It's not rocket science - Science, Technology, and Innovation (STI) can unleash sustainable industrialization in Africa

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Abstract

STI has been crucial to the economic transformation of many developing countries, notably in East Asia. However, Africa is yet to effectively harness the power of STI to drive its economic transformation, including through industrialization. Limited industrialization is also one of the key factors contributing to high unemployment rates, especially among the burgeoning youth population in Africa. This youth bulge can represent a demographic dividend with the right policies that situate science, technology, engineering, and mathematics (STEM) at the heart of education systems, and STI policy through leveraging intellectual property (IP) rights as enablers. This policy proposal outlines a strategic approach for African countries to promote industrialization, leveraging STEM education and IP rights as enablers of STI.

In spite of its existing development strategies[1], fast-growing internal markets, youth labour force, and abundant natural resources, Africa remains the world's least industrialized region[2] with a narrow industrial base and low manufacturing value added (MVA). Africa possesses 60 percent of the world's arable lands, 30 percent of the world's minerals, and has the youngest population worldwide.[3] As of 2022, about 40 percent of the population was aged 15 years and younger, compared to a global average of 25 percent.[4]

Realizing the need to fully harness Africa's abundant resources through leveraging the benefits of science, technology, and innovation (STI) and promote industrialization, African countries have adopted the STI Strategy for Africa-2024 (STISA-2024), which places STI at the centre of Africa's socio-economic development (African Union [AU], 2014a).[5] STISA-2024 seeks to improve competencies and institutional capacity for STI development through investment in education, especially in areas such as Science, Technology, Engineering, and Mathematics (STEM) education, research and development (R&D), and protection of knowledge production (including inventions and indigenous knowledge) by strengthening intellectual property (IP) rights and regulatory regimes at all levels.

Industrialization in Africa

Landscape of Industrialization in Africa

Industrialization is central to Africa's development prospects. Yet, 45 out of the 54 countries remain dependent on exports of agricultural, mining, and extractive industries,[6] indicating the urgent need for economic diversification through industrialization. Its manufacturing value added as a proportion of Gross Domestic Product (GDP)[7] is the lowest in the world , with 10.4% in 2022 (Figure 1), and its share of global manufacturing has declined to 2%.[8] The typical African manufacturing firm remains small and informal. Most African countries are at the low end of the global value chain (GVC) in the apparel, food, and automotive

1 These include; UN 2030 Sustainable Development Goals (SDGs), AU Agenda 2063, Industrial Development Decades for Africa (IDDA) I, II, and III; and the Strategy for the Implementation of the Action Plan for Accelerated Industrial Development of Africa (AIDA)

2 Hai H (2020). Article: Making Industrialization in Africa Sustainable, United Nations Chronicle, 1 December 2020 - https://www.un.org/en/un-chronicle/making-industrialization-africa-sustainable#

3 Foresight Africa (2022). Report on top priorities for the continent in 2022, Africa Growth Initiative at Brookings Institution https://www.brookings.edu/wp-content/uploads/2022/01/foresightafrica2022_fullreport.pdf

4 Statista (2023) https://www.statista.com/statistics/1226211/population-of-africa-by-age-group/#

5 Khan M J (2022). The Status of Science, Technology and Innovation in Africa, SAGE Journals, Volume 26, Issue 3 - https://www.researchgate.net/publication/359525365_The_Status_of_Science_Technology_and_Innovation_in_Africa

