th place), the Republic of South Africa (69th place), Tunisia (81st place), Egypt (86th place), Botswana (87th place), the Republic of Cabo Verde (90th place), Senegal (92nd place), Kenya (96th place), Ghana (101st place).

Mauritius tops the ranking among African countries due to the largest venture capital transactions, while also having a positive trend in the number of trademark applications submitted, the volume of imports of information and communication technology services, and the number of newly established small innovative enterprises[10]. Tax advantages, reliable legal regulation, and a well-developed financial infrastructure have helped transform the island state into a key participant in venture capital transactions, with about 40% of foreign direct investment in Africa being carried out through Mauritius[11].

The North African countries of Morocco, Algeria, and Egypt are showing marked improvements in the innovation ranking. Morocco has achieved the greatest success in advancing in the ranking, moving from 84th to 66th place in the GII in ten years due to digitalization and increased spending on education. Algeria is among the top twenty in the world in terms of the number of graduates in technical fields, and progress has been made in intellectual property-related indicators, including patents, trademarks and industrial designs, which allowed the country to take 115th place in the ranking in 2024. Egypt ranks 86th, and Cairo was included in the GII's Top 100 science and technology clusters for the first time in 2024[12].

The Republic of South Africa leads the region in terms of business development and the level of knowledge and technology. Its high level of innovation performance (3rd place in Africa) is due to the highest market capitalization on the continent. The Republic of South Africa is also among the countries that recorded the highest rates of labor productivity growth in the world between 1970 and 2020[13].

Botswana was the sixth most innovative country on the continent in 2024, having made a significant leap from 106th to 86th place in 2022. Increased spending on education, an increase in research and development spending and an increase in payments for intellectual property have become the main drivers of growth [Bosupeng 2015].

The Republic of Cabo Verde and Senegal have improved their positions in the ranking, becoming the most innovative economies in West Africa. Nigeria, despite being a country with one of the largest economies on the continent and a developed ecosystem for startups [Umar et al. 2022], ranked only 113th in the ranking in 2024.

An analysis of the GII over the past decade shows that the countries of the Global North are increasing their innovation potential, while the countries of the Global South are experiencing difficulties. Eight of the twenty-seven countries in Sub-Saharan Africa included in the GII in 2024 have improved their rating, but countries such as Angola, Cameroon, Mozambique, Niger, Burkina Faso, and Mali are not yet able to ensure sustainable and long-term growth in most innovation indicators.

It should be noted that the GII does not take into account informal innovations typical of developing countries. In addition, indicators reflecting the availability of

[10] Global Innovation Index 2022: What is the Future of Innovation-driven Growth? *WIPO*. 2022. https://wipo.int/publications/ru/details.jsp?id=4622 (accessed: 05.05.2025)

[11] World Investment Report 2023. *UNCTAD*. 2023. https://unctad.org/publication/world-investment-report-2023 (accessed: 05.05.2025)

[12] Global Innovation Index 2024 Unlocking the Promise of Social Entrepreneurship. *WIPO*. 2024. https://www.wipo.int/web-publications/global-innovation-index-2024/en/ (accessed: 05.05.2025)

[13] Global Innovation Index 2022: What is the Future of Innovation-driven Growth? *WIPO*. 2022. https://www.wipo.int/publications/ru/details.jsp?id=4622 (accessed: 06.05.2025)

innovative resources and indicators characterizing the results of innovation activities are combined into a comprehensive index with subjective weights. The subjective nature of the indicators included in the index, the values of which are formed on the basis of expert assessments and the results of surveys of executives (mainly Western companies), as well as the problem of incomplete and outdated statistical data on innovation in Africa, distort the real value of GII for a number of countries on the continent. High-income countries gain an advantage in GII due to their well-developed infrastructure, even if their innovation systems are less effective in modern conditions.

ALTERNATIVE ASSESSMENT APPROACHES

Innovation in Africa is becoming increasingly important in the context of the fight against poverty, climate change, and digitalization of all spheres of public life. However, their assessment remains a difficult task due to the uneven development of the continent's countries, weak institutional structures, and the predominance of "invisible" innovation processes.

Traditional indicators such as investments in research and development, the number of patents, or the position in global rankings discussed earlier do not take into account the specifics of the continent's ecosystems, especially for Sub-Saharan Africa, where informal innovations, adaptive technologies, and local solutions that lack adequate patent protection prevail.

The informal sector remains a key element of the African economy, generating up to 60% of GDP in individual countries [Etim 2020], as well as up to 75% of employment [Allard 2017], but its contribution to innovation is ignored. For the analysis of the level of innovation development to take into account the contribution of the informal sector, it can be complemented by a quantitative assessment of the social effects of the development and implementation of innovations in Africa that affect poverty, access to education, digital competence, the number of rural clinics using telemedicine or schools with digital educational materials.

It is also important to include innovations in the analysis that involve the reuse of open technologies that are not included in patent registries to solve specific problems of the continent. For example, the Nigerian startup Zipline uses unmanned aerial vehicles to deliver medicines to rural areas, but its activities are not reflected in traditional innovation indicators due to the lack of patents.

In African countries, when introducing new products and technologies, there is usually not a progressive advancement but a *leapfrogging* over several levels of technological development at once, bypassing the intermediate stages (see *Fig.* 1).

Mobile payments in Africa have become a global phenomenon and have ensured the continent's global leadership in this area due to a combination of technological innovations, high rates of mobile communications, investments in FinTech with the specific features of the continent, namely weak banking infrastructure, expressed in an insufficient number of bank branches and ATMs, problems with their constant replenishment with cash, and the high demand of the population for financial services. This has become a vivid example of the development of adaptive innovations—creative solutions implemented in conditions of lack of resources, limited infrastructure, and institutional gaps typical of the continent. As a result of this innovation, more than 570 million Africans, most of whom have never had bank accounts or used plastic cards to make payments, have gained access to banking transactions, the volume of which

exceeded $850 billion in 2024[14]. At the same time, these transformations did not affect the position of Kenya and Nigeria in the GII—their ranking has only worsened over the past ten years, dropping from 85th to 96th place and from 110th to 113th place, respectively, which raises the question of the relevance of global metrics for the African context.

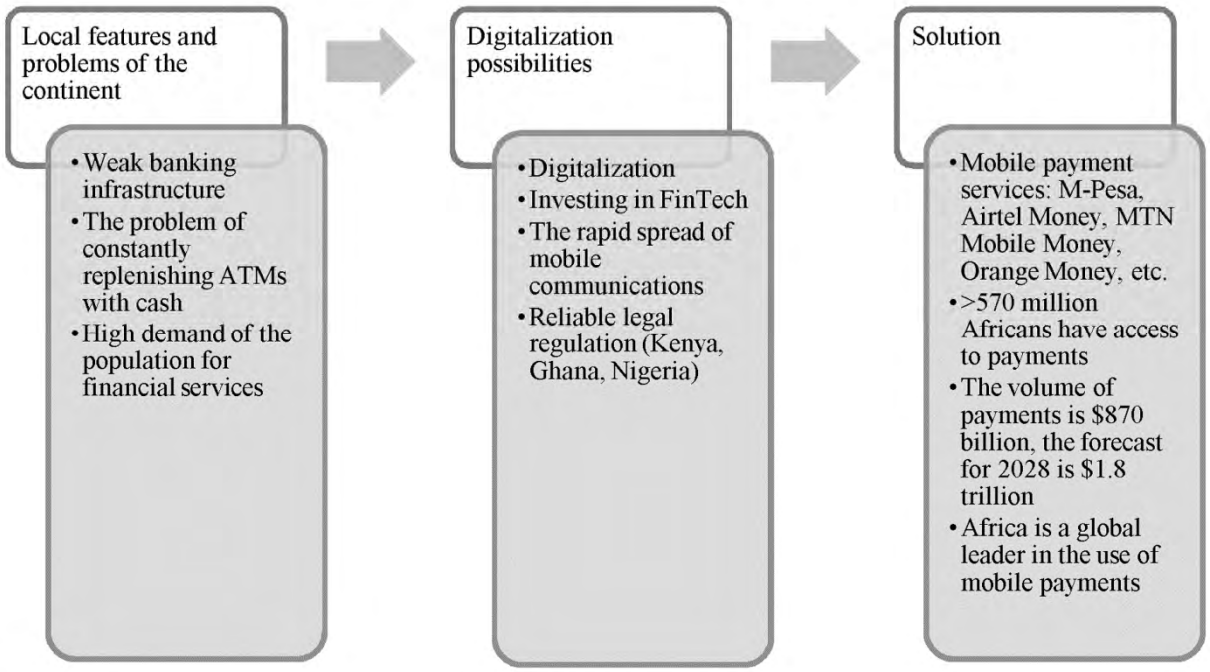

Fig. 1. **Mobile payment market development in Africa.**
Designed by the author.