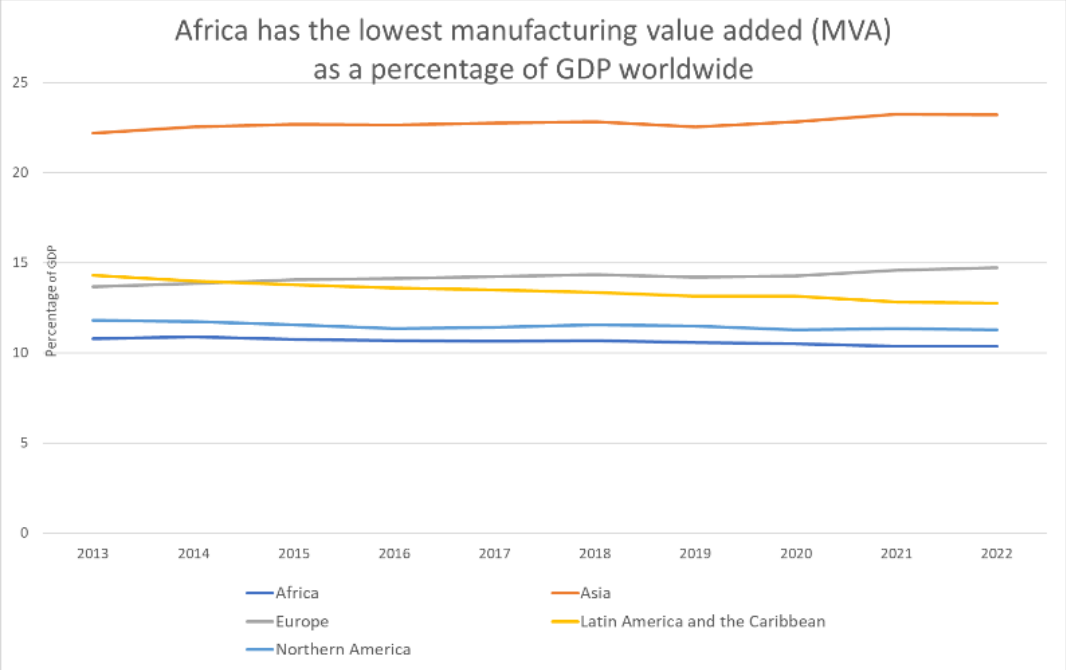
6 UNCTAD (2022); Rethinking the Foundations of Export Diversification in Africa, Economic Development in Africa Report 2022. https://unctad.org/edar2022#:~:text=UNCTAD's%20Economic%20Development%20in%20Africa,export%20diversification%20remains%20a%20challenge. Nine (9) non-commodity-dependent African countries are Comoros, Djibouti, Egypt, Eswatini, Lesotho, Mauritius, Morocco, South Africa and Tunisia

7 UN-SDG indicator 9-2-1, "manufacturing value added as a proportion of GDP and per capita." https://unstats.un.org/sdgs/dataportal

8 African Development Bank Group (2022). Africa Industrialization Index 2022, page 7. https://www.afdb.org/en/documents/africa-industrialization-index-2022

industries.[9] According to the African Industrialization Index of the African Development Bank, the top three countries leading industrialization are South Africa, Morocco, and Tunisia,[10] while Africa's 33 least developed countries (LDCs) have recorded only limited progress in SDG industrialization indicators.[11]

Figure 1. Manufacturing value added (MVA) as a percentage of GDP



Data source: UN SDG Indicators Database

Challenges to Promote Industrialization

Industrialization is indispensable for economic diversification, job creation, and higher productivity. However, African countries face numerous challenges in their industrialization pursuit. For instance, inadequate infrastructure is the most pressing constraint on industrialization, and the continent's infrastructure needs were estimated at $130-170 billion per year.[12] Half of Africans currently have no access to energy, and 30% lack access to clean water - two essential inputs for agro-processing and other industries.[13] Small domestic markets and high tariffs on regional trade have also long held back Africa's manufacturing, though the African Continental Free Trade Area (AfCFTA) promises to address these by creating larger regional markets.

Among outstanding challenges, limited access to technology and innovation, skills and education gaps pose serious concerns. STI is key to overcoming these bottlenecks. It is estimated that only 52% of working-age Africans will have completed secondary education by 2030.[14] The youth bulge can represent a demographic dividend with the right policies to situate STI at the heart of education systems and leverage STEM education and IP rights as enablers.

Opportunities to leverage science, technology, and innovation (STI) to promote industrialization

3.1 Landscape of STI in Africa

African Member States recognize the role that STI can play in advancing industrialization and Africa's socio-

9 World Bank (2000), Trading for development in the age of Global Value Chain, page 25. https://www.worldbank.org/en/publication/wdr2020

10 AfDB (2022). Page 29-30. A small group of mainly conflict-affected countries are lagging (from bottom Gambia, Burundi, Guinea-Bissau).

11UNIDO (2023), International Yearbook of Industrial Statistics Edition 2023, page 18. https://www.unido.org/sites/default/files/unido-publications/2023-12/UNIDO_IndustrialStatistics_Yearbook_2023.pdf

12African Development Bank Group (2018), African Economic Outlook 2018, page XV. - https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African_Economic_Outlook_2018_-_EN.pdf

13AfDB (2022), page 11.

14Ibid.

economic development and growth through the establishment of regional frameworks such as the AU STISA-2024 and national policies.[15] However, studies show that a lack of implementation of policies and strategies by African governments is hampering the implementation of STISA-2024. This is demonstrated by the lack of funding for STI programmes. Presently, there is no AU funding mechanism for the implementation of STISA-2024, despite the calls for the establishment of an African Science, Technology, and Innovation Fund.[16] According to Brookings Institution, the lack of investment in STI has undermined Africa's economic transformation at both the structural level (the transfer of resources from low to higher-productivity sectors) and the sectoral level (the increase of productivity within sectors)[17].