The African continent is also one of the most dynamic and fastest-growing regions for the introduction and use of cryptocurrencies. Nigeria, Kenya, the Republic of South Africa, and Ghana occupy a leading position in the world in terms of *peer-to-peer* transactions and the level of ownership of cryptocurrencies by the population, which is due not only to limited access to traditional financial services in these countries and the need for cheaper and faster channels for cross-border money transfers but also due to high inflation and devaluation of national currencies. At the same time, there is a massive use of global cryptocurrencies, as well as central banks' own digital currencies (CBDC), for example, *eNaira* in Nigeria and *e-Cedi* in Ghana.

The estimated proportion of the population with access to banking services through mobile services, the level of use of crowdsourcing platforms and the volume of crowdfunding investments, as well as the possibility of making payments through cryptocurrencies, can also become quite informative indicators characterizing the level of innovative development in African countries.

However, when analyzing it, it should be borne in mind that the rapid "spread of financial technologies is a serious blow to the financial sovereignty of the countries of the continent" [Degterev 2024]. The concentration of critical financial infrastructure and cash

[14] Vorniceanu D. Mobile money: paving the way to the 1.4 bln African consumer market. *The Paypers*. 23.09.2024. https://thepaypers.com/payments/thought-leader-insights/mobile-money-paving-the-way-to-the-14-bln-african-consumer-market (accessed: 11.05.2025)

flows from foreign corporations limits the ability of African states to fully control their financial ecosystem, regulate capital flows, ensure cybersecurity and protection of citizens' data, as well as pursue independent monetary policy. The experience of Western countries imposing illegal sanctions related to restrictions on the further use of previously introduced innovative technologies turns technologies and innovations into instruments of political pressure that can be used against any state.

Colonialism had a significant impact on the trajectory of innovative development in Africa. The colonialists introduced technologies that primarily served their own economic interests. The concept of "technology transfer," which became widespread in the 1980s, also did not lead to significant changes in the socioeconomic development of the African continent. This technology was often *intermediate* or *appropriate*, not in the progressive sense of the concept of E. Schumacher [Schumacher 1973], as "adapted to local conditions and resources," but in the sense of being limited and insufficient for integrated industrial development, creating dependence on maintenance and further technological updates from the metropolises, without stimulating deep localization or the development of their own engineering competencies. Traditional African knowledge and local technological practices were systematically devalued and suppressed by the colonial administration and educational systems oriented towards European standards. This had a significant impact on the development of endogenous innovation systems.

Innovation surveys conducted on the continent, in terms of IPD analysis, in addition to accounting for patents and trademarks, should be complemented by know-how developed by African inventors, since local innovations not only solve current problems but also create the basis for sustainable development of the continent. Such innovations include the Cardiopad[15], a portable heart disease diagnostic device created by Cameroonian inventor Arthur Zang from improvised tools; the iCow[16], a mobile cattle management application developed in Kenya; and the MamaOpe[17], a smart jacket for early diagnosis of pneumonia in children in Uganda. These solutions, although effective, rarely meet the criteria of classical innovation indexes, but they contribute to the development of endogenous innovation systems and the formation of innovative potential in African countries.

In addition, the conventional innovation models imported from other regions often do not take into account the environmental realities of Africa. The eco-friendly criterion is not a limitation for the continent's innovators but rather a source of opportunity. Innovations, initially developed as environmentally sustainable, make it possible to solve the most pressing problems of the continent and, at the same time, create world-class competitive technologies. Innovations that ignore the environmental factor risk becoming unviable in the face of climate change and the global shift towards sustainability.

In the context of the development of the African Continental Free Trade Area, the assessment of the number of cross-border startups, as well as innovative projects being implemented in several African countries, is very relevant.

Unlike in developed countries, where innovation is often associated with high technology, in Africa, such trivial things as the access to electric energy and 4G/5G

[15] Harris E. Cardiopad: Reaching the Hearts of Rural Communities in Africa. *WIPO Magazine*. 22.09.2014. https:/wipo.int/web/wipo-magazine/articles/cardiopad-reaching-the-hearts-of-rural-communities-in-africa-38958 (accessed: 11.05.2025)

[16] Nsehe M. The Best African Mobile Apps: iCow. *Forbes*. 02.08.2011. https://forbes.com/sites/mfonobongnsehe/2011/08/02/the-best-african-mobile-apps-icow/ (accessed: 11.05.2025)

[17] Engels Z. Uganda: MamaOpe Smart Jacket for Pneumonia. *TheBorgenProject*. 29.09.2020. https://borgenproject.org/mamaope-smart-jacket/ (accessed: 11.05.2025)

mobile network coverage outside large cities, which characterizes the level of mobile Internet penetration in rural areas, are also important in terms of analysis and forecasting.

CONCLUSION

The innovative development of the African continent is progressive but uneven. North African countries are increasing their innovation potential in terms of GERD, patents, and position in global rankings, which in many ways contrasts with most sub-Saharan African countries.