African Heads of State and Government committed to raising their national gross expenditure on research and development (GERD) to at least 1 percent of their GDP, with the aim of increasing innovation, productivity, and economic growth[18]. However, as of 2018, only 25 countries[19] had STI policy frameworks, most of which are framed around increasing GERD as a percentage of GDP. There is no African country that has met this target, and this was pushed further by the impact of the COVID-19 pandemic.[20] Over the past decade, African countries have increased their national or domestic investments in R&D, and foreign funding has also grown[21]. Despite this, Africa's GERD only grew from an average of 0.26 in 2000 to 0.54 in 2020.

According to UNCTAD, only 27 African countries now have a policy intended to drive STI for national goals. Seychelles, South Africa, Kenya, Namibia, and Eswatini have begun to revise their STI policy frameworks and reconfigure their institutional arrangements to make them effective for implementing the SDGs and Agenda 2063[22].

Another challenge is the lack of data on STI for assessment on implementing regional frameworks such as STISA-2024. Due to a lack of data, many African countries are faced with challenges in assessing the effectiveness of their STI policies and strategies. The lack of a common set of African STI indicators has hindered the region's capacity to make evidence-based STI decisions. The lack of monitoring and evaluation, as well as budgets for STI policy implementation, are major impediments to leveraging STI to achieve sustainable industrialization. Businesses and civil society tend to be excluded from STI prioritization and agenda-setting.

3.2 STEM education

STEM education forms the basis for developing STI. The AU Agenda 2063 envisages a continent with well-educated and skilled citizens, and this should be underpinned by STI. It is breakthroughs in STI, driven by a workforce skilled in STEM that will enable African countries to advance in industrialization.[23] Empirical research indicates that through its investment in STEM education and STI, China has been able to move up the GVC due to structural transformation fused by trade and foreign direct investment (FDI) liberalization since 2000, which enabled producers in China to expand their product varieties. Overall, STI has contributed to the increase in domestic value added to Chinese exports.[24]

15 Khan M (2022)., , The Status of Science, Technology and Innovation in Africa, SAGE Journals, Volume 26, Issue 3, March 2022 - https://www.researchgate.net/publication/359525365_The_Status_of_Science_Technology_and_Innovation_in_Africa

16 The African Academy of Sciences (2018). Africa Beyond 2030 - Leveraging Knowledge and Innovation to Secure Sustainable Development Goals - https://old.aasciences.africa/sites/default/files/inline-files/Africa%20Beyond%202030.pdf

17 Brookings Institution (2022), Foresight Africa: Top Priorities of the Continent - https://www.brookings.edu/wp-content/uploads/2022/01/foresightafrica2022_fullreport.pdf

18 UNECA (2018). "Towards Achieving the African Union's recommendation of expenditure of 1% of GDP on Research and Development", No. ECA/18/004 - https://repository.uneca.org/bitstream/handle/10855/24306/b11889202.pdf?sequence=1&isAllowed=y

19 Algeria, Angola, Botswana, Burundi, Cameroon, Egypt, Ethiopia, The Gambia, Ghana, Kenya, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Seychelles, Sudan, Swaziland, South Africa, Tunisia, Tanzania, Uganda, Zambia, and Zimbabwe.

20 Kigotho W (2021). Countries spend less than 1% of GDP on research, University World News, Africa Edition, 17 June 2021 - https://www.universityworldnews.com/post.php?story=20210616151534847

21 The African Academy of Sciences (2018), Leveraging Knowledge and Innovation to Secure Sustainable Development Goals, Africa Beyond 2030 - https://old.aasciences.africa/sites/default/files/inline-files/Africa%20Beyond%202030.pdf

22 Mugabe J (2019). Building Capacity to Govern Science, Technology, and Innovation Policy for Sustainable Development Goals in Africa, UNCTAD. 13 June 2019 - https://unctad.org/news/building-capacity-govern-science-technology-and-innovation-policy-sustainable-development

23 Souter D, Adam L, Butcher N, Sibthorpe C, Tusu T (2014). ICTs for Education in Africa. World Bank - https://openknowledge.worldbank.org/entities/publication/

24 Kee H L. (2016). Article: How has China moved-up the global value chains?, World Bank 11 January 2016 - https://blogs.worldbank.org/en/developmenttalk/how-has-china-moved-global-value-chains

Human capital, in the form of well-educated and highly qualified people, is essential to the achievement of STISA-2024's strategic objectives aimed at promoting sustainable industrialization. The rise in automation and technological advancements in infrastructure and urban design, energy, health, and food systems, which are all part of industrialization, require an updated skill set for jobs such as technicians, technologists, engineers, and scientists. To develop and enhance such STI skills and talents within the continent, African Governments have been focused on improving the STEM skills outputs within the education system.[25]

However, the African region is falling behind in STEM education outputs compared to the rest of the regions. According to the African Development Bank, less than 25% of African students in secondary and tertiary institutions pursue STEM career fields.[26] Furthermore, several African countries have limited capacity and output of technical skills training necessary for technicians needed to promote industrialization. According to UNESCO, Africa has the lowest number of engineering professionals per capita of all regions of the world. For example, Eswatini has only one engineering graduate of more than 170,000 compared to 1,100 people in the UK.[27] Such low STEM skill output has negatively impacted the development and growth of knowledge-based industries.

Implementing STEM education policy has proved difficult in most African countries, considering the investment needed to review school curricula, undertake continuing teacher development programmes and infrastructure development, and establish links between education and relevant industries. It is argued that if African Governments can allocate at least 20 percent of their budget to education, schools can provide minimum STEM education and the required facilities.[28] For instance, Rwanda has invested in STEM education to enhance its STI as a foundation to grow and diversify its economy.[29] Reference to STEM is articulated, with a number of performance indicators in key documents including national development policies, education, STI and ICT policies. Over the years, the Government of Rwanda has prioritized the education sector in national budget allocation. This is reflected by an increase in budget for this sector by nearly 20% from FRW 479.1 billion in 2021/22 to FRW 573.5 billion in 2022/23[30]. There is also a need for collaboration and partnerships among academic institutions, industry, government, and non-governmental organizations to increase the investment in STEM education.

3.3 Calibrating effective intellectual property (IP) ecosystems

IP rights protection is closely linked to scientific and technological innovations. Among IP rights, patents, utility models, and industrial designs are likely to be the most relevant for industrial policies, [31] and appropriate IP institutions promote the dissemination of the latest STI information. While much research has analyzed the complex relationships between IP protection, innovation, and industrialization, the relationship between them remains inconclusive. For instance, empirical research indicated that all successful industrialization and/or catching-up economic development occurred under relatively weak IP regimes, allowing easier knowledge acquisition and imitation.[32] However, strong IP rights regimes are vigorously promoted by advanced economies on the innovation frontier in order to effectively protect IP.[33]

25 AUDA-NEPAD (2021). Leaving No One Behind: Accelerating Science, Technology, Engineering, And Mathematics (STEM) Education in Africa, 7 June 2021 - https://www.nepad.org/blog/leaving-no-one-behind-accelerating-science-technology-engineering-and-mathematics-stem

26 AUDA-NEPAD (2021), Rwanda As a model: Improving STEM Education Curricula in Africa, 21 June 2021 - https://www.nepad.org/blog/rwanda-model-improving-stem-education-curricula-africa

27 UNESCO (2021). Report on Engineering for Sustainable Development - https://unesdoc.unesco.org/ark:/48223/pf0000375644/PDF/375644eng.pdf.multi

28 Kagia K (2023). STEM education in Africa: Risk and opportunity. Brookings, Washington DC. 10 February 2023 - https://www.brookings.edu/blog/africa-in-focus/2023/02/10/stem-education-in-africa-risk-and-opportunity/

29 World Bank (2022).; Rwanda Economic Update: Regional Integration in Post-COVID Era, February 2022 - https://www.worldbank.org/en/news/press-release/2022/02/02/rwanda-economic-update-regional-integration-in-post-covid-era#:

30 UNICEF (2023), Education Budget Brief– Investing in Child Education in Rwanda (2022/2023) - https://www.unicef.org/rwanda/media/4596/file/Education-Budget-Brief-2022-2023.pdf

31 Correa, Carlos M (2015), Intellectual property: how much room is left for industrial policy? UNCTAD Discussion paper. No. 223. https://unctad.org/system/files/official-document/osgdp20155_en.pdf. Patents (drugs, engines, and electronics), utility models (mechanical industry), and industrial designs (clothing, automobiles, and electronics).