The undisputed leader of the continent is Egypt, which has exponentially increased research and development spending over the past decade to 1% of GDP, as outlined in the pan-African and national science and innovation strategies.

The total GERD for African countries currently exceeds $40 billion, and given that the economic growth rates of the continent's leading economies exceed the global level, it can be assumed that the indicator's value will increase over the long term and in some cases outstrip the GDP growth rate.

In the coming decades, investments in science and technology are expected to increase on the continent, not only from public sources but also from private national capital and the development of crowdfunding platforms.

The relationship between GERD and the number of researchers in African countries is non-linear; however, there is a direct correlation: the higher the spending on science, technology, and innovation, the more researchers are involved in research and development.

The patent landscape of the continent is uneven, with applicants from Egypt, Morocco, Kenya, and the Republic of Mauritius making a significant contribution, while the growth of patent applications is mainly driven by non-residents. The low patent activity of African researchers is primarily determined by systemic barriers associated with the long period of consideration of patent applications and the high cost of filing applications for patent registration. Most African innovators prefer more expeditious and low-cost ways to protect intellectual property rights by registering trademarks or keeping IPD in the know-how mode.

The GII, as well as other international ratings reflecting the level of innovative development, is subjective and does not take into account informal innovations typical of developing countries. The situation in Africa, despite the growth of innovative indicators, has remained virtually unchanged over the past decade and is deteriorating for individual states such as Nigeria and Kenya. High-income countries gain a priori an advantage in GII due to their well-developed infrastructure, even if their innovation systems are less effective in modern conditions. This contradiction highlights the need to develop more flexible criteria that take into account the unique ways of African innovation.

The problem of measuring innovation in Africa requires a revision of established paradigms, the abandonment of Eurocentric criteria, and the harmonization of methods for collecting data on innovation at the AU level, as well as the development of a special pan-African index or indicator system. The continent's success lies not so much in the field of breakthrough technologies but rather in the ability to adapt solutions to local realities.

In order to improve the effectiveness of the analysis of the level of innovative development of African countries, it is necessary to supplement the conventional metrics, which often ignore the unique socio-economic, cultural, and infrastructural features of the continent, with alternative assessment approaches that take into account informal

innovations and adaptive technologies. Research in this area will form the basis for studying and building unique models of innovative development in African countries and will identify the most promising partners for expanding scientific and technical cooperation.

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Научная статья

ОЦЕНКА УРОВНЯ ИННОВАЦИОННОГО РАЗВИТИЯ СТРАН АФРИКИ: ТРАДИЦИОННЫЕ ИНДИКАТОРЫ И АЛЬТЕРНАТИВНЫЕ ПОДХОДЫ

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Аннотация. Инновации играют ключевую роль в социально-экономическом развитии Африки, однако их измерение сталкивается с уникальными методологическими и контекстуальными вызовами. В статье рассматривается проблема оценки уровня инновационного развития стран Африки, которая остается актуальной в условиях глобализации и цифровизации мировой экономики, а также приводятся ограничения классических подходов, включая недостаточную статистическую базу и низкую сопоставимость данных между странами. Традиционные индикаторы, такие как количество патентов, расходы на научные исследования и разработки и публикационная активность, часто не учитывают специфику африканских экосистем, где преобладают неформальные инновации, адаптивные технологии и локальные решения. Автором проводится оценка уровня инновационного развития стран Африки и предлагаются подходы, учитывающие уникальные экономические, инфраструктурные и культурные особенности континента. Особое внимание уделяется развитию успешных инновационных экосистем в отдельных африканских странах (Кения, Нигерия), где сочетание традиционных и альтернативных показателей позволяет более точно оценить динамику развития. Результаты демонстрируют необходимость адаптации существующих метрик для африканского контекста, а также потенциал альтернативных подходов в формировании более объективной картины инновационного прогресса региона. Предоставляя детальное понимание африканских инновационных процессов, данное исследование призвано помочь политикам, международным организациям и инвесторам в разработке стратегий, учитывающих локальную специфику. Статья вносит вклад в глобальную дискуссию, переосмысливая

подходы к измерению инноваций и бросая вызов европоцентристским парадигмам и метрикам, формируя основы для изучения и построения уникальных моделей инновационного развития стран Африки.

Ключевые слова: инновации, оценка уровня инновационного развития, затраты на исследования и разработки, результаты интеллектуальной деятельности, глобальный инновационный индекс, адаптивные инновации, Африка

Конфликт интересов: автор заявляет об отсутствии конфликта интересов.

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