32 Cimoli, Mario, Coria, Benjamin and Primi, Annalisa (2009), Intellectual Property and Industrial Development: A Critical Assessment. https://academic.oup.com/book/32519/chapter-abstract/270244879?redirectedFrom=fulltext

33 Ibid.

After adopting the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (WTO-TRIPS), which set international minimum IP requirements, African countries have limited IP policy space to create an enabling environment for industrialization. Therefore, national IP policies should be strategically crafted and selectively applied to avoid their negative effect for economic development and maximize the positive IP impacts for local innovations and technology transfer. Africa should also leverage policy space provided by the TRIPS flexibilities to promote industrialization.[34]

The number of patent registrations filed in countries is widely used to measure innovation, but Africa should scale it up to catch up with other regions. In 2022, Africa accounted for only 0.7% of the world's patent applications, with the number of resident applications constituted only 19.3%, indicating that most of the applications were submitted by non-residents.[35] The presence of appropriately tailored IP protection provides incentives for domestic innovation and technological development, including through R&D investment. In turn, a lack of IP protection may slow technological advances even in developing countries, while some argue that weak IP protection may promote imitative duplication or reverse engineering activity for technology acquisition.[36]

The kind of IP to adopt depends on an individual country's capacity for technological absorption, its level of productive capacities, and its innovation potential.[37] As for the patent system, the empirical literature explains that if there is a beneficial effect on innovation from patents, it is likely to be centered in the pharmaceutical, biotechnology, and medical instrument areas.[38] For most African countries, the main policy could be to rigorously define the patentability standards and thereby avoid the grant of unwarranted patent rights that may be used to block local innovation.[39] Many African patent offices, however, do not conduct substantive patent examinations with limited infrastructure to ensure that the information contained in patent applications is made electronically available to the public.[40] In LDCs, adopting utility models may have great potential in encouraging local technological activity. However, 14 of the 33 African LDCs do not have legislation on utility models,[41] affecting their ability to leverage IP for industrialization strategically.

As for international technology transfer, research indicates[42] that it typically occurs via trade, FDI, joint ventures with local partners having appropriate absorbing capacity. The presence of enforceable IP rights should, thus, encourage all these activities. The trade literature also suggests that the strength of a country's IP system affects the willingness of advanced economies to export manufacturing products, especially if the concerned country has an imitative capacity.[43]

National IP policies, therefore, need to be crafted based on a country's unique requirements and strategic priorities, considering its stage of economic development, economic structure, export basket, levels of science and education, and R&D environment.[44]

Policy recommendations/conclusions

- The African Union and national governments should urgently adopt a cross-sector approach, which involves the inclusion of all major stakeholders/players in the implementation process of STISA-2024 and the Strategy for the Implementation of the Action Plan for Accelerated Industrial Development of Africa (AIDA).
- African Governments and partners need to regularly track and record STI-related data to promote sound STI policymaking and implementation. Accurate data will enable updating STI policies and strategies and

[34] UNECA (2021), Towards a Common Investment Area in the African Continental Free Trade Area, page 209. https://www.uneca.org/commoninvestmentarea. These flexibilities are; transitional periods, bolar exception, research/experimental use exception, compulsory licensing and government use and exhaustion.

[35] WIPO (2023), World Intellectual Property Indicators 2023, p25. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-941-2023-en-world-intellectual-property-indicators-2023.pdf. For instance, Asia, 67.9%, North America, 18.3%, and Europe, 10.3%.

[36] Rai, Munmun, Singh Love Kumar, Sharma, Aarti (2009), IP: A strong determinant of economic growth. page 2. https://www.researchgate.net/publication/40542662_Intellectual_property-A_strong_determinant_of_Economic_Growth

[37] UNCTAD (2024), page 6.

[38] HALL, Bronwyn,(2020), Patents, Innovation and Development. page 6. https://eml.berkeley.edu/~bhhall/papers/BHH20_Penrose_paper.pdf

39 Correa (2015)

[40] Mgbeoji, Ikechi (2014), "African patent offices not fit for purpose", in Innovation & Intellectual Property: Collaborative Dynamics in Africa, Claremont, University of Cape Town Press

41 UNCTAD (2023), Revisiting development innovations in least developed countries: A practical review of selected intellectual property rights measures, Annex 3. https://unctad.org/system/files/official-document/aldc2023d3_en.pdf

42 Hall (2000) page 12.

43 Ibid.

44 UNCTAD (2024), page 16.

determining how much to allocate to build STI capacities and frameworks.

- African Governments should prioritize and increase investments in STEM education to unleash the potential of their workforce. To enhance the effectiveness of STEM education-related policies, there is a need to focus on improving the quality and relevance of education systems by aligning them with the specific skill requirements of the industrial sector.
- African countries should promote a conducive ecosystem that supports R&D and technological advancements. Policymakers should implement policies that facilitate collaboration between the Government, industry, and academia/research institutions.
- African Governments should strategically calibrate IP ecosystems, considering existing frameworks such as the WTO-TRIPS, industrial composition, R&D environment, and the advancement of industrialization.
- African countries should strengthen their IP office capacities to promote STI information sharing and provide effective IP protections, including robust and reliable patents.

